2016
Road and Bridge Specifications

VDOT Virginia Department of Transportation

INTRODUCTION

These Road and Bridge Specifications are standard for all contracts awarded by the Commonwealth Transportation Board or the Commissioner. The requirements stated herein may be revised or amended from time to time, but only to the extent permitted under Supplemental Specifications, Special Provisions, and Special Provision Copied Notes included in the specific contract.

Reference by date and title will be made to these Specifications on plans and other contract documents as notification of their application to those documents. Copies of these Specifications may be obtained from the office of the State Construction Engineer at 1401 E. Broad St., Richmond, VA 23219 or online at http://www.virginiadot.org/business/const/spec-default.asp.

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2016 VDOT Road and Bridge Specifications

TABLE OF CONTENTS

DIVISION I—GENERAL PROVISIONS 1

SECTION 101—DEFINITIONS OF ABBREVIATIONS, ACRONYMS, AND TERMS 3
101.01—Abbreviations and Acronyms 3
101.02—Terms. 4

SECTION 102 BIDDING REQUIREMENTS AND CONDITIONS 16
102.01—Prequalification of Bidders 16
102.02—Content of Proposal. 17
102.03—Interpretation of Quantities in Proposal 17
102.04—Examination of Site of Work and Proposal. 17
102.05—Preparation of Bid. 19
102.06—Irregular Bids 21
102.07—Proposal Guaranty (Bid Bond) 22
102.08—Disqualification of Bidder. 22
102.09—Submission of Bid. 24
102.10—Withdrawal of Bid. 24
102.11—eVA Business-To-Government Vendor Registration. 24
102.12—Public Opening of Bids. 24
102.13—”E-Verify” - Verification of Work Authorization. 25

SECTION 103—AWARD AND EXECUTION OF CONTRACTS 25
103.01—Consideration of Bids 25
103.02—Award of Contract. 26
103.03—Cancellation of Award. 26
103.04—Forfeiture of Proposal Guaranty 26
103.05—Requirements of Contract Bond 27
103.06—Contract Documents 27
103.07—Failure to Furnish Bonds or Certificate of Insurance 29
103.08—Contract Audit. 29
103.09—Execution of Contract 30
103.10—Assignments, Transfers, or Assumptions of the Contract. 31

SECTION 104—SCOPE OF WORK 31
104.01—Intent of Contract 31
104.02—Changes in Quantities or Alterations in the Work. 31
104.03—Differing Site Conditions 34

SECTION 105—CONTROL OF WORK 34
105.01—Notice to Proceed 34
105.02—Pre-Construction Conference 35
105.03—Authorities of Project Personnel, Communication and Decision Making 36
105.04—Gratuities. 42
105.05—Character of Workers, Work Methods, and Equipment. 42
105.06—Subcontracting 43
105.07—Cooperation of Contractor 44

105.08—Cooperation With Regard to Utilities 44
105.09—Cooperation among Contractors 45
105.10—Plans and Working Drawings 46
105.11—Conformity with Plans and Specifications 48
105.12—Coordination of Plans, Standard Drawings, Specifications, Supplemental Specifications, Special Provisions, and Special Provision Copied Notes. 49
105.13—State Force Construction Surveying 50
105.14—Maintenance during Construction. 54
105.15—Removing and Disposing of Structures and Obstructions 59
105.16—Cleanup 60
105.17—Inspection of Work 60
105.18—Removal of Unacceptable and Unauthorized Work 61
105.19—Submission and Disposition of Claims 61

SECTION 106—CONTROL OF MATERIAL 64
106.01—Source of Supply and Quality Requirements 64
106.02—Material Delivery 65
106.03—Local Material Sources (Pits and Quarries) 65
106.04—Disposal Areas 68
106.05—Rights For and Use of Materials Found on Project. 70
106.06—Samples, Tests, and Cited Specifications 71
106.07—Plant Inspection. 71
106.08—Storing Materials. 72
106.09—Handling Materials 73
106.10—Unacceptable Materials. 73
106.11—Material Furnished by the Department 73
106.12—Critical Materials 73

SECTION 107— LEGAL RESPONSIBILITIES 74
107.01—Laws to Be Observed 74
107.02—Permits, Certificates, and Licenses 74
107.03—Federal-Aid Provisions 78
107.04—Furnishing Right of Way. 78
107.05—Patented Devices, Materials, and Processes 78
107.06—Personal Liability of Public Officials 78
107.07—No Waiver of Legal Rights 78
107.08—Protecting and Restoring Property and Landscape. 79
107.09—Contractor's Responsibility for Utility Property and Services 79
107.10—Restoration of Work Performed by Others 80
107.11—Use of Explosives 80
107.12—Responsibility for Damage Claims. 81
107.13—Labor and Wages. 82
107.14—Equal Employment Opportunity. 83
107.15—Use of Small, Women-Owned, and Minority-Owned Businesses (SWaMS) 87
107.16—Environmental Stipulations. 90
107.17—Construction Safety and Health Standards 101
107.18—Sanitary Provisions 102
107.19—Railway-Highway Provisions 102
107.20—Construction Over or Adjacent to Navigable Waters 112
107.21—Size and Weight Limitations 113

SECTION 108—PROSECUTION AND PROGRESS OF WORK 114
108.01—Prosecution of Work 114
108.02—Limitation of Operations 114
108.03—Progress Schedule 115
108.04—Determination and Extension of Completion Date 118
108.05—Suspension of Work Ordered by the Engineer 119
108.06—Failure to Complete on Time 120
108.07—Default of Contract 120
108.08—Termination of Contract 121
108.09—Acceptance 124
108.10—Termination of Contractor's Responsibilities 125

SECTION 109—MEASUREMENT AND PAYMENT 125
109.01—Measurement of Quantities 125
109.02—Plan Quantities 128
109.03—Scope of Payment 129
109.04—Payment for Non-Significant Changes and Additional Units of In-scope Work 130
109.05—Payment for Contract Changes 130
109.06—Common Carrier Rates 137
109.07—Eliminated Items 138
109.08—Partial Payments 138
109.09—Payment for Material on Hand 140
109.10—Final Payment 141

DIVISION II—MATERIALS 143

SECTION 200—GENERAL 145
200.01—Description 145
200.02—Conformance with Specifications 145
200.03—General Sampling and Testing Procedures 145
200.04—Acceptance Procedures for Aggregates 146
200.05—Handling and Storing Aggregates 147
200.06—Technician and Batcher Certification 147

SECTION 201—MINERAL FILLER 148
201.01—Description 148
201.02—Detail Requirements 148

SECTION 202—FINE AGGREGATE 148
202.01—Description 148
202.02—Materials 148
202.03—Detail Requirements 149

SECTION 203—COARSE AGGREGATE 150
203.01—Description 150
203.02—Materials 150
203.03—Detail Requirements 150

SECTION 204—STONE FOR MASONRY, RIPRAP, POROUS BACKFILL, AND GABIONS 153
204.01—Description 153

204.02—Detail Requirements 153

SECTION 205—CRUSHER RUN AGGREGATE 153
205.01—Description 153
205.02—Materials 153
205.03—Detail Requirements 154

SECTION 206—LIGHTWEIGHT AGGREGATE 154
206.01—Description 154
206.02—Detail Requirements 155

SECTION 207—SELECT MATERIAL 155
207.01—Description 155
207.02—Detail Requirements 155
207.03—Job-Mix Formula for Select Material, Type I 156
207.04—Mixing. 157
207.05—Acceptance of Select Material, Type I 157
207.06—Referee System for Select Material, Type I 158
207.07—Payment Adjustment System for Select Material, Type I 158

SECTION 208—SUBBASE AND AGGREGATE BASE MATERIAL 159
208.01—Description 159
208.02—Materials 159
208.03—Detail Requirements 159
208.04—Job-Mix Formula. 160
208.05—Mixing. 160
208.06—Acceptance 161
208.07—Referee System 162
208.08—Payment Adjustment System. 162

SECTION 209—OPEN-GRADED SHOULDER MATERIAL. 163
209.01—Description 163
209.02—Detail Requirements 163
209.03—Mixing. 164

SECTION 210—ASPHALT MATERIALS 164
210.01—Description 164
210.02—Materials 164
210.03—Virginia Asphalt Acceptance Program (VAAP) 165
210.04—VDOT Asphalt Acceptance Program Requirements and Compliance 165
210.05—Sampling 166
210.06—Testing. 166
210.07—Tests. 167
210.08—Storing and Shipping. 170
210.09—Payment Adjustment System. 170

SECTION 211—ASPHALT CONCRETE 170
211.01—Description 170
211.02—Materials 171
211.03—Job-Mix Formula. 175
211.04—Asphalt Concrete Mixtures 180

211.05—Testing . . . 181
211.06—Tests. . . . 182
211.07—Plant Inspection. . . . 183
211.08—Acceptance . . . 183
211.09—Adjustment System . . . 184
211.10—Referee System . . . 185
211.11—Handling and Storing Aggregates . . . 186
211.12—Asphalt Concrete Mixing Plant. . . . 186
211.13—Preparation of Mixture . . . 189
211.14—Storage System . . . 190
211.15—Initial Production . . . 190

SECTION 212—JOINT MATERIALS . . . 191
212.01—Description . . . 191
212.02—Detail Requirements . . . 191

SECTION 213—DAMP-PROOFING AND WATERPROOFING MATERIALS . . . 198
213.01—Description . . . 198
213.02—Detail Requirements . . . 198

SECTION 214—HYDRAULIC CEMENT . . . 198
214.01—Description . . . 198
214.02—Detail Requirements . . . 199

SECTION 215—HYDRAULIC CEMENT CONCRETE ADMIXTURES . . . 199
215.01—Description . . . 199
215.02—Materials . . . 199
215.03—Detail Requirements . . . 200

SECTION 216—WATER FOR USE WITH CEMENT OR LIME. . . . 200
216.01—Description . . . 200
216.02—Detail Requirements . . . 200

SECTION 217—HYDRAULIC CEMENT CONCRETE . . . 201
217.01—Description . . . 201
217.02—Materials . . . 201
217.03—Handling and Storing Materials . . . 203
217.04—Measurement of Materials . . . 204
217.05—Equipment . . . 205
217.06—Classification of Concrete Mixtures . . . 207
217.07—Proportioning Concrete Mixtures . . . 209
217.08—Acceptance . . . 213
217.09—Mixing. . . . 217
217.10—Placement Limitations . . . 219
217.11—Self Consolidating Concrete (SCC) . . . 219
217.12—Low Shrinkage Class A4 Modified Concrete . . . 220
217.13—Latex-modified Concrete, Very-Early-Strength (LMCVE), for Bridge Deck Overlays . . . 221
217.14—High Early Strength Latex Modified Concrete (HESLMC) for Bridge Deck Overlays . . . 221

SECTION 218—HYDRAULIC CEMENT MORTAR AND GROUT 222
218.01—Description 222
218.02—Materials 222
218.03—Detail Requirements 222

SECTION 219—RIGHT-OF-WAY MONUMENTS. 223
219.01—Description 223
219.02—Detail Requirements 223

SECTION 220—CONCRETE CURING MATERIALS 223
220.01—Description 223
220.02—Detail Requirements 224

SECTION 221—GUARDRAIL 225
221.01—Description 225
221.02—Detail Requirements **225**

SECTION 222—MASONRY UNITS. 226
222.01—Description 226
222.02—Detail Requirements 226

SECTION 223—STEEL REINFORCEMENT. 227
223.01—Description 227
223.02—Detail Requirements 227

SECTION 224—CASTINGS 229
224.01—Description 229
224.02—Material. 229
224.03—Detail Requirements 229

SECTION 225—STEEL FORGINGS AND STEEL SHAFTING 229
225.01—Description 229
225.02—Detail Requirements 230

SECTION 226—STRUCTURAL STEEL. 230
226.01—Description 230
226.02—Detail Requirements 230

SECTION 227—STEEL GRID FLOORING 233
227.01—Description 233
227.02—Materials 233
227.03—Detail Requirements 233

SECTION 228—STEEL PILES. 233
228.01—Description 233
228.02—Detail Requirements 233

SECTION 229—ALUMINUM ALLOY. 234
229.01—Description 234
229.02—Detail Requirements 234

SECTION 230—BRONZE AND COPPER ALLOY 235
230.01—Description 235
230.02—Detail Requirements 235

SECTION 231—PAINT. 235
231.01—Description 235
231.02—Materials 236
231.03—Detail Requirements 237

SECTION 232—PIPE AND PIPE ARCHES. 240
232.01—Description 240
232.02—Detail Requirements 241

SECTION 233—GALVANIZING. 246
233.01—Description 246
233.02—Detail Requirements 246
233.03—Repair of Galvanized Surfaces 246

SECTION 234—GLASS BEADS FOR REFLECTORIZING TRAFFIC MARKINGS 247
234.01—Description 247
234.02—Detail Requirements 247

SECTION 235—RETROREFLECTORS 247
235.01—Description 247
235.02—Detail Requirements 247

SECTION 236—WOOD PRODUCTS. 249
236.01—Description 249
236.02—Detail Requirements 249

SECTION 237—STRUCTURE BEDDING MATERIAL AND BEARING PADS 251
237.01—Description 251
237.02—Detail Requirements 251

SECTION 238—ELECTRICAL AND SIGNAL COMPONENTS. 254
238.01—Description 254
238.02—Detail Requirements 254

SECTION 239—SODIUM CHLORIDE AND CALCIUM CHLORIDE. 261
239.01—Description 261
239.02—Detail Requirements 261

SECTION 240—LIME 262
240.01—Description 262
240.02—Detail Requirements 262

SECTION 241—FLY ASH 263
241.01—Description 263
241.02—Detail Requirements 263

SECTION 242—FENCES. 263
242.01—Description 263

242.02—Detail Requirements 263

SECTION 243—EPOXY-RESIN SYSTEMS 267
243.01—Description 267
243.02—Detail Requirements 267
243.03—Handling and Storing Materials 270
243.04—Acceptance 271

SECTION 244—ROADSIDE DEVELOPMENT MATERIALS. 272
244.01—Description 272
244.02—Detail Requirements 272

SECTION 245—GEOSYNTHETICS AND LOW PERMEABILITY LINERS 288
245.01—Description 288
245.02—Shipping, Handling, and Storage Requirements. 288
245.03—Testing and Documentation. 289

SECTION 246—PAVEMENT MARKING 292
246.01—Description 292
246.02—Detail Requirements 292
246.03—Pavement Marking Materials 294

SECTION 247—REFLECTIVE SHEETING. 309
247.01—Description 309
247.02—Detail Requirements 309
247.03—Reflective Sheeting Warranty Requirements 312

SECTION 248—STONE MATRIX ASPHALT CONCRETE. 313
248.01—Description 313
248.02—Materials 313
248.03—Composition of SMA Mixture 317
248.04—Acceptance 318
248.05—SMA Mixing Plant 319

SECTION 249—FLOWABLE BACKFILL. 320
249.01—Description 320
249.02—Materials 320
249.03—Mix Design 320

SECTION 250 - CARBON FIBER MESH 321
250.01—Description 321
250.02—Materials 321

SECTION 251 - GALVANIC ANODES 321
251.01—Description 321
251.02—Detail Requirements 321

SECTION 252 - GRAVITY-FILL POLYMER CRACK SEALERS. 322
252.01—Description 322
252.02—Materials 322

DIVISION III—ROADWAY CONSTRUCTION 323

SECTION 301—CLEARING AND GRUBBING 325
301.01—Description 325
301.02—Procedures 325
301.03—Measurement and Payment 326

SECTION 302—DRAINAGE STRUCTURES 326
302.01—Description 326
302.02—Materials 327
302.03—Procedures 327
302.04—Measurement and Payment 341

SECTION 303—EARTHWORK 345
303.01—Description 345
303.02—Materials 345
303.03—Erosion and Siltation Control and Stormwater Pollution Prevention 346
303.04—Procedures 350
303.05—Tolerances 359
303.06—Measurement and Payment 359

SECTION 304—CONSTRUCTING DENSITY CONTROL STRIPS 368
304.01—Description 368
304.02—Materials 368
304.03—Equipment 368
304.04—Procedures 368
304.05—Tolerances 369
304.06—Measurement and Payment 370

SECTION 305—SUBGRADE AND SHOULDERS 370
305.01—Description 370
305.02—Materials 370
305.03—Procedures 370
305.04—Measurement and Payment 373

SECTION 306—LIME STABILIZATION 374
306.01—Description 374
306.02—Materials 374
306.03—Procedures 374
306.04—Measurement and Payment 377

SECTION 307—HYDRAULIC CEMENT STABILIZATION 377
307.01—Description 377
307.02—Materials 378
307.03—Field Laboratory 378
307.04—Weather Limitations 378
307.05—Procedures 378
307.06—Measurement and Payment 382

SECTION 308—SUBBASE COURSE 383
308.01—Description 383

308.02—Materials 383
308.03—Procedures 383
308.04—Tolerances 384
308.05—Measurement and Payment 385

SECTION 309—AGGREGATE BASE COURSE 385
309.01—Description 385
309.02—Materials 385
309.03—Equipment 385
309.04—Procedures 386
309.05—Density Requirements 386
309.06—Measurement and Payment 387

SECTION 310—TACK COAT 387
310.01—Description 387
310.02—Materials 387
310.03—Procedures 387
310.04—Measurement and Payment 390

SECTION 311—PRIME COAT 390
311.01—Description 390
311.02—Materials 390
311.03—Procedures 390
311.04—Measurement and Payment 391

SECTION 312—SEAL COAT 392
312.01—Description 392
312.02—Materials 392
312.03—Equipment 392
312.04—Procedures 392
312.05—Measurement and Payment 393

SECTION 313—ASPHALT-STABILIZED OPEN-GRADED MATERIAL 394
313.01—Description 394
313.02—Materials 394
313.03—Proportioning 394
313.04—Acceptance 395
313.05—Placing limitations 395
313.06—Procedures 395
313.07—Measurement and Payment 396

SECTION 314—PENETRATION SURFACE COURSES 396
314.01—Description 396
314.02—Materials 397
314.03—Weather Limitations 397
314.04—Equipment 397
314.05—Procedures 398
314.06—Measurement and Payment 399

SECTION 315—ASPHALT CONCRETE PLACEMENT 399
315.01—Description 399
315.02—Materials 399

315.03—Equipment . . . 400
315.04—Placement Limitations . . . 401
315.05—Procedures . . . 402
315.06—Pavement Samples . . . 412
315.07—Pavement Tolerances . . . 412
315.08—Measurement and Payment . . . 413

SECTION 316—HYDRAULIC CEMENT CONCRETE PAVEMENT . . . 415
316.01—Description . . . 415
316.02—Materials . . . 415
316.03—Equipment . . . 415
316.04—Procedures . . . 417
316.05—Thickness and Finished Grade Tolerances . . . 427
316.06—Measurement and Payment . . . 427

SECTION 317— STONE MATRIX ASPHALT CONCRETE PLACEMENT . . . 428
317.01—Description . . . 428
317.02—Materials . . . 429
317.03—Composition of SMA Mixture . . . 429
317.04—Acceptance . . . 429
317.05—SMA Mixing Plant . . . 429
317.06—Weather Restrictions . . . 429
317.07—Placing and Finishing . . . 429
317.08—Compaction . . . 430
317.09—Trial Section . . . 431
317.10—Prepaving Conference . . . 432
317.11—Measurement and Payment . . . 432

DIVISION IV—BRIDGES AND STRUCTURES . . . 433

SECTION 401—STRUCTURE EXCAVATION . . . 435
401.01—Description . . . 435
401.02—Materials . . . 435
401.03—Procedures . . . 435
401.04—Measurement and Payment . . . 439

SECTION 402—SHEET PILES . . . 441
402.01—Description . . . 441
402.02—Materials . . . 441
402.03—Procedures . . . 441
402.04—Measurement and Payment . . . 442

SECTION 403—BEARING PILES . . . 442
403.01—Description . . . 442
403.02—Materials . . . 442
403.03—Pile Types . . . 442
403.04—Determination of Pile Lengths . . . 446
403.05—Initial Preparation . . . 447
403.06—Driving Piles . . . 447
403.07—Determination of Nominal Pile Resistance . . . 455
403.08—Driving Criteria . . . 461

403.09—Order List . . . 462
403.10—Measurement and Payment . . . 462

SECTION 404—HYDRAULIC CEMENT CONCRETE OPERATIONS . . . 464
404.01—Description . . . 464
404.02—Materials . . . 464
404.03—Procedures . . . 464
404.04—Bridge Deck Construction . . . 476
404.05—Expansion and Fixed Joints . . . 479
404.06—Bridge Seat Bearing Areas . . . 480
404.07—Finishing Concrete Surfaces . . . 480
404.08—Measurement and Payment . . . 483

SECTION 405—PRESTRESSED CONCRETE . . . 483
405.01—Description . . . 483
405.02—Materials . . . 484
405.03—Plant Review . . . 484
405.04—Concrete Controls . . . 485
405.05—Procedures . . . 485
405.06—Tolerances . . . 492
405.07—Measurement and Payment . . . 494

SECTION 406—REINFORCING STEEL . . . 494
406.01—Description . . . 494
406.02—Materials . . . 494
406.03—Procedures . . . 494
406.04—Measurement and Payment . . . 497

SECTION 407—STEEL AND OTHER METAL STRUCTURES . . . 497
407.01—Description . . . 497
407.02—Materials . . . 498
407.03—Working Drawings . . . 498
407.04—Fabrication Procedures . . . 498
407.05—Handling, Storing, and Shipping Materials . . . 505
407.06—Erection Procedures . . . 506
407.07—Measurement and Payment . . . 513

SECTION 408—BEARING DEVICES AND ANCHORS . . . 514
408.01—Description . . . 514
408.02—Materials and Fabrication . . . 515
408.03—Procedures . . . 515
408.04—Measurement and Payment . . . 532

SECTION 409—STEEL GRID FLOORS . . . 532
409.01—Description . . . 532
409.02—Materials . . . 533
409.03—Procedures . . . 533
409.04—Measurement and Payment . . . 534

SECTION 410—RAILINGS AND PARAPETS . . . 534
410.01—Description . . . 534

410.02—Materials 534
410.03—Procedures 535
410.04—Measurement and Payment 537

SECTION 411—PROTECTIVE COATING OF METAL IN STRUCTURES 537
411.01—Description 537
411.02—Materials 538
411.03—Certifications 538
411.04—General Surface Preparation and Application Standards 539
411.05—Existing Structures 546
411.06—New Structures 548
411.07—Galvanized Surfaces 549
411.08—Observation Period 551
411.09—Environmental Protection 551
411.10—Health and Safety Protection 555
411.11—Measurement and Payment 556

SECTION 412—WIDENING, REPAIRING, AND RECONSTRUCTING EXISTING STRUCTURES 557
412.01—Description 557
412.02—Materials 557
412.03—Procedures 559
412.04—Measurement and Payment 581

SECTION 413—DISMANTLING AND REMOVING EXISTING STRUCTURES OR REMOVING PORTIONS OF EXISTING STRUCTURES 584
413.01—Description 584
413.02—Procedures 584
413.03—Measurement and Payment 586

SECTION 414—RIPRAP 586
414.01—Description 586
414.02—Materials 587
414.03—Procedures 588
414.04—Measurement and Payment 591

SECTION 415—CONCRETE SLOPE PROTECTION 592
415.01—Description 592
415.02—Materials 592
415.03—Procedures 592
415.04—Measurement and Payment 593

SECTION 416—WATERPROOFING 594
416.01—Description 594
416.02—Materials 594
416.03—Procedures 594
416.04—Measurement and Payment 595

SECTION 417—DAMP-PROOFING 596
417.01—Description 596
417.02—Materials 596
417.03—Procedures 596

417.04—Measurement and Payment 596

SECTION 418—TIMBER STRUCTURES. 596
418.01—Description 596
418.02—Materials 597
418.03—Procedures. 597
418.04—Measurement and Payment 600

SECTION 419—BRIDGE CONDUIT SYSTEMS AND LIGHTING SYSTEMS. 601
419.01—Description 601
419.02—Materials 601
419.03—Procedures. 601
419.04—Measurement and Payment 601

SECTION 420—ADHESIVE-BASED JOINT SEALING SYSTEMS 601
420.01—Description 601
420.02—Materials 601
420.03—Procedures. 602
420.04—Measurement and Payment 604

SECTION 421—ELASTOMERIC EXPANSION DAMS 605
421.01—Description 605
421.02—Materials 605
421.03—Procedures. 605
421.04—Measurement and Payment 605

SECTION 422—NAVIGATION LIGHTS. 606
422.01—Description 606
422.02—Materials 606
422.03—Procedures. 606
422.04—Measurement and Payment 607

SECTION 423 – TOOTH EXPANSION JOINT ASSEMBLY. 607
423.01—Description 607
423.02—Materials 607
423.03—Procedures. 607
423.04—Measurement and Payment 608

SECTION 424 - ASPHALT PLUG JOINTS 608
424.01—Description 608
424.02—Materials 608
424.03—Procedures. 609
424.04—Measurement and Payment 610

SECTION 425—RIGID CONCRETE BRIDGE DECK OVERLAYS. 611
425.01—Description 611
425.02—Materials 611
425.03—Procedures. 611
425.04—Measurement and Payment 618

SECTION 426—REPAIRING EXISTING STEEL STRUCTURES 619
426.01—Description 619

426.02—Materials . . . 619
426.03—Procedures . . . 619
426.04—Measurement and Payment . . . 630

SECTION 427—SILICONE JOINT SEALANTS . . . 632
427.01—Description . . . 632
427.02—Materials . . . 632
427.03—Procedures . . . 632
427.04—Measurement and Payment . . . 634

SECTION 428—CONCRETE SURFACE PENETRANT SEALER . . . 634
428.01—Description . . . 634
428.02—Materials . . . 634
428.03—Procedures . . . 635
428.04—Measurement and Payment . . . 635

SECTION 429—BRIDGE DECK WATERPROOFING MEMBRANE SYSTEMS . . . 635
429.01—Description . . . 635
429.02—Types of Waterproofing Membranes . . . 636
429.03—Materials . . . 636
429.04—Equipment . . . 637
429.05—Traffic Restrictions . . . 637
429.06—Procedures . . . 637
429.07—Quality Control and Quality Assurance and Acceptance of Waterproofing Membrane Thickness for Type I and Type II Membranes . . . 644
429.08—Waterproofing Membrane Acceptance . . . 645
429.09—Measurement and Payment . . . 645

SECTION 430—NBIS INSPECTION USING UNDER BRIDGE INSPECTION DEVICE . . . 646
430.01—Description . . . 646
430.02—Notification Requirements . . . 646
430.03—Rescheduling Inspection . . . 646
430.04—Traffic Control during Inspection . . . 647
430.05—Measurement and Payment . . . 647

SECTION 431—EPOXY BRIDGE DECK OVERLAYS . . . 647
431.01—Description . . . 647
431.02—Materials . . . 648
431.03—Procedures . . . 648
431.04—Measurement and Payment . . . 650

DIVISION V—INCIDENTAL CONSTRUCTION . . . 651

SECTION 501—UNDERDRAINS, CROSSDRAINS, AND EDGEDRAINS . . . 653
501.01—Description . . . 653
501.02—Materials . . . 653
501.03—Procedures . . . 653
501.04—Measurement and Payment . . . 656

SECTION 502—INCIDENTAL CONCRETE ITEMS . . . 656
502.01—Description . . . 656

502.02—Materials 656
502.03—Procedures 657
502.04—Measurement and Payment 662

SECTION 503—CONTRACTOR BOUNDARY SURVEYING 664
503.01—Description 664
503.02—Materials 664
503.03—Procedures 664
503.04—Measurement and Payment 665

SECTION 504—SIDEWALKS, STEPS, AND HANDRAILS 666
504.01—Description 666
504.02—Materials 666
504.03—Procedures 667
504.04—Measurement and Payment 669

SECTION 505—GUARDRAIL AND W-BEAM MEDIAN BARRIERS 670
505.01—Description 670
505.02—Materials 670
505.03—Procedures 671
505.04—Measurement and Payment 674

SECTION 506—RETAINING WALLS 678
506.01—Description 678
506.02—Materials 678
506.03—Procedures 678
506.04—Measurement and Payment 680

SECTION 507—FENCES 680
507.01—Description 680
507.02—Materials 680
507.03—Procedures 681
507.04—Measurement and Payment 682

SECTION 508—DEMOLITION OF PAVEMENT AND OBSCURING ROADWAY 683
508.01—Description 683
508.02—Procedures 683
508.03—Measurement and Payment 684

SECTION 509—FLOWABLE BACKFILL PLACEMENT 685
509.01—Description 685
509.02—Materials 685
509.03—Procedures 685
509.04—Measurement and Payment 686

SECTION 510—RELOCATING OR MODIFYING EXISTING MISCELLANEOUS ITEMS 686
510.01—Description 686
510.02—Materials 686
510.03—Procedures 687
510.04—Measurement and Payment 687

SECTION 511—ALLAYING DUST 687
511.01—Description 687
511.02—Materials 687
511.03—Procedures 688
511.04—Measurement and Payment 688

SECTION 512—MAINTAINING TRAFFIC 688
512.01—Description 688
512.02—Materials 688
512.03—Procedures 689
512.04—Measurement and Payment 711

SECTION 513—MOBILIZATION 715
513.01—Description 715
513.02—Measurement and Payment 715

SECTION 514 – FIELD OFFICE 716
514.01—Description 716
514.02—Procedures 716
514.03—Measurement and Payment 720

SECTION 515—PLANING OR MILLING PAVEMENT 720
515.01—Description 720
515.02—Equipment 721
515.03—Procedures 721
515.04—Performance Pavement Planing Testing 722
515.05—Measurement and Payment 722

SECTION 516—DEMOLITION OF BUILDINGS AND CLEARING PARCELS 724
516.01—Description 724
516.02—Procedures 724
516.03—Measurement and Payment 725

SECTION 517—CONTRACTOR CONSTRUCTION SURVEYING 726
517.01—Description 726
517.02—General Requirements 726
517.03—Contractor Responsibility for Examination of Data 727
517.04—Construction (C) projects 727
517.05—Minimum Plan (M) projects 729
517.06—No Plan (N) projects 731
517.07—Measurement and Payment 731

SECTION 518—TRAINEES ON CONSTRUCTION PROJECTS 732
518.01—Description 732
518.02—Procedures 732
518.03—Measurement and Payment 733

SECTION 519—SOUND BARRIER WALLS 734
519.01—Description 734
519.02—Materials 738
519.03—Procedures 741
519.04—Measurement and Payment 745

SECTION 520—WATER AND SANITARY SEWER FACILITIES 746
520.01—Description 746
520.02—Materials 746
520.03—Procedures 747
520.04—Testing 752
520.05—Disinfecting Water Mains 755
520.06—Measurement and Payment 755

SECTION 521—MAILBOX POST 758
521.01—Description 758
521.02—Materials 758
521.03—Procedures 758
521.04—Measurement and Payment 758

DIVISION VI—ROADSIDE DEVELOPMENT 759

SECTION 601—SELECTIVE TREE REMOVAL, TRIMMING, AND CLEANUP 761
601.01—Description 761
601.02—Materials 761
601.03—Procedures 761
601.04—Measurement and Payment 761

SECTION 602—TOPSOIL 762
602.01—Description 762
602.02—Materials 762
602.03—Procedures 762
602.04—Measurement and Payment 762

SECTION 603—SEEDING 763
603.01—Description 763
603.02—Materials 763
603.03—Procedures 763
603.04—Measurement and Payment 766

SECTION 604—SODDING 767
604.01—Description 767
604.02—Materials 767
604.03—Procedures 768
604.04—Measurement and Payment 768

SECTION 605 – PLANTING 769
605.01—Description 769
605.02—Materials 769
605.03—Qualifications of Personnel 770
605.04—Procedures 770
605.05—Completion of Installation Phase 777
605.06—Plant Care and Maintenance 779
605.07—Establishment Period 779
605.08—Termination of Establishment Period 782
605.09—Guarantee 783
605.10—Measurement and Payment 783

SECTION 606—ROLLED EROSION CONTROL PRODUCTS (RECP) 786
606.01—Description 786
606.02—Materials 786
606.03—Procedures 786
606.04—Measurement and Payment 787

SECTION 607—HERBICIDE SPRAYING 788
607.01—Description 788
607.02—Materials 788
607.03—Procedures 788
607.04—Measurement and Payment 788

SECTION 608—MOWING 789
608.01—Description 789
608.02—Equipment 789
608.03—Measurement and Payment 789

SECTION 609—TREE WELLS AND TREE WALLS 789
609.01—Description 789
609.02—Materials 789
609.03—Procedures 790
609.04—Measurement and Payment 790

SECTION 610—GABIONS 790
610.01—Description 790
610.02—Materials 790
610.03—Procedures 791
610.04—Measurement and Payment 791

DIVISION VII—TRAFFIC CONTROL DEVICES 793

SECTION 700—GENERAL 795
700.01—Description 795
700.02—Materials 795
700.03—General Requirements 796
700.04—Working Drawings 798
700.05—Procedures 799
700.06—Measurement and Payment 814

SECTION 701—TRAFFIC SIGNS 817
701.01—Description 817
701.02—Materials 817
701.03—Procedures 817
701.04—Measurement and Payment 823

SECTION 702—DELINEATORS 823
702.01—Description 823
702.02—Materials 824
702.03—General Requirements 824
702.04—Procedures 824
702.05—Measurement and Payment 825

SECTION 703—TRAFFIC SIGNALS 826
703.01—Description 826
703.02—Equipment 826
703.03—Procedures 852
703.04—Measurement and Payment 862

SECTION 704—PAVEMENT MARKINGS AND MARKERS. 866
704.01—Description 866
704.02—Materials 866
704.03—Procedures 867
704.04—Measurement and Payment 876

SECTION 705—LIGHTING SYSTEMS 876
705.01—Description 876
705.02—Materials 876
705.03—Procedures 877
705.04—Measurement and Payment 879

DIVISION VIII—INTELLIGENT TRANSPORTATION SYSTEMS 881

SECTION 801—ITS INFRASTRUCTURE COMPONENTS 883
801.01—Description 883
801.02—Materials 883
801.03—Equipment 883
801.04—Procedures 895
801.05—Measurement and Payment 902

SECTION 802—UNINTERRUPTIBLE POWER SUPPLY FOR ITS APPLICATIONS 903
802.01—Description 903
802.02—Equipment 903
802.03—Procedures 906
802.04—Measurement and Payment 906

SECTION 803—CCTV VIDEO EQUIPMENT 907
803.01—Description 907
803.02—Materials 907
803.03—Equipment 907
803.04—Procedures 921
803.05—Measurement and Payment 925

SECTION 804—DYNAMIC MESSAGE SIGNS 927
804.01—Description 927
804.02—Materials 927
804.03—Equipment 928
804.04—DMS Equipment 929
804.05—Procedures 954
804.06—Measurement and Payment 958

SECTION 805—VEHICLE DETECTION AND DATA COLLECTION 959
805.01—Description 959
805.02—Materials 959

805.03—Procedures . . . 968
805.04—Measurement and Payment . . . 971

SECTION 806—ENVIRONMENTAL SENSOR STATIONS . . . 971
806.01—Description . . . 971
806.02—Materials . . . 971
806.03—Equipment . . . 972
806.04—Procedures . . . 977
806.05—Measurement and Payment . . . 979

SECTION 807—WIRELESS TRANSCEIVERS . . . 980
807.01—Description . . . 980
807.02—Materials . . . 980
807.03—Procedures . . . 989
807.04—Measurement and Payment . . . 990

SECTION 808—FIBER OPTIC CABLE AND INTERCONNECT . . . 991
808.01—Description . . . 991
808.02—Materials . . . 992
808.03—Procedures . . . 998
808.04—Measurement and Payment . . . 1002

SECTION 809—MANAGED FIELD ETHERNET SWITCH . . . 1002
809.01—Description . . . 1002
809.02—Equipment . . . 1003
809.03—Procedures . . . 1006
809.04—Measurement and Payment . . . 1008

SECTION 810—PRIMARY NETWORK SWITCH AND LAYER 3 FIELD AGGREGATION ETHERNET SWITCH . . . 1008
810.01—Description . . . 1008
810.02—Equipment . . . 1009
810.03—Procedures . . . 1017
810.04—Measurement and Payment . . . 1020

SECTION 811—ETHERNET TERMINAL SERVER . . . 1021
811.01—Description . . . 1021
811.02—Materials . . . 1021
811.03—Procedures . . . 1023
811.04—Measurement and Payment . . . 1025

SECTION 812—ITS CONDUIT . . . 1026
812.01—Description . . . 1026
812.02—Materials . . . 1026
812.03—Procedures . . . 1026
812.04—Measurement and Payment . . . 1029

LIST OF TABLES

Number	Title	Page
I-2A	Process Guidelines for Requests Generated by the Contractor	40
I-2B	Process Guidelines for Requests Generated by the Department	41
I-3	VOC Emissions Control Areas	94
I-1	Schedule of Liquidated Damages	120
I-2	Reserved for Future Use	
II-1	Fine Aggregate	149
II-2	Soundness of Fine Aggregate	149
II-3	Sizes of Open-Graded Coarse Aggregates	151
II-4	Soundness of Coarse Aggregate	152
II-5	Abrasion	152
II-6	Design Range: Select Material, Type I	155
II-7	Process (P) and Range (R) Tolerance: Select Material, Type I	156
II-8	Atterberg Limits: Select Material, Type I	157
II-9	Design Range for Dense-Graded Aggregates	159
II-10	Process Tolerances for Each Laboratory Sieve	159
II-11	Atterberg Limits	160
II-12	Standard Deviation	163
II-12A	Aggregate Properties	172
II-13	Asphalt Concrete Mixtures: Design Range	176
II-14	Mix Design Criteria	177
II-14A	Recommended Performance Grade of Asphalt Content	179
II-15	Process Tolerance	184
II-16	Standard Deviation	185
II-17	Requirements for Hydraulic Cement Concrete	208
II-17A	Concrete Price Reduction Schedule	214
II-18	Reserved for Future Use	
II-19	Requirements: Epoxy Component A	268
II-20	Reserved for Future Use	
II-21	Requirements: Mixed Epoxy Systems	269
II-22	Fine Aggregate (Silica Sand) in Epoxy	270
II-22A	Minimum HECP Performance and Physical Requirements	277
II-22B	Reserved for Future Use	
II-22C	Rolled Erosion Control Products	284
II-22D	Permanent Turf Reinforcement Mats	285
II-23	Cellulose Fiber Properties	315
II-24	SMA Design Range	317
II-25	SMA Mixture Requirements	317
II-26	Specified Performance Grade of Asphalt and Use of RAP	317
III-1	Liquid Asphalt Application Temperature	389
III-2	Cold Weather Paving Limitations	404
III-3	Density Requirements	407
III-4	Payment Schedule for Lot Densities	408
III-5	Payment Schedule for Surface, Intermediate, and Base Courses	410
IV-1	Pile Tolerance Criteria	454

IV-2 Reserved for Future Use
IV-3 Bolt Tension 509
IV-4 Nut Rotation from Snug Tight Condition 510
IV-5 Reserved for Future Use
IV-6 Coating Systems 543

VII-1 Nut Rotation beyond Snug Tight on Anchor Bolts 813
VII-2 Torque Verification of Nuts on Anchor Bolts 813
VII-3 Pavement Markings 874

VIII-1 SPD Minimum Requirements 885
VIII-2 Resolution Specifications 915
VIII-3 Display Characteristics 937
VIII-4 Modified Object Ranges for Mandatory Objects 947
VIII-5 Modified Object Ranges for the Multi-Configuration Conformance Group 949
VIII-6 Optional Object Requirements 949
VIII-7 Data Collection Periods 964

CROSS-REFERENCE TABLE for SECTION NUMBERS and TITLES

2016 R&B SPECIFICATIONS DIVISION I—GENERAL PROVISIONS	2007 R&B SPECIFICATIONS DIVISION I—GENERAL PROVISIONS
SECTION 101—DEFINITIONS OF ABBREVIATIONS, ACRONYMS, AND TERMS	**SECTION 101—DEFINITIONS OF ABBREVIATIONS, ACRONYMS, AND TERMS**
101.01—Abbreviations and Acronyms (No Change)	101.01—Abbreviations and Acronyms.
101.02—Terms (No Change)	101.02—Terms
SECTION 102 BIDDING REQUIREMENTS AND CONDITIONS	**SECTION 102 BIDDING REQUIREMENTS AND CONDITIONS**
102.01—Prequalification of Bidders	102.01—Prequalification of Bidders
102.02—Content of Proposal.	102.02—Content of Proposal.
102.03—Interpretation of Quantities in Proposal	102.03—Interpretation of Quantities in Proposal
102.04—Examination of Site of Work and Proposal	102.04—Examination of Site of Work and Proposal
102.05—Preparation of Bid	102.05—Preparation of Bid
102.06—Irregular Bids	102.06—Irregular Bids
102.07—Proposal Guaranty	102.07—Proposal Guaranty
102.08—Disqualification of Bidder	102.08—Disqualification of Bidder
102.09—Submission of Bid (New Section title)	102.09—Submission of Bid
102.10—Withdrawal of Bid	102.10—Withdrawal of Bid
102.11—eVA Business-to-Government Vendor Registration	102.11—eVA Business-to-Government Vendor Registration
102.12—Public Opening of Bids	102.12—Public Opening of Bids
102.13—"E Verify" —Verification of Work Authorization (New Section)	
SECTION 103—AWARD AND EXECUTION OF CONTRACTS	**SECTION 103—AWARD AND EXECUTION OF CONTRACTS**
103.01—Consideration of Bids	103.01—Consideration of Bids
103.02—Award of Contract	103.02—Award of Contract

(Continued)

2016 R&B SPECIFICATIONS DIVISION I—GENERAL PROVISIONS	2007 R&B SPECIFICATIONS DIVISION I—GENERAL PROVISIONS
103.03—Cancellation of Award	103.03—Cancellation of Award
103.04—Forfeiture of Proposal Guaranty	103.04—Forfeiture of Proposal Guaranty
103.05—Requirements of Contract Bond	103.05—Requirements of Contract Bond
103.06—Contract Documents	103.06—Contract Documents
103.07—Failure To Furnish Bonds or Certificate of Insurance	103.07—Failure To Furnish Bonds or Certificate of Insurance
103.08—Contract Audit	103.08—Contract Audit
103.09—Execution of Contract	103.09—Execution of Contract
103.10—Assignments, Transfers or Assumptions of the Contract (New Section Number and Title)	
SECTION 104—SCOPE OF WORK	**SECTION 104—SCOPE OF WORK**
104.01—Intent of Contract	104.01—Intent of Contract
104.02—Changes in Quantities or Alterations in the Work (New Section Title)	104.02—Alteration of Quantities or Character of Work
104.03—Differing Site Conditions	104.03—Differing Site Conditions
SECTION 105—CONTROL OF WORK	**SECTION 105—CONTROL OF WORK**
105.01—Notice to Proceed	105.01—Notice to Proceed
105.02—Pre-Construction Conference	105.02—Pre-Construction Conference
105.03—Authorities of Project Personnel, Communication and Decision Making (Expanded Section Title)	105.03—Authorities of Project Personnel
105.04—Gratuities	105.04—Gratuities
105.05—Character of Workers, Work Methods, and Equipment	105.05—Character of Workers, Work Methods, and Equipment
105.06—Subcontracting	105.06—Subcontracting
105.07—Cooperation of Contractor	105.07—Cooperation of Contractor
105.08—Cooperation With Regard to Utilities	105.08—Cooperation With Regard to Utilities
105.09—Cooperation among Contractors	105.09—Cooperation among Contractors

105.10—Plans and Working Drawings	105.10—Plans and Working Drawings
105.11—Conformity with Plans and Specifications	105.11—Conformity with Plans and Specifications
105.12—Coordination of Plans, Standard Drawings, Specifications, Supplemental Specifications, Special Provisions, and Special Provision Copied Notes	105.12—Coordination of Plans, Standard Drawings, Specifications, Supplemental Specifications, Special Provisions, and Special Provision Copied Notes
105.13—State Force Construction Surveying	105.13—State Force Construction Surveying
105.14—Maintenance During Construction	105.14—Maintenance During Construction
105.15—Removing and Disposing of Structures and Obstructions	105.15—Removing and Disposing of Structures and Obstructions
105.16—Cleanup	105.16—Cleanup
105.17—Inspection of Work	105.17—Inspection of Work
105.18—Removal of Unacceptable and Unauthorized Work	105.18—Removal of Unacceptable and Unauthorized Work
105.19—Submission and Disposition of Claims	105.19—Submission and Disposition of Claims
SECTION 106—CONTROL OF MATERIAL	**SECTION 106—CONTROL OF MATERIAL**
(No Changes)	
SECTION 107—LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC	**SECTION 107—LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC**
107.01—Laws To Be Observed	107.01—Laws To Be Observed
107.02—Permits, Certificates, and Licenses	107.02—Permits, Certificates, and Licenses
107.03 — Federal-Aid Provisions	107.03 — Federal-Aid Provisions
107.04—Furnishing Right of Way	107.04—Furnishing Right of Way
107.05—Patented Devices, Materials, and Processes	107.05—Patented Devices, Materials, and Processes
107.06 — Personal Liability of Public Officials	107.06 — Personal Liability of Public Officials
107.07 — No Waiver of Legal Rights	107.07 — No Waiver of Legal Rights
107.08—Protecting and Restoring Property and Landscape	107.08—Protecting and Restoring Property and Landscape
107.09—Contractor's Responsibility for Utility Property and Services	107.09—Contractor's Responsibility for Utility Property and Services
107.10—Restoration of Work Performed by Others	107.10—Restoration of Work Performed by Others

(Continued)

2016 R&B SPECIFICATIONS DIVISION I—GENERAL PROVISIONS	2007 R&B SPECIFICATIONS DIVISION I—GENERAL PROVISIONS
107.11—Use of Explosives	107.11—Use of Explosives
107.12—Responsibility For Damage Claims	107.12—Responsibility For Damage Claims
107.13—Labor and Wages	107.13—Labor and Wages
107.14—Equal Employment Opportunity	107.14—Equal Employment Opportunity
107.15—Use of Small, Women-Owned and Minority Owned Businesses (SWaMs) (New Section Title)	107.15—Use of Minority Business Enterprises (MBEs)
107.16—Environmental Stipulations	107.16—Environmental Stipulations
107.17—Construction Safety and Health Standards	107.17—Construction Safety and Health Standards
107.18 — Sanitary Provisions	107.18 — Sanitary Provisions
107.19—Railway-Highway Provisions	107.19—Railway-Highway Provisions
107.20—Construction Over or Adjacent to Navigable Waters	107.20—Construction Over or Adjacent to Navigable Waters
107.21—Size and Weight Limitations	107.21—Size and Weight Limitations
SECTION 108—PROSECUTION AND PROGRESS OF WORK	**SECTION 108—PROSECUTION AND PROGRESS OF WORK**
108.01—Prosecution of Work	108.01—Prosecution of Work
108.02—Limitation of Operations	108.02—Limitation of Operations
108.03—Progress Schedule	108.03—Progress Schedule
108.04—Determination and Extension of Completion Date (New Section Title)	108.04—Determination and Extension of Contract Time Limit
108.05—Suspension of Work Ordered by the Engineer	108.05—Suspension of Work Ordered by the Engineer
108.06—Failure To Complete on Time	108.06—Failure To Complete on Time
108.07—Default of Contract	108.07—Default of Contract
108.08—Termination of Contract	108.08—Termination of Contract
108.09—Acceptance	108.09—Acceptance
108.10—Termination of Contractor's Responsibilities	108.10—Termination of Contractor's Responsibilities

SECTION 109—MEASUREMENT AND PAYMENT	SECTION 109—MEASUREMENT AND PAYMENT
109.01—Measurement of Quantities	109.01—Measurement of Quantities
109.02—Plan Quantities	109.02—Plan Quantities
109.03—Scope of Payment	109.03—Scope of Payment
109.04—Payment for Non-Significant Changes and Additional Units of In-scope Work (New Section Title)	109.04—Compensation for Altered Quantities
109.05—Payment For Contract Changes (New Section Title)	109.05—Extra and Force Account Work
109.06—Common Carrier Rates	109.06—Common Carrier Rates
109.07—Eliminated Items	109.07—Eliminated Items
109.08—Partial Payments	109.08—Partial Payments
109.09—Payment for Material on Hand	109.09—Payment for Material on Hand
109.10—Final Payment	109.10—Final Payment
2016 R&B SPECIFICATIONS DIVISION II—MATERIALS	**2007 R&B SPECIFICATIONS DIVISION II—MATERIALS**
SECTION 210—ASPHALT MATERIALS	**SECTION 210—ASPHALT MATERIALS**
Section 210.01—Description	Section 210.01—Description
Section 210.02—Materials	Section 210.02—Materials
210.03—Virginia Asphalt Acceptance Program (New Section)	Section 210.03—Detail Requirements
210.04—VDOT Asphalt Acceptance Program Requirements and Compliance (New Section)	Section 210.04—Payment Adjustment System
210.05—Sampling (New Section)	
210.06—Testing (New Section)	
210.07—Tests (New Section)	
210.08—Storing and Shipping (New Section)	

(Continued)

2016 R&B SPECIFICATIONS DIVISION II—MATERIALS	2007 R&B SPECIFICATIONS DIVISION II—MATERIALS
Section 210.09—Payment Adjustment System (New Section Number)	
SECTION 217—HYDRAULIC CEMENT CONCRETE (New Sections)	**SECTION 217—HYDRAULIC CEMENT CONCRETE**
Section 217.11—Self-Consolidating Concrete (SCC) (New Section)	
Section 217.12—Low Shrinkage Class A-4 Modified Concrete (New Section)	
Section 217.13—Latex Modified Concrete, Very Early Strength (LMCVES) for Bridge Deck Overlays (New Section)	
Section 217.14—High Early Strength Latex Modified Concrete (HESLMC) for Bridge Deck Overlays (New Section)	
SECTION 246—PAVEMENT MARKINGS	**SECTION 246—PAVEMENT MARKINGS**
Section 246.01—Description	Section 246.01—Description
Section 246.02—Detail Requirements	Section 246.02—Detail Requirements
Section 246.03—Pavement Marking Materials (New Section)	
SECTION 249—FLOWABLE BACKFILL (New Section)	
Section 249.01—Description	
Section 249.02—Materials	
Section 249.03—Mix Design	
SECTION 250—CARBON FIBER MESH (New Section)	
Section 250.01—Description	
Section 250.02—Materials	
SECTION 251—GALVANIC ANODES (New Section)	
Section 251.01—Description	
Section 251.02—Materials	

SECTION 252—GRAVITY-FILL POLYMER CRACK SEALERS (New Section)	
Section 252.01—Description	
Section 252.02—Materials	
2016 R&B SPECIFICATIONS DIVISION III—ROADWAY CONSTRUCTION	**2007 R&B SPECIFICATIONS DIVISION III—ROADWAY CONSTRUCTION**
SECTION 303—EARTHWORK	**SECTION 303—EARTHWORK**
Section 303.03—Erosion and Siltation Control and Stormwater Pollution Prevention (New Section Title)	Section 303.03—Erosion and Siltation Control
2016 R&B SPECIFICATIONS DIVISION IV—BRIDGES AND STRUCTURES	**2007 R&B SPECIFICATIONS DIVISION IV—BRIDGES AND STRUCTURES**
SECTION 407—STEEL AND OTHER METAL STRUCTURES (Section Title Change)	**SECTION 407—STEEL STRUCTURES**
SECTION 411—PROTECTIVE COATING OF METAL IN STRUCTURES	**SECTION 411—PROTECTIVE COATING OF METAL IN STRUCTURES**
Section 411.01—Description	Section 411.01—Description
Section 411.02—Materials	Section 411.02—Materials
Section 411.03—Certificates	Section 411.03—Certificates
Section 411.04—General Surface Preparation and Application Standards	Section 411.04—General Surface Preparation and Application Standards
Section 411.05—Existing Structures	Section 411.05—Existing Structures
Section 411.06—New Structures	Section 411.06—New Structures
Section 411.07—Galvanized Surfaces	Section 411.07—Galvanized Surfaces
Section 411.08—Observation Period (New Section)	Section 411.08—Environmental Protection
Section 411.09—Environmental Protection	Section 411.09—Health and Safety

(Continued)

2016 R&B SPECIFICATIONS DIVISION IV—BRIDGES AND STRUCTURES	2007 R&B SPECIFICATIONS DIVISION IV—BRIDGES AND STRUCTURES
Section 411.10—Health and Safety	Section 411.10—Measurement and Payment
Section 411.11—Measurement and Payment	
SECTION 423—TOOTH EXPANSION JOINT ASSEMBLY (New Section)	
Section 423.01—Description	
Section 423.02—Materials	
Section 423.03—Procedures	
Section 423.04—Measurement and Payment	
SECTION 424—ASPHALT PLUG JOINTS (New Section)	
Section 424.01—Description	
Section 424.02—Materials	
Section 424.03—Procedures	
Section 424.04—Measurement and Payment	
SECTION 425—RIGID CONCRETE BRIDGE DECK OVERLAYS (New Section)	
Section 425.01—Description	
Section 425.02—Materials	
Section 425.03—Procedures	
Section 425.04—Measurement and Payment	
SECTION 426—REPAIRING EXISTING STEEL STRUCTURES (New Section)	
Section 426.01—Description	
Section 426.02—Materials	
Section 426.03—Procedures	

Section 426.04—Measurement and Payment	
SECTION 427—SILICONE JOINT SEALANTS (New Section)	
Section 427.01—Description	
Section 427.02—Materials	
Section 427.03—Procedures	
Section 427.04—Measurement and Payment	
SECTION 428—CONCRETE SURFACE PENETRANT SEALER (New Section)	
Section 428.01—Description	
Section 428.02—Materials	
Section 428.03—Procedures	
Section 428.04—Measurement and Payment	
SECTION 429—BRIDGE DECK WATERPROOFING MEMBRANE SYSTEMS (New Section)	
Section 429.01—Description	
Section 429.02—Types of Waterproofing Membranes	
Section 429.03—Materials	
Section 429.04—Equipment	
Section 429.05—Traffic Restrictions	
Section 429.06—Procedures	
Section 429.07—Quality Control, Quality Assurance, and Acceptance of Waterproofing Membrane Thicknesses for Type I and Type II Membranes	
Section 429.08—Waterproofing Membrane Acceptance	
Section 429.09—Measurement and Payment	

(Continued)

2016 R&B SPECIFICATIONS DIVISION IV—BRIDGES AND STRUCTURES	2007 R&B SPECIFICATIONS DIVISION IV—BRIDGES AND STRUCTURES
SECTION 430—NBIS INSPECTION USING BRIDGE INSPECTION DEVICES (New Section)	
Section 430.01—Description	
Section 430.02—Notification Requirements	
Section 430.03—Rescheduling Inspection	
Section 430.04—Traffic Control During Inspection	
Section 430.05—Measurement and Payment	
SECTION 431—EPOXY BRIDGE DECK OVERLAYS (New Section)	
Section 431.01—Description	
Section 431.02—Materials	
Section 431.03—Procedures	
Section 431.04—Measurement and Payment	
2016 R&B SPECIFICATIONS DIVISION V—INCIDENTAL CONSTRUCTION	**2007 R&B SPECIFICATIONS DIVISION V—INCIDENTAL CONSTRUCTION**
SECTION 509—FLOWABLE BACKFILL PLACEMENT (New Section)	**SECTION 509—PATCHING HYDRAULIC CEMENT CONCRETE PAVEMENT**
Section 509.01—Description	Section 509.01—Description
Section 509.02—Materials	Section 509.02—Materials
Section 509.03—Procedures	Section 509.03—Procedures
Section 509.04—Measurement and Payment	Section 509.04—Measurement and Payment
SECTION 511—ALLAYING DUST	**SECTION 511—ALLAYING DUST**
Section 511.01—Description	Section 511.01—Description

Section 511.02—Materials (New Section)	
Section 511.03—Procedures	Section 511.02—Procedures
Section 511.04—Measurement and Payment	Section 511.03—Measurement and Payment
SECTION 515—PLANING OR MILLING PAVEMENT (New Section Title)	**SECTION 515—PLANING PAVEMENT**
Section 515.01—Description	Section 515.01—Description
Section 515.02—Equipment (New Section)	
Section 515.03—Procedures	Section 515.02—Procedures
Section 515.04—Performance Pavement Planing Testing (New Section)	
Section 515.05—Measurement and Payment	Section 515.03—Measurement and Payment
SECTION 517—CONTRACTOR CONSTRUCTION SURVEYING	**SECTION 517—CONTRACTOR CONSTRUCTION SURVEYING**
Section 517.01—Description	Section 517.01—Description
Section 517.02—General Requirements	Section 517.02—General Requirements
Section 517.03—Contractor Responsibility for Examination of Data	Section 517.03—Contractor Responsibility for Examination of Data
Section 517.04—Construction (C) Projects	Section 517.04—Construction (C) Projects
Section 517.05—Minimum Plan (M) Projects	Section 517.05—Minimum Plan (M) Projects
Section 517.06—No Plan (N) Projects (New Section)	
Section 517.07— Measurement and Payment	Section 517.06— Measurement and Payment
2016 R&B SPECIFICATIONS DIVISION VI—ROADSIDE DEVELOPMENT	**2007 R&B SPECIFICATIONS DIVISION VI—ROADSIDE DEVELOPMENT**
SECTION 605—PLANTING	**SECTION 605—PLANTING**
Section 605.01—Description	Section 605.01—Description
Section 605.02—Materials	Section 605.02—Materials
Section 605.03—Qualifications of Personnel (New Section)	

(Continued)

2016 R&B SPECIFICATIONS DIVISION VI—ROADSIDE DEVELOPMENT	2007 R&B SPECIFICATIONS DIVISION VI—ROADSIDE DEVELOPMENT
Section 605.04—Procedures	Section 605.03—Procedures
Section 605.05—Completion of Installation Phase (New Section)	
Section 605.06—Plant Care and Maintenance (New Section Title)	Section 605.04—Care of Plants
Section 605.07—Establishment Period	Section 605.05—Establishment Period
Section 605.08—Termination of Establishment Period (New Section)	
Section 605.09—Guarantee	Section 605.06—Guarantee
Section 605.10—Measurement and Payment	Section 605.07—Measurement and Payment
SECTION 606—ROLLED EROSION CONTROL PRODUCTS (New Section Title)	**SECTION 606 —SOIL RETENTION COVERINGS**
Section 606.01—Description	Section 606.01—Description
Section 606.02—Materials	Section 606.02—Materials
Section 606.03—Procedures	Section 606.03—Procedures
Section 606.04—Measurement and Payment	Section 606.04—Measurement and Payment
2016 R&B SPECIFICATIONS DIVISION VII—TRAFFIC CONTROL DEVICES	**2007 R&B SPECIFICATIONS DIVISION VII—TRAFFIC CONTROL DEVICES**
SECTION 700—GENERAL	**SECTION 700—GENERAL**
Section 700.01—Description	Section 700.01—Description
Section 700.02—Materials	Section 700.02—Materials
Section 700.03—General Requirements (New Section)	
Section 700.04—Working Drawings	Section 700.03—Working Drawings
Section 700.05—Procedures	Section 700.04—Procedures
Section 700.06—Measurement and Payment	Section 700.05—Measurement and Payment

SECTION 701—TRAFFIC SIGNS	SECTION 701—TRAFFIC SIGNS
Section 701.01—Description	Section 701.01—Description
Section 701.02—Materials	Section 701.02—Materials
Section 701.03—General Requirements (New Section)	
Section 701.04—Working Drawings (New Section)	
Section 701.05—Procedures	Section 701.03—Procedures
Section 701.06—Measurement and Payment	Section 701.04—Measurement and Payment
2016 R&B SPECIFICATIONS DIVISION VIII—INTELLIGENT TRANSPORTATION SYSTEMS (New Division)	
SECTION 801—INFRASTRUCTURE COMPONENTS	
Section 801.01—Description	
Section 801.02—Materials	
Section 801.03—Equipment	
Section 801.04—Procedures	
Section 801.05—Measurement and Payment	
SECTION 802—UNINTERRUPTIBLE POWER SUPPLY FOR ITS APPLICATIONS	
Section 802.01—Description	
Section 802.02—Materials	
Section 802.03—Equipment	
Section 802.04—Procedures	
Section 802.05—Measurement and Payment	

(Continued)

2016 R&B SPECIFICATIONS DIVISION VIII—INTELLIGENT TRANSPORTATION SYSTEMS (New Division)	
SECTION 803—CCTV VIDEO EQUIPMENT	
Section 803.01—Description	
Section 803.02—Materials	
Section 803.03—Equipment	
Section 803.04—Procedures	
Section 803.05—Measurement and Payment	
SECTION 804—DYNAMIC MESSAGE SIGNS (FULL COLOR)	
Section 804.01—Description	
Section 804.02—Materials	
Section 804.03—Equipment	
Section 804.04—Procedures	
Section 804.05—Measurement and Payment	
SECTION 805—VEHICLE DETECTION AND DATA COLLECTION	
Section 805.01—Description	
Section 805.02—Materials	
Section 805.03—Equipment	
Section 805.04—Procedures	
Section 805.05—Measurement and Payment	
SECTION 806—ENVIRONMENTAL SENSOR STATIONS	
Section 806.01—Description	
Section 806.02—Materials	
Section 806.03—Equipment	

Section 806.04—Procedures	
Section 806.05—Measurement and Payment	
SECTION 807—WIRELESS TRANSCEIVERS	
Section 807.01—Description	
Section 807.02—Materials	
Section 807.03—Equipment	
Section 807.04—Procedures	
Section 807.05—Measurement and Payment	
SECTION 808—FIBER OPTIC CABLE AND INTERCONNECT	
Section 808.01—Description	
Section 808.02—Materials	
Section 808.03—Procedures	
Section 808.04—Measurement and Payment	
SECTION 809—FIELD ETHERNET SWITCH	
Section 809.01—Description	
Section 809.02—Materials	
Section 809.03—Procedures	
Section 809.04—Measurement and Payment	
SECTION 810—PRIMARY NETWORK AND L3 FIELD AGGREGATION ETHERNET SWITCH	
Section 810.01—Description	
Section 810.02—Materials	
Section 810.03—Procedures	
Section 810.04—Measurement and Payment	

(Continued)

2016 R&B SPECIFICATIONS DIVISION VIII—INTELLIGENT TRANSPORTATION SYSTEMS (New Division)	
SECTION 811—ETHERNET TERMINAL SERVER	
Section 811.01—Description	
Section 811.02—Materials	
Section 811.03—Procedures	
Section 811.04—Measurement and Payment	
SECTION 812—ITS CONDUIT	
Section 812.01—Description	
Section 812.02—Materials	
Section 812.03—Procedures	
Section 812.04—Measurement and Payment	

Division I
GENERAL PROVISIONS

SECTION 101—DEFINITIONS OF ABBREVIATIONS, ACRONYMS, AND TERMS

101.01—Abbreviations and Acronyms

In these Specifications and other Contract Documents, the following abbreviations and acronyms shall be interpreted as follows:

AAR ..... Association of American Railroads
AASHTO ..... American Association of State Highway and Transportation Officials
ABS ..... Acrylonitrilebutadienestyrene (an elastomer)
AC ..... Alternating current
ACI ..... American Concrete Institute
ADT ..... Annual average daily traffic
AED ..... Associated Equipment Distributors
AISC ..... American Institute of Steel Construction
AISI ..... American Iron and Steel Institute
ANSI ..... American National Standards Institute
APA ..... Engineered Wood Association
API ..... American Petroleum Institute; American Pipe Institute
ASCE ..... American Society of Civil Engineers
ASME ..... American Society of Mechanical Engineers
ASTM ..... American Society for Testing and Materials
AWG ..... American wire gage
AWPA ..... American Wood Preservers Association
AWS ..... American Welding Society
AWWA ..... American Water Works Association
BOCA ..... Building Officials and Code Administrators
C ..... Celsius, when preceded by "degree(s)"
CABB ..... Contractor Advertisement Bulletin Board
CBR ..... California bearing ratio
CRSI ..... Concrete Reinforcing Steel Institute
DBE ..... Disadvantaged Business Enterprise
DC ..... Direct current
DHV ..... Design hourly volume
ECTC ..... Erosion Control Technology Council
EEI ..... Edison Electric Institute
EEO ..... Equal employment opportunity
EIA ..... Electronic Industries Alliance
EPA ..... Environmental Protection Agency
EPDM ..... Ethylenepropylenedienemonomer (an elastomer)
ESCCC ..... Erosion and Sediment Control Contractor Certification
F ..... Fahrenheit, when preceded by "degree(s)"
F/A ..... Filler/asphalt ratio
FAT ..... Field Acceptance Test
FHWA ..... Federal Highway Administration
FOOH ..... Field Office Overhead
FS ..... Federal Specifications, General Services Administration
HOOH ..... Home Office Overhead
ICEA ..... Insulated Cable Engineers Association

IMSA ..... International Municipal Signal Association
ITE.....Institute of Transportation Engineers
LCD ..... Liquid crystal display
LPG ..... Liquid petroleum gas
MEKP..... Methyl ethyl ketone peroxide
MIL..... Military specifications
MSDS .....Materials Safety Data Sheet
MUTCD .....*Manual on Uniform Traffic Control Devices for Streets and Highways* and the Virginia supplement to same
NEC .....National Electrical Code
NEMA ..... National Electrical Manufacturers Association
NIST ..... National Institute of Standards and Technology
NOAA ..... National Oceanic and Atmospheric Administration
NRC.....Nuclear Regulatory Commission
PCI..... Precast / Prestressed Concrete Institute
PE .....Polyethylene
PTL..... Plywood Testing Laboratory
PVC .....Polyvinylchloride
PVF.....Polyvinylfluoride
SAE..... Society of Automotive Engineers
SAT .....System Acceptance Test
SOR .....Schedule of Record
SP..... Special Provision
SPCN ..... Special Provision Copied Note
SPIB..... Southern Pine Inspection Bureau
SS ..... Supplemental Specification
SSPC..... Society for Protective Coatings
SWaM.....Small, Women-Owned, and Minority-Owned Businesses
SWPPP ..... Storm Water Pollution Prevention Plan
TAPPI..... Technical Association of the Pulp and Paper Industry
TFE.....Polytetrafluoroethylene
TIE..... Ticket Information Exchange (Miss Utility)
TOCIT.....Traffic Operations Center Integration Test
UL.....Underwriters' Laboratories, Inc.
VAC.....Volts alternating current
VDC.....Volts direct current
VDOT .....Virginia Department of Transportation
VEP.....Value engineering proposal
VFA.....Voids filled with asphalt
VMA ..... Voids in mineral aggregate
VOSH..... Virginia Occupational Safety and Health
VTM .....Virginia Test Methods; voids in total mix
VWAPM ..... Virginia Work Area Protection Manual

101.02—Terms

In these Specifications and other Contract Documents, the following terms and pronouns used in place of them shall be interpreted as follows:

–A–

Adjustment. An increase or decrease in the Contract amount or in the Contract time, unless the context dictates otherwise.

Advertisement, Notice of. A public announcement, as required by law, inviting bids for work to be performed or materials to be furnished that indicates, among other terms and conditions, approximate quantities of work to be performed, location of work to be performed, character and quantity of materials to be furnished, and time and place for opening bids.

Affiliate. Any business entity that is closely associated to another business entity so that one has the power to control the other either directly or indirectly; or, where one business entity systematically shares resources, officers, and/or other management with another business entity to the extent that a business relationship legally exists or is publicly perceived to exist; or, when a third party has the power to control both; or, where one business entity has been so closely allied with another through an established course of dealings, including but not limited to the lending of financial wherewithal or engaging in joint ventures, so as to cause a public perception that the two firms are one entity.

Alkali soil. Soil in which total alkali chlorides calculated as sodium chloride are more than 0.10 percent based on total solids.

Award. The decision of the Board or Commissioner to accept the bid of the lowest responsive and responsible bidder for the Work or such other criteria set forth in the solicitation. The award of the Contract is subject to the execution and approval of a satisfactory Contract for the Work, and such other approvals and conditions as may be specified or required by law.

Award date. The date on which the decision is made by the Board or Commissioner to accept the bid or proposal of the lowest responsive and responsible bidder or such other criteria set forth in the solicitation.

–B–

Backfill. Material used to replace or the act of replacing material removed during construction; may also denote material placed or the act of placing material adjacent to structures.

Balance point. The approximate point, based on estimated shrinkage or swell, where the quantity of earthwork excavation and borrow, if required, is equal to the quantity of embankment material plus any surplus excavation material.

Base course. A layer of material of specified thickness on which the intermediate or surface course is placed.

Base flood. The flood or tide having a one percent chance of being exceeded in any given year.

Bid. The offer of a bidder, submitted by electronic proposal (or on paper if so specified in the Proposal) to perform the Work and furnish the materials, equipment, and labor at the prices set forth therein; valid only when properly signed and guaranteed.

Bidder. Any individual, partnership, corporation, limited liability company, or joint venture that formally submits a bid for the work contemplated, or for any portion thereof, acting directly or through a duly authorized representative.

Bids, Invitation for. See **Advertisement, Notice of.**

Board. Commonwealth Transportation Board.

Borrow. Suitable material not available from designated Regular Excavation or other sources of useable materials on-site that is used primarily for embankment.

Brackish water. Water in which total alkali chlorides calculated as sodium chloride are more than 0.10 percent based on total solids.

Bridge. A structure, including supports, that is erected over a depression or an obstruction, such as water, a highway, or a railway, that has a track or passageway for carrying traffic.

Bridge lift. A layer of fill material placed in excess of standard depth over an area that does not support the weight of hauling equipment and for which compaction effort is not required.

Business. Any corporation, partnership, limited liability company, joint venture, firm, association, individual, or sole proprietorship operated for profit.

–C–

Calendar day. Any day shown on the calendar, including Saturday and Sunday, beginning at 12:01 a.m. and ending at midnight.

Camber. A vertical curvature induced or fabricated into beams or girders and a deck slab or slab span formwork; a vertical curvature set in the grade line of a pipe culvert to accommodate differential settlement.

Change Order. Previously known as a Work Order. A written order (Form C-10) signed by the Engineer to incorporate changes, alterations or other modifications into the Contract. A Change Order may be used to add, modify, or delete: pay items, Contract time, Contract Documents, or other terms of the Contract. Change Orders may be issued on a bilateral or unilateral basis. The term change order means bilateral Change Order, except where the Change Order is designated or understood from the context as being a unilateral Change Order.

> **Bilateral Change Order.** A written change order signed by both the Engineer and the Contractor where the Engineer and Contractor agree upon the scope, the cost, and the time adjustment for the proposed change, alteration, or other modification to the Contract. Form C-10 shall be used to modify the Contract to include the approved change. This type of change order is what is typically meant when the term change order is used elsewhere in Department publications.
>
> **Unilateral Change Order.** A written change order signed only by the Engineer used to effect a change, alteration, or other modification to the Contract when the Engineer and the Contractor cannot agree upon the scope, the cost, or the time estimation of the proposed change, alteration, or other modification to the Contract or where due to issues of emergency, safety, environmental damage, or other similar critical factors the Department must act quickly and unilaterally to effect the change. In these cases, the Department must act unilaterally to establish a scope, cost, or time adjustment for, the change, alteration, or other modification to the Contract. Form C-10 shall be used to modify the Contract to include the approved change.

Channel. A watercourse or drainage way.

Claim. The Contractor's written request or demand for an adjustment to the Contractor's compensation or to the Contract time, for costs, expenses, or other damages, adjustment of the Contract terms, or for any entitlement available under the Contract, made within the time, in the form, and pursuant to the provisions for claims specified in the Contract Documents.

Commissioner. The Chief Executive Officer of the Virginia Department of Transportation, whose full title is the Commissioner of Highways or as otherwise designated by the Code of Virginia.

Commonwealth. Commonwealth of Virginia.

Completion Date. The date specified in the Contract, on Form C-7, by which the Contractor shall achieve Final Acceptance according to Section 108.09.

Completion Date, Substantial. The date on or before which the project is complete such that it can be safely and effectively used by the public without delays, disruption, or other impediments and only clean up and Work of a minor nature, as agreed to by the Engineer, remains to be finished.

Composite hydrograph. A graph showing the mean daily discharge versus the calendar day, indicating trends in high and low flow for a one-year period.

Construction area. The area where authorized construction occurs.

Construction limits (On-Site). The disturbed area required for the construction of a Project including the intersection of side slopes with the original ground, plus slope rounding and slopes for drainage ditches, bridges, culverts, channels, temporary or incidental construction, and identified by the surface planes as shown and/or described within the Contract Documents.

Contract. The written agreement executed by and between the Department and the Contractor that sets forth the obligations of the parties thereunder. The documents that make up the Contract are specified in Section 103.06. Oral agreements, representations or promises will not be considered a part of the Contract.

Contract Amount. The sum stated as the bid total in the executed Proposal (Form C-7), as adjusted according to the Contract.

Contract Engineer. See **State Construction Contract Engineer.**

Contract execution date. The date on which the Contract is signed by the Chief Engineer.

Contract item, bid item, or pay item. A specifically described unit of work for which a price is provided in the Contract Schedule of Items.

Contract time. The time allowed in the Contract for final completion of the Work, including all authorized time extensions, beginning on the notice to proceed date and ending at the Contract time limit.

Contract time limit. The date, whether set by a number of calendar days or fixed calendar date, for final completion of the Work prescribed in the Contract, including all authorized time extensions.

Contractor. The business that has a direct contract with the Department, which is in writing and signed by the Engineer, to perform the prescribed Work as an independent contractor and not as an agent for the Department, the Commissioner or the Board.

Controlling item of work. See **Critical Path Work.**

Corporation. A business entity organized and existing under the laws of the Commonwealth or other jurisdiction by virtue of articles of incorporation, amendment, or merger.

Critical Activity. Any activity on the critical path.

Critical Path. The longest continuous sequence of work or chain of activities throughout the project that defines the overall time needed to complete the project.

Critical Path Work. Any work on the critical path. A delay to any critical path work is expected to delay completion of the project.

Cul-de-sac. An area at the terminus of a dead end street or road that is constructed for the purpose of allowing vehicles to turn around.

Culvert. A structure that is not classified as a bridge which provides an opening under any roadway.

Cut. When used as a noun with reference to earthwork, that portion of a roadway formed by excavating below the existing surface of the earth and limited by design or the direction of the Engineer.

Cut Slope. See also **Fill Slope.** A surface plane generally designated by design or the direction of the Engineer which is formed during excavation below existing ground elevations that intersects with existing ground at its termini.

–D–

Day. A Calendar Day, unless specifically stated otherwise.

Deflection. The vertical or horizontal movement occurring between the supports of a bridge superstructure, guardrail, other structure, or the components (beams, girders, and slabs) thereof that results from their own weight and from dead and live loads. Although all parts of a structure are subject to deflections, usually only those deflections that occur in the superstructure are of significance during construction.

Department. Virginia Department of Transportation.

Design flood. The magnitude of flood that a given structure can convey without exceeding a designated flood level.

Detour. The removal of traffic from one roadway or highway to an alternate roadway or highway.

Digital Identification (I.D.). An encrypted signature that is the legal equivalent of a written signature thus allowing for the digital signing of the bid.

Direct Costs. Project-specific costs the Contractor incurs in the performance of the Work, consisting of labor; material; ownership cost, operating expense, or invoiced rental rates of equipment; and job-site general and administrative overhead.

Disincentive. If provided for in the Contract, an agreed monetary sum that the Department deducts from compensation due or to become due to the Contractor if a specified milestone is not satisfactorily completed on or before the specified milestone date.

Disposable material. Material generally found to be unsuitable for roadway construction or surplus material that is to be placed in a disposal area, unless specified otherwise.

Disposal areas. Areas generally located outside of the Construction Limits identified in the Contract where unsuitable or surplus material is deposited.

Disqualification. The suspension or revocation of a bidder's prequalification privileges.

Diversion. A traffic shift that temporarily moves an existing Road to a new alignment.

Drainage ditch. An artificial depression constructed to carry off surface water.

–E–

Earthwork. The work consisting of constructing roadway earthwork in conformity with the specified tolerances for the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer. Earthwork shall include regular, borrow, undercut and minor structure excavation; constructing embankments; disposing of surplus and unsuitable material; shaping; grading; compaction; sloping; dressing; and temporary erosion control work.

Easement. A grant of the right to use property for a specific use.

Embankment. A structure of soil, soil aggregate, soil-like materials, or broken rock between the existing ground and subgrade.

Employee. Any person working on the project who is under the direction or control of or receives compensation from the Contractor or subcontractor at any tier.

Engineer. The Chief Engineer, as designated by the Commissioner, who acts directly or through his duly authorized representative(s) and who is responsible for highway design, construction, and maintenance. The Engineer and his representative(s) act within the scope of the particular duties or the authority given to them by the Code of Virginia, the Commissioner, these Specifications, and the Contract Documents.

Equipment. Machinery, tools, and other apparatus, together with the necessary supplies for upkeep and maintenance, that are necessary for acceptable completion of the work.

Excavation (Excavate). The act of creating a man-made cavity in the existing soil for the removal of material necessary to obtain a specific elevation or to install a structure, material, component, or item necessary to complete a specific task or form a final surface or subsurface.

Extra work. Any work that was not provided for or included in the Contract as awarded but the Engineer determines is essential to the satisfactory fulfillment of the Contract within its intended scope and is identified in an authorized change order for its execution subject to the limitations, exceptions and provisions in Sections 104.02, 104.03, and 109.05.

–F–

Falsework. A temporary framework used to support work in the process of constructing permanent structural units.

Federal agencies or officers. An agency or officer of the federal government and any agency or officer succeeding in accordance with the law to the powers, duties, jurisdictions, and authority of the agency or officer mentioned.

Fill Slope. See also **Cut Slope.** A surface plane formed during embankment above existing ground elevations that intersects with existing ground at its termini.

Final Acceptance. Acceptance of the project after Final Completion of all the Work specified in the Contract, as determined by and contingent on a final inspection by the Engineer.

Firm. A commercial partnership of two or more persons formed for the purpose of transacting business.

Flood frequency. A statistical average recurrence interval of floods of a given magnitude.

Force account work. A type of extra work for which the Contractor is compensated as specified in Section 109.05 (b) Payment by Force Account pursuant to an executed Force Account authorization (Form C-115), for use when the scope or quantity of the extra work is undefined.

Formwork. A temporary structure or mold used to retain the plastic or fluid concrete in its designated shape until it hardens. Formwork shall be designed to resist the fluid pressure exerted by plastic concrete and additional fluid pressure generated by vibration and temporary construction loads.

Frontage street or road. A local street or road auxiliary to and located on the side of a highway for service to abutting property and adjacent areas and control of access.

–G–

Gage. U.S. Standard Gage.

Grade separation. Any structure that provides a traveled way over or under another traveled way or over a body of water.

–H–

Highway. The entire right of way reserved for use in constructing or maintaining the roadway and its appurtenances.

Historical flood level. The highest flood level that is known to have occurred at a given location.

Holidays. The days specifically set forth in Section 108.02 or in the Contract Documents.

Hydrologic data sheet. A tabulation of hydrologic data for facilities conveying a 100-year discharge equal to or greater than 500 cubic feet per second.

–I–

Incentive. If provided for in the Contract, an agreed monetary sum that the Department pays to the Contractor if a specified milestone or condition is satisfactorily completed or achieved, and accepted by the Department on or before the specified milestone date.

Inspector. The Engineer's authorized representative who is assigned to make detailed inspections of the quality and quantity of the work and its conformance to the requirements and provisions of the Contract.

Invert. The lowest point in the internal cross-section of a pipe or other drainage structure.

–J–K–

Joint venture. Two or more businesses that join together in the nature of a partnership for the purpose of bidding on and constructing a project, for which they are all jointly and individually liable to the Department.

–L–

Laboratory. The testing laboratory of the Department or any other testing laboratory that may be designated by provisions in the Contract or by the Engineer.

Liquidated damages. As used in Section 108.06, the agreed damages the Contractor owes to the Department when the Contractor fails to complete the project within the specified Contract time limit. These damages include, but are not limited to, additional costs associated with administration, engineering, supervision, and inspection of the project, and other expenses.

–M–

Major Item. Any pay item specifically indicated as such in the Schedule of Items included in the Contract.

Material. Any substance that is used in the Work specified in the Contract.

Median. The portion of a divided highway that separates the traveled ways.

Milestone. An event or a date that marks the start or completion of a specified portion of the Work. If provided for in the Contract, milestones are used to specify when the Work or a specified portion thereof must be completed in accordance with the Contract Documents. The Contract may provide for one or more Completion milestone.

Minimum Plan Concept Project. A project of a very limited scope and duration that requires few details to describe the proposed work.

Minor Item. Any pay item that is not specified as being a Major Item in the Schedule of Items included in the Contract.

–N–

Non-Contract item. Item(s) of work that is required to permit completion of the specified work in an acceptable manner, located within the Limits of Construction, but is not included in the Contract Documents and will be completed by others prior to or during the construction of the Project.

No Plan Project. Generally a project of a very limited scope and duration that requires no plans to describe proposed work.

Notice to Proceed. Written notice to the Contractor authorizing the prosecution of work.

–O–

Ordinary high water. A water elevation based on analysis of all daily high waters that will be exceeded approximately 25 percent of the time during any 12 month period.

–P–Q–

Pavement structure. The combination of select or stabilized materials, subbase, base, and surface courses, described in the Typical Pavement Section in the Plans that is placed on a subgrade to support the traffic load and distribute it to the roadbed.

Pay item. See Contract item.

Phase inspection. The inspection of work at predetermined stages in lieu of continuous inspection.

Plans. The approved project plans and profiles, which may include but are not limited to survey data, typical sections, summaries, general notes, details, plan and profile views, cross-sections, special design drawings, computer output listings, supplemental drawings or exact reproductions thereof, and all sub-

sequently approved revisions thereto which show the location, character, dimensions, and details of the Work specified in the Contract.

Prequalification. The procedure for qualifying a contractor or subcontractor to bid or work on Department contracts, as specified in the Department's Rules Governing Prequalification Privileges.

Profile grade. The line of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal centerline of the roadbed.

Project. The designated section of highway, roadway, or property including all work to be performed according to the Contract Documents.

Project showing. The scheduled event at which the Department's representative meets with prospective bidders to describe and answer questions regarding the proposed work.

Proposal (Bid Proposal). The Department documents in the Notice of Advertisement for Bids that contain the project requirements and other information upon which a bid is to be based. The Proposal includes the plans, Specifications, Special Provisions, Supplemental Specifications, referenced Standards, addenda, revisions, all other documents referred to therein, whether or not attached, and the electronic forms on which the Department requires bids to be submitted.

–R–

Ramp. A connecting roadway between two highways or traveled ways or between two intersecting highways at a grade separation.

Right of way. A general term denoting the Commonwealth's land, property, or interest therein, that is acquired for or devoted to a highway or other transportation facilities. As used herein, the term does not denote the legal nature of the Commonwealth's ownership.

Road. A general term denoting a public way for purposes of vehicular travel including the entire area within the right of way; the entire area reserved for use in constructing or maintaining the roadway and its appurtenances.

Road and Bridge Specifications. See **Specifications.**

Roadbed. The graded portion of a highway within the top and side slopes that is prepared as a foundation for the pavement structure and shoulders.

Roadbed material. The material below the subgrade in cuts, embankments, and embankment foundations that extends to a depth and width that affects the support of the pavement structure.

Roadside. A general term that denotes the area within the right of way that adjoins the outer edges of the roadway; extensive areas between the roadways of a divided highway.

Roadside development. Items that are necessary to complete a highway that provide for the preservation of landscape materials and features; rehabilitation and protection against erosion of areas disturbed by construction through placing seed, sod, mulch, and other ground covers; and such suitable plantings and other improvements as may increase the effectiveness and service life and enhance the appearance of the highway.

Roadway. The portion of a highway within the limits of construction and all structures, ditches, channels, and waterways which are necessary for the correct drainage thereof.

Rootmat. Any material that, by volume, contains approximately 60 percent or more roots.

–S–

Schedule Impact Analysis (SIA). A process of analyzing a schedule to determine the impact on the project schedule of a change in the Work or condition, or of a delay event, for the purposes of quantifying and apportioning the effects to the party responsible for the impact.

Schedule of Record (SOR). The most recent baseline progress schedule accepted by the Engineer. Upon acceptance by the Engineer, the initial baseline progress schedule or a subsequently revised baseline progress schedule shall be the SOR. The SOR is the agreed, official and only baseline schedule with which all work required to complete the project will be planned and executed, on which all subsequent schedule updates shall be based, and against which progress of the Work will be evaluated.

Seawater. Water in which total alkali chlorides calculated as sodium chloride are more than 0.10 percent of total solids.

Select borrow. Borrow material that has specified physical characteristics.

Select material. Material obtained from roadway cuts, borrow areas, or commercial sources that is designated or reserved for use as a foundation for the subbase, subbase material, shoulder surfacing, or other specified purposes designated in the Contract Documents.

Shoulder. The portion of the roadway contiguous with the traveled way that is for the accommodation of stopped vehicles, emergency use, and lateral support of the base and surface courses.

Sidewalk. The portion of the roadway constructed primarily for the use of pedestrians.

Skew. The acute angle formed by the intersection of a line normal to the centerline of the roadway with a line parallel to the face of the abutments or, in the case of culverts, with the centerline of the culverts.

Special Provision (SP). See **Specifications.**

Special Provision Copied Note (SPCN). See **Specifications.**

Specialty Item. A Contract item designated as a "Specialty Item" in the Proposal that requires highly specialized knowledge, abilities, craftsmanship, or equipment not ordinarily provided by contractors prequalified to bid on the Contract as a whole. Specialty Items are usually limited to minor components of the overall Contract.

Specifications. A general term that includes all directions, provisions, and requirements, necessary for the proper fulfillment of the Contract. Specifications are found in the following Contract Documents:

> **Road and Bridge Specifications.** The standard specifications applicable to contracts awarded by the Commonwealth Transportation Board or Commissioner.
>
> **Special Provision (SP).** Specifications or requirements for a particular project that add to or modify the standard specifications.
>
> **Special Provision Copied Note (SPCN).** Specific specifications or requirements, usually limited in scope, for a particular project.
>
> **Supplemental Specifications (SS).** Additions and revisions to the Road and Bridge Specifications.

Standard drawings. Unless otherwise specified, applicable drawings in the Department's Road and Bridge Standards and such other standard drawings as are referred to on the plans.

State. Commonwealth of Virginia.

State Construction Contract Engineer. The Chief Engineer's authorized representative for administering the Notice of Advertisement for Bids, receiving bids for such, and awarding contracts for the Department.

Station. When used as a definition or term of measurement, 100 linear feet.

Storm Sewer System. A drainage system consisting of a series of at least two interconnecting pipes and structures (minimum of two drop inlets, manholes, junction boxes, etc.) designed to intercept and convey stormwater runoff from a specific storm event without surcharge.

Street. A general term denoting a public way for purposes of vehicular travel including the entire area within the right of way; the entire right of way reserved for use in constructing or maintaining the roadway and its appurtenances.

Structures. Bridges, culverts, catch basins, inlets, retaining walls, cribs, manholes, end walls, buildings, steps, fences, sewers, service pipes, underdrains, foundation drains, and other features that may be encountered in the work and are not otherwise classed herein.

Subbase. A layer(s) of specified or selected material of designed thickness that is placed on a subgrade to support a base course.

Subcontract. A contract between the Contractor and any other business to perform part of the Contract subject to the requirements of the Contract Documents including, but not limited to, Sections 102.01 and 105.06.

Subcontractor. Any business that has a subcontract, including any business that provides on-site labor, but not any business that furnishes or supplies only materials or equipment for the Project.

Subgrade. The top earthwork surface of a roadbed, prior to application of Select or Stabilized material courses, shaped to conform to the typical section on which the pavement structure and shoulders are constructed, or the surface that must receive an additional material layer, such as Topsoil, Stone or other Select Material.

Subgrade stabilization. The modification of roadbed soils by admixing with stabilizing or chemical agents that will increase the load bearing capacity, firmness, and resistance to weathering or displacement.

Sublet. See **Subcontract.**

Substructure. The part of a structure that is below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with the back walls, wingwalls, and wing protection railings.

Superintendent. The Contractor's Project representative who is authorized to receive and fulfill instructions from the Engineer and who supervises and directs the Work on the Contractor's behalf.

Superstructure. The portion of a structure that is above the substructure.

Supplemental Specifications (SS). See **Specifications.**

Supplier. Any business who manufactures, fabricates, distributes, supplies, or furnishes materials or equipment, but not on-site labor, for use in performing the Work on or for the project according to the requirements of the Contract Documents including, but not limited to, Sections 102 and 106.

Surety. A business bound with and for the Contractor for full and complete fulfillment of the Contract and for payment of debts pertaining to the Work. When applied to the proposal guaranty, it refers to the business that engages to be responsible in the execution by the bidder, within the specified time, of a satisfactory Contract and the furnishing of an acceptable payment and contract bond.

Surface course. One or more top layers of a pavement structure designed to accommodate the traffic load, which is designed to resist skidding, traffic abrasion, and disintegrating effects of weather. Also see wearing course.

Surplus material. Material that is present on a project as a result of unbalanced earthwork quantities, excessive swell, slides, undercutting, or other conditions beyond the control of the Contractor, or is designated as surplus material in the Contract Documents.

Suspension. A written notice issued by the Engineer to the Contractor that orders the Work on a project to be stopped wholly or in part as specified. The notice will include the reason for the suspension.

–T–

Temporary structure. Any structure that is required to maintain traffic while permanent structures or parts of structures specified in the Contract are constructed or reconstructed. The temporary structure shall include earth approaches.

Theoretical maximum density. The maximum compaction of materials that can be obtained in accordance with the values established VTM-1.

Tidewater, Virginia. Areas within the Commonwealth as defined in the Department of Conservation and Recreation Erosion and Sediment Control Manual.

Time Impact Analysis (TIA). A forward-looking, prospective schedule impact analysis method that adds a modeled delay to the current schedule in place at the time of a change or delay to determine the possible time impact of the change or delay to project completion.

Ton. A short ton; 2,000 pounds avoirdupois.

Top of earthwork. The uppermost surface of the regular or embankment excavation, not including select material, which is shaped to conform to the typical section shown in the plans or directed by the Engineer.

Topsoil. The uppermost original layer of material that will support plant life and contains more than 5 percent organic material reasonably free from roots exceeding 1 inch in diameter, brush, stones larger than 3 inches in the largest dimension, and toxic contaminants.

Traveled way. The portion of the roadway for the movement of vehicles, not including shoulders.

–U–

Unsuitable Material. Any material which contains more than 5 percent by weight organic matter, or which has unstable bearing capacity, excessive moisture content, plasticity indexes or liquid indexes,

or other characteristics defined by the Engineer or the Contract Documents as unsuitable for the use intended.

Utilities. Private, county, city, municipal or public facility, structure, or infrastructure, designed, owned and maintained for public use or to provide a public service such as electricity, water, sanitary sewer, storm sewer, drainage culverts, telecommunications, conduits, gas, oil, fiber optics, cable television, that is not identified as a Pavement Structure, Roadway, Highway, Street or Traveled Way.

–V–

Vouchered. The action of approval by the Department; constitutes the date of release to the State Comptroller for payment.

–W–X–Y-Z–

Wearing course. (See **Surface course**) The top and final layer of any pavement.

Work. The furnishing of all materials, labor, tools, equipment, and incidentals necessary or convenient for the successful completion of the project and the carrying out of the duties and obligations specified in the Contract.

Working drawings. Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data the Contractor is required to submit to the Engineer for review.

SECTION 102— BIDDING REQUIREMENTS AND CONDITIONS

102.01—Prequalification of Bidders

(a) All prospective bidders, including all members of a joint venture, shall be prequalified with the Department and shall have received a certification of qualification in accordance with the Rules Governing Prequalification Privileges prior to bidding. This requirement may be waived by a project-specific provision in the Proposal. The Rules Governing Prequalification Privileges may be found on the Department's website at www.virginiadot.org/business/const/prequal.asp.

All subcontractors shall be prequalified prior to performing any work on the Contract, except that prequalification will not be required for subcontractors when all of the pay items on which they are working fit one of the following descriptions: items denoted in the Proposal as "Specialty Items;" items that the Contract Engineer declares during the Advertisement period to be Specialty Items; or an item that is otherwise indicated in the Proposal as having a waiver of prequalification.

In order to be eligible for SWaM or DBE credit, SWaM or DBE subcontractors must be VDOT prequalified and SWaM or DBE certified at the time of bid submission.

When an individual is prequalified to bid jointly only with a specific company, the joint venture will be considered a unified entity for qualification purposes.

b) Prequalified bidders shall be subject to disqualification and removal from the Department's List of Prequalified Vendors in accordance with Section 102.08, the Rules Governing Prequalification Privileges, and other applicable laws.

102.02—Content of Proposal

(a) **Standard Proposal -** The Proposal will specify the location of the proposed Work, include all of the following, and will be considered part of the bid.

- a description of the Work, including an estimate of the various quantities and kinds of work to be performed or materials to be furnished, and a schedule of items for which unit bid prices are invited.

- the Contract time in which the Work shall be completed, and the date and time by which bids must be submitted.

- any Specifications, plans, attachments, revisions, addenda, and any other documents specified or referenced in the Proposal.

(b) **Combination or Conditional Proposals -** If the Department so elects, Proposals may be issued for projects in combination or separately. Bids may be submitted for either the combination or separate units of the combination. The Department may make awards on combination bids or separate bids to its best advantage. Combination bids other than those set up in the Proposals by the Department will not be considered. Conditional bids will be considered only when so stated in the Proposal.

102.03—Interpretation of Quantities in Proposal

The quantities of work to be performed and materials to be furnished identified in the Proposal are approximate only, and provided as a basis for cost analysis and comparison. The Contractor will be paid for the quantities of work accepted and materials furnished and correctly placed or installed according to the Contract. The quantities of work to be performed and materials to be furnished may vary, be increased, diminished, or eliminated, as provided within the Contract without invalidating the Contract. A variance, increase, decrease, or elimination of the quantities in the Proposal will not be sufficient grounds for granting an increase in the bid price, except as specified for a significant change in Section 104.02. Costs for items determined by the Contractor to be necessary for completion of the job for which no pay item is listed in the Proposal shall be included in the prices for other pay items. The Contractor will be paid according to Section 109 and other applicable Contract provisions.

102.04—Examination of Site of Work and Proposal

(a) **Evidence of Examination of Site of Work and Proposal**

The submission of a bid will be considered conclusive evidence that the bidder has (1) conducted a reasonable examination of the site of the proposed Work, the Proposal and other documents referenced therein, and the plans before submitting a bid, (2) is satisfied as to the nature, character, qualities, quantities, and conditions to be encountered in performing the Work and the requirements specified in the Proposal, and (3) has taken such matters into con-

sideration when submitting the bid. A reasonable site investigation may include investigating the project site, borrow sites, disposal areas, and hauling routes related to the performance of the Work.

(b) **Subsurface Data**

Subsurface data may be included in the Proposal or may be made available for review by the bidder in the office of the District Materials Engineer or State Materials Engineer. Data not included in the Proposal are not part of the Contract, but are made available to the bidder in good faith to notify the bidder of information in possession of the Department. The Department does not warrant any data not included in the Proposal or Contract, or any conclusions drawn from such data, either expressly or by implication. The bidder shall make his own interpretation of the subsurface data that may be available and satisfy himself with regard to the nature, condition, and extent of the material to be excavated, graded, or driven through. The submission of a bid will be considered conclusive evidence that the bidder is satisfied with regard to the subsurface conditions to be encountered in the work and has taken such conditions into consideration when submitting the bid.

(c) **Notice of Alleged Ambiguities, Conflicts, Errors or Omissions**

If a bidder has any questions or doubts about a word, phrase, clause, specification, or any other portion of the Proposal or alleges an ambiguity, conflict, error, or omission, the bidder shall submit a question about the ambiguity, conflict, error, or omission not later than 10 days prior to the due date of receipt of bids and request an interpretation thereof on the CABB (Contractor Advertisement Bulletin Board) website at http://cabb.virginiadot.org. Authorized interpretations will be issued by the State Construction Contract Engineer to each person who received a Proposal, and will be posted on the CABB system. The Department will not be responsible for any other explanations or interpretations of the alleged ambiguities, conflicts, errors or omissions.

The bidder shall not take advantage of obvious or apparent ambiguities, conflicts, errors, or omissions in the Proposal. If the bidder fails to submit a question on the CABB and request an interpretation of an obvious or apparent ambiguity, conflict, error, or omission within the specified time, the bidder shall waive any right it may have had to its own interpretation of the ambiguity, conflict, error, or omission. Further, if awarded the Contract the bidder waives any claims and shall not be entitled to any additional compensation or time, or entitled to sue the Department based on such obvious or apparent ambiguity, conflict, error, or omission.

It is recognized that the bidder's review of the Proposal is made in the bidder's capacity as a contractor and not as a licensed design professional unless otherwise specifically provided in the Contract. The bidder is not required to ascertain that the Contract is in accordance with applicable laws, statutes, ordinances, building codes, and rules and regulations, but any nonconformity discovered by or made known to the bidder shall be reported promptly to the State Construction Contract Engineer.

(d) **Utilities**

In general, the bid proposal will indicate the various utility items known to exist, will indicate items to be adjusted or improvements proposed by the respective owners and will designate any items that are to be adjusted by the Contractor. Information contained in the bid proposal regarding utility locations is advisory only and shall not be construed as being a representation of completeness or accuracy. The bidder shall contact the owners of the various utilities to

determine the exact location of the utilities and the owner's schedule of work. Unless otherwise noted, all utility adjustments will be performed by the Utility or its representative. The Contractor shall cooperate with the owners of any utilities in their adjustment operations. Prior to preparing a bid, the bidder shall contact known utility owners to determine the nature, extent, and location of existing, adjusted, or proposed new utility facilities within the areas of construction. It is understood and agreed that the Contractor (1) has considered in his bid all of the permanent and temporary utility appurtenances in their present and relocated positions and, any proposed utility capital improvements, and (2) the Contractor has contacted the utility owner with regard to the Contractor's proposed schedule of work. The Contractor shall include in his proposed schedule the amount of time to make utility adjustments, from time estimates furnished by the utility owners. Any costs associated with contacting, and coordinating with the utilities shall be reflected in the bid price for other items in the Contract. In the event the utility owners are non-responsive to the Contractor's efforts to contact them, the Contractor shall notify the Department prior to submitting a bid, as required in Section 102.03(c).

102.05—Preparation of Bid

(a) **General**

The bidder shall submit its bid by approved electronic media, unless otherwise provided for in the Proposal. The bidder shall furnish a unit or lump sum price as called for in the Proposal, in numerical figures, for each pay item listed. The bidder shall also show the products of the unit prices and quantities in numerical figures in the column provided for that purpose and the total amount of the bid.

If a unit or lump sum price is omitted, the bid will be rejected. If there is a discrepancy between the unit price and its extension, the unit price will govern.

In the event there is a discrepancy between the bidder's electronically generated Proposal form and the official Proposal form as furnished by the Department, the official Proposal form will govern.

Bids will be considered irregular and may be rejected for any of the reasons stated in Section 102.06.

The bidder shall submit a proposal guaranty in accordance with Section 102.07.

A bid will be rejected and the bidder disqualified for any of the reasons stated in Section 102.08.

All bidders shall return Form No. C-48 listing all subcontractors/suppliers that were solicited to supply quotes for work on this project within 10 calendar days after the date designated in the proposal for the opening of bids. This form shall show the VDOT vendor identification number (if applicable), legal names of subcontractors, suppliers, and vendors, whether SWaM or DBE, and utilization or non-utilization for work on this project.

(b) **Design Options**

Except as otherwise specified in the Proposal, when regular and alternate design options are shown in the Proposal, the bidder shall submit a bid price for at least one design option. The Department may award the Contract to the responsive and responsible bidder who submitted

the lowest bid for the regular design option or the lowest bid for the alternate design option, whichever is deemed to be in the best interest of the Commonwealth.

(c) **Debarred Suppliers**

The bidder is cautioned against utilizing price quotes for materials for use in the preparation of bids from suppliers or vendors that are debarred by the Department. The Engineer will not approve for use any material furnished by a supplier debarred by the Department. The bidder shall ascertain from the Department's listings which suppliers are debarred. Lists of approved suppliers can be found on the Department's Materials Division web site at www.virginiadot.org/business/resources/Materials/Approved-Lists.

If a previously debarred supplier is reinstated to eligibility subsequent to the award of a contract, the Engineer may approve the use of the supplier when requested by the Contractor.

(d) **Required Certifications**

A bidder who makes a false certification on the Bidder Certification of Prequalification Classification and Work Capacity Form will be subject to forfeiture of his proposal guaranty or disqualification from bidding on future work for a 90-day period, or both. The State Contract Engineer will determine the imposition and extent of such sanctions.

A sworn statement shall be executed by the bidder or his agent certifying that the bidder has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action to restrain free competitive bidding in connection with the Proposal. The sworn statement shall be part of the electronic bid or in the form of an affidavit furnished by the Department and shall be sworn to before a person who is authorized by the laws of the Commonwealth to administer oaths. The electronic bids shall contain the identical sworn statement. For the purpose of this Section, affixing a Digital ID to the bid will be considered by the Department conditional evidence of signing before a person who is authorized by the laws of the Commonwealth to administer oaths.

(e) **Acknowledgement of Addenda**

The bidder shall acknowledge all addenda to the Proposal documents issued prior to receipt of bids by checking the appropriate box on the Department's electronic bidding system prior to submitting its electronic bid submission. Bidders are responsible for checking the Department's advertisement page at http://cabb.virginiadot.org for addenda to ensure that they have seen and considered all addenda before submitting a bid. Failure to acknowledge any addendum by the method outlined above may result in the bid being rejected as non-responsive and irregular.

(f) **Signing the Bid**

Bids shall be signed with a digital identification. The names of persons authorized to sign bids shall be on file with the Department. A name will be considered to be on file if it appears as that of an officer, a partner, a member, a manager or an owner on the current Contractor's Prequalification Application. Requests by the bidder to revise the list of persons authorized to sign bids on their behalf shall be submitted in writing and approved prior to the date bids are opened. A bid signed by someone whose name is not on file as someone authorized by the bidder may be rejected. If the individual signing the bid for a

joint venture is not previously identified as authorized to sign a bid, the firm of record is responsible for the bid.

102.06—Irregular Bids

Bids will be considered irregular and may be rejected for any of the reasons below.

(a) The bidder fails to comply with Sections 102.05 and 102.07.

(b) The bidder adds any provisions reserving the right to accept or reject an award or enter into a contract pursuant to an award except as otherwise permitted in these Specifications.

(c) The bidder fails to provide Certification of Prequalification Classification and Work Capacity.

(d) The bid is not properly signed.

(e) The bidder fails to acknowledge all addenda to the Proposal documents by checking the appropriate box on the Department's electronic bidding system prior to submitting its electronic bid submission.

(f) There are unauthorized additions, conditional or alternate bids, or irregularities of any kind that may make the bid incomplete, indefinite, or ambiguous.

(g) The prices in the bid are obviously mathematically and materially unbalanced, either in excess or below the cost analysis values as determined by the Department. A mathematically unbalanced bid is a bid containing lump sum or unit price items that do not include reasonable labor, equipment, and material costs plus a reasonable proportionate share of the Bidder's overhead costs, other indirect costs, and anticipated profit. A materially unbalanced bid is when the Department determines that an award to the Bidder submitting a mathematically unbalanced bid will not result in the lowest ultimate cost to the Department.

(h) The bidder fails to submit a statement concerning collusion.

(i) The bid submitted identifies a project different than the project for which the bid is submitted.

(j) The bid is not totaled or is totaled incorrectly.

(k) Erasures or alterations in the bidder's entries on paper bids, when allowed, are not initialed by the bidder.

(l) Attachments included in the bid are detached or altered when the bid is submitted except as otherwise provided for herein.

(m) The bidder fails to register with "eVA Internet e-procurement solution" prior to the award of the Contract.

(n) The bidder, if required, fails to register with "E-Verify" program prior to the award of the Contract.

(o) The bidder, if required, fails to register or obtain authorization to transact business in Virginia from the State Corporation Commission prior to bidding.

102.07—Proposal Guaranty (Bid Bond)

A bid in excess of $250,000.00 will be rejected unless accompanied by a proposal guaranty, also known as a bid bond, made payable to the Commonwealth of Virginia, and executed on the Department's form (Form C-24), or on a form that contains the exact same wording as the Department's form. The amount of the proposal guaranty shall be 5 percent of the total bid.

The proposal guaranty shall be accompanied by a certified copy of the power of attorney for the surety's attorney-in-fact.

When the principal is a joint venture, each member of the joint venture shall be named and shall execute the proposal guaranty. Each surety to the proposal guaranty shall be named, and shall execute the proposal guaranty, and shall provide a certified copy of the power of attorney for the surety's attorney-in-fact.

102.08—Disqualification of Bidder

(a) *Any* of the reasons set out in the Rules Governing Prequalification Privileges may be considered sufficient for the disqualification of a bidder or the rejection of a bid, or both. Such reasons for disqualification are not exclusive and disqualification may occur based on other requirements in these Specifications.

1. The bidder does not have sufficient financial ability to perform the Contract. If a bond is required to ensure performance of a Contract, evidence that the bidder can acquire a surety bond from a corporation included on the U. S. Treasury Listing of Approved Sureties in the amount and type required by the public body will be sufficient to establish the financial ability of the bidder to perform the Contract.

2. The bidder or any current officer, director, owner, project manager, procurement manager, or chief financial official thereof has been convicted of, or pled guilty or nolo contendere within the past 10 years to a crime related to governmental or nongovernmental construction or contracting, including, but not limited to, a violation of (i) Ethics in Public Contracting statutes, § 2.2-4367 et seq. of the Code of Virginia, (ii) the Virginia Governmental Frauds Act, § 18.2-498.1 et seq. of the Code of Virginia, (iii) Conspiracy to Rig Bids to Government statutes § 59.1-68.6 et seq. of the Code of Virginia, (iv) any substantially similar law of the United States or another state, or (v) any criminal offense indicating a lack of moral or ethical integrity as may reasonably be perceived to relate to or reflect upon the bidder's business practices.

3. The bidder or any officer, director or owner thereof is currently debarred pursuant to an established debarment procedure from bidding or contracting by any public body, agency of another state, or agency of the federal government.

4. The bidder failed to respond to the Department's request for clarifying information requested by the Department relevant to the preceding paragraphs 1 through 3.

5. The bidder fails to register and participate in the E-Verify program as required by § 2.2-4308.2 of the Code of Virginia.

6. The bidder or any officer, director, or owner thereof has had a judgment entered against them for violation of the Virginia Fraud Against Taxpayers Act (Code of Virginia § 8.01-216.1, et seq.).

7. More than one bid for the same work is submitted by an individual, partnership, corporation or joint venture under the same or different name. A bid submitted by an affiliate of an individual, partnership, corporation, or any party of a joint venture will be considered as more than one bid submitted for the same work. Affiliate as used herein shall conform to the definition in Section 101.02 - Terms.

8. Evidence of collusion among bidders; participants in such collusion will not be considered for future bids until new applications for prequalification are approved according to the Rules Governing Prequalification Privileges.

9. Incompetency or inadequate machinery, plants, or other equipment as revealed by the bidder's financial and experience statements required by these Specifications and the Rules Governing Prequalification Privileges.

10. Unsatisfactory workmanship or unsatisfactory progress toward timely completion of the Work as described within Sections 102.01, 102.08, 105.05, 108.03, 108.07, or other applicable Specifications as demonstrated by performance records of current or past work for the Department, other agencies or departments of the Commonwealth, other public bodies in the Commonwealth, or agencies or departments of other states in the United States or federal government.

11. Uncompleted work under contract with the Department that in the judgment of the Engineer might hinder or prevent prompt completion of additional work if awarded.

12. Failure to promptly pay or settle satisfactorily all undisputed bills for materials, labor, equipment, supplies, or other items specified in contracts in force at the time the new work comes before the Board for award.

13. Failure to comply with any prequalification rule or regulation of the Department.

14. Failure to cooperate properly with representatives of the Commonwealth inspecting, monitoring or administering construction or disorderly conduct toward any such representative in contracts.

15. Default under a previous contract with the Commonwealth.

16. Failure to pay amounts owed to the Department, as specified in Section 109.10, on other contracts.

17. Making materially false statements in a bid or certified statement submitted to the Department.

18. Documentation of the failure to meet SWaM or DBE requirements on the Department's projects according to Section 107.15.

(b) Temporary disqualification of a bidder as provided herein will result in the temporary disqualification of each member of a joint venture and any affiliate of the bidder having substantially the same operational management or drawing from the same equipment or labor resource pool. Temporary disqualification will also result in disqualification of the bidder, each member of a joint venture, and affiliates as defined herein, for performance of work as subcontractors that in the opinion of the State Contract Engineer, could adversely affect other work under contract to the Department.

(c) Disqualified bidders may challenge and appeal their disqualification according to the Rules Governing Prequalification Privileges.Disqualified bidders may be allowed to re-apply for prequalification and be reinstated on the List of Prequalified Vendors at the discretion of the State Contract Engineer, upon satisfactory compliance with any requirements that may be imposed. In addition, the disqualified bidder shall submit a new prequalification application package and satisfy all prequalification requirements of these Specifications and the Rules Governing Prequalification Privileges.

102.09—Submission of Bid

Each bid shall be submitted to the Department by approved electronic media in accordance with the policy and procedures in effect at the time of the advertisement and bid. This information will be posted on the Department's Construction website at www.virginiadot.org/business/const, under "Electronic Bidding".

Bids shall be submitted prior to the time and at the place specified in the Notice of Advertisement for Bids. Bids received after that time will be returned to the bidder unopened. The date for the opening of bids may be deferred by the Department, in which case the bidders will be notified.

102.10—Withdrawal of Bid

A bidder may withdraw a bid in accordance with the following.

(a) **Standard Withdrawal:** Bids may be withdrawn as allowed by the electronic bidding system until bid closing. A bidder may withdraw a bid provided the request for the withdrawal is written and signed by a person(s) who qualifies to execute the bid in accordance with Section 102.05.

(b) **Conditional Withdrawal:** A bidder who desires to bid on more than one project for which bids are to be opened on the same date and desires to protect himself against receiving awards for more projects than he is equipped to handle may secure the protection desired by completing the portion of the electronic bid for the conditional withdrawal of bids.

102.11—eVA Business-To-Government Vendor Registration

Before a Contract is awarded, the apparent successful bidder shall be a registered vendor in "eVA Internet e-procurement solution" (www.eVA.virginia.gov), or the bid will be rejected. When registering with eVA it is the bidder's responsibility to have its correct payment and physical addresses entered in eVA in order to receive payments on any contracts that the Department may award. The bidder shall also ensure that his prequalification address(es) matches that registered with eVA.

102.12—Public Opening of Bids

Electronic bids will be decrypted, and along with all other bids opened and read publicly at the time and place specified in the Notice of Advertisement. Interested parties are invited to be present at the opening or view the lettings in real time on the Department's Construction website at www.VDOT.Virginia.gov. As-Read results will be posted on this website as soon as possible on the day of the reading.

102.13—"E-Verify" - Verification of Work Authorization

By signing and submitting the bid, the bidder certifies that it does not, and shall not during the performance of the Contract knowingly employ an unauthorized alien as defined in the federal Immigration Reform and Control Act of 1986.

(a) "E-Verify program" means the electronic verification of work authorization program of the Illegal Immigration Reform and Immigrant Responsibility Act of 1996 (P.L. 104-208), Division C, Title IV, § 403(a), as amended, operated by the U.S. Department of Homeland Security, or a successor work authorization program designated by the U.S. Department of Homeland Security or other federal agency authorized to verify the work authorization status of newly hired employees under the Immigration Reform and Control Act of 1986 (P.L. 99-603).

(b) Contractors with more than an average of 50 employees for the previous 12 months entering into a contract in excess of $50,000 with the Department shall register and participate in the E-Verify program to verify information and work authorization of their newly hired employees performing work pursuant to such contract. Bidders are not required to be registered with E-Verify program at the time bids are submitted, however, prior to award, the lowest responsive and responsible bidder must be registered with E-Verify program or the bid will be rejected.

(c) Contractors who fail to comply with Section 102.13(b) shall be debarred from contracting with any agency of the Commonwealth for a period up to one year. Such debarment shall cease upon registration and participation in the E-Verify program.

SECTION 103—AWARD AND EXECUTION OF CONTRACTS

103.01—Consideration of Bids

After bids have been opened and read, the Department will evaluate bid submittals to determine whether all requirements of Section 102 and the Proposal have been met. Bids not submitted in accordance with Section 102 and the Proposal will be rejected.

Bids will be compared on the basis of the summation of the products of the quantities shown in the bid schedule and the unit bid prices.

The Department may correct arithmetical errors in the bid prior to such comparison, in accordance with Section 102.05. The results of the comparisons will be available to the public after the determination has been made to award the Contract.

The Board reserves the right to reject any or all bids, waive informalities, advertise for new bids, or proceed to do the Work otherwise if it deems that the best interest of the Commonwealth would be promoted thereby.

The Department may, as part of its deliberations toward award of a contract, enter into a Memorandum of Understanding (MOU) with the apparent lowest responsive and responsible bidder if any of the following is determined to be necessary:

(a) Provide and document further clarification of a specification or drawing.

(b) Establish an order of priority (ranking) where there are conflicting specification requirements.

(c) Ensure proper understanding of the intent\meaning of a specification or drawing.

(d) Document the inclusion of inadvertently excluded pages from the Contract.

(e) Document the correct unit of measurement where a conflict exists within the bid documents.

(f) Document the elimination of an item(s).

(g) Limit the Department's exposure to contract overruns or potential unbalancing of a bid item.

This listing is not to be interpreted as all inclusive, but is provided to give examples of the types of issues that may be addressed in such an agreement. The MOU is not intended to be used to negotiate "as bid" unit prices/quantities or to renegotiate bid requirements with the apparent lowest responsive and responsible bidder, but merely to address intent, clarify points of confusion or limit the possible future effects of such issues on project budget. If the terms of the MOU are acceptable to both parties, the Department and the apparent lowest responsive and responsible bidder will document their acceptance of the terms of the MOU by both parties' signatures. In the case of Federal Oversight projects, FHWA concurrence is also required. The MOU will be added to and become part of the executed Contract.

103.02—Award of Contract

If the Contract is awarded, the award will be made to the lowest responsive and responsible bidder without discrimination on the grounds of race, color, gender, or national origin. In the event of tie bids, preference will be given to the lowest responsive and responsible bidder who is a resident of Virginia otherwise the tie will be decided by lot.

Whenever any bidder is a resident of any other state and such state under its laws allows a resident contractor of that state a preference, a like preference may be allowed to the lowest responsive and responsible bidder who is a resident of Virginia. The award date will not be later than midnight on the 60th day after the opening of bids. If the Board, or the Commissioner; where permitted by law, has not awarded the Contract within this period, the bidder may withdraw his bid without penalty or prejudice unless the time limit is extended by mutual consent. The Virginia Department of General Services shall post and maintain an updated list on its website of all states that allow their resident contractors an absolute preference or a percentage preference and the percentage amounts.

103.03—Cancellation of Award

The Board, or the Commissioner, where permitted by law, may cancel the award of any contract at any time before the execution of the Contract by all parties without liability to the Commonwealth.

103.04—Forfeiture of Proposal Guaranty

The apparent low bidder's proposal guaranty shall be subject to forfeiture if the apparent low bidder withdraws his bid prior to award, or fails to sign and return the Contract. The proposal guaranty shall be forfeited according to the forfeiture provisions in Code of Virginia (§ 2.2-4336) and the proposal guaranty. The apparent low bidder's refusal to sign a Memorandum of Understanding shall not be grounds for proposal guaranty forfeiture.

103.05—Requirements of Contract Bond

Within 15 calendar days after notification of award of the Contract the successful bidder shall furnish the following bonds for contracts in excess of $250,000.00:

(a) A performance bond in the sum of the Contract amount, conditioned upon the faithful performance of the Contract in strict conformity with the plans, Specifications and conditions of the Contract, and.

(b) A payment bond in the sum of the Contract amount, conditioned upon the prompt payment for all labor, materials, public utility services and rental of equipment used in the prosecution of the work for the Contract.

Bidders will not be awarded an unbonded contract when their bid plus the balance of other unbonded contracts exceeds $250,000.00 or as otherwise limited by their current prequalification status.

The bonds shall be made on official forms furnished by the Department and shall be executed by the bidder and a surety company carrying a minimum "Best Rating" of "B +" and authorized to do business in Virginia in accordance with the laws of Virginia and the rules and regulations of the State Corporation Commission. To be considered properly executed, the bonds shall include authorized signatures and titles.

103.06—Contract Documents

The Contract shall include the following documents unless otherwise specified by Special Provisions or Special Provision Copied Notes:

(a) **Contract:** The Contract shall include:

- the fully executed Proposal including all addenda or revisions thereto issued prior to the bid date; the Schedule of Items showing the prices submitted by the bidder; and any Supplemental Specifications, Special Provisions, Special Provision Copied Notes, and attachments issued with the Proposal.
- these Specifications.
- the Plans.
- the edition of the Road and Bridge Standard Drawings cited on the title sheet of the Plans including all addenda or revisions thereto issued prior to the bid date.
- Any Memoranda of Understanding agreed to between the Engineer and the Contractor conforming to Section 103.01.
- any change orders that the Engineer issues after the Contract execution date.

(b) **Contract Performance and Payment Bonds:** Contract bonds shall conform to Section 103.05.

(c) **Affidavits and Documents:** Affidavits and documents shall include those required to be made a part of the Contract by any federal or state law in effect on the date of the Notice of Advertisement.

(d) **Workers' Compensation Insurance Certificate:** The Contractor shall procure and continue to maintain for the duration of the Work until final acceptance, Workers' Compensation and Employers' Liability Insurance for all of its employees engaged in the Work in an amount not less than the minimum required by Code of Virginia (§ 2.2-4332), and the Virginia Workers' Compensation Act, Code of Virginia §65.2-100 et seq. When any of the Work is sublet, the Contractor shall require each subcontractor to provide similar Workers' Compensation and Employers' Liability Insurance for all of the subcontractor's employees engaged in the Work.

Within 15 days after the date of the notice of award of the Contract, the bidder shall submit a Certificate of Insurance verifying Workers' Compensation coverage using the Department's forms (Form C-73). The certificate shall be executed by an approved and authorized insurance company as required by state law and shall cover the Contract. The Contractor shall likewise obtain a Certificate of Insurance for Workers' Compensation coverage from each subcontractor prior to performance of work and shall provide a copy to the Department.

The Contractor shall notify the Department in writing at least 30 days prior to the cancellation or reduction of the bonds or insurance required under this Section. The Contractor shall cease all operations on the effective date of the cancellation or reduction unless and until new bonds or insurance are in force and the same evidence of bonds or insurance are provided to the Department.

(e) Progress Schedule: The Contractor shall submit a progress schedule in accordance with Section 108.03 or as specified in the Contract.

(f) **Contractor's Bodily Injury and Property Damage Liability Insurance Certificate:** The Contractor shall procure and maintain at his own expense, for the duration of the Work until final acceptance, insurance of the kinds and in the amounts specified herein. The minimum limits of liability for this insurance shall be as follows:

A Combined Single Limit for Bodily Injury Liability and Property Damage Liability

$1,000,000	Each Occurrence
$2,000,000	Aggregate

Within 15 days after the date of the notice of award of the Contract, the bidder shall submit Certificates of Insurance showing compliance with the above using the Department's form (Form C-73). The certificates shall be executed by an approved and authorized insurance company authorized to do business in Virginia and with a minimum *"Best Rating"* of *"B +",* and shall cover the Contract it accompanies.

The Contractor's Bodily Injury and Property Damage Liability Insurance shall cover liability of the Contractor for damage because of bodily injury to, or death of persons and damage to, or destruction of property, that may be suffered by persons other than the Contractor's own employees as a result of the negligence of the Contractor in performing the Work.

Insurance provided in compliance with this Section shall include liability of the Contractor for damage to or destruction of property that may be suffered by persons other than the Contractor's own employees as a result of blasting operations of the Contractor in performing the work covered by the Contract.

If any part of the Work is sublet, insurance meeting the same requirements shall be provided by or on behalf of the subcontractors and evidence of such insurance shall be submitted with the sublet request.

Insurance coverage in the minimum amounts set forth herein shall not be construed to relieve the Contractor or subcontractor(s) of liability in excess of such coverage, nor shall it preclude the Commonwealth from taking such actions as are available to it under any other provision of this Contract or otherwise in law.

103.07—Failure to Furnish Bonds or Certificate of Insurance

The successful bidder's failure to furnish to the Department acceptable bonds, workers' compensation insurance certificates or the Contractor's Bodily Injury and Property Damage Liability Insurance certificates within 15 days after the date of Award Recommendation Letter shall be considered just cause for cancellation of the award and forfeiture of the proposal guaranty. In such event, the proposal guaranty shall become the property of the Commonwealth, not as a penalty but in liquidation of damages sustained. The Contract may then be awarded to the next lowest responsive and responsible bidder, or the Work may be re-advertised or constructed otherwise, as determined by the Board or the Department.

103.08—Contract Audit

The Contractor shall permit the Department to audit, examine, and copy all documents, computerized records, electronic mail, or other records of the Contractor during the life of the Contract and for a period of not less than five years after the date of final payment, or the date the Contractor is declared in default of Contract, or the date of termination of the Contract. The documents and records shall include, but not be limited to:

(a) Those that were used to prepare and compute the bid, prepare all schedules used on the project, record the progress of work on the project, accounting records, purchasing records, personnel payments, or records necessary to determine employee credentials, vendor payments, and written policies and procedures used to record, compute, and analyze all costs incurred on the project, including those used in the preparation or presentation of claims to the Department.

(b) Records pertaining to the project as the Department may deem necessary in order to permit adequate evaluation and verification of Contractor's compliance with Contract requirements, compliance with the Department's business policies, and compliance with provisions for pricing change orders or claims submitted by the Contractor or the Contractor's subcontractors, insurance agents, surety bond agents, and material suppliers shall be made available to the auditor(s) at the Department's request. The Contractor shall make his personnel available for interviews when requested by the Department.

(c) Upon request, the Contractor shall provide the Department with data files on data disks or other suitable alternative computer data exchange format. Data furnished by the Contractor that cannot be verified will be subject to a complete audit by the Department.

The Contractor shall ensure that the requirements of this provision are made applicable to his subcontractors, insurance agents, surety bond agents, and material suppliers. The Contractor shall cooperate and

shall cause all related parties to furnish or make available in an expeditious manner all such information, materials, and data.

The Contractor shall provide immediate access to records for the audit and provide immediate acceptable facilities for the audit. Failure on the part of the Contractor to afford the Department immediate access or proper facilities for the audit will be considered failure to cooperate and will result in disqualification as a bidder in accordance with Section 102.08.

Upon completion of the Contract audit, any adjustments or payments the Contractor owes to the Department as a result of the audit shall be made to the Department within 60 days from presentation of the Department's findings to the Contractor. Failure on the part of the Contractor to make such payment may result in disqualification as a bidder in accordance with Section 102.08.

If the Contractor disagrees with the findings of the Department's audit, the Contractor may dispute the findings in accordance Section 105.19 or the Code of Virginia as amended and as applicable, except that if the time provided for the Contractor to submit a claim within 60 days after final payment has expired, the Contractor shall instead submit a written claim to dispute the findings to the Engineer within 60 days from the date the Contractor received the findings. Failure on the part of the Contractor to submit a claim disputing the Department's findings within such 60-day period shall constitute a waiver and release of any claim disputing the Department's findings.

103.09—Execution of Contract

(a) The bid as submitted, including the Contract Documents specified in Section 103.06 shall constitute the Contract upon submittal of the Contract bond, Contractor's bodily injury and property damage liability insurance certificates, and workers' compensation insurance certificate and the Department's final execution of the Contract. After the Department has recommended the bid for award, the apparent low bidder shall be required to sign and return a paper copy of the Contract to the State Contract Engineer. Failure to sign and return the Contract will result in cancellation of the award and forfeiture of the proposal guaranty. If the Contract is not awarded within the time limit specified in Section 103.02, the bidder may withdraw his bid without penalty or prejudice unless the time limit is extended by mutual consent. The Department will execute the Contract upon receipt of the Contractor's signed Contract. The Contract shall be considered binding and effective only when it has been fully executed by all parties.

(b) **Notice of Contract execution.** The Contract Engineer will notify the Contractor of the date that the Department has executed the Contract. The Contract Engineer or his designee will confirm the Contract execution date in such notice. The notice will identify the Engineer's authorized representative responsible for written directives and changes to the Contract, who will contact the Contractor to arrange a pre-construction and scheduling conference.

(c) **Unbonded Contracts**

In the event the successful bidder on an unbonded contract is unwilling or unable to fulfill the Contract and fails to notify the Department prior to the Department's execution of the Contract, the bidder will be declared in default in accordance with Section 108.07.

In the event the bidder, on an unbonded contract, notifies the Department prior to the Department's execution of the Contract of such unwillingness or inability to fulfill the Contract, the

bidder will be enjoined from bidding on unbonded contracts for a period of no less than 90 days from the date of notice by the Department.

A bidder who has never been enjoined or defaulted on an unbonded contract and who notifies the Department prior to the Department's execution of the Contract of such unwillingness or inability to fulfill the Contract will not be enjoined for the first occurrence; however, said bidder will not be permitted to rebid or perform work on that specific Contract.

103.10—Assignments, Transfers, or Assumptions of the Contract

The Contractor shall not assign, transfer, convey, or allow any person or business to assume or take over, in whole or in part, the Contract, the Contractor's duties, or performance obligations, arising under, from or relating to the Contract, except for subcontracting as provided in Section 105.06 or the rights of a surety issuing a performance bond for the Contract, without the Engineer's specific written authorization. Any such unauthorized assignment, transfer, conveyance, assumption, or take over agreement shall be void and shall constitute a material breach of the Contract. No assignment, transfer, conveyance, assumption, or take over agreement shall relieve the Contractor from its duties and obligations under the Contract, or release the Contractor of any liability under the Contract bonds.

SECTION 104—SCOPE OF WORK

104.01—Intent of Contract

The intent of the Contract is to provide for completion of the Work specified therein in accordance with the Contract for the Contract amount and within the Contract time limit. Further, it is understood that the Contractor shall perform the Work under the Contract as an independent contractor and not as an agent of the Department, the Commissioner or the Board.

104.02—Changes in Quantities or Alterations in the Work

(a) **General**

The Engineer reserves the right to make, in writing, at any time during the Work, such changes in quantities and such alterations in the work as are necessary to complete the project satisfactorily. Such changes in quantities and alterations shall not invalidate the Contract or release the surety, and the Contractor shall agree to perform the Work as altered. No change alteration or modification in or deviations from the Contract, or the giving by the Department of any extension of time for the performance of the Contract, or the forbearance on the part of the Department shall release or exonerate in whole or in part either the Contractor or any surety on the obligations of any bond given in connection with the Contract. Neither the Department nor the Contractor shall be under any obligation to notify the surety or sureties of any such alteration, change, extension or forbearance, notice thereof being expressly waived. Any increase in the Contract amount shall automatically result in a corresponding increase in the penal amount of the bonds without notice to or consent from the surety, such notice and consent being hereby waived. Decreases in the Contract amount shall not, however, reduce the penal amount of the bonds unless specifically provided in any change order as authorized in accordance with Section 109.05 decreasing the scope of the work.

(b) **Significant Changes in the Character of Work**

The work or changes in quantities, significantly change the character of the work under the Contract, an adjustment, excluding anticipated profits for reduced or eliminated work, may be made to the Contract. The basis for the adjustment shall be agreed upon prior to the performance of the affected Work. If a basis cannot be agreed upon, an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

The Engineer may, at his option, direct the Contractor to accomplish the change or alteration on a force account basis when the circumstances meet the requirements for force account work under Section 109.05.

If the Engineer's changes or alterations do not result in a significant change in the character of the Work, the changed or altered work will be paid for at the Contract price for the actual quantities of work performed.

The term significant change shall be construed to apply only to the following circumstances:

1. When the character of the Work, as changed or altered, differs materially in kind or nature from that involved or included in the original proposed construction.

2. When the actual quantity of a Major Item of work, as defined elsewhere in the Contract, increases or decreases more than 25 percent of the original Contract quantity. Any adjustment for an increase or decrease in cost due to an increase in quantity of more than 25 percent shall be calculated only on that quantity in excess of 125 percent of the original pay item quantity. Any adjustment for an increase or decrease in cost due to a decrease in quantity to less than 75 percent of the original pay item quantity shall apply to the actual amount of work performed.

3. When the actual quantity of piling increases or decreases more than 25 percent of the original pay item quantity, whether or not such item has been designated as a Major Item. Compensation for such increases or decreases shall be the same as for a Major Item of work.

4. When the actual quantity of a Minor Item of work, as defined elsewhere in the Contract, increases more than 200 percent of the original pay item quantity and the amount paid for such item can be demonstrated as not representative of the true cost of the work when considering the applicable unit price.

(c) **Value Engineering Proposals**

The Contractor may submit to the Engineer written Value Engineering Contractor Proposals (VECP) for modifying the plans, Specifications, or other Contract requirements for the purpose of reducing the total cost and/or Contract time without reducing the design capacity or quality of the finished product. If the Department accepts the VECP, the Department and the Contractor will equally divide the net savings or Contract time, or both. When an accepted VECP includes Contract time savings, one-half of such time savings shall be used to reduce the Contract time and the remaining one-half of such time savings shall be used exclusively by the Contractor as extra time. The Contractor shall identify in the SOR, a VECP contractor float activity for each accepted VECP that includes Contract time savings. The VECP extra time may be used by the Contractor to mitigate its delays on the project.

Each VECP shall result in a net savings over the Contract cost or Contract time, or both, without impairing essential functions and characteristics of the item(s) or of any other part of the project, including, but not limited to, service life, reliability, economy of operation, ease of maintenance, aesthetics, and safety. At least the following information shall be submitted with each VECP:

- Statement that the proposal is submitted as a VECP.
- Statement concerning the basis for the VECP benefits to the Department and an itemization of the pay items and requirements affected by the VECP.
- Detailed estimate of the cost or Contract time, or both, under the existing Contract and under the VECP.
- Proposed specifications and recommendations as to the manner in which the VECP changes are to be accomplished.
- Statement as to the time by which a Contract change order adopting the VECP must be issued so as to obtain the maximum cost-effectiveness.

The Department will process the VECP in the same manner as prescribed for any other proposal that would necessitate issuance of a change order. The Department may accept a VECP in whole or part by issuing a change order that will identify the VECP on which it is based. The Department will not be liable to the Contractor for failure to accept or act on any VECP submitted pursuant to these requirements or for delays in the work attributable to any VECP. Until a VECP is put into effect by a change order, the Contractor shall remain obligated to the terms and conditions of the existing Contract. If an executed change order has not been issued by the date on which the Contractor's proposal specifies that a decision should be made or such other date as the Contractor may subsequently have specified in writing, the VECP shall be deemed rejected.

The change order effecting the necessary modification of the Contract will establish the net savings agreed on, and provide for adjustment of the Contract prices or Contract time, or both. The Contractor shall absorb all costs incurred in preparing a VECP. Costs for reviewing and administering a VECP will be borne by the Department. The Department may include in the agreement any conditions it deems appropriate for consideration, approval, and implementation of the VECP. The Contractor's 50 percent share of the net savings or Contract time, or both, shall constitute full compensation to him for effecting all changes pursuant to the VECP change order.

Unless specifically provided for in the change order authorizing the VECP, acceptance of the VECP and performance of the work thereunder will not change the Contract time limit.

The Department may adopt a VECP for general use in contracts the Department administers if it determines that the VECP is suitable for application to other contracts. VECPs identical with or similar to previously submitted VECPs will be eligible for consideration and compensation under these provisions if the Department has not previously adopted the VECPs for general application to other contracts the Department administers. When a VECP is adopted for general use, compensation pursuant to these requirements will be applied only to those awarded contracts for which the VECP was submitted prior to the date of adoption of the VECP.

Proposed changes in the basic design of a bridge or pavement type or those changes that require different right of way limits will not normally be considered an acceptable VECP. If a VECP is based on or is similar to a change in the plans, Specifications, or Special Provisions the Department has adopted prior to submission of the VECP, the Engineer will not accept the VECP.

The Engineer will be the sole judge of the acceptability of a VECP. The requirements herein apply to each VECP initiated, developed, and identified as such by the Contractor at the time of its submission to the Engineer. However, nothing herein shall be construed as requiring the Engineer to approve a VECP.

Subject to the provisions herein, the Department or any other public agency shall have the right to use all or part of an accepted VECP without obligation or compensation of any kind to the Contractor.

If the Department accepts a VECP, Section 104.02(b) herein, which pertains to the adjustment of Contract unit prices attributable to alterations of Contract quantities, will not apply to the items adjusted or deleted as a result of putting the VECP into effect by a change order.

104.03—Differing Site Conditions

Type I: During the progress of the Work, if subsurface or latent physical conditions differing materially from those indicated in the Contract are encountered at the site, the Contractor shall promptly notify the Engineer in writing of the specific differing conditions before the site is disturbed further and before the affected work is performed.

Type II: During the progress of the Work, if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract, are encountered at the site the Contractor shall promptly notify the Engineer in writing of the specific differing conditions before the site is disturbed further and before the affected work is performed.

Upon receipt of such written notification, the Engineer will acknowledge receipt and investigate the conditions. If it is determined by the Engineer that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an adjustment, excluding anticipated profits, will be made and the Contract may be modified in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the Contract is warranted.

No adjustment that results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.

SECTION 105—CONTROL OF WORK

105.01—Notice to Proceed

Unless otherwise indicated in the Contract, the Notice to Proceed date will be the date selected by the Contractor on which the Contractor intends to begin the work. That date shall be no earlier than

15 nor later than 30 calendar days after the date of Contract execution. The State Contract Engineer will contact the Contractor on the date of Contract execution to inform him that the Contract has been executed. The State Contract Engineer will also confirm this date in the Letter of Contract Execution. Copies of the Letter of Contract Execution will be distributed to Department personnel involved in the administration of the Contract and to the Contractor. Within 10 calendar days after the date of Contract execution the Contractor shall submit to the Engineer written notice of the date he has selected as his Notice to Proceed date. If the Contractor fails to provide written notice of his selected Notice to Proceed Date within 10 calendar days of Contract execution, the selected Notice to Proceed Date will become the date 15 calendar days after the date of Contract execution. The Contractor shall begin work no later than 10 calendar days after the date he has selected as his Notice to Proceed date, unless the Notice to Proceed date is otherwise indicated in the Contract, in which case the Contractor shall begin work within 10 calendar days after the specific Notice to Proceed date indicated in the Contract.

Contract Time will commence on the date of the Notice to Proceed. The Letter of Contract Execution will identify the Chief Engineer's authorized representative, hereafter referred to as the Engineer, who is responsible for written directives and changes to the Contract. The Engineer will contact the Contractor after notice of award to arrange a pre-construction conference.

In the event the Contractor, for matters of his convenience, wishes to begin work earlier than 15 calendar days or later than 30 calendar days after the date of Contract execution, he shall make such a request in writing to the Engineer within 10 calendar days of the date of Contract execution or once a Notice to Proceed Date has been established, if he wishes to begin work more than 10 calendar days after his selected Notice to Proceed date or the Notice to Proceed Date indicated in the Contract, he shall make such a request to the Engineer in writing no later than 5 calendar days after the Notice to Proceed date. If this requested start date is acceptable to the Department, the Contractor will be notified in writing; however, the Contract Completion Date will not be adjusted but will remain binding. The Contractor's request to adjust the start date for the work on the Contract will not be considered as a basis for claim that the time resulting from the Contractor's adjusted start date, if accepted by the Engineer, is insufficient to accomplish the work nor shall it relieve the Contractor of his responsibility to perform the work in accordance with the scope of work and Contract requirements. In no case shall work begin before the Department executes the Contract or prior to the Notice to Proceed date unless otherwise permitted by the Contract or authorized by the Engineer. The Contractor shall notify the Engineer at least 24 hours prior to the date on which he will begin the work.

105.02—Pre-Construction Conference

After notification of award and prior to the Notice to Proceed date the Contractor shall attend a pre-construction conference scheduled by the Engineer to discuss the Contractor's planned operations for prosecuting and completing the Work in accordance with the Contract. At the pre-construction conference the Engineer and the Contractor will identify in writing the authorities and responsibilities of project personnel for each party. The Contractor and the Department shall also come prepared to discuss key issues and project specific requirements necessary for preparation and submittal of the baseline progress schedule; unless a separate Scheduling Conference is otherwise scheduled as mutually agreed to by the Engineer and the Contractor, in accordance with Section 108.03 and other applicable Contract provisions.

The Engineer will be responsible for setting the conference agenda, conducting discussions, and ensuring that minutes of the conference are taken and later timely distributed to all attendees. The pre-construction conference will be the time to review the Contract plans and documents. To that end, the conference

agenda may include but not be limited to discussions on the general sequence of work, including the expected primary work tasks as defined by the Contractor, and proposed means and methods for the entire scope of work, potential problems or impacts, constructability issues, special considerations such as limitations and access issues, agreements with local agencies or governments, utility impacts or relocations including railroads, coordination with schedules of the utilities and subcontractors and associated work, sources and delivery of critical materials, submittals required by Contract including shop drawings, location of field office, labs, etc., environmental concerns including permits and erosion and siltation efforts, maintenance of traffic issues, and EEO\DBE\SWaM requirements.

The Contractor shall provide the Engineer with a list of all equipment available for use in the prosecution of the Work on the Contract at the pre-construction conference or no later than one week prior to the first monthly progress estimate. The make, model, size, capacity, and year of manufacture shall be listed for each piece of equipment. Where possible the Contractor shall provide this list in an electronic format. This list may take the form of the Contractor's fleet list of equipment. The Contractor shall provide the Engineer an updated list of equipment as changes occur.

105.03—Authorities of Project Personnel, Communication and Decision Making

(a) **Authority of Engineer**

During prosecution of the Work, the Engineer will answer all questions that may arise as to the quantity, quality, and acceptability of materials furnished and work performed; rate of progress of the Work; interpretation of the plans and Specifications; the Contractor's acceptable fulfillment of the Contract; disputes and mutual rights between contractors; and the Contractor's compensation.

The Engineer has the authority to suspend the Work wholly or in part if the Contractor has created conditions that are unsafe or fails to correct conditions that are unsafe for workers or the general public or fails to carry out the provisions of the Contract. The Engineer may also suspend the Work for such periods as he may deem necessary because of catastrophic or extraordinary weather as defined in Section 108.04, conditions considered unsuitable for prosecution of the Work, or any other condition or reason deemed to be in the public interest.

The Engineer may issue written clarifications or directives that either enhance or alter the Contract. The Engineer may issue written orders for such work as may be necessary to complete the Contract satisfactorily.

(b) **Authority of Inspector**

Inspectors representing the Department are authorized to inspect all work performed and materials furnished. Inspection may extend to all or any part of the Work and to the preparation, fabrication, and manufacture of the materials to be used. The Inspectors are not authorized to alter or waive the provisions of these Specifications or make changes in the plans.

The Inspectors are not authorized to make final acceptance of the project, approve any operation or item, or act as foreman for the Contractor. However, the Inspectors will have the authority to reject defective work and material and suspend work that is being improperly performed, subject to the concurrence of the Engineer. Such inspections shall not relieve the Contractor of any obligation to furnish acceptable materials or provide completed construction that is in accordance with the Contracts requirements.

The Inspectors will exercise only such additional authority as the Engineer may delegate. The Engineer will advise the Contractor in writing of delegations of authority that will affect his operations.

(c) **The Contractor**

The Contractor shall not construe reviews, approvals, or inspections by the Department, the Engineer, or the Department's inspectors, agents, and employees as a waiver, release, warranty, or assumption of liability on the part of the Department. The Contractor understands and agrees that reviews, approvals, and inspections are for the Department's sole use and benefit. Any such reviews, approvals, and inspections shall not relieve the Contractor of its contractual duties and obligations or be conclusive as to the acceptability of the Contractor's performance.

(d) **Communication and Decision Making**

1. **Description.** The intent of this provision is to establish procedures, processes and guidelines for making decisions and managing communications regarding the Work. The information contained herein is not meant to be all inclusive but to serve as a minimal general framework for promoting efficient and effective communication and decision making at both the project and, if needed, executive administrative level. It is also not meant to override the decision-making processes or timeframes of specific Contract requirements.

2. **Definitions**

For the purposes of this provision the following terms will apply and be defined as follows:

Submittals - Documents required by the Contract that the Contractor must submit for the Department's review, acceptance, or approval. Submittals may include shop drawings, working drawings, material test reports, material certifications, project progress schedules, and schedule updates. The Contractor shall provide submittals as early as practicable so as not to delay review, acceptance, or approval of the Work.

Confirmation of verbal instructions (COVI) - Contractor-requested written confirmation of the Department's instructions concerning the Work. When time and/or costs are or will be impacted, the Contractor must comply with the requirements applicable to requests for adjustments of the Contract amount or Contract time.

Requests for information (RFI) - Requests where either the Contractor or the Department asks that the other party supply information to provide better understanding of or to clarify a certain aspect of the Work.

Requests for Department action (RDA) - Requests where the Contractor asks the Department to take certain action that the Contractor feels is required for proper completion of all or a portion of the Work.

Contractor change requests (CCR) - Requests where the Contractor asks the Department to make an adjustment to the Contract because of excusable and/or compensable events, instructions that have or have not been given, or other work requiring time and/or cost beyond that specified or envisioned within the Contract.

Requests for Contractor action (RCA) - Requests where the Department asks the Contractor to take certain action that is in the best interests of the project and/or is required for proper completion of all or a portion of the Work.

Responsible Person - The individual in the normal or escalated resolution process, for either the Contractor or the Department, having the direct authority, responsibility and accountability to formulate and respond to each category of information request.

3. **Process for Decision Making**

a. Project teams composed of the Contractor's and the Department's representatives, who are directly responsible for the administration, prosecution, and inspection of the Work, shall define and agree upon the field decision-making process during the pre-construction conference. This process should be written down and distributed to all affected parties once it is established. Where there are responsibilities, authority or personnel changes associated with this process, such changes shall be distributed to all affected parties as quickly as practicable after they are effective so as not to delay or impede this process.

The process for making field decisions with respect to the Work detailed in the Contract requires the following basic steps:

(1) The Contractor and the Area Construction Engineer agree on the decision-making process, the identity, authority and accountability of the individuals involved, and on the cycle times for responses required for each category of decision.

(2) The requesting party requiring a decision generates the appropriate request documents, and calls for a decision from the individual who is accountable for the particular facet of the Work under consideration within the agreed period.

(3) The responding party has an internal decision-making process that supports the individual who is accountable and provides the information required within the agreed period for each category of decision.

(4) The party receiving the decision has an internal process for accepting the decision or for rejecting the decision and initiating further action according to the decision-making process within an agreed period of time.

b. The process also requires that clear and well-understood mechanisms be in place to log and track requests; document the age and status of outstanding requests and actions to be taken on requests that have not been answered within the agreed period.

c. Both the Department and the Contractor shall agree on the following:

(1) The documentation and perhaps format to be developed for each category of information requested.

(2) The name (as opposed to organizational position) of all individuals with the responsibility, authority, and accountability to formulate and respond to each category of information requested. The District Administrator (DA) or Chief

Executive Officer (CEO) of the Contractor may delegate the responsibility and authority for formulating and responding to requests, however, the accountability for meeting the established response time(s) remains with the District Administrator and CEO.

(3) The cycle times for each stage in the decision-making process.

(4) The performance measures to be used to manage the process.

(5) The action to be taken if cycle times are not achieved and information is not provided in a timely manner.

d. The general guideline and timeframe matrix in Tables I-2A and I-2B will apply. These guidelines, however, are general in scope and may not apply to specific Contract time frames for response identified within the Contract requirements. In such cases, specific Contract time frames shall apply.

TABLE I-2A
Process Guidelines for Requests Generated by the Contractor

Process	Situation	Normal resolution process		Escalated process		Process if no resolution
		By	Within (calendar days)	By	Within	
Submittal	Contractor requests the Department's review, acceptance or approval of shop drawings, materials data, test reports, project progress schedules, or other submittals required by Specifications or other Contract	Department's Designated Project Manager	Acknowledge: 3 days[1] Accept or Return: 14 days Final Determination\Approve: 30 days or as outlined in Contract.	DA or his designee	7 days	Submit RDA or CCR
Confirmation of Verbal Instruction (COVI)	Routine field issues, within the framework of the Contract, Contractor resolves through negotiation with the Department's field personnel.	Department's Appropriate field personnel	Confirmation: 1 day	DA or his designee	7 days	Submit Request for RDA
Request for Information (RFI)	Contractor needs the Department to supply information to provide better understanding of or to clarify a certain aspect of the work.	Department's Designated Project Manager	Action: 14 days (or appropriate Action Plan)	DA or his designee	7 days	Submit RDA or CCR
Request for Dept. Action (RDA)	Contractor needs the Department to take certain action Contractor feels is required for proper completion of a portion of the Work or the project.	Department's Designated Project Manager	Acknowledge: 3 days[1] Action: 14 days (or appropriate Action Plan)	DA or his designee	7 days	Submit CCR
Contract Change Request (CCR)	Contractor needs the Department to make an adjustment to the Contract because of excusable and/or compensable events, instructions that have or have not been given or other work that will require time and/or cost beyond that specified or envisioned within the original Contract.	Department's Designated Project Manager	Acknowledge: 3 days 1 Action: 30 days (45 days if federal oversight project)	DA or his designee	7 days	Claims process

[1] Process initiated on the last business day of a week shall be acknowledged before 5 PM on the next VDOT business day.

TABLE I-2B
Process Guidelines for Requests Generated by the Owner

Process	Situation	Normal resolution process		Escalated process		Process if no resolution
		By	Within (calendar days)	By	Within	
1. RFI	Department requests the Contractor to supply information to provide better understanding of or to clarify a certain aspect of the work. (RFI)	Contractor's Project Superintendent	Action: 14 days (or appropriate written Action Plan)	Contractor's Project Manager	7 days	Submit RCA or Issue Unilateral Change order
2. RCA	Department requests the Contractor to take certain action(s) that is/are in the best interests of the project and/or is/are required for proper completion of a portion of the work or the project. (RCA)	Contractor's Project Superintendent	• Response or Action to safety and environmental issues: 1 day • Otherwise acknowledge: 3 days[1] • Action: 14 days (or appropriate Action Plan)	Contractor's Project Manager	7 days	Issue Unilateral Change order
3. Unilateral Change order	Department orders the Contractor to perform work beyond that specified or envisioned in the original Contract and undertakes action(s) to make an adjustment to the Contract.	Contractor's Project Superintendent	Acknowledge: 3 days[1] Action: 30 days	CEO or his designee	7 days	Claims or termination process

[1] Process initiated on the last business day of a week shall be acknowledged before 5 PM on next project business day.

105.04—Gratuities

The Contractor and its subcontractors and suppliers shall not offer, give or confer upon any of the Department's employees or personnel any gifts, gratuities, payments, loans, subscriptions, advances, deposits of money, services, favors, or anything of more than nominal value, present or promised, unless consideration of substantially equal or greater value is exchanged.

The Contractor shall not employ any personnel of the Department for any services without the Engineer's prior written consent.

If the Engineer determines after investigation that the Contractor or the Contractor's employees, representatives, or agents of any person acting in his behalf have violated this Section, the Engineer may, at his discretion, disqualify the Contractor from bidding on future contracts with the Department for a period of 6 months from the date of the Engineer's determination of such violation. Any implicated employees, agents, or representatives of the Contractor may be prohibited from working on any contract the Department awards for the period of the Contractor's disqualification.

105.05—Character of Workers, Work Methods, and Equipment

(a) **Workers**

Workers shall have sufficient skill and experience to perform properly the Work assigned to them. Workers engaged in special or skilled work shall have sufficient experience in such work and in the operation of equipment required to perform it properly and satisfactorily. The term "workers" means the Contractor's employees, its subcontractors at any tier, or any of their respective employees.

The Contractor shall immediately remove from the Project any workers who, in the Engineer's opinion, do not perform their work in a proper, skillful and satisfactory manner or are intemperate or disorderly. The Engineer shall direct the Contractor to do so in writing and such workers shall not be employed again on any portion of the Work without the Engineer's written approval. If the Contractor fails to immediately remove the workers, or furnish suitable and sufficient workers for satisfactory prosecution of the Work, the Engineer may withhold all monies that are or may become due the Contractor and may suspend the Work until the Contractor has complied with the Engineer's directive.

(b) **Equipment**

Equipment shall be of sufficient size and quantity, and in such good mechanical condition as to comply with the Contract requirements and to produce a satisfactory quality of work. Equipment shall be such that no damage to the roadway, adjacent property, other highways, or no danger to the public, will result from its use. The Engineer may order the removal and require replacement of unsatisfactory equipment.

(c) **Work Methods**

When methods and equipment to be used by the Contractor are not prescribed in the Contract, the Contractor is free to use whatever methods or equipment he feels will accomplish the Work in conformity with the Contract requirements.

When the Contract specifies that construction be performed by the use of particular methods and equipment, they shall be used unless others are authorized by the Engineer. If the Contractor desires to use a different method or type of equipment, he may request permission from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment he proposes to use and an explanation of the reasons for desiring to make the change. If permission is not given, the Contractor shall use the specified methods and equipment. If permission is given, it will be on the condition that the Contractor shall be fully responsible for producing construction work in conformity with Contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not strictly conform to the Contract requirements, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The Contractor shall remove any deficient work and replace it with work of the specified quality or take such other corrective action as the Engineer may direct. No change will be made in the basis of payment for the construction items involved or the Contract time limit as the result of authorizing or denying a change in methods or equipment under these provisions.

105.06—Subcontracting

(a) No portion of the Contract shall be subcontracted or otherwise disposed of without the written consent of the Engineer. The Contractor shall notify the Engineer of the name of the firm to whom the work will be subcontracted, and the amount and items of work involved. Such notification shall be made and verbal approval given by the Engineer prior to the subcontractor beginning work.

(b) The Contractor shall perform with his own organization work amounting to not less than 30 percent of the total original Contract amount, excluding any specialty items designated by the Department. Specialty items may be performed by subcontract and the amount of any such specialty items performed may be deducted from the total original Contract amount before computing the amount of work required to be performed by the Contractor's own organization.

The term "perform work with its own organization" refers to workers employed or leased by the Contractor, and equipment owned or rented by the Contractor, with or without operators. Such term does not include employees or equipment of a subcontractor or lower tier subcontractor, agents of the Contractor, or any other assignees. The term may include payments for the costs of hiring leased employees from an employee leasing firm meeting all relevant Federal and State regulatory requirements. Leased employees may only be included in this term if the Contractor meets all of the following conditions:

1. The Contractor maintains control over the supervision of the day-to-day activities of the leased employees;

2. The Contractor remains responsible for the quality of the work of the leased employees;

3. The Contractor retains all power to accept or exclude individual employees from work on the project; and

4. The Contractor remains ultimately responsible for the payment of predetermined minimum wages, the submission of payrolls, statements of compliance and all other Federal regulatory requirements.

(c) The Contractor shall not subcontract any part of the Contract work to a contractor who is not prequalified with the Department in accordance with Section 102.01, unless otherwise indicated in the Contract. This restriction does not apply to Contract specialty items, service providers, engineers, consultants, manufacturers, suppliers, or haulers. Consent to subcontract or otherwise dispose of any portion of the Contract work shall not relieve the Contractor of any responsibility for the satisfactory fulfillment of the entire Contract. All subcontracts shall be evidenced by written binding agreements that shall be available to the Department upon request, before, during, and after their approval.

105.07—Cooperation of Contractor

The Contractor shall give the Work the constant attention necessary to facilitate quality and progress, and shall fully cooperate with the Engineer, Inspector, and other contractors involved in the prosecution of the Work. If any portion of a project is located within the limits of a municipality, military installation, or other federally owned property, the Contractor shall cooperate with the appropriate officials and their agents in the prosecution of the Work to the same extent as with the Department.

The Contractor shall have on the project at all times during prosecution of the Work a competent Superintendent who is capable of reading and understanding the plans and Specifications, experienced in the type of work being performed, and who shall receive instructions from the Engineer or his authorized representatives. The Superintendent shall have full authority to execute the orders and directions of the Engineer without delay and supply promptly such materials, equipment, tools, labor, and incidentals as may be required.

105.08—Cooperation With Regard to Utilities

The adjustment of utilities consists of the relocation, removal, replacement, rearrangement, reconstruction, improvement, disconnection, connection, shifting, or altering of an existing utility in any manner.

Existing utilities within the Department's knowledge at the design stage of the project will be indicated on the plans. Where possible, the Department will make arrangements for adjusting these utilities prior to project construction. The utility owner will adjust existing private and public utilities that require adjustment, unless the Contract requires the Contractor to perform such adjustment as a pay item. The new location of such utilities will not normally be shown on the plans. Some utilities may remain or be adjusted within the construction limits simultaneously with project construction operations.

The Contractor shall coordinate project construction with planned utility adjustments and take all necessary precautions to prevent disturbance of the utilities. The Contractor shall report to the Engineer any failure on the part of the utility owner to cooperate or proceed with the planned utility adjustments.

The Contractor shall perform Contract utility work in a manner that will cause the least inconvenience to the utility owner and those being served by the utility owner.

The Contractor shall protect existing, adjusted, or new utilities that are shown on the plans, marked by Miss Utility, or otherwise known to the Contractor that are to remain within the right of way so as to prevent disturbance or damage resulting from construction operations. If during prosecution of the work the Contractor encounters an existing utility that requires adjustment he shall not interfere with the utility but shall take the proper precautions to protect the utility and shall promptly notify the Engineer of the need for adjustment.

If the Contractor desires the temporary or permanent adjustment of utilities for his own benefit, he shall conduct all negotiations with the utility owners and pay all costs in connection with the adjustment.

The Contractor shall promptly notify the Engineer in writing if the Contractor encounters utilities that are not shown on the plans, marked by Miss Utility, or otherwise known to the Contractor before the site is disturbed further and before the affected work is performed. Upon receipt of the Contractor's written notification, the Engineer will acknowledge receipt and investigate the conditions. The Engineer will notify the Contractor whether or not an adjustment to the Contract is warranted. Adjustments will be made according to Sections 108.04 and 109.05, as applicable.

No adjustment that results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.

105.09—Cooperation among Contractors

The Department may at any time contract or approve concurrent Contracts for performance of other work on, near, or within the same geographical area of the work specified in an existing Contract. Contractors shall not impede or limit access to such work by others.

When separate Contracts are awarded within the limits of one project, contractors shall not hinder the work being performed by other Contractors. Contractors working on the same project shall cooperate with each other. In the case of dispute, all Contractors shall proceed as directed by the Engineer.

When Contracts are awarded to separate Contractors for known concurrent construction in a common area, the Contractors, in conference with the Engineer, shall establish a written joint schedule of operations. The schedule shall be based on the limitations of the individual Contracts and the joining of the work of one Contract with the others. The schedule shall set forth the approximate dates and sequences for the several items of work to be performed and shall ensure completion within the respective Contract time limit. The schedule shall be submitted to the Engineer for review and approval no later than 30 days after the award date of the later Contract and prior to the first monthly progress estimate. The schedule shall be agreeable to, signed by, and binding on each Contractor. The Engineer may allow modifications of the schedule when benefit to the Contractors and the Department will result.

Any modification of the schedule shall be in writing, mutually agreed to and signed by the contractors, and shall be binding on the contractors in the same manner as the original agreement.

If the contractors fail to agree on a joint schedule of operations, they shall submit their individual schedules to the Engineer, who will prepare a schedule that will be binding on each Contractor.

The joint schedule and any modification thereof shall become a part of each Contract involved. The failure of any Contractor to abide by the terms of the joint schedule will be justification for declaring the Contractor in default of his Contract.

Each Contractor shall assume all liability, financial or otherwise, in connection with his Contract and shall protect and save harmless the Commonwealth from any and all damages and claims that may arise because of any inconvenience, delay, or loss he experiences as a result of the presence and operations of other contractors working in or near the work covered by his Contract. He shall also assume all responsibility for any of his work not completed because of the presence or operation of other Contractors.

The Department will not assume any responsibility for acts, failures, or omissions of one Contractor that delay the work of another except as provided herein.

105.10—Plans and Working Drawings

(a) **General**

The Contractor will be supplied with two copies of the executed Contract. The Department's Road and Bridge Specifications and the Department's Road State and Bridge Standards are available on the Department's website and are available for purchase by the Contractor from the office of the Contract Engineer.

(b) **Plans**

Plans will be furnished to the Contractor without charge as follows:

Original Contract Amount in Dollars		Number of Plan Sets	
From	**To**	**Full Size**	**Half Size**
0	1,999,999	4	6
2,000,000	4,999,999	6	8
5,000,000	9,999,999	8	10
10,000,000 or more		10	10

Plan revisions issued while the project is under construction will be furnished to the Contractor in the same sizes and number.

The Contractor shall keep one complete set of plans, standard drawings, Contract assemblies, and Specifications available on the project at all times. For maintenance projects, certain sign projects, and other projects having no field office or on which the Contractor has no office, the Contractor shall keep one complete set of plans, Contract assemblies, and Specifications with him while prosecuting the work. In the event items of work are required as per the Standard Drawings, the Contractor shall also keep the appropriate Standard Drawings on the project during the performance of that work.

Plans consisting of general drawings and showing such details as are necessary to give a comprehensive understanding of the work specified will be furnished by the Department. Except as otherwise shown on the plans, dimensions shown on the plans are measured in the respective horizontal or vertical planes. Dimensions that are affected by gradients or vertical curvatures shall be adjusted as necessary by the Contractor to accommodate actual field conditions and shall be specifically denoted as "field adjusted" on the working drawings. Failure on the part of the Contractor to so denote field adjustments on the working drawings shall not relieve the Contractor of the responsibility to accommodate and incorporate such existing conditions into the finished work.

(c) **Working Drawings**

The Contractor shall furnish nine sets of detailed working drawings to the extent and with the details required by the Contract Documents unless otherwise indicated in the Contract

Documents. Working drawings and submittals shall be identified by the complete state project and job designation number, as well as the federal project number if applicable. Items or component materials shall be identified by the specific Contract item number and Specification reference in the Contract. Any changes from the requirements of the Contract shall be specifically denoted, together with justification, and submitted to the Engineer for review. Working drawings shall be submitted in sufficient time to allow for review, discussion and correction prior to the beginning of the work they reference and avoid causing any delay to the Work. Work shall not be performed or materials ordered prior to the completion of the Department's review of the working drawings.

Reviewed working drawings will be returned to the Contractor within 30 days from the date of receipt by the Department. If a railroad, municipality, or other entity as specified in the Contract or on the plans is required to review the working drawings, the reviewed working drawings will be returned within 45 days from the date of receipt by the Department. If the working drawings are not returned by the time specified, no additional compensation will be allowed except that an extension of time in accordance with Section 108.04 will be considered if the work element detailed by the working drawings is on the project's critical path or involves a controlling item of work. Three sets of working drawings marked with any suggested modifications or comments will be returned to the Contractor. The other sets will be retained by the Department.

The Department's review of the Contractor's working drawings will be limited to evaluation for conformance with the Contract requirements. The Department's review will not relieve the Contractor from responsibility for errors in the working drawings or from complying with the Contract requirements for a fully functional finished work item as specified or designed.

Deviations from the Contract requirements initiated by the Contractor shall be requested in writing and clearly identified on the working drawings. Explicit supporting justification shall be furnished specifically describing the reason for the requested deviations, as well as any impact such deviations shall have on the schedule of work. Failure to address time or other impacts associated with the Contractor's request will be cause for rejection of the Contractor's request. Deviations from the Contract requirements shall not be made unless authorized by the Engineer. Such authorization shall not relieve the Contractor from the responsibility for complying with the Contract requirements for a fully functional finished work item as specified or designed.

If working drawings detailing change(s) initiated by the Contractor require more than two resubmissions or revisions, the cost of additional reviews by the Department or its designated representative(s) will be assessed to the Contractor.

The Contractor shall submit as-built working drawings upon completion of the Work, if required by the Contract.

The cost of working drawings furnished by the Contractor shall be included in the cost of appropriate Contract items.

The Contractor may authorize the fabricator in writing to act for him in matters relating to working drawings. Such authorization shall have the force and effect of any other representative of the Contractor's organization.

Provide working drawings according to the following:

1. **Steel Structures**

   Working drawings for steel structures, including metal handrails, shall consist of shop detail, erection, and other working drawings showing details, dimensions, sizes of units, and other information necessary for the fabrication and erection of metal work.

2. **Falsework**

   Working drawings for falsework supporting a bridge superstructure shall be signed and sealed by a Professional Engineer, holding a valid license to practice engineering in the Commonwealth of Virginia.

3. **Concrete Structures and Prestressed Concrete Members**

   Working drawings for concrete structures and prestressed concrete members shall provide such details as required for the successful prosecution of the work and which are not included in the plans furnished by the Department. Drawings shall include plans for items such as prestressing strand details and elongation calculations, location of lift points, falsework, bracing, centering, form work, masonry, layout diagrams, camber management plan for prestressed members, and bending diagrams for reinforcing steel when necessary or when requested. Such drawings shall be signed and sealed by a Professional Engineer, holding a valid license to practice engineering in the Commonwealth of Virginia.

4. **Lighting, signal and pedestal poles, overhead and bridge mounted sign structures, breakaway support systems, anchor bolts, framing units, panels, and foundations**

   Prior to fabrication or construction, the Contractor shall submit for review one original and six copies of each working drawing and design calculation for lighting, signal and pedestal poles, overhead and bridge mounted sign structures, breakaway support systems, anchor bolts, framing units, panels, and foundations. All sheets of these submittals shall include the Professional Engineer's signature and seal. Certification for foundations will be required only when the designs are furnished by the Contractor. The designs shall be in accordance with the specific editions of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals as required in Section 700. Such designs shall be signed and sealed by a Professional Engineer, holding a valid license to practice engineering in the Commonwealth of Virginia.

5. **Reinforced Concrete Pipe**

   When specified, and prior to manufacture of reinforced concrete pipe, the Contractor shall furnish to the Department a certification of the acceptability of the design of such pipe, as determined from a review that has been signed and sealed by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia. Such certification shall cover all design data, supporting calculations and materials. Pipe designs previously certified or approved by the Department will not require recertification.

105.11—Conformity with Plans and Specifications

All materials to be used in the Work shall conform to the qualities, technical requirements, values or range of values specified in the Contract. Less than complete conformity may be permitted if

obtaining exact or complete conformity would not be feasible and if authorized in writing by the Engineer.

Permissible tolerances for the elevation of subgrade and finished grade and for the thickness of the various courses of pavement structure are specified in the Contract. If permissive tolerances are exceeded, or if consistent deviations from the plans or abrupt changes in grade occur, even though within the tolerances, the affected areas shall be reconstructed to conform to the specified tolerance and provide a smooth riding surface. When it is not feasible to reconstruct the areas, payment will be made in accordance with the applicable specification for each material placed or adjusted in accordance with Section 105.18.

When the plans require the finished surface to tie into any structural item whose elevation is fixed, the elevation of the finished surface must coincide with the elevation of the structural item.

105.12—Coordination of Plans, Standard Drawings, Specifications, Supplemental Specifications, Special Provisions, and Special Provision Copied Notes

The plans, Standard Drawings, Specifications, Supplemental Specifications, Special Provisions, Special Provision Copied Notes, and other Contract Documents defined in Section 103.06 are parts of the Contract. A requirement occurring in one Contract Document shall be as binding as though occurring in all. The Contract Documents are intended to be complementary, and to include, describe and provide all items necessary for the Contractor's proper and complete performance of the Work.

In case of a discrepancy, the following order of priority will apply, with the highest governing item appearing first and the least governing item appearing last:

(a) Special Provision Copied Notes. The Contract items, units and unit prices listed in the Contract's Schedule of Items have the same status as Special Provision Copied Notes.

(b) Special provisions.

(c) Plans.

(d) Supplemental Specifications.

(e) Specifications.

(f) Standard Drawings (including all revisions issued through the date of Advertisement).

Calculated dimensions, unless obviously incorrect, will govern over scaled dimensions.

Drawings (with the exception of Standard Drawings), sketches, general notes, and other written information that are not included in Special Provisions or Special Provision Copied Notes used in No Plan and Minimum Plan Concept projects will have the same status as plans.

The Contractor shall not take advantage of any obvious or apparent ambiguity, conflict, error or omission in the plans or the Contract. If after beginning work the Contractor discovers an ambiguity, conflict, error, or omission in the Contract, he shall immediately notify the Engineer and before proceeding further with the affected work. The Engineer will then make such corrections and interpretations as may be deemed necessary for fulfilling the intent of the Contract.

105.13—State Force Construction Surveying

(a) **General Description:**

This work shall consist of the Department performing all surveying and providing surveying and stakeout sketches and information as detailed herein for the successful prosecution of work as indicated on the plans and as directed by the Engineer. Stakeout work will be in accordance with the details and requirements of the Department's Survey Manual and the provisions herein. Survey services will be provided to the extent detailed herein for Construction, Minimum Plan, and No Plan projects.

(b) **Request for Survey Services:**

Once the Contractor requests survey services, the Department will begin the requested work within 3 working days. The Contractor shall not expect the Department survey party to work in the field during adverse weather conditions that could be detrimental to the survey equipment or paperwork, therefore the Contractor shall plan the need for such services accordingly.

It shall be the Contractor's responsibility to preserve all Department furnished centerline or baseline controls, references, and location benchmarks. After initial stakeout, an hourly charge equal to the current hourly rate for Department survey services per district will be billed to the Contractor for resetting stakes where the cause for the resetting of such stakes is due to the fault of the Contractor or his operations. This rate will also apply to travel time to and from the project.

If the Contractor requests stakes after the initial staking and he is not ready to accommodate such work, the Contractor will be billed the hourly rate for Department survey services per district measured in travel time to and from the project. Such fees will be billed to the Contractor on the next monthly estimate.

(c) **Contractor Responsibility for Examination of Data:**

For Construction or Minimum Plan projects, the Contractor shall be responsible for examining all surveying work that the Department provides for accuracy. Should a disagreement involving the accuracy of stakeout or survey work arise during construction, the Contractor shall within one business day of confirming the disagreement provide written notice to the Engineer, precisely describing and documenting the discrepancy. The Contractor's failure to furnish written notice of such discrepancy within the timeframe specified will bar any claim for time impact or costs. The Engineer will determine the validity of the Contractor's assertion in the notice, respond to the Contractor within 3 working days of receipt of the Contractor's notice, and provide direction on how to proceed. When the Contractor provides the written notice within the timeframe specified, the Engineer will consider a time extension according to Section 108.04, or additional compensation according to 109.05.

For No Plan projects, the Examination of Data specified above is not required.

(d) **Survey Services Furnished:**

Unless otherwise stated, the Department will provide horizontal and vertical controls for the project construction stakeout. The Contractor shall preserve all controls the Department provides.

Where available, electronic data files along with paper sketches and drawings will be furnished by the Department when requested in writing by the Contractor. All electronic data files furnished by the Department to the Contractor will be in the format of the Department's current computer hardware and software, or a format fully compatible with such hardware and software.

Additional surveying work and supplemental layout work shall be performed by the Contractor as needed to successfully complete the Work. The Contractor shall provide and protect temporary construction benchmarks within the construction limits. Temporary construction benchmarks shall be located not farther than 500 feet apart for the total length of the project or as indicated on the plans. Temporary construction benchmarks that are disturbed during construction operations shall be reestablished by the Contractor at no additional cost to the Department. All drawings, field notes, and computations from such survey work performed by the Contractor shall be submitted to the Engineer.

The Department will perform the following surveying work based on the type of project.

1. **Construction (C) Projects.**

    a. **Digital Terrain Model (DTM) and Construction Cross-Sections:** The Department will provide original location Digital Terrain Model (DTMs), which will serve as the basis of payment for earthwork. The Contractor shall be responsible for taking construction DTMs or cross-sections of areas where the Contractor does not agree with the Department-furnished original location DTMs. The Contractor shall submit its DTM information to the Engineer for verification prior to any excavation by the Contractor in these alleged areas of disagreement. All DTMs shall be compatible to the Department's current DTM format.

    b. **Borrow Pits:** The Department will provide all borrow pit DTMs or cross-sections, both original and final. The Engineer will not consider any alleged discrepancy in borrow volume unless the Contractor substantiates the alleged discrepancy with independent DTMs or cross-sections of borrow areas both original and final.

    c. **Horizontal and Vertical Control for Bridges:** The Department will furnish certified plats, field notes, coordinates and computations prior to the Contractor beginning work on these structures.

    d. **Horizontal and Vertical Controls for all Box Culverts, all Pipe Culvert Installations (including single and multiple line installations) with total hydraulic openings equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size:** The Department will stake all such installations and furnish certified plats, including notes, coordinates, or computations used to support the platted information, prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

e. **Horizontal and Vertical Control for Pipe Culvert Installations (including single and multiple line installations) having total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Department will stake horizontal and vertical control for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. The Department will furnish sketches prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes shall apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

f. **Horizontal and Vertical Control for additional centerlines or baselines for roadways, ramps, loops and connections:** Upon written request, the Department will provide horizontal and vertical controls for additional centerlines or baselines for roadways, ramps, loops and connections.

g. **Grading and paving construction:** The Department will provide fine grade or other grade stakes required for the construction of the project as the work progresses except as stated herein.

Fine grade stakes will be set on all projects on which the plans show a definite grade line. Fine grade hubs will be set on at least one side with distances and grades referenced to the finished centerline grade. Typically, on curves, the Department will provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same Contract, only one set of fine grade stakes will be provided to the Contractor. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes will be provided by the Department only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches will be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections will be staked only if requested by the Contractor.

The Department will set all slope stakes. Upon written request from the Contractor cut/fill sheets for slope stakes will be furnished by the Department to the Contractor within 3 working days of the survey party's arrival at the project site or a timeframe agreed upon by the Contractor and the Engineer after reviewing the length and complexity of the project.

h. **Right of way and boundary stakeout affecting property ownership:** Right of Way will be staked by the Department prior to the start of the project. Right of way stakes will be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes will be marked with both the station and offset back to centerline. All final boundary stakeout will be performed by the Department's survey party.

i. **Setting right of way monuments:** Final right of way monumentation will be performed by the Department in accordance with the following:

(1) **RM-1:** The Department will furnish and install RM-1 right of way monuments in accordance with the Road and Bridge Standards.

(2) **RM-2:** The Department will furnish and install RM-2 right of way monuments and optional locator posts, including the required caps, in accordance with the Road and Bridge Standards.

(3) **Other monumentation:** The Department will determine if an alternative form of permanent monumentation will be used if RM-1 or RM-2 monuments are unsuitable for marking the right of way at various locations. The Department will indicate this alternative monument usage on the final as-built plan in accordance with the Department's Survey Manual.

2. **Minimum Plan (M) Projects.**

a. **Digital Terrain Model (DTM) and Construction Cross-Sections:** "M" projects are based on plan quantities; therefore DTM and construction cross-sections are not required, except for borrow pits.

Should the Engineer determine at any time that an actual measurement is warranted, the Department will make the necessary measurement in the field.

b. **Borrow Pits:** Same as for Construction (C) Projects.

c. **Horizontal and vertical control for bridges:** Same as for Construction (C) Projects.

d. **Horizontal and Vertical Control for all Box Culverts, all Pipe Culvert Installations (including single and multiple line installations) with a total hydraulic openings equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size:** Same as for Construction (C) Projects.

e. **Horizontal and Verticals Control for Pipe Culvert installations (including single and multiple line installations) having total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** Same as for Construction (C) Projects.

f. **Horizontal and Vertical Control for additional centerlines or baselines for roadways, ramps, loops and connections:** At certain locations and at the discretion of the Engineer, a minimum number of centerline grade stakes may be furnished by the Department from which the approximate depth of centerline cuts and fills may be obtained.

g. **Grading and paving construction:** Same as for Construction (C) Projects, except that slope stakes are not required on "M" projects.

h. **Right of way and boundary stakeout affecting property ownership:** Same as for Construction (C) Projects.

i. **Setting right of way monuments:** Same as for Construction (C) Projects.

3. **No Plan (N) Projects.**

The location of any reference points that the Department may have established, and any control data which the Department may have available will be provided to the Contractor upon request. The Department will be responsible for the accuracy of such reference points and control data.

105.14—Maintenance during Construction

(a) **Traffic Control**

1. The Contractor shall have at least one person on the project site during all work operations who is currently verified either by the Department's Intermediate Work Zone Traffic Control training or by the American Traffic Safety Services Association (ATSSA) Virginia Intermediate Traffic Control Supervisor (TCS) training by a Department approved training provider. This person must have their verification card with them while on the project site. This person shall be responsible for the oversight of work zone traffic control within the project limits in compliance with the Contract requirements, the VWAPM, and the MUTCD. This person's duties shall include the supervision of the installation, adjustment (if necessary), inspection, maintenance, and removal when no longer required, of all work zone traffic control devices on the project.

   If none of the Contractor's on-site personnel responsible for the supervision of such work have the required verification with them or if they have an outdated verification card showing they are not currently verified as a Traffic Control Supervisor (TCS) either by the Department in Intermediate Work Zone Traffic Control, or by the ATSSA, the Engineer will suspend all work on the project until the Work is appropriately supervised in accordance with the requirements herein.

2. The Contractor shall have at least one person on site who is, at a minimum, verified in Basic Work Zone Traffic Control by the Department for each construction and/or maintenance operation that involves installing, maintaining, or removing work zone traffic control devices. This person shall be responsible for the placement, maintenance, and removal of work zone traffic control devices.

   In the event none of the Contractor's on-site personnel for any construction and/or maintenance operation have, at a minimum, the required verification in Basic Work Zone Traffic Control, the Engineer will suspend that construction/maintenance operation until that operation is appropriately staffed in accordance with the requirements herein.

3. **Flagging Traffic:** Certified flaggers shall be provided in sufficient number and locations as necessary for control and protection of vehicular and pedestrian traffic in accordance with the VWAPM. Flaggers shall be able to communicate to the traveling public in English while performing the job duty as a flagger at the flagger station. Flaggers shall use sign paddles to regulate traffic in accordance with the VWAPM.

   Certification for flaggers will be awarded upon a candidate's satisfactory completion of an examination. Certification cards shall be carried by flaggers while performing flagging duties. Flaggers found not to be in possession of their certification card shall be removed from the flagging site and operations requiring flagging will be suspended by the En-

gineer until a certified flagger is on-site to perform flagging duties in accordance with the requirements herein. Further, flaggers performing duties improperly will have their certifications revoked.

(b) **Maintenance of Traffic**

1. The Contractor shall prosecute the Work so as to avoid obstructions to traffic to the greatest extent practicable. The Contractor shall provide for the safety and convenience of the general public and residents along the roadway, and for the protection of persons and property.

   Highways closed to traffic shall be protected by barricades and other warning devices as required by the Contract, the VWAPM, and the MUTCD. Barricades and warning devices shall be illuminated where required during periods of darkness and low visibility. The Contractor shall erect warning devices in advance of a location on the project where operations or obstructions may interfere with the use of the road by traffic and at all intermediate points where the new work crosses or coincides with an existing roadway. The Contractor shall maintain sign faces and reflective surfaces of warning devices in a clean and visible condition. The Contractor shall cover or remove signs when the messages thereon are not applicable. Barricades, warning signs, lights, temporary signals, and other protective devices shall conform to Section 512.

2. The road shall be kept open to all traffic while undergoing improvements, unless otherwise permitted in the Contract. The Contractor shall keep the portion of the project being used by public, pedestrian, and vehicular traffic in such condition that all such traffic will be safely and adequately accommodated. However, removal of snow and control of ice on roads open to public travel will be performed by the Department.

   The Contractor shall keep the portions of the road being used by the public free from irregularities and obstructions that could present a hazard or annoyance to traffic. When directed by the Engineer, allaying of dust shall be performed and paid for in accordance with Section 511. Holes in hard surface pavements shall be filled with approved asphalt patching material. Where such work is not specified in the Contract and determined to be required by the Engineer, and not the result of any failure or fault of the Contractor and due to causes beyond the Contractor's control, the cost to remedy such hazards will be handled according to 109.05.

   If any damage is sustained by an accepted unit or portion of the project attributable to causes beyond the control of the Contractor, the Engineer may authorize the Contractor to make the necessary repairs. These repairs will be paid for at the Contract price for the items requiring repair. In the absence of Contract prices covering the items of repair, the repair work will be paid for in accordance with Section 109.05.

3. **Detours:** Detours may be indicated on the plans or in the special provisions or may be used with the Engineer's approval. Unless otherwise designated in the Contract, the Contractor shall furnish, install and maintain all directional markings, for through-traffic on off-project detours authorized or requested by the Engineer with the exception of municipalities. Municipalities shall be responsible for off-project roadway maintenance within their own corporate limits. Detours over existing state roads shall be designated, marked, and maintained by the Contractor. Directional markings for detours shall include signs. Responsibility for installation and maintenance of the signs shall be in accordance with

Section 512.03(a). If any project is located wholly or in part within a municipality's corporate limits and through traffic is to be detoured at the municipality's request, the municipality will provide and maintain the detours within the corporate limits and will furnish, install and maintain all directional markings. The provision of detours and marking of alternate routes will not relieve the Contractor of the responsibility for ensuring the safety of the public or from complying with any Contract requirements affecting the rights of the public within his Contract area of operations, including those concerning lights and barricades. Maintenance of all other detours shall be the Contractor's responsibility.

The Department will furnish the right of way for temporary highways, vehicular watercourse crossings, diversion channels, sediment and erosion control features or bridges required by the Contract.

4. **Maintenance of Traffic During Suspension of Work:** During any suspension of work, the Contractor shall temporarily open to traffic such portions of the project and temporary roadways as may be agreed upon by the Contractor and Engineer.

5. **Minimizing Traffic Delays:** Two-way traffic shall be maintained at all times unless the Contract or the Engineer permits one-way traffic. The Contractor shall not stop traffic without the Engineer's permission.

   If one-way traffic is permitted, the Contractor shall provide certified flaggers to direct the traffic. When specified in the Contract as a pay item, pilot vehicles shall be furnished in accordance with Section 512. Upon the Contractor's request and where deemed appropriate by the Department, the Department will install traffic signals that may be used for the control of one-way traffic. The Contractor shall pay the costs of installation, electrical service, maintenance or repair work, and a predetermined rental charge per day for the signals and removal when no longer needed.

6. **Connections and Entrances:** Connections with other roads and public and private entrances shall be kept in a reasonably smooth condition at all times.

   Stabilization or surfacing material shall be applied to connections and entrances. When specified in the Contract, such material will be paid for at the Contract unit price for the specific material. Where such material is not specified in the Contract and determined to be required by the Engineer, the cost for stabilization or surfacing material will be handled in accordance with Section 109.05.

   The Contractor shall schedule construction operations so that approved continuous access is provided for all property adjacent to the construction when the property is shown on the plans to require access. When frontage roads are shown on the plans, they shall be constructed prior to the closing of any access routes unless other approved access is provided and is acceptable to the property owner.

   The Contractor shall not disturb connections or entrances until necessary. Once disturbed, the Contractor shall maintain and complete connections or entrances as follows:

   a. **Connections:** Connections that had an original paved surface shall be brought to a grade that will smoothly and safely accommodate vehicular traffic through the intersection, using temporary pavement as soon as practicable after connections are disturbed. Connections that had an original unpaved surface shall be brought to a grade

that will smoothly and safely accommodate vehicular traffic through the intersection, using either the required material or a temporary aggregate stabilization course that shall be placed as soon as practicable after connections are disturbed.

If there are delays in prosecution of work for connections, connections that were originally paved shall have at least two lanes maintained with a temporary paved surface. Those that were not originally paved shall be maintained with a temporary aggregate stabilization course.

b. **Entrances:** Entrances shall be graded concurrently with the roadway with which they intersect. Once an entrance has been disturbed, it shall be completed as soon as is practicable, including placing the required base and surface course or stabilization. If the entrance must be constructed in stages, such as when there is a substantial change in the elevation of the roadway with which it intersects, the surface shall be covered with a temporary aggregate stabilization course or other suitable salvaged material until the entrance can be completed and the required base and surface or stabilization course can be placed.

7. **Obstruction Crossing Roadways:** Where the Contractor places obstructions such as suction or discharge pipes, pump hoses, steel plates, or any other obstruction that must be crossed by vehicular traffic, they shall be bridged as directed by the Engineer at the Contractor's expense. Traffic shall be protected by the display of warning devices both day and night. If operations or obstructions placed by the Contractor damage an existing traveled roadway, the Contractor shall cease operations and repair damages to the roadway at no additional cost to the Department.

8. **Patching Operations:** Where existing hydraulic cement concrete pavement is to be patched, the operation of breaking and excavating old pavement shall extend for a distance of not more than two miles. Patching shall be coordinated with excavating so that an area of not more than one-half mile in which excavated patches are located shall be left at the end of any day's work. Necessary precautions shall be taken to protect traffic during patching operations.

9. **Temporary Structures:** The Contractor shall construct, maintain, and remove temporary structures and approaches necessary for use by traffic. Unless otherwise specified in the Contract, the cost of these operations shall be included in pay items for the new structure. After new structures have been opened to traffic, temporary structures and approaches shall be removed. The materials contained therein shall remain the property of the Contractor.

   The proposed design of temporary structures shall be submitted to the Engineer prior to the beginning of construction in accordance with Section 105.10.

10. **Haul Route:** The Contractor shall select haul routes between the project and material source(s) that will minimize disturbance to the community. The Contractor shall furnish to the Engineer, for review, his plan for the haul route and for minimizing the adverse effects of hauling operations on persons who reside adjacent to the haul route or persons who otherwise use a portion of the haul route for ingress or egress to their residential or work area. The Department may select alternate haul routes, divide the hauling traffic over several routes, and impose other restrictions deemed necessary to minimize the impact of the hauling operation on local residents.

11. **Opening Sections of Projects to Traffic**

Certain sections of the Work may be opened to traffic when specified in the Contract or when directed by the Engineer. Such opening shall not constitute acceptance of the Work or any part thereof or a waiver of any provision of the Contract.

On any section of the Work opened by order of the Engineer where the Contract does not provide for traffic to be carried through the Work, the Contractor will not be required to assume any expense entailed in maintaining the road for traffic. The Department will pay such expense or will compensate the Contractor in accordance with Section 109.05. Repair of slides and repair of damage attributable to traffic will be compensated for in accordance with Section 109.05. Slides shall be removed by the Contractor in accordance with Section 303.

On any section of the Work opened by order of the Engineer where the Contract does not provide for traffic to be carried through the Work, any additional cost incurred to complete other items of work solely because of the changed working conditions will be compensated according to Section 109.05.

If the Contractor is not continuously prosecuting the Work to the Engineer's satisfaction as determined by the Schedule of Record, the Contractor shall not be relieved of the responsibility for maintenance of the completed work during the period that the section of the Work is opened to traffic prior to final acceptance. The Contractor shall be responsible for any expense resulting from the opening of such portions of the Work under these circumstances, except for slides. The Contractor shall conduct the remainder of the construction operations so as to cause the least obstruction to traffic.

(c) Maintenance of Work

1. The Contractor shall maintain the Work, the project site, construction area and roadway from the beginning of construction operations until final acceptance with adequate equipment and forces to keep the roadway and structures in a safe and satisfactory condition at all times and to ensure the continuous and effective day by day prosecution of the Work. VDOT will perform maintenance of items outside of the scope of work of the Contract. As determined by the Engineer, where maintenance is necessary within the project limits but does not affect Contract work, and not the result of any failure or fault of the Contractor and due to causes beyond the Contractor's control, the cost to perform such maintenance will be handled according to Section 109.05.

   If any damage is sustained by an accepted unit or portion of the project attributable to causes beyond the control of the Contractor, the Engineer may authorize the Contractor to make the necessary repairs. These repairs will be paid for at the Contract price for the items requiring repair. In the absence of Contract prices covering the items of repair, the repair work will be paid for in accordance with Section 109.05.

2. Where the Contract specifies placing a course on another course or subgrade of embankment, base, subgrade, concrete, asphalt pavement, or other courses previously constructed, the Contractor shall maintain the courses or subgrades previously constructed in accordance with the Contract requirements when placing such course. This maintenance includes, but is not limited to draining, re-compacting, re-grading, or, if unacceptable or destroyed, the removal of work the Department previously accepted.

3. **Grading Operations:** When the Contractor elects to complete the rough grading operations for the entire project or exceed the length of one full day's surfacing operations, the rough grade shall be machined to a uniform slope from the top edge of the existing pavement to the ditch line.

   When the surface is to be widened on both sides of the existing pavement, construction operations involving grading or paving shall not be conducted simultaneously on sections directly opposite each other.

   The surface of pavement shall be kept free from soil and other materials that might be hazardous to traffic. Prior to opening of new pavement to traffic, shoulders shall be roughly dressed for a distance of 3 feet from the edge of the paved surface.

(d) **Maintenance Cost**

The Contractor shall bear all costs of performing maintenance work before final acceptance, and of constructing and maintaining necessary approaches, crossings, intersections, and other features without direct compensation except as provided for herein. When the Contractor confines his operation to the surface of the roadway and reasonable width of the shoulder and the surface is disturbed or damaged by his operations or equipment, he shall be responsible for the restoration and maintenance of the surface that is disturbed or damaged.

(e) **Failure to Maintain Roadway or Structures:** If the Contractor fails to remedy unsatisfactory maintenance immediately after receipt of a notice by the Engineer, the Engineer may proceed with adequate forces, equipment, and material to maintain the project. The cost of the maintenance, plus 25 percent for supervisory and administrative personnel, will be deducted from monies due the Contractor for the project.

105.15—Removing and Disposing of Structures and Obstructions

The Contractor shall remove and dispose of or store, as directed by the Engineer, fences, buildings, structures, or encumbrances within the construction limits unless separate pay items for this work are included in the Contract. Payment for these operations will be in accordance with Section 301.03. Materials so removed, including existing drains or pipe culverts, shall become the property of the Contractor, with the exception of those materials to be stored or delivered to the Department or others as designated in the Contract.

(a) **Signs:** The Contractor shall relocate all signs within the construction limits that conflict with construction work as approved by the Engineer. Signs that are not needed for the safe and orderly control of traffic during construction as determined by the Engineer shall be removed and stored at a designated location within the project limits. The removed signs shall be stored above ground in a manner that will preclude damage and shall be reinstalled in their permanent locations prior to final acceptance. If any of the removed signs are not to be reinstalled, the Contractor shall notify the Engineer at the time the signs have been properly stored. Such signs will be removed from the storage area by the Department. Any sign that is damaged or lost because of the fault of the Contractor shall be repaired or replaced at his expense. Costs for removing, storing, protecting, and reinstalling such signs shall be included in the price bid for other items in the Contract, and no additional compensation will be made.

(b) **Mailboxes and Newspaper Boxes:** When removal of existing mailboxes and newspaper boxes is made necessary by construction operations, the Contractor shall place them in temporary

locations so that access to them will not be impaired. Prior to final acceptance, boxes shall be placed in their permanent locations as designated by the Engineer and left in the same condition as when found. Boxes or their supports that are damaged through negligence on the part of the Contractor shall be replaced at his expense. The cost of removing and resetting existing boxes shall be included in other pay Contract items. New mailboxes designated in the plans shall be paid for in accordance with Section 521.

105.16—Cleanup

Removal from the project of rubbish, scrap material, and debris caused by the Contractor's personnel or construction operations shall be a continuing process throughout the course of the Work. The work site shall be kept in a neat, safe and orderly condition at all times.

Before final acceptance, the highway, borrow pits, quarries, disposal areas, storage areas, and all ground occupied by the Contractor in connection with the Work shall be cleaned of rubbish, surplus materials, and temporary structures, except where the Contractor owns or controls the property. All parts of the Work shall be left in a neat, safe and orderly condition.

Within 30 days after final acceptance, the Contractor shall remove his equipment, materials and debris from the right of way and from property adjacent to the project that he does not own or control.

105.17—Inspection of Work

Inspection will be performed at critical stages. However, all stages, materials, and details of the Work are subject to inspection. The Contractor shall provide the Engineer and Inspectors full and safe access to all parts of the Work. The Contractor shall furnish the Engineer and Inspectors such information and assistance as required to make complete, timely and detailed inspections. The Engineer, Inspectors and their appointed representatives shall have ready access to machines, plants and plant equipment used in processing or placing materials.

Prior to the beginning of operations, the Engineer will meet with the Contractor to establish an understanding of the critical stages of work that shall be performed in the presence of the Inspector. In order for the Department to schedule inspection of the critical stages of work, the Contractor shall keep the Engineer informed of planned operations in accordance with Section 108.03. The Contractor shall advise the Engineer at least 24 hours in advance of any changes in the Contractor's planned operations or critical stage work requiring Department inspection.

If the Engineer requests it, the Contractor shall remove or uncover such portions of the finished work as may be directed at any time before final acceptance. The Contractor shall restore such portions of the finished work to comply with the appropriate Contract specification requirements. If the work exposed is acceptable, the uncovering or removing and replacing the covering or making good the parts removed will be paid for as extra work in accordance with Section 104.02. If the work is unacceptable, the cost of uncovering or removing and replacing the covering or making good the parts removed shall be borne by the Contractor.

When any unit of government, political subdivision, or public or private corporation is to pay a portion of the cost of work specified in the Contract, its representatives shall have the right to inspect such work. The exercise of this right shall not be construed as making them a party or parties to the Contract or conferring on them the right to issue instructions or orders to the Contractor.

If materials are used or work is performed without inspection by an authorized representative of the Department, the Contractor may be ordered to remove and replace such work or material at his own expense unless the Department's representative failed to inspect the work or material after having been given reasonable notice in writing that the material was to be used or the work was to be performed.

If an inspection reveals that work has not been properly performed, or materials used are unacceptable, the Contractor will be so advised and he shall immediately inform the Department of his schedule for correcting such work and materials, and the time when a reinspection can be made.

105.18—Removal of Unacceptable and Unauthorized Work

Work that does not conform to the Contract requirements, whether the result of unacceptable workmanship, use of unacceptable materials, damage through carelessness, or any other cause within the Contractor's control, will be considered unacceptable work.

Unacceptable work shall be remedied or removed as determined by the Engineer and replaced in an acceptable manner at the Contractor's expense. The Engineer may accept the unacceptable work at a reduced price when acceptance is considered to be in the best interest of the public.

Work that is done contrary to the instructions of the Engineer, contrary to the requirements of the Contract, beyond the lines shown on the plans or as designated by the Engineer except as specified herein, or without authority will be considered unauthorized and will not be paid for. The Engineer may order the Contractor to remove or replace unauthorized work at the Contractor's expense.

The Contractor shall not perform destructive sampling or testing of the work without written authorization of the Engineer. Unauthorized destructive sampling or testing will cause the work to be considered unacceptable.

In the event the Contractor is granted authorization to perform destructive sampling or testing, the Contractor shall obtain the approval of the Engineer for the method and location of each test prior to beginning such sampling or testing. In addition, destructive sampling and testing shall be performed in the presence of the Engineer.

If the Contractor fails to comply immediately with any order of the Engineer made under this Section, the Engineer will have the authority to cause unacceptable or unauthorized work to be removed and replaced and to deduct the cost of such removal and replacement, plus 25 percent for supervisory and administrative personnel, from any monies due or to become due the Contractor.

105.19—Submission and Disposition of Claims

(a) **Notice of Intent to File a Claim**

Early or prior knowledge by the Department of an existing or impending claim for damages could alter the plans, scheduling, or other Department action or result in mitigation or elimination of the basis for the claim. Therefore, the Contractor shall submit a written statement describing the act of omission or commission by the Department or its agents that allegedly caused damage to the Contractor and the nature of the claimed damage to the Engineer at the time of each and every occurrence that the Contractor believes to be the basis of a claim or prior to the beginning of the work upon which a claim and any subsequent action will be based. "Occur-

rence" includes, but is not limited to the Engineer's denial of the Contractor's timely request for time extension, additional compensation, change order, adjustment, or other request under the Contract, or any other decision, instruction, directive, or order that the Contractor believes will result in a claim. The written statement shall clearly state that it is a "notice of intent to file a claim." If such damage is deemed certain in the opinion of the Contractor to result from his acting on an order from the Engineer, he shall immediately take written exception to the order. Submission of a notice of intent to file a claim as specified shall be mandatory. Failure to submit such notice of intent shall be a conclusive waiver to such claim for damages by the Contractor. An oral notice or statement will not be sufficient nor will a notice or statement after the event. Oral statements recorded in meeting minutes also will not be sufficient.

In addition, at the time of each and every occurrence that the Contractor believes to be the basis of a claim or prior to beginning the work upon which a claim and any subsequent action will be based, the Contractor shall furnish the Engineer an itemized list of materials, equipment, and labor for which additional compensation will be claimed. The Contractor shall afford the Engineer every facility for keeping an actual cost record of the work. The Contractor and the Engineer shall compare records and bring them into agreement at the end of each day. Failure on the part of the Contractor to afford the Engineer proper facilities for keeping a record of actual costs will constitute a waiver of a claim for such extra compensation except to the extent that it is substantiated by the Department's records. The filing of such notice of intent by the Contractor and the keeping of cost records by the Engineer shall in no way establish the validity of a claim.

(b) **Time for Submittal of Claim**

Upon completion or termination of the Contract, the Contractor may, within 60 days after the final estimate date established by the Department pursuant to Code of Virginia § 33.2-1101, deliver to the Department a certified written claim, which must be a signed original claim document, along with an electronic copy of the claim document as a Portable Document Format (PDF) file, for the amount he deems he is entitled to under the Contract. For the purpose of this Section, the final estimate date shall be that date set forth in a letter from the Department to the Contractor sent by certified mail and shall be considered as the date of notification of the Department's final estimate. Regardless of the manner of delivery of the claim, the State Construction Engineer must receive and have physical possession of the Contractor's written claim within the 60 day period that commences with the final estimate date. Submittals received by the Department either before the final estimate date or after the 60 day period shall not have standing as a claim.

(c) **Content of Claim**

The Contractor's certified written claim shall set forth in detail the facts upon which the claim

3. Identification of the provisions of the Contract that the Department allegedly breached, and the acts or omissions constituting such breach.

4. A detailed statement of the amount of the actual cost for materials, labor and equipment sought in the claim.

5. A copy of the notice(s) of intent to file a claim that the Contractor submitted to the Department for the claim(s).

(d) **Certification of Claim.**

The Contractor shall submit with the claim a written certification of the claim in the following form:

Pursuant to the Code of Virginia, I hereby certify that this Contract claim submission for Virginia Department of Transportation Project No. _____ in _____ County, Virginia, is a true and accurate representation of additional costs, expenses, damages and/or delays incurred by _____ (Contractor) or its subcontractors or suppliers in the performance of the required Contract work. Any statements, representations, writings, or documents, made or used and known to be false, shall be considered a violation of the Virginia Governmental Frauds Act, punishable as allowed by the Code of Virginia for a Class 6 Felony, and shall be considered a violation of the Virginia Fraud Against Taxpayers Act, subject to the civil penalties allowed by the Code of Virginia.

_____(Contractor)

By:_____

As officer or duly appointed agent of _____(Contractor)

Title: _____

Date: _____

State Of: _____

City/County of _____, To-Wit:

I, the undersigned, a Notary Public in and for the City/County and State aforesaid, do hereby certify that _____ , whose name is signed to the foregoing instrument, bearing date of the_____ day of_____, 20__, has this day acknowledged the same before me in my City/County and State aforesaid.

Given under my hand this _____ day of _____ , 20___.

Notary Public: _____

Notary Registration No.: _____

My commission expires: _____

Claims submitted by the Contractor for itself or its subcontractors or suppliers during the statutory period for submitting Contract claims that are submitted without the Contractor's certification described above shall not have standing as a claim and shall not be considered by the Department.

(e) **Review of Claim**

Within 90 days from the receipt of the claim, the Department will make an investigation and notify the Contractor by certified mail of its decision. However, by mutual agreement, the Department and Contractor may extend the 90-day period for another 30 days.

If the Contractor is dissatisfied with the Department's decision, within 30 days from receipt of the decision the Contractor shall notify the Commissioner in writing that it desires to appear before the Commissioner, whether in person or through counsel, and present additional facts and arguments in support of its claim. The Commissioner will schedule and meet with the Contractor within 30 days after receiving the request. However, the Commissioner and Contractor, by mutual agreement, may schedule the meeting to be held after 30 days but before the 60th day from the receipt of the Contractor's written request. Within 45 days from the date of the meeting, the Commissioner will investigate the claim, including the additional facts presented, and notify the Contractor in writing of his decision. However, the Commissioner and Contractor, by mutual agreement, may extend the 45-day period for another 30 days. If the Commissioner deems that all or any portion of a claim is valid, he shall have the authority to negotiate a settlement with the Contractor subject to any approvals required by the Code of Virginia.

Any monies that become payable as the result of claim settlement after payment of the final estimate will not be subject to payment of interest unless such payment is specified as a condition of the claim settlement.

(f) **Compensation for Claims**

The Engineer will determine time extension according to 108.04 and compensation according to 109.05 if the Department concludes that the Contractor has established entitlement to compensation or a time extension for the claim.

SECTION 106—CONTROL OF MATERIAL

106.01—Source of Supply and Quality Requirements

The materials used throughout the Work shall conform to the requirements of the Contract. The Contractor shall regulate his supplies so that there will be a sufficient quantity of tested material on hand at all times to prevent any delay of work. Except as otherwise specified, materials, equipment, and components that are to be incorporated into the finished Work shall be new and fit for their intended purpose. Within 30 days after notification of award of the Contract, but not later than 7 days prior to the beginning of construction operations under the Contract, the Contractor shall submit a statement of the known origin, composition and manufacture of all materials to be used in the work, including optional or alternate items. Material requirements not previously reported shall be submitted at least 60 days prior to their use on the project, but not less than 2 weeks prior to delivery. The Contractor's statement shall be electronically submitted by use of Form C-25 and shall be identified by the complete project number, and all items

or component materials shall be identified by the specific Contract item number and the Specification reference shown in the Contract.

At the option of the Engineer, materials may be approved at the source of supply. If it is found during the life of the Contract that previously approved sources of supply do not supply materials or equipment conforming to the Contract requirements, do not furnish the valid test data required to document the quality of the material or equipment, or do not furnish documentation to validate quantities to document payment, the Contractor shall change the source of supply and furnish material or equipment from other approved sources. The Contractor shall notify the Department of this change, and provide the same identifying information noted in this Section, at least 60 days prior to their use on the project, but not less than 2 weeks prior to delivery.

Materials shall not contain toxic, hazardous, or regulated solid wastes or be furnished from a source containing toxic, hazardous or regulated solid wastes.

When optional materials are included in the Contract, the Contractor shall advise the Engineer in writing of the specific materials selected. Thereafter, the Contractor shall use the selected materials throughout the project unless a change is authorized in writing by the Engineer. However, when the Contractor has an option as to the type of pipe that may be used, he may use any of the approved types for each size of pipe, but he shall use the same type for a particular line. The Engineer may authorize other types and sources in an emergency that will not unreasonably delay delivery of the selected material.

Equipment and material guaranties or warranties that are normally given by a manufacturer or supplier, or are otherwise required in the Contract, shall be obtained by the Contractor and assigned to the Commonwealth in writing. The Contractor shall also provide an in-service operation guaranty on all mechanical and electrical equipment and related components for a period of at least 6 months, beginning on the date of partial acceptance of that specific item(s) or final acceptance of the project.

106.02—Material Delivery

The Contractor shall advise the Engineer at least 2 weeks prior to the delivery of any material from a commercial source. Upon delivery of any such material to the project, the Contractor shall provide the Engineer with one copy of all invoices (prices are not required). The following materials shall also comply with Section 109.01: asphalt concrete; dense graded aggregate, to include aggregate base, subbase, and select material; fine aggregate; open graded coarse aggregate; crusher run aggregate; and road stabilization aggregate. The printed weights of each load of these materials, as specified in Section 109.01, shall accompany the delivery, and such information shall be furnished to the Inspector at the project.

106.03—Local Material Sources (Pits and Quarries)

The requirements set forth herein apply exclusively to non-commercial pits and quarries from which materials are obtained for use on contracts awarded by the Department.

(a) Local material sources shall be concealed from view from the completed roadway and any existing public roadway. Concealment shall be accomplished by selectively locating the pit or quarry and spoil pile, providing environmentally compatible screening between the pit or quarry site and the roadway, or using the site for another purpose after removal of the material, or restoration equivalent to the original use (such as farm land, pasture, turf, etc.). The foregoing requirements shall also apply to any pit or quarry opened or reopened by a subcontractor or

supplier. However, the requirements will not apply to commercial sand and gravel and quarry operations actively processing material at the site prior to the date of the Notice of Advertisement.

(b) The Contractor shall furnish the Engineer a statement signed by the property owner in which the property owner agrees to the use of his property as a source of material for the project. Upon completion of the use of the property as a material source, the Contractor shall furnish the Engineer a release signed by the property owner indicating that the property has been satisfactorily restored. The requirements for a signed statement and release will not apply to commercial sources, sources owned by the Contractor, and sources furnished by the Department.

(c) Local material pits and quarries that are not operated under a local or State permit shall not be opened or reopened without authorization by the Engineer. The Contractor shall submit for approval a site plan, including, but not limited to, the following:

1. The location and approximate boundaries of the excavation;

2. Procedures to minimize erosion and siltation;

3. Provision of environmentally compatible screening;

4. Restoration;

5. Cover vegetation;

6. Other use of the pit or quarry after removal of material, including the spoil pile;

7. The drainage pattern on and away from the area of land affected, including the directional flow of water and a certification with appropriate calculations that verify all receiving channels are in compliance with Minimum Standard 19 of the Virginia Erosion and Sediment Control Regulations;

8. Location of haul roads and stabilized construction entrances if construction equipment will enter a paved roadway;

9. Constructed or natural waterways used for discharge;

10. A sequence and schedule to achieve the approved plan; and

11. The total drainage area for temporary sediment traps and basins shall be shown. Sediment traps are required if the runoff from a watershed area of less than three acres flows across a disturbed area. Sediment basins are required if the runoff from a watershed area of three acres or more flows across a disturbed area. The Contractor shall certify that the sediment trap or basin design is in compliance with VDOT Standards and Specifications, and all local, state, and federal laws. Once a sediment trap or basin is constructed, the dam and all outfall areas shall be immediately stabilized.

The Contractor's design and restoration shall be in accordance with the Contract requirements and in accordance with the requirements of the federal, state, and local laws and regulations.

If the approved plan provides for the continued use or other use of the pit or quarry beyond the date of final acceptance, the Contractor shall furnish the Department a bond made payable to the Commonwealth of Virginia in an amount equal to the Engineer's estimate of the cost of performing the restoration work. If the pit or quarry is not used in accordance with the approved plan within eight months after final acceptance, the Contractor shall perform restoration work as directed by the Engineer, forfeit his bond, or furnish the Engineer with evidence that he has complied with the applicable requirements of the State Mining Law.

(d) Topsoil on Department owned or furnished borrow sites shall be stripped and stockpiled as directed by the Engineer for use as needed within the construction limits of the project or in the reclamation of borrow and disposal areas.

(e) If payment is to be made for material measured in its original position, material shall not be removed until Digital Terrain Model (DTM) or cross-sections have been taken. The material shall be reserved exclusively for use on the project until completion of the project or until final DTM or cross-sections have been taken.

(f) If the Contractor fails to provide necessary controls to prevent erosion and siltation, if such efforts are not made in accordance with the approved sequence, or if the efforts are found to be inadequate the Department will withdraw approval for the use of the site and may cause the Contractor to cease all contributing operations and direct his efforts toward corrective action or may perform the work with state forces or other means as determined by the Engineer. If the Contractor does not perform such work, the cost of performing the work, plus 25 percent for supervisory and administrative personnel, will be deducted from monies due or to become due the Contractor.

(g) Costs for applying seed, fertilizer, lime, mulch, and for restoration drainage, erosion and siltation control, regrading haul roads, and screening shall be included in the Contract price for the type of excavation or other appropriate Contract items.

(h) If the Contractor fails to fulfill the provisions of the approved plan for screening or restoring material sources, the Department may withhold and use for the purpose of performing such work any monies due the Contractor at the time of the final estimate. The Contractor shall be liable for penalties, fines, or the Department's costs or damages that result from his failure to prevent erosion or siltation and take restorative action.

(i) After removing all the material needed from the local material sources, the Contractor shall remove metal, lumber, and other debris resulting from his operations and shall shape and landscape the area in accordance with the approved plan for such work.

(j) **Sources Furnished by the Department:** Sources furnished by the Department will be made available to the Contractor together with the right to use such property as may be required for a plant site, stockpiles, and haul roads. The Contractor shall confine his excavation operations to those areas of the property specified in the Contract. The Contractor shall be responsible for excavation that shall be performed in order to furnish the specified material.

(k) **Sources Furnished by the Contractor:** The use of material from sources other than those furnished by the Department will not be permitted until test results have been approved by the Engineer and written authority for its use has been issued by the appropriate agency, organization or individual.

The Contractor shall acquire the necessary rights to take material from sources he locates and shall pay all related costs, including costs that may result from an increase in the length of the haul. Costs of exploring, sampling, testing, and developing such sources shall be borne by the Contractor. The Contractor shall obtain representative samples from at least two borings in parcels of 10 acres or less and at least three additional borings per increment of 5 acres or portion thereof to ensure that lateral changes in material are recorded. Drill logs for each test shall include a soil description and the moisture content at intervals where a soil change is observed or at least every 5 feet of depth for consistent material. Samples obtained from the boring shall be tested by an approved laboratory for grading, Atterberg limits, CBR, maximum density, and optimum moisture. The Department will review and evaluate the material based on test results provided by the Contractor. The Department will reject any material from a previously approved source that fails a visual examination or whose test results show that it does not conform to the Specifications or specific Contract requirements.

106.04—Disposal Areas

The Contractor shall dispose of unsuitable or surplus material shown on the plans according to Contract requirements. The Contractor shall dispose of unsuitable or surplus material off the right of way. The Contractor shall obtain the necessary rights to property to be used as a disposal area.

The Contractor shall handle and dispose of the materials specified in this Section in accordance with the following requirements.

(a) **Disposal Areas**

The Contractor shall dispose of materials not used on the project off the right of way.

If an approved disposal area is not designated in the Contract, the Contractor shall obtain the necessary rights to property to be used as an approved disposal area. If the Contractor, having shown reasonable effort, is unsuccessful in obtaining the necessary rights to property to be used as an approved disposal area, the Department will obtain rights for a disposal area, unless otherwise provided for in the Contract. If not shown in the Contract, compensation will be in accordance with Sections 104.02 and 109.05.

Prior to the Department approving the Contractor's proposed disposal area, the Contractor shall submit a site plan that shall show:

1. The location and approximate boundaries of the disposal area.

2. Procedures to minimize erosion and siltation.

3. Provision of environmentally compatible screening.

4. Restoration.

5. Cover vegetation.

6. Other use of the disposal site.

7. The drainage pattern on and away from the area of land affected, including the directional flow of water and a certification with appropriate calculations that verify all receiving

channels are in compliance with Minimum Standard 19 of the Virginia Erosion and Sediment Control Regulations.

8. Location of haul roads and stabilized construction entrances if construction equipment will enter a paved roadway.

9. Constructed or natural waterways used for discharge.

10. A sequence and schedule to achieve the approved plan.

11. The total drainage area for temporary sediment traps and basins shall be shown. Sediment traps are required if the runoff from a watershed area of less than three acres flows across a disturbed area. Sediment basins are required if the runoff from a watershed area of 3 acres or more flows across a disturbed area. The Contractor shall certify that the sediment trap or basin design is in compliance with VDOT Standards and Specifications, all local, state, and federal laws. Once a sediment trap or basin is constructed, the dam and all outfall areas shall be immediately stabilized.

Disposal areas shall be cleared but need not be grubbed. The clearing work shall not damage grass, shrubs, or vegetation outside the limits of the approved area and haul roads thereto. After the material has been deposited, the area shall be shaped to minimize erosion and siltation of nearby streams and landscaped in accordance with the approved plan for such work or shall be used as approved by the Engineer. The Contractor's design and restoration shall conform to the Contract requirements and federal, state, and local laws and regulations.

If the Contractor fails to provide and maintain necessary controls to prevent erosion and siltation, if such efforts are not made in accordance with the approved sequence, or if the efforts are found to be inadequate, the Department will withdraw approval for the use of the site and may cause the Contractor to cease all contributing operations and direct his efforts toward corrective action, or may perform the work with state forces or other means as determined by the Engineer and deduct the cost of performing the work, plus 25 percent for supervisory and administrative personnel, from monies due or to become due the Contractor.

The Contractor shall furnish the Engineer a statement signed by the property owner in which the owner agrees to the use of his property for the deposit of material from the project. Upon completion of the use of the property as an approved disposal area, the Contractor shall furnish the Engineer a release signed by the property owner indicating that the property has been satisfactorily restored. This requirement will not apply to commercial sources, sources owned by the Contractor, and sources furnished by the Department.

(b) **Materials encountered by the Contractor shall be handled and disposed of as follows:**

1. Unsuitable material for the purpose of this Specification is defined as material having poor bearing capacity, excessive moisture content, extreme plasticity or other characteristics as defined by the Engineer that makes it unacceptable for use in the Work and shall be disposed of at an approved disposal area, landfill licensed to receive such material, or as the Engineer directs in writing.

2. Surplus material as shown on the plans shall be disposed of by flattening slopes, used to fill in ramp gores and medians, or if not needed, disposed of at an approved disposal area, a landfill licensed to receive such material, or as the Engineer directs in writing.

Surplus material stockpile areas on the right of way shall be cleared but need not be grubbed. The clearing work shall not damage grass, shrubs, or vegetation outside the limits of the approved area and the haul roads thereto. Placement of fill material shall not adversely affect existing drainage structures. If necessary, modified existing drainage structures, as approved by the Engineer, shall be paid for in accordance with Section 109.05. Within 7 days after the material has been deposited, the area shall be shaped and stabilized to minimize erosion and siltation.

3. Organic materials such as, but not limited to, tree stumps and limbs (not considered merchantable timber), roots, rootmat, leaves, grass cuttings, or other similar materials shall be chipped or shredded and used on the project as mulch, given away, sold as firewood or mulch, burned at the Contractor's option if permitted by local ordinance, or disposed of at a facility licensed to receive such materials. Organic material shall not be buried in state rights-of-way or in an approved disposal area.

4. Inorganic materials such as brick, cinder block, broken concrete without exposed reinforcing steel, or other such material may be used in accordance with Section 303.04 or shall be disposed of at an approved disposal area or landfill licensed to receive such materials. If disposed of in an approved disposal area, the material shall have enough cover to promote soil stabilization in accordance with Section 303 and shall be restored in accordance with other provisions of this Section.

   Concrete without exposed reinforcing steel, may be crushed and used as rock in accordance with Section 303. If approved by the Engineer, these materials may be blended with soils that meet AASHTO M57 requirements and deposited in fill areas within the right of way in accordance with the requirements of Section 303 as applicable.

5. Excavated rock in excess of that used within the project site in accordance with Section 303 shall be treated as surplus material.

6. Other materials such as, but not limited to, antifreeze, asphalt (liquid), building forms, concrete with reinforcing steel exposed, curing compound, fuel, hazardous materials, lubricants, metal, metal pipe, oil, paint, wood or metal from building demolition, or similar materials shall not be disposed of at an approved disposal area but shall be disposed of at a landfill licensed to receive such material.

7. Coal or other valuable materials uncovered during prosecution of the Work that are not specifically addressed by the Contract shall be disposed of as the Engineer directs in writing.

106.05—Rights For and Use of Materials Found on Project

With the approval of the Engineer, the Contractor may use in the project any materials found in the excavation that comply with the requirements of the Specifications. Unless otherwise specified, the Contractor will be paid for both the excavation of such materials at the Contract unit price and for the Contract item for which the excavated material is used. However, the Contractor shall replace at his own expense with other acceptable material the excavation material removed and used that is needed for use in embankments, backfills, approaches, or otherwise. The Contractor shall not excavate or remove any material from within the construction limits that is not within the grading limits, indicated by the typical section, slope and grade lines shown in the plans without written authorization by the Engineer. The Contractor

shall not own and shall not have the right to sell, trade or exchange, any coal or other valuable materials uncovered during the prosecution of the work without the Engineer's specific written authorization.

106.06—Samples, Tests, and Cited Specifications

Materials will be inspected and tested by the Engineer before or during their incorporation in the Work. However, the inspection and testing of such material shall not relieve the Contractor of the responsibility for furnishing material that conforms to the Specifications. The Department may retest all materials that have been accepted at the source of supply after delivery and will reject those that do not conform to the requirements of the Specifications. Stored material may be re-inspected prior to use. Work in which untested materials are used without the written permission of the Engineer may be considered unacceptable.

Unless reference is made to a specific dated Specification, references in these Specifications to AASHTO, ASTM, VTM, and other standard test methods and materials requirements shall refer to either the test specifications that have been formally adopted or the latest interim or tentative specifications that have been published by the appropriate committee of such organizations as of the date of the Notice of Advertisement. Unless otherwise indicated, tests for compliance with specification requirements will be made by and at the Department's expense except that the cost of retests, exclusive of the first retest, shall be borne by the Contractor. Samples shall be furnished by the Contractor at his expense, and those that are not tested by the Contractor will be tested by a representative of the Department.

The inspection cost of structural steel items fabricated in a country other than the continental United States shall be borne by the Contractor. Inspection of structural fabrication shall be performed in accordance with the requirements of the appropriate VTM by a commercial laboratory approved by the Department. Additional cleaning or repair necessary because of environmental conditions in transit shall be at the Contractor's expense.

In lieu of testing, the Engineer may approve the use of materials based on the receipt of the manufacturer's certification furnished by the Contractor. However, furnishing the certificate shall not relieve the Contractor of the responsibility for furnishing materials that conform to the Specifications or the Contract requirements.

Materials requiring an MSDS will not be accepted at the project site for sampling or at the Department's laboratories for testing without the document.

106.07—Plant Inspection

If the Engineer inspects materials at the source, the following conditions shall be met:

(a) The Engineer shall have the cooperation and assistance of the Contractor and producer of the materials.

(b) The Engineer shall have full access to parts of the plant that concern the manufacture or production of the materials being furnished.

(c) For materials accepted under a quality assurance plan, the Contractor or producer shall furnish equipment and maintain a plant laboratory at locations approved for plant processing of materials. The Contractor or producer shall use the laboratory and equipment to perform quality control testing.

The laboratory shall be of weatherproof construction, tightly floored and roofed, and shall have adequate lighting, heating, running water, ventilation, and electrical service. The ambient temperature shall be maintained between 68 degrees F and 86 degrees F and thermostatically controlled. The laboratory shall be equipped with a telephone, intercom, or other electronic communication system connecting the laboratory and scale house if the facilities are not in close proximity to each other. The laboratory shall be constructed in accordance with the requirements of local building codes.

The Contractor or producer shall furnish, install, maintain, and replace, as conditions necessitate, testing equipment specified by the appropriate ASTM, AASHTO method or VTM being used and provide necessary office equipment and supplies to facilitate keeping records and generating test reports. The Contractor or producer's technician shall maintain current copies of test procedures performed in the laboratory. The Contractor shall calibrate or verify all balances, scales and weights associated with testing performed as specified in AASHTO R18. The Contractor or producer shall also provide and maintain an approved test stand for accessing truck beds for the purpose of sampling and inspection. The Department may approve a single laboratory to service more than one plant belonging to the same Contractor or producer.

For crushed glass, the plant equipment requirements are waived in lieu of an independent third-party evaluation and certification of crushed glass properties by an AASHTO Materials Reference Laboratory (AMRL)-accredited commercial soil testing laboratory demonstrating that the supplied material conforms to Section 203. Random triplicate samples will be evaluated and analyzed for every 1,000 tons of material supplied to the project. The averaged results will be used for evaluation purposes. Suppliers of crushed glass shall maintain third party certification records for a period of 3 years.

106.08—Storing Materials

Materials shall be stored in a manner so as to ensure the preservation of their quality and fitness for the Work. When considered necessary by the Engineer, materials shall be stored in weatherproof buildings on wooden platforms or other hard, clean surfaces that will keep the material off the ground. Materials shall be covered when directed by the Engineer. Stored material shall be located so as to facilitate their prompt inspection. Approved portions of the right of way may be used for storage of material and equipment and for plant operations. However, equipment and materials shall not be stored within the clear zone of the travel lanes open to traffic.

The Contractor shall provide additional required storage space at his expense. Private property shall not be used for storage purposes without the written permission of the owner or lessee. The Contractor shall furnish copies of the owner's written permission to the Engineer. Upon completion of the use of the property, the Contractor shall furnish the Engineer a release signed by the property owner indicating that the property has been satisfactorily restored.

Chemicals, fuels, lubricants, bitumens, paints, raw sewage, and other harmful materials as determined by the Engineer and the VPDES *General Permit for Discharge of Stormwater from Construction Activities* shall not be stored within any floodplain unless no other location is available and only then shall the material be stored in a secondary containment structure(s) with an impervious liner. Also, any storage of these materials in proximity to natural or man-made drainage conveyances or otherwise where the materials could potentially reach a waterway if released under adverse weather conditions, must be stored in a bermed or diked area or inside a container capable of preventing a release. Double-walled storage

tanks shall meet the berm/dike containment requirement except for storage within flood plains. Any spills, leaks or releases of such materials shall be addressed in accordance with Section 107.16(b) and (e). Accumulated rain water may also be pumped out of the impoundment area into approved dewatering devices. All proposed pollution prevention measures and practices must be identified by the Contractor in his Pollution Prevention Plan as required by the Specifications, other Contract documents and/or the VDPES *General Permit for Discharge of Stormwater from Construction Activities.*

106.09—Handling Materials

Materials shall be handled in a manner that will preserve their quality, integrity and fitness for the Work. Aggregates shall be transported in vehicles constructed to prevent loss or segregation of materials.

106.10—Unacceptable Materials

Materials that do not conform to the Contract requirements shall be considered unacceptable. Such materials, whether in place or not, will be rejected, and shall be removed from the site of the work and replaced at no cost to the Department. If it is not practical for the Contractor to remove rejected material immediately, the Engineer will mark the rejected material for identification. Rejected material whose defects have been corrected shall not be used until the Engineer gives written approval for its use. Upon the Contractor's failure to comply promptly with any order of the Engineer made under this Section, the Engineer may, in addition to other rights and remedies, have the unacceptable material removed and replaced, and deduct the cost of such removal and replacement from monies due or to become due the Contractor.

106.11—Material Furnished by the Department

The Contractor shall furnish all materials required to complete the Work except those specified to be furnished by the Department.

Material furnished by the Department will be delivered or made available to the Contractor at the locations specified in the Contract. The cost of handling and placing materials after delivery to the Contractor shall be included in the Contract price for the Contract item with which they are used.

After receipt of the materials, the Contractor shall be responsible for material delivered to him, including shortages, deficiencies, and damages that occur after delivery, and any demurrage charges.

106.12—Critical Materials

Raw or manufactured materials or supplies that are necessary for the fabrication, construction, installation, or completion of any item of work that is or becomes in extremely short supply regionally or nationally as substantiated by recognized public reports such as news media, trade association journals, or government reports, due to catastrophic events of nature, needs of national defense, or industrial conditions beyond the control of the Department or Contractor, will be declared critical materials by the Department.

When the supply of materials becomes critical, the provisions of this Section will become applicable to the Contract.

When all items of work involving noncritical materials have been completed by the Contractor or have progressed to a point where no further work is practicable prior to receipt of critical materials, a complete suspension of work will be granted by the Department. Requests for partial suspension orders because of delays attributable to non-receipt of critical materials will be considered on the basis of merit in each case.

The Department reserves the right to substitute critical materials or methods by means of a change order.

Contractors, via their manufacturers or suppliers, that request relief due to critical shortage of materials as specified in this Section shall immediately supply information and other supporting data to permit the Department an opportunity to assess possible alternatives or methods to avoid undue delay or expenditure.

SECTION 107— LEGAL RESPONSIBILITIES

107.01—Laws to Be Observed

The Contractor shall keep fully informed of federal, state, and local laws, bylaws, ordinances, orders, decrees, and regulations of governing bodies, courts, and agencies having any jurisdiction or authority that affects those engaged or employed on the Work, the conduct of the Work, or the execution of any documents in connection with the Work. The Contractor shall observe and comply with such laws, ordinances, regulations, orders, or decrees and shall defend, indemnify, and hold harmless the Commonwealth and its agents, officers, or employees from and against any claim for liability, fine, penalty, or cost, including attorney's fees, arising from or based on their violation, whether by himself, his agents, employees, or subcontractors. The Contractor shall execute and file the documents, statements, certifications, and affidavits required under any applicable federal or state law or regulation required by or affecting his bid, or the Contract, or prosecution of the Work thereunder. The Contractor shall permit examination of any records made subject to such examination by any federal or state law or by regulations promulgated thereunder by any state or federal agency charged with enforcement of such law.

107.02—Permits, Certificates, and Licenses

(a) **General**

The Contractor shall conform to the permit conditions as shown in the Contract. Construction methods shall conform to the stipulations of the permit or certification conditions, or both. The Contractor shall assume all obligations and costs incurred as a result of complying with the terms and conditions of the permits and certificates.

If any of the permits listed below are applicable to the project, the Contract will indicate such and the applicable permit stipulations or conditions will be considered a part of the Contract.

1. **Department of the Army, Corps of Engineers Nationwide Permits:** A nationwide permit is issued to the Department by the U.S. Army Corps of Engineers to place fill or dredge material in waters of the United States including wetlands.

2. **The State Program General Permit for Linear Transportation Projects (SPGP- 01 2A & B):** The SPGP-01 2A & B is a permit issued to the Department by the U.S. Army

Corps of Engineers to proceed with linear transportation projects involving work, structures and filling both temporary and permanent, in waters of the United States including wetlands.

3. **Letter of Permission (LOP-1):** The LOP-1 is a regional permit issued to the Department by the U.S. Army Corps of Engineers to proceed with roadway projects involving work, structures and filling, both temporary and permanent, in waters of the United States including wetlands.

4. **Virginia Marine Resources Commission – Virginia General Permit (VGP-1):** A VGP-1 permit is issued to the Department by the Virginia Marine Resources Commission and is required on projects that cross in, on, or over state-owned land which is submerged below low water (channelward of the mean low water line), in tidal areas, including tidal wetlands, or below ordinary high water anywhere in the Commonwealth of Virginia.

5. **Virginia Water Protection Permit (VWPP):** The VWPP is issued to the Department by the Virginia Department of Environmental Quality, Water Division and is required for activities that result in a discharge to surface waters and wetlands. The VWPP is issued as an individual or general permit.

6. **Virginia Department of Environmental Quality – VPDES General Permit For Discharge of Stormwater From Construction Activities (VPDES Construction Permit):** All construction activities undertaken by or for VDOT involving land disturbances equal to or exceeding one acre must be covered by the VPDES Construction Permit. According to IIM-LD-242 and Section 107.16, VDOT is responsible for securing VPDES Construction Permit coverage for all applicable land disturbing activities performed on VDOT rights of way or easements, including off-site support facilities that are located on VDOT rights of way or easements that directly relate to the construction site activity. The Contractor shall be responsible for securing VPDES Construction Permit coverage for support facilities that are not located on VDOT rights of way or easements.

   The Contractor shall be responsible for all costs to obtain VPDES Construction Permit coverage for all support facilities (both on-site and off-site) not included in the construction plans or Contract for the project. The Department will not be responsible for any inconvenience, delay, or loss experienced by the Contractor as a result of his failure to gain access to any support facility areas at the time contemplated.

7. **Coastal Zone Management (CZM) Consistency Concurrence:** This clearance is issued to the Department by the Virginia Department of Environmental Quality for projects in navigable waters requiring a U.S. Coast Guard bridge permit.

8. **Tennessee Valley Authority (TVA) Permit:** The TVA Section 26a permit is issued to the Department by the Tennessee Valley Authority and is required for construction activities in or along the Tennessee River or its tributaries.

9. **U.S. Coast Guard Bridge Permit:** This permit is required for bridge projects over navigable waters. The Department is responsible for acquiring these permits.

10. **Other Permits, Certificates and Licenses:** Except as otherwise specified herein, the Contractor shall procure all necessary permits, certificates or licenses that have not been obtained by the Department. The Contractor shall pay all charges, fees, and taxes and shall comply with all conditions of the permits, certificates or licenses.

(b) The Contractor shall not stockpile materials (including fill, construction debris, and excavated and woody materials) within the waterway or wetlands. The Contractor shall construct cofferdams, stream channel retaining structures, and all necessary dikes using non-erodible materials or, if specified in the permit(s), faced with coarse non-erodible materials. If faced with non-erodible material, filter cloth shall be placed between the granular fill and riprap in accordance with Sections 204, 245, 303.03, and 414. Temporary structures shall be removed from the waterway with minimal disturbance of the streambed. Discharge of dredge or fill material shall be placed in accordance with the best management practice, project permits, and all applicable laws and regulations. Dredged or fill material shall be removed to an approved, contained, upland location in accordance with Section 106.04. The disposal area will be of sufficient size and capacity to properly contain the dredge material, to allow for adequate dewatering and settling of sediment, and to prevent overtopping. The disposal area shall be stabilized prior to placement of dredge material.

(c) The Contractor's activities shall not substantially disrupt the movement of those species of aquatic life indigenous to the water body including those species that normally migrate through the area. The Contractor, to the maximum extent practicable, shall not permanently restrict or impede the passage of normal or expected high flows or cause the relocation of the water. The Contractor shall avoid and minimize all temporary disturbances to surface waters during construction. The Contractor shall remove any temporary fill in its entirety and return the affected areas to their preexisting elevation conditions within 30 days of completing work, which shall include re-establishing pre-construction contours and planting or seeding with appropriate wetland vegetation according to cover type (emergent, scrub/shrub, or forested). The Contractor shall perform all work activities during low-flow conditions and shall isolate the construction area via the implementation of non-erodible cofferdams, sheet piling, stream diversions, or similar structures.

(d) The Contractor shall accomplish all construction, construction access (e.g., cofferdams, sheet piling, and causeways) and demolition activities associated with this project in a manner that minimizes construction or waste materials from entering surface waters. Access roads and associated bridges or culverts shall be constructed to minimize the adverse effects on surface waters. Access roads constructed above preconstruction contours and elevations in surface waters must be bridged or culverted to maintain surface flows. All utility line work in surface waters shall be performed in a manner that minimizes disturbance, and the area shall be returned to its original contours and restored within 30 days of completing work in the area.

(e) The Contractor shall 1) stockpile excavated material in a manner that prevents reentry into the stream, 2) restore original streambed and streambank contours, 3) revegetate barren areas, and 4) implement strict erosion and sediment control measures throughout the project period.

(f) The Contractor shall provide fill material that is clean and free of contaminants in toxic concentrations or amounts in accordance with all applicable laws and regulations. The Contractor shall comply with all applicable FEMA-approved state or local floodplain management requirements.

(g) The Contractor shall adhere to any time-of-year restriction conditions as required by state and federal permitting agencies. No in-stream work shall be permitted during in-stream time-of-year restriction.

(h) The Contractor shall prohibit wet or uncured concrete from entry into surface waters. The Contractor shall not dispose of excess or waste concrete in surface waters and prevent wash

water from discharging into surface waters. The Contractor shall employ measures to prevent spills of fuels or lubricants into state waters. All pollution prevention measures and practices proposed by the Contractor shall be identified in the Contractor's Pollution Prevention Plan as required by the Specifications, other Contract documents and/or the VPDES *General Permit for Discharge of Stormwater from Construction Activities.*

(i) The Contractor shall not violate the water quality standards as a result of the construction activities. The Contractor shall not alter the physical, chemical, or biological properties of surface waters and wetlands or make them detrimental to the public health, to animal or aquatic life, to the uses of such waters for domestic or industrial consumption, for recreation, or for other uses.

(j) The Contractor shall not proceed with work covered by a permit until the work is released in writing by the Engineer.

(k) If the Department has not released work covered by a U.S. Army Corps of Engineers permit and the Contractor has completed all other work within the limits of the project, the Contractor shall so advise the Engineer in writing. Upon receipt of the notification, the Engineer will evaluate the status of the project and advise the Contractor within 45 days of the portion of the project that is acceptable under Section 108.09. If the Engineer determines that all of the work except that encumbered by the permit application is acceptable under Section 108.09, the Contractor will be notified accordingly. The Department or the Contractor may then elect to continue or terminate the remaining portion of the Contract.

(l) The party electing to terminate the Contract shall so advise the other party in writing after the 45-day period. The terms of Contract termination will be in accordance with Section 108.08. No compensation will be made for delays encountered or for work not performed except for an extension of time as determined in accordance with Section 108.04.

(m) The Contractor shall submit a request to the Engineer in writing if he wants to deviate from the plans or change his proposed method(s) regarding any proposed work located in waterways or wetlands. Such work may require additional environmental permits. If the Engineer determines that the activities are necessary for completion of the work, the Contractor shall furnish the Engineer all necessary information pertaining to the activity. The Contractor shall be responsible for designing and supplying all plans, sketches and notes necessary to acquire any permit modification required for changes in the proposed construction methods. Such information shall be furnished at least 180 days prior to the date the proposed changed activity is to begin. For other than the VPDES *General Permit for Discharge of Stormwater from Construction Activities,* the District Environmental Manager will apply for the necessary permits modifications to the permits obtained by the Department. The Contractor shall not begin the activity until directed to do so by the Engineer. Additional compensation will not be made for delay to the work or change in the Contractor's proposed methods that result from jurisdiction agency review or disapproval of the Contractor's proposed methods.

(n) If additional permits are required to perform dredging for flotation of construction equipment or for other permanent or temporary work as indicated in the Contractor's accepted plan of operation, but have not been obtained by the Department, the Contractor shall furnish the Engineer, at least 75 days prior to the proposed activity, all necessary information pertaining to the proposed activity in order for the Department to apply for the permits. The Contractor shall not begin the proposed activity until the additional permits have been secured and the Engineer has advised the Contractor that the proposed activity may proceed.

(o) The Contractor shall permit representatives of state and federal environmental regulatory agencies to make inspections at any time in order to insure that the activity being performed under authority of the permit(s) is in accordance with the terms and conditions prescribed herein.

107.03—Federal-Aid Provisions

When the U.S. government pays all or any portion of the cost of a project, the Contractor shall comply with the federal laws and rules and regulations made pursuant to such laws applicable to the project. The Work shall be subject to inspection by the appropriate federal agency. Such inspection shall in no sense make the federal government a party of the Contract and will in no way interfere with the rights of either party to the Contract. For Federally-aided projects, the provisions contained in Form FHWA-1273 and other federal provisions incorporated into the Contract must be made a part of, and physically incorporated into all subcontracts so as to be binding in those agreements.

107.04—Furnishing Right of Way

The Department will secure necessary rights of way and easements in advance of construction. The Department will not be responsible for any delay in the acquisition of a right of way other than consideration of an extension of time. The Department will provide notification of known delays in the proposal for work to assist bidders in planning the work and composing their bids. Easements for temporary uses and detours requested by the Contractor and approved by the Department in lieu of a detour within the right of way or easement area shall be acquired by the Contractor without the Department being a party to the agreement.

107.05—Patented Devices, Materials, and Processes

If the Contractor employs any design, device, material, or process covered by a patent or copyright outside the Contract requirements he shall provide for its use by obtaining a legal agreement with the patentee or owner. The Contractor and the surety shall defend, indemnify, and save harmless the Commonwealth, any affected third party, or political subdivision from and against any and all claims, lawsuits, or legal actions for infringement because of such use. The Contractor shall indemnify the Commonwealth for costs, expenses, or damages, including attorneys' fees, resulting from infringement during prosecution or after completion of the Work.

107.06—Personal Liability of Public Officials

In carrying out any of the provisions of these Specifications or in exercising any power or authority granted to them by or within the scope of the Contract, there shall be no liability upon the Board, Commissioner, Engineer, or their authorized representatives, either personally or as officials of the Commonwealth. In all such matters, they act solely as agents and representatives of the Commonwealth.

107.07—No Waiver of Legal Rights

The Department shall not be precluded or estopped by any measurement, estimate, approval, acceptance, or certificate made either before or after final acceptance of the Work, or payment therefor, from showing (1) the true amount and character of the work performed and materials furnished by the Contractor, (2)

that any such measurement, estimate, acceptance, certificate or payment is untrue or incorrectly made, or (3) that the work or materials do not comply with the Contract requirements. The Department shall not be precluded or estopped, notwithstanding any such measurement, estimate, approval, acceptance, certificate, or payment in accordance therewith, from recovering from the Contractor or his surety, or both, such cost or damage as the Department may sustain by reason of the Contractor's failure to comply with the Contract requirements. The Department's acceptance of the whole or any part of the Work, or the Department's payment for the whole or any part of the Work, or the Department's granting of any extension of time, or the Department's taking any possession of any part of the Work, shall not operate as a waiver of any portion of the Contract or of any right or power herein reserved, or of any right to costs or damages. The Department's express written waiver of any breach of the Contract shall not be held to be a waiver of any other or subsequent breach.

107.08—Protecting and Restoring Property and Landscape

The Contractor shall preserve property and improvements along the boundary lines of and adjacent to the Work unless their removal or destruction is specified in the Contract. The Contractor shall use suitable precautions to prevent damage to such property.

When the Contractor finds it necessary to enter on private property, beyond the limits of the construction easement shown on the plans, he shall secure from the owner or lessee a written permit for such entry prior to moving thereon. An executed copy of this permit shall be furnished to the Engineer.

The Contractor shall be responsible for any damage or injury to property during the prosecution of the work resulting from any act, omission, neglect, or misconduct in the Contractor's method of executing the work or attributable to defective work or materials. This responsibility shall not be released until final acceptance of the project and a written release from the owner or lessee of the property is obtained.

When direct or indirect damage is done to property by or on account of any act, omission, neglect, or misconduct in the Contractor's method of executing the Work or in consequence of the non-execution thereof on the part of the Contractor, the Contractor shall restore such property to a condition similar or equal to that existing before such damage was done by repairing, rebuilding, or restoring, as may be directed by the Engineer, or shall make a settlement with the property owner for such property damage. The Contractor shall secure from the owner a written release from any claim against the Department without additional compensation therefor. A copy of this release shall be furnished the Engineer.

107.09—Contractor's Responsibility for Utility Property and Services

At points where the Contractor's operations are on or adjacent to the properties of any utility, including railroads, and damage to which might result in expense, loss, or inconvenience, work shall not commence until arrangements necessary for the protection thereof have been completed.

The Contractor shall cooperate with owners of utilities so that removal and adjustment operations may progress in a timely, responsible, and reasonable manner, duplication of adjustment work may be reduced to a minimum, and services rendered by those parties will not be unnecessarily interrupted.

If any utility service is interrupted as a result of accidental breakage or of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate fully with the authority in the restoration of service. If utility service is interrupted, repair work shall be continuous until service is restored. No work shall be undertaken around fire hydrants until provisions for continued service have

been approved by the local fire authority. When the Contractor's work operations require the disconnection of "in service" fire hydrants, the Contractor shall notify the locality's fire department or communication center at least 24 hours prior to disconnection. In addition, the Contractor shall notify the locality's fire department or communications center no later than 24 hours after reconnection of such hydrants. The Contractor shall be responsible for any damage to utilities that, in the investigation and determination of the Engineer, is found to be attributable to the Contractor's neglect, means or methods of performing the work.

Nothing in this Section shall be construed to be in conflict with Section 107.08.

The Contractor shall comply with all requirements of the Virginia Underground Utility Damage Prevention Act (the Miss Utility law). The Contractor shall not make or begin any excavation or demolition without first notifying the Miss Utility notification center for the area where the project is located. The Contractor shall wait to begin its excavation or demolition until 7:00 a.m. on the third working day following the Contractor's notice to the notification center, unless the underground utilities cannot be marked within that time due to extraordinary circumstances. The Contractor may commence excavation or demolition work only if confirmed through the Ticket Information Exchange (TIE) System, or the Contractor is notified directly, that all applicable utilities have either marked their underground line locations or reported that no lines are present in the work vicinity.

107.10—Restoration of Work Performed by Others

The Department may construct or reconstruct any utility service within the construction limits or grant a permit for the same at any time. The Contractor shall not be entitled to any damages occasioned thereby other than a consideration of an extension of time, unless the Contractor's Work is damaged, altered or impeded by the condition.

When authorized by the Engineer, the Contractor shall allow any person, firm, or corporation to make an opening in the highway within the limits of the project upon presentation of a duly executed permit from the Department or any municipality for sections within its corporate limits. When directed by the Engineer, the Contractor shall satisfactorily repair portions of the work disturbed by the openings. The work for such repairs as authorized and directed by the Engineer will be paid for in accordance with Section 109.05 and shall be subject to the same conditions as the original work performed.

107.11—Use of Explosives

Explosives shall be stored and used in a safe and secure manner in compliance with federal, state, and local laws and ordinances. Prior to prosecuting the Work, the Contractor shall conduct an on-site review of the work involved and develop a plan of operations for performing excavation work. Where feasible, the Contractor shall explore other means of loosening and or reducing the size of the excavation without blasting. When blasting becomes necessary, the Contractor's plan of operations shall include a blasting plan detailing the blasting techniques to be used during excavation operations requiring the use of explosives. Both plans shall be submitted to the Engineer for review prior to commencing blasting operations.

The Contractor shall be responsible for damage resulting from the use of explosives. The Contractor shall notify each property and utility owner having a building, structure, or other installation above or below ground in proximity to the site of the Work of his intention to use explosives. Notice shall be given sufficiently in advance of the start of blasting operations to enable the owners to take steps to protect

their property. The review of the Contractor's plan of operations, blasting plan, and the notification of property owners shall in no way relieve the Contractor of his responsibility for damage resulting from his blasting operations.

107.12—Responsibility for Damage Claims

(a) The Contractor shall defend, indemnify, and save harmless the Commonwealth, the Board, and their respective officers, agents, and employees, and the city, town, county, or other municipality in which the Work is performed and their respective officers, agents, and employees, from and against any suits, actions, or claims for costs, expenses or damages, including attorneys' fees, brought for or on account of any injuries or damages received or sustained by any persons or property resulting from or arising out of the following:

1. the Work performed by the Contractor;

2. by or in consequence of any neglect in safeguarding the Work by the Contractor;

3. through the use of unacceptable materials in the construction or the improvement; or

4. resulting from any act, omission, neglect, or misconduct of the Contractor.

The Commissioner may retain as much of the monies due or to become due the Contractor under and by virtue of his Contract as the Commonwealth considers necessary to ensure that a fund will be available to pay a settlement or judgment of such suits, actions, or claims. If no monies are due, the Contractor's surety and insurers will be held accountable until all such suits, claims and actions have been settled and suitable evidence to that effect has been furnished the Board. Any extension of time granted the Contractor, in which to complete the Contract shall not relieve him or his surety of this responsibility.

(b) It is not intended by any of the provisions of any part of the Contract to establish the public or any member thereof as a third party beneficiary of the Contract, or to authorize anyone not a party to the Contract to enter into a suit for personal injuries or property damage pursuant to the terms or provisions of the Contract.

(c) The Contractor shall comply with all requirements, conditions, and terms of the Contract, including but not limited to, environmental permits, commitments identified in the Contract, and applicable environmental laws and regulations. The Contractor shall not cause damage, except as allowed under the terms of the Contract, or as allowed under applicable permits or laws, to the air, water, soil, or other natural resources, or cause damage to adjacent or off-site property.

When any act, omission, or work performed or neglected by other action of the Contractor occurs, that violates the requirements, conditions, or terms of the Contract, and affects the health, safety, or welfare of the public or natural resources, the Engineer will direct the Contractor to take prompt action to repair, replace, or restore the damage or injury within a time frame established by the Engineer, and to comply with Section 107.01. If the Contractor fails to make such repair, replacement, or restoration within the established time frame, the Engineer will have the damage or injury repaired, replaced, or restored and will deduct the cost of such repair, replacement, or restoration from monies due or to become due the Contractor.

(d) If the Department determines by its own investigation that injury or damage has occurred as a result of an act, omission, or work performed or neglected by the Contractor, the Department may suspend the Contractor from future bidding for a period of time commensurate with the severity of the injury or damage as determined by the Engineer. Injury is defined as harm or impairment to persons, property or natural resources. Damage is defined as the loss or harm resulting from an injury. In addition, the Department may recover either (i) the loss or damage that the Department suffers as a result of such act, omission or other action or (ii) any liquidated damages established in such Contract; plus (iii) reasonable attorney's fees, expert witness fees, staff salaries, incidental and equipment charges associated with any investigation.

Upon the Department's determination that injury or damage has occurred as a result of an act, omission, or work performed or neglected by the Contractor, the Contractor shall be responsible for and shall reimburse the Department for all expenses associated with the injury or damage. Expenses include, but are not limited to: costs for investigating the injury or damage, financial penalties incurred by the Department as a result of the injury or damage, salary and expenses incurred by employees or consultants of the Commonwealth, road user expenses as determined by the Department due to damage or loss of use of the project area, attorneys' fees, and expert witness fees. The Department may deduct the reimbursement of expenses from any payments due or to become due the Contractor.

Upon determination by the Department of willful, flagrant, or repetitious acts, omissions, or work performed or neglected by the Contractor related to injury or damage as provided in this Section, the Contractor shall in addition to reimbursing the Department for all expenses as provided herein, be subject to other appropriate sanctions, as permitted by law, policy, and Specifications, including but not limited to, suspension of work, termination for default, and removal from the bidders' list.

If the Contractor disputes the Department's determination in any respect, the Contractor, may submit a claim in accordance with Section 105.19.

107.13—Labor and Wages

The Contractor shall comply with the provisions and requirements of the workers' compensation law and public statutes that regulate hours of employment on public work.

(a) **Predetermined Minimum Wages:** The provisions of laws requiring the payment of a minimum wage of a predetermined minimum wage scale for the various classes of laborers and mechanics, when such a scale is incorporated in the Contract, shall be expressly made a part of any Contract hereunder. The Contractor and his agents shall promptly comply with all such applicable provisions.

Any classification not listed and subsequently required shall be classified or reclassified in accordance with the wage determination. If other classifications are used, omission of classifications shall not be cause for additional compensation. The Contractor shall be responsible for determining local practices with regard to the application of the various labor classifications.

(b) **Labor Rate Forms:** The Contractor shall complete Form C-28, indicating by classification the total number of employees, excluding executive and administrative employees, employed on the project. The Contractor shall also indicate on the form the compensation rate per hour for each classification. The Contractor shall submit an original and two copies of the form prior to

the due date of the second estimate for payment and for each 90 day period thereafter until the work specified in the Contract has been completed.

If at the time of final acceptance the period since the last labor report is 30 days or more, the Contractor shall furnish an additional labor report as outlined herein prior to payment of the final estimate.

(c) **Job Service Offices:** In advance of the Contract starting date, the Contactor may contact the Job Service Office of the Virginia Employment Commission at the nearest location to secure referral of available qualified workers in all occupational categories. The closest office may be obtained by accessing the VEC website at http://www.vec.virginia.gov and "clicking" on "VEC Local Offices" to access "**VEC Workforce Centers**".

107.14—Equal Employment Opportunity

(a) The Contractor shall comply with the applicable provisions of presidential executive orders and the rules, regulations, and orders of the President's Committee on Equal Employment Opportunity.

(b) The Contractor shall maintain the following records and reports as required by the Contract EEO provisions:

1. Record of all applicants for employment
2. New hires by race, work classification, hourly rate, and date employed
3. Minority and non-minority employees employed in each work classification
4. Changes in work classifications
5. Employees enrolled in approved training programs and the status of each
6. Minority subcontractor or subcontractors with meaningful minority group representation
7. Copies of Form C-57 submitted by subcontractors

(c) If the Contract has a stipulation or requirement for trainees, the Contractor shall submit semi-annual training reports in accordance with the instructions shown on the forms furnished by the Department. If the Contractor fails to submit such reports in accordance with the instructions, his monthly progress estimate for payment may be delayed.

(d) The Contractor shall cooperate with the Department in carrying out EEO obligations and in the Department's review of activities under the Contract. The Contractor shall comply with the specific EEO requirements specified herein and shall include these requirements in every subcontract of $10,000 or more with such modification of language as may be necessary to make them binding on the subcontractor.

(e) **EEO Policy:** The Contractor shall accept as operating policy the following statement:

It is the policy of this Company to assure that applicants are employed and that employees are treated during employment without regard to their race, religion, sex, color, or na-

tional origin. Such action shall include employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship or on the job training.

(f) **EEO Officer:** The Contractor shall designate and make known to the Department an EEO Officer who can effectively administer and promote an active Contractor EEO program and who shall be assigned adequate authority and responsibility to do so.

(g) **Dissemination of Policy:**

1. Members of the Contractor's staff who are authorized to hire, supervise, promote, and discharge employees or recommend such action or are substantially involved in such action shall be made fully aware of and shall implement the Contractor's EEO policy and contractual responsibilities to provide equal employment opportunity in each grade and classification of employment. The following actions shall be taken as a minimum:

   a. Periodic meetings of supervisory and personnel office employees shall be conducted before the start of work and at least once every 6 months thereafter, at which time the Contractor's EEO policy and its implementation shall be reviewed and explained. The meetings shall be conducted by the EEO Officer or another knowledgeable company official.

   b. New supervisory or personnel office employees shall be given a thorough indoctrination by the EEO Officer or another knowledgeable company official covering all major aspects of the Contractor's EEO obligations within 30 days following their reporting for duty with the Contractor.

   c. The EEO Officer or appropriate company official shall instruct employees engaged in the direct recruitment of employees for the project relative to the methods followed by the Contractor in locating and hiring minority group employees.

2. In order to make the Contractor's EEO policy known to all employees, prospective employees, and potential sources of employees such as, but not limited to, schools, employment agencies, labor unions where appropriate, and college placement officers, the Contractor shall take the following actions:

   a. Notices and posters setting forth the Contractor's EEO policy shall be placed in areas readily accessible to employees, applicants for employment, and potential employees.

      The Contractor shall furnish, erect, and maintain at least two bulletin boards having dimensions of at least 48 inches in width and 36 inches in height at locations readily accessible to all personnel concerned with the project. The boards shall be erected immediately upon initiation of the Contract work and shall be maintained until the completion of such work, at which time they shall be removed from the project. Each bulletin board shall be equipped with a removable glass or plastic cover that, when in place, will protect posters from weather or damage. The Contractor shall promptly post official notices on the bulletin boards. The costs for such work shall be included in the price bid for other Contract items.

   b. The Contractor's EEO policy and the procedures to implement such policy shall be brought to the attention of employees by means of meetings, employee handbooks, or other appropriate means.

(h) **Recruitment:**

1. When advertising for employees, the Contractor shall include in all advertisements for employees the notation "An Equal Opportunity Employer" and shall insert all such advertisements in newspapers or other publications having a large circulation among minority groups in the area from which the project work force would normally be derived.

2. Unless precluded by a valid bargaining agreement, the Contractor shall conduct systematic and direct recruitment through public and private employee referral sources likely to yield qualified minority group applicants, including, but not limited to, state employment agencies, schools, colleges, and minority group organizations. The Contractor shall identify sources of potential minority group employees and shall establish procedures with such sources whereby minority group applicants may be referred to him for employment consideration.

3. The Contractor shall encourage his employees to refer minority group applicants for employment by posting appropriate notices or bulletins in areas accessible to all employees. In addition, information and procedures with regard to referring minority group applicants shall be discussed with employees.

(i) **Personnel Actions:** Wages, working conditions, and employee benefits shall be established and administered, and personnel action of any type shall be taken without regard to race, color, religion, sex, or national origin.

1. The Contractor shall conduct periodic inspections of project sites to ensure that working conditions and employee facilities do not indicate discriminatory treatment of personnel.

2. The Contractor shall periodically evaluate the spread of wages paid within each classification to determine whether there is evidence of discriminatory wage practices.

3. The Contractor shall periodically review selected personnel actions in depth to determine whether there is evidence of discrimination. Where evidence is found, the Contractor shall promptly take corrective action. If the review indicates that the discrimination may extend beyond the actions reviewed, corrective action shall include all affected persons.

4. The Contractor shall investigate all complaints of alleged discrimination made to him in connection with obligations under the Contract, attempt to resolve such complaints, and take appropriate corrective action. If the investigation indicates that the discrimination may affect persons other than the complainant, corrective action shall include those persons. Upon completion of each investigation, the Contractor shall inform every complainant of all avenues of appeal.

(j) **Training:**

1. The Contractor shall assist in locating, qualifying, and increasing the skills of minority group and women employees and applicants for employment.

2. Consistent with work force requirements and as permissible under federal and state regulations, the Contractor shall make full use of training programs, i.e., apprenticeship and on the job training programs for the geographical area of Contract performance.

Where feasible, 25 percent of apprentices or trainees in each occupation shall be in their first year of apprenticeship or training.

3. The Contractor shall advise employees and applicants for employment of available training programs and the entrance requirements for each.

4. The Contractor shall periodically review the training and promotion potential of minority group employees and shall encourage eligible employees to apply for such training and promotion.

5. If the Contract provides a pay item for trainees, training shall be in accordance with Section 518.

(k) **Unions:** If the Contractor relies in whole or in part on unions as a source of employees, best efforts shall be made to obtain the cooperation of such unions to increase opportunities for minority groups and women in the unions and to effect referrals by such unions of minority and women employees. Actions by the Contractor, either directly or through his Contractor's Association acting as agent, shall include the following procedures:

1. In cooperation with the unions, best efforts shall be used to develop joint training programs aimed toward qualifying more minority group members and women for membership in the unions and to increase the skills of minority group employees and women so that they may qualify for higher-paying employment.

2. Best efforts shall be used to incorporate an EEO clause into union agreements to the end that unions shall be contractually bound to refer applicants without regard to race, color, religion, sex, or national origin.

3. Information shall be obtained concerning referral practices and policies of the labor union except that to the extent the information is within the exclusive possession of the union. If the labor union refuses to furnish the information to the Contractor, the Contractor shall so certify to the Department and shall set forth what efforts he made to obtain the information.

4. If a union is unable to provide the Contractor with a reasonable flow of minority and women referrals within the time limit set forth in the union agreement, the Contractor shall, through his recruitment procedures, fill the employment vacancies without regard to race, color, religion, sex, or national origin, making full efforts to obtain qualified or qualifiable minority group persons and women. If union referral practice prevents the Contractor from complying with the EEO requirements, the Contractor shall immediately notify the Department.

(l) **Subcontracting:** The Contractor shall use best efforts to use minority group subcontractors or subcontractors with meaningful minority group and female representation among their employees. Contractors shall obtain lists of SWaM and DBE construction firms from the Department. If SWaM and DBE goals are established in the proposal, the Contractor shall comply with Section 107.15.

The Contractor shall use best efforts to ensure subcontractor compliance with his EEO obligations.

(m) **Records and Reports:** The Contractor shall keep such records as are necessary to determine compliance with his EEO obligations. The records shall be designed to indicate the following:

1. the number of minority and nonminority group members and females employed in each work classification on the project.

2. the progress and efforts being made in cooperation with unions to increase employment opportunities for minorities and females if unions are used as a source of the work force.

3. the progress and efforts being made in locating, hiring, training, qualifying, and upgrading minority and female employees.

4. the progress and efforts being made in securing the services of minority group subcontractors or subcontractors with meaningful minority group and female representation among their employees.

Records shall be retained for a period of 3 years following the Completion Date of the Contract work and shall be available at reasonable times and places for inspection by authorized representatives of the Department.

Each month for the first three months after construction begins and every month of July thereafter for the duration of the project, Form C-57 shall be completed to indicate the number of minority, nonminority, and female employees currently engaged in each work classification shown on the form. The completed Form C-57 shall be submitted within 3 weeks after the reporting period. Failure to do so may result in delay of approval of the Contractor's monthly progress estimate for payment.

107.15—Use of Small, Women-Owned, and Minority-Owned Businesses (SWaMS)

It is the policy of the Department that Small, Women-Owned, and Minority-Owned Businesses (SWaMs) shall have the maximum opportunity to participate in the performance of the Contract. The Contractor is encouraged to take necessary and reasonable steps to ensure that SWaMs have the maximum opportunity to compete for and perform work on the Contract, including participation in any subsequent subcontracts. Any SWaMs used by the Contractor, including the Contractor himself, shall perform a commercially useful function, as defined in 7VAC10-21-220.

A SWaM firm shall mean a small business concern (as defined pursuant to the Code of Virginia, Title 2.2 -1401 for the purpose of reporting small, women-owned, and minority-owned business participation in state contracts and purchases pursuant to §§ 2.2-1404 and 2.2-1405. To that end the following terms shall apply:

Small business means a business that is at least 51 percent independently owned and, controlled by one or more individuals who are U.S. citizens or legal resident aliens and together with affiliates, has 250 or fewer employees, or average annual gross receipts of $10 million or less averaged over the previous three years. One or more of the individual owners shall control both the management and daily business operations of the small business.

Women-owned business means a business concern that is at least 51 percent owned by one or more women who are U.S. citizens or legal resident aliens, or in the case of a corporation, partnership, or limited liability company or other entity, at least 51 percent of the equity ownership interest is owned by one or more women who are citizens of the United States or non-citizens who are in full compliance with the

United States immigration law, and both the management and daily business operations are controlled by one or more women who are U.S. citizens or legal resident aliens.

Minority-owned business means a business concern that is at least 51 percent owned by one or more minority individuals or in the case of a corporation, partnership, or limited liability company or other entity, at least 51 percent of the equity ownership interest in the corporation, partnership, or limited liability company or other entity is owned by one or more minority individuals and both the management and daily business operations are controlled by one or more minority individuals.

Minority individual means an individual who is a citizen of the United States or a non-citizen who is in full compliance with United States immigration law and who satisfies one or more of the following definitions:

1. African American means a person having origins in any of the original peoples of Africa and who is regarded as such by the community of which this person claims to be a part.

2. Asian American means a person having origins in any of the original peoples of the Far East, Southeast Asia, the Indian subcontinent, or the Pacific Islands, including but not limited to Japan, China, Vietnam, Samoa, Laos, Cambodia, Taiwan, Northern Mariana, the Philippines, a U.S. territory of the Pacific, India, Pakistan, Bangladesh, or Sri Lanka and who is regarded as such by the community of which this person claims to be a part.

3. Hispanic American means a person having origins in any of the Spanish-speaking peoples of Mexico, South or Central America, or the Caribbean Islands or other Spanish or Portuguese cultures and who is regarded as such by the community of which this person claims to be a part.

4. Native American means a person having origins in any of the original peoples of North America and who is regarded as such by the community of which this person claims to be a part or who is recognized by a tribal organization.

5. a member of another group, or other individual, found to be economically and socially disadvantaged by the Small Business Administration under 8(a) of the Small Business Act as amended (15 U.S.C. 637[a]).

State agency means any authority, board, department, instrumentality, institution, agency, or other unit of state government. “State agency” shall not include any county, city, or town.

A list of Virginia Department of Minority Business Enterprise (DMBE) certified SWaM firms is maintained on the DMBE web site (http://www.dmbe.state.va.us/) under the **SWaM Vendor Directory** link.

SWaM certification entitles firms to participate in VDOT’s SWaM program; however, this certification does not guarantee that the firm will obtain work nor does it attest to the firm’s abilities to perform any particular work.

The Contractor is encouraged to use the services of banks owned or controlled by minorities or females; however, use of such services will not be credited toward participation achievement for the Contract. The Department has on file, and will make available on request, the names and addresses of known minority and female owned banks in the Commonwealth of Virginia.

The Contractor shall designate and make known to the Department a liaison officer who is assigned the responsibility of actively and effectively administering, encouraging and promoting a responsive program for the use of SWaMs.

The performance of the Contract for the purpose of this specification shall be interpreted to include, but not necessarily be limited to, subcontracting; furnishing materials, supplies, and services; and leasing equipment or, where applicable, any combination thereof.

If the Contractor intends to sublet a portion of the work on the project in accordance with Section 105.06, the Contractor is encouraged to seek out and consider SWaMs as potential subcontractors. The Contractor is encouraged to contact SWaMs to solicit their interest, capability, and prices and shall retain on file the proper documentation to substantiate such contacts.

By signing the bid, the bidder certifies to the following:

- That on the work proposed to be sublet and shown on Form C-31 for *Contractors Proposal to Sublet,* the bidder has taken reasonable steps to seek out and consider SWaMs as potential subcontractors.

- That, if awarded the project, any work proposed to be sublet and not shown on the form for *Contractors Proposal to Sublet,* the same reasonable steps certified herein will be taken.

If the Department has determined that specific opportunities for participation by SWaMs are available on a particular Contract and the bidder chooses to claim credit for SWaM participation, the extent of such participation will be shown as a percentage of the Contract amount and will be indicated in the proposal on Form C-61, *SWaM Participation.*

If the bidder is a SWaM that is owned and controlled by a minority female(s), participation achievement may be shown as either minority or female, but not both, as the certification indicates. Further, each bidder shall comply with Section 102.01.

If the apparent low bidder is a currently certified SWaM firm, the SWaM requirements of this provision will not be applicable except for those referring to the reporting of participation achievement.

The following are examples of efforts the Department encourages bidders and Contractors to make in soliciting SWaM participation. Other factors or types of efforts may be relevant in appropriate cases. The Contractor is encouraged to:

(a) attend any pre-solicitation or pre-bid meetings at which SWaMs could be present and\or informed of contracting and subcontracting opportunities;

(b) advertise in general circulation, trade association and minority-focus media concerning the subcontracting opportunities;

(c) provide written notice to a reasonable number of specific SWaMs that their interest in the Contract is being solicited in sufficient time to allow the SWaMs to participate effectively;

(d) follow-up initial solicitations of interest by contacting SWaMs to determine with certainty whether the SWaMs are interested;

(e) select portions of the work to be performed by SWaMs in order to increase the likelihood of obtaining SWaM participation (including, where appropriate, breaking down proposed contract work into economically feasible units to facilitate SWaM participation);

(f) provide interested SWaMs with adequate information about the plans, Specifications, and Contract requirements;

(g) negotiate in good faith with interested SWaMs, not rejecting SWaMs as unqualified without sound reasons based on a thorough investigation of their capabilities;

(h) make efforts to assist interested SWaMs in obtaining bonding, lines of credit, or insurance required by the Department or Contractor;

(i) make efforts to assist interested SWaMs in obtaining necessary equipment, supplies, materials, or other necessary or related assistance or services; and

(j) effectively use the services of available minority, woman and small business community organizations; minority, woman and small business contractors' groups; local, state and federal minority, woman and small business assistance offices; and other organizations that provide assistance in the recruitment and placement of SWaMs.

Any agreement between a bidder and a SWaM whereby the SWaM agrees not to provide quotations for performance of work to other bidders is prohibited.

No later than 14 days after the date stated in the bid proposal, in accordance with Section 102.12, if the apparent low bidder as read at the bid opening, is reporting participation commitment on the Contract, he shall submit by fax to the Department a fully executed Form C-61 showing the name(s) and certification numbers of the currently certified SWAMS who will perform work to be reported as said participation credit.

The signatures on Form C-61 shall be those of the bidder or authorized representatives of the bidder as shown on Forms C-37 and C-38A or as authorized by letter from the bidder.

Any award made by the Board prior to receipt of the information required will be conditional, pending receipt of such information.

The Contractor shall furnish, and require each subcontractor to furnish, on a quarterly basis, information relative to all SWaM involvement on the project. The information shall be indicated on Form C-63, DBE and SWAM Payment Compliance Report or by copies of canceled checks with appropriate identifying notations. If participation achievement is to be fulfilled with a SWaM whose name has not been previously furnished to the Department for the Contract in question, an initial or revised Form C-61, whichever is appropriate, shall be submitted prior to such SWaM beginning the work. Failure to provide the Department the forms by the fifth of the month following each quarterly reporting period may result in delay of the Contractor's estimate for payment.

If a SWaM, through no fault of the Contractor, is unable or unwilling to fulfill his agreement with the Contractor, the Contractor shall immediately notify the Department and provide all relevant facts. If any subcontractor is relieved of the responsibility to perform work under their subcontract, the Contractor is encouraged to take the appropriate steps to obtain a SWaM to perform an equal or greater dollar value of the remaining subcontracted work. The substitute SWaM's name, description of the work, and dollar value of the work shall be submitted to the Department on Form C-61 prior to such SWaM beginning the work, if such work is to be counted for participation achievement.

107.16—Environmental Stipulations

By signing the bid, the bidder shall have stipulated (1) that any facility to be used in the performance of the Contract (unless the Contract is exempt under the Clean Air Act as amended [42 U.S.C. 1857, et seq., as amended by P.L. 91-604], the Federal Water Pollution Control Act as amended [33 U.S.C. 1251

et seq. as amended by P.L. 92-500], and Executive Order 11738 and regulations in implementation thereof [40 C.F.R., Part 15]) is not listed on the EPA's List of Violating Facilities pursuant to 40 C.F.R. 15.20; and (2) that the bidder shall promptly notify Department prior to the award of the Contract if the bidder receives any communication from the Director, Office of Federal Activities, EPA, indicating that a facility to be used for the Contract is under consideration to be listed on the EPA's List of Violating Facilities.

No separate payment will be made for the work or precautions described herein except where provided for as a specific item in the Contract or except where provision has been made for such payment in these Specifications.

Reference is made in various subsections of this section to Tidewater, Virginia. For the purposes of identifying the affected regions assigned to this designation and the requirements therein Tidewater, Virginia is defined as the Counties of Accomack, Arlington, Caroline, Charles City, Chesterfield, Essex, Fairfax, Gloucester, Hanover, Henrico, Isle of Wight, James City, King George, King and Queen, King William, Lancaster, Mathews, Middlesex, New Kent, Northampton, Northumberland, Prince George, Prince William, Richmond, Spotsylvania, Stafford, Surry, Westmoreland and York and the Cities of Alexandria, Chesapeake, Colonial Heights, Fairfax, Falls Church, Fredericksburg, Hampton, Hopewell, Newport News, Norfolk, Petersburg, Poquoson, Portsmouth, Richmond, Suffolk, Virginia Beach and Williamsburg.

(a) **Erosion and Siltation:** The Contractor shall exercise every reasonable precaution, including temporary and permanent soil stabilization measures, throughout the duration of the project to control erosion and prevent siltation of adjacent lands, rivers, streams, wetlands, lakes, and impoundments. Soil stabilization and/or erosion control measures shall be applied to erodible soil or ground materials exposed by any activity associated with construction, including clearing, grubbing, and grading, but not limited to local or on-site sources of materials, stockpiles, disposal areas, and haul roads.

The Contractor shall comply with Sections 301.02 and 303.03. Should the Contractor as a result of negligence or noncompliance, fail to provide soil stabilization in accordance with these specifications, the cost of temporary soil stabilization in accordance with Section 303 shall be at the Contractor's expense. If the delay in stabilizing an exposed area of land is due to circumstances beyond the Contractor's control, the Department will be responsible for the expense.

Temporary measures shall be coordinated with the work to ensure effective and continuous erosion and sediment control. Permanent erosion control measures and drainage facilities shall be installed as the work progresses.

For projects that disturb 10,000 square feet or greater of land or 2,500 square feet or greater in Tidewater, Virginia, the Contractor shall have within the limits of the project during land disturbance activities, an employee certified by the Department in erosion and sediment control who shall inspect erosion and sediment control and pollution prevention practices, devices and measures for proper installation and operation and promptly report their findings to the Inspector. Failure on the part of the Contractor to maintain appropriate erosion and sediment control or pollution prevention devices in a functioning condition may result in the Engineer notifying the Contractor in writing of specific deficiencies. Deficiencies shall be corrected immediately or as otherwise directed by the Engineer. If the Contractor fails to correct or take appropriate actions to correct the specified deficiencies within 24 hours (or as otherwise directed) after receipt of such notification, the Department may do one or more of the following: require the Contractor to suspend work in other areas and concentrate efforts towards correcting the

specified deficiencies, withhold payment of monthly progress estimates, or proceed to correct the specified deficiencies and deduct the entire cost of such work from monies due the Contractor. Failure on the part of the Contractor to maintain a Department certified erosion and sediment control employee within the project limits when land disturbance activities are being performed will result in the Engineer suspending work related to any land disturbance activity until such time as the Contractor is in compliance with this requirement.

(b) **Pollution:**

1. **Water:** The Contractor shall exercise every reasonable precaution throughout the duration of the project to prevent pollution of rivers, streams, and impoundments. Pollutants such as, but not limited to, chemicals, fuels, lubricants, bitumens, raw sewage, paints, sedimentation, and other harmful material shall not be discharged into or alongside rivers, streams, or impoundments or into channels leading to them. The Contractor shall provide the Engineer a contingency plan for reporting and immediate actions to be taken in the event of a dump, discharge, or spill within 8 hours after he has mobilized to the project site.

   Construction discharge water shall be filtered to remove deleterious materials prior to discharge into state waters. Filtering shall be accomplished by the use of a standard dewatering basin or a dewatering bag or other measures approved by the Engineer. Dewatering bags shall conform to Section 245. During specified spawning seasons, discharges and construction activities in spawning areas of state waters shall be restricted so as not to disturb or inhibit aquatic species that are indigenous to the waters. Neither water nor other effluence shall be discharged onto wetlands or breeding or nesting areas of migratory waterfowl. When used extensively in wetlands, heavy equipment shall be placed on mats. Temporary construction fills and mats in wetlands and flood plains shall be constructed of approved non-erodible materials and shall be removed by the Contractor to natural ground when the Engineer so directs.

   If the Contractor dumps, discharges, or spills any oil or chemical that reaches or has the potential to reach a waterway, he shall immediately notify all appropriate jurisdictional state and federal agencies in accordance with Sections 107.01 and 107.16(e) and the VPDES *General Permit For Discharge of Stormwater From Construction Activities* and shall take immediate actions to contain, remove, and properly dispose of the oil or chemical.

   Solids, sludges, or other pollutants removed in the course of the treatment or management of pollutants shall be disposed of in a manner that prevents any pollutant from such materials from entering surface waters in compliance with all applicable state and federal laws and regulations.

   Excavation material shall be disposed of in approved areas above the mean high water mark shown on the plans in a manner that will prevent the return of solid or suspended materials to state waters. If the mark is not shown on the plans, the mean high water mark shall be considered the elevation of the top of stream banks.

   Constructing new bridge(s) and dismantling and removing existing bridge(s) shall be accomplished in a manner that will prevent the dumping or discharge of construction or disposable materials into rivers, streams, or impoundments.

   Construction operations in rivers, streams, or impoundments shall be restricted to those areas where identified on the plans and to those that must be entered for the construction

of structures. Rivers, streams, and impoundments shall be cleared of falsework, piling, debris, or other obstructions placed therein or caused by construction operations. Stabilization of the streambed and banks shall occur immediately upon completion of work or if work is suspended for more than 14 days.

The Contractor shall prevent stream constriction that would reduce stream flows below the minimum, as defined by the State Water Control Board, during construction operations.

If it is necessary to relocate an existing stream or drainage facility temporarily to facilitate construction, the Contractor shall design and provide temporary channels or culverts of adequate size to carry the normal flow of the stream or drainage facility. The Contractor shall submit a temporary relocation design to the Engineer for review and acceptance in sufficient time to allow for discussion and correction prior to beginning the work the design covers. Costs for the temporary relocation of the stream or drainage facility shall be included in the Contract price for the related pipe or box culvert, unless specifically provided for under another Pay Item. Stabilization of the streambed and banks shall occur immediately upon completion of, or during the work or if the work is suspended for more than 14 days.

Temporary bridges or other minimally invasive structures shall be used wherever the Contractor finds it necessary to cross a stream more than twice in a 6-month period, unless otherwise authorized by water quality permits issued by the U. S. Army Corps of Engineers, Virginia Marine Resources Commission or the Virginia Department of Environmental Quality for the Contract.

2. **Air:** The Contractor shall comply with Section 107.01 and the State Air Pollution Control Law and Rules of the State Air Pollution Control Board, including notifications required therein.

   Burning shall be performed in accordance with all applicable local laws and ordinances and under the constant surveillance of watchpersons. Care shall be taken so that the burning of materials does not destroy or damage property or cause excessive air pollution. The Contractor shall not burn rubber tires, asphalt, used crankcase oil, or other materials that produce dense smoke. Burning shall not be initiated when atmospheric conditions are such that smoke will create a hazard to the motoring public or airport operations. Provisions shall be made for flagging vehicular traffic if visibility is obstructed or impaired by smoke. At no time shall a fire be left unattended.

   Asphalt mixing plants shall be designed, equipped, and operated so that the amount and quality of air pollutants emitted will conform to the rules of the State Air Pollution Control Board.

   a. **VOC Emission Control Areas -** The Contractor is advised that when the project is located in a volatile organic compound (VOC) emissions control area identified in the State Air Control Board Regulations (9 VAC 5-20-206) and in the Table I-3 below the following limitations shall apply:

      (1) Open burning is prohibited during the months of May, June, July, August, and September.

      (2) Cutback asphalt is prohibited April through October except when use or application as a penetrating prime coat or tack is necessary. See 9 VAC 5-40,

Article 39 (Emission Standards for Asphalt Paving Operations); 9 VAC 5-20-206 (Regulations for the Control and Abatement of Air Pollution), and 9 VAC 5-130 (Regulation for Open Burning) for further clarification.

TABLE I-3

VOC Emissions Control Area	VDOT District	Jurisdiction
Northern Virginia	NOVA	Alexandria City Arlington County Fairfax County Fairfax City Falls Church City Loudoun County Manassas City Manassas Park City Prince William County
Northern Virginia	Fredericksburg	Stafford County
Fredericksburg	Fredericksburg	Spotsylvania County Fredericksburg City
Hampton Roads	Fredericksburg	Gloucester County
Hampton Roads	Hampton Roads	Chesapeake City Hampton City Isle of Wight County James City County Newport News City Norfolk City Poquoson City Portsmouth City Suffolk City Virginia Beach City Williamsburg City York County
Richmond	Richmond	Charles City County Chesterfield County Colonial Heights City Hanover County Henrico County Hopewell City Petersburg City Prince George County Richmond City
Western Virginia	Staunton	Frederick County Winchester City
Western Virginia	Salem	Roanoke County Botetourt County Roanoke City Salem City

(3) Emission standards for asbestos incorporated in the EPA's National Emission Standards for Hazardous Air Pollutants apply to the demolition or renovation of any institutional, commercial, or industrial building, structure, facility, installation, or portion thereof that contains friable asbestos or where the Contractor's methods for such actions will produce friable asbestos.

The Contractor shall submit demolition notification the United States Environmental Protection Agency (USEPA) and the Virginia Department of Labor and Industry a minimum of 10 business days prior to starting work on the following bridge activities:

(a) Dismantling and removing existing structures

(b) Moving an entire structure

(c) Reconstruction and repairs involving the replacement of any load-bearing component of a structure

Address notifications to:

Virginia Department of Labor and Industry
Asbestos Program
Powers-Taylor Building
13 South Thirteenth Street
Richmond, VA 23219

Land and Chemical Division
EPA Region III
Mail Code LC62
1650 Arch St.
Philadelphia, PA 19103-2029

The Contractor shall provide written notification to the Engineer a minimum of 3 full business days prior to work being performed.

3. **Noise:** The Contractor's operations shall be performed so that exterior noise levels measured during a noise-sensitive activity shall not exceed 80 decibels. Such noise level measurements shall be taken at a point on the perimeter of the construction limit that is closest to the adjoining property on which a noise sensitive activity is occurring. A noise-sensitive activity is any activity for which lowered noise levels are essential if the activity is to serve its intended purpose and not present an unreasonable public nuisance. Such activities include, but are not limited to, those associated with residences, hospitals, nursing homes, churches, schools, libraries, parks, and recreational areas.

The Department may monitor construction-related noise. If construction noise levels exceed 80 decibels during noise sensitive activities, the Contractor shall take corrective action before proceeding with operations. The Contractor shall be responsible for costs associated with the abatement of construction noise and the delay of operations attributable to noncompliance with these requirements.

The Department may prohibit or restrict to certain portions of the project any work that produces objectionable noise between 10 PM and 6 AM. If other hours are established by local ordinance, the local ordinance shall govern.

Equipment shall in no way be altered so as to result in noise levels that are greater than those produced by the original equipment.
When feasible, the Contractor shall establish haul routes that direct his vehicles away from developed areas and ensure that noise from hauling operations is kept to a minimum.

These requirements shall not be applicable if the noise produced by sources other than the Contractor's operation at the point of reception is greater than the noise from the Contractor's operation at the same point.

(c) **Forest Fires:** The Contractor shall take all reasonable precautions to prevent and suppress forest fires in any area involved in construction operations or occupied by him as a result of such operations. The Contractor shall cooperate with the proper authorities of the state and federal governments in reporting, preventing, and suppressing forest fires. Labor, tools, or equipment furnished by the Contractor upon the order of any forest official issued under authority granted the official by law shall not be considered a part of the Contract. The Contractor shall negotiate with the proper forest official for compensation for such labor, tools, or equipment.

(d) **Archeological, Paleontological, and Rare Mineralogical Findings:** In the event of the discovery of prehistoric ruins, Indian or early settler sites, burial grounds, relics, fossils, meteorites, or other articles of archeological, paleontological, or rare mineralogical interest during the prosecution of work, the Contractor shall act immediately to suspend work at the site of the discovery and notify the Engineer. The Engineer will immediately notify the proper state authority charged with the responsibility of investigating and evaluating such finds. The Contractor shall cooperate and, upon the request of the Engineer, assist in protecting, mapping, and removing the findings. Labor, tools, or equipment furnished by the Contractor for such work will be paid for in accordance with Section 104.03. Findings shall become the property of the Commonwealth unless they are located on federal lands, in which event they shall become the property of the U.S. government.

When such findings delay the progress or performance of the work, the Contractor shall notify the Engineer in accordance with Sections 108.03 and Section 109.05.

(e) **Storm Water Pollution Prevention Plan and VPDES General Permit for the Discharge of Stormwater from Construction Activities**

A Stormwater Pollution Prevention Plan (SWPPP) identifies potential sources of pollutants which may reasonably be expected to affect the stormwater discharges from the construction site and any on-site or off-site support facilities located on VDOT rights of way and easements. The SWPPP also describes and ensures implementation of practices which will be used to minimize or prevent pollutants in such discharges.

The SWPPP shall include, but not be limited to, the approved Erosion and Sediment Control (ESC) Plan, the approved Stormwater Management (SWM) Plan (if applicable), the approved Pollution Prevention Plan and all related Specifications, Standards, and notes contained within all Contract documents and shall be required for all land-disturbing activities that disturb 10,000 square feet or greater, or 2,500 square feet or greater in Tidewater, Virginia.

Land-disturbing activities that disturb one acre or greater require coverage under the Department of Environmental Quality's VPDES General Permit for the Discharge of Stormwater from Construction Activities (hereafter referred to as the VPDES Construction Permit). According to IIM-LD-242, VDOT will apply for and secure VPDES Construction Permit coverage for

all applicable land disturbing activities on VDOT rights of way or easements for which it has contractual control, including off-site (outside the project limits) support facilities on VDOT rights of way or easements that directly relate to the construction activity.

The Contractor shall be responsible for securing VPDES Construction Permit coverage and complying with all permit conditions for all support facilities that are not located on VDOT rights of way or easements.

The required contents of a SWPPP for those land disturbance activities requiring coverage under the VPDES Construction Permit are found in Section II of the permit.

While a SWPPP is an important component of the VPDES Construction Permit, it is only one of the many requirements that must be addressed in order to be in full compliance with the conditions of the permit.

The Contractor and all other persons that oversee or perform activities covered by the VPDES Construction Permit shall be responsible for reading, understanding, and complying with all of the terms, conditions, and requirements of the permit and the project's SWPPP including, but not limited to, the following:

1. Project Implementation Responsibilities

   The Contractor shall be responsible for the installation, maintenance, inspection, and, on a daily basis, ensuring the functionality of all erosion and sediment control measures and all other stormwater runoff control and pollution prevention measures identified within or referenced within the SWPPP, the construction plans, the specifications, all applicable permits, and all other Contract documents.

   The Contractor shall be solely responsible for the temporary erosion and sediment control protection and permanent stabilization of all borrow areas and soil disposal areas located outside of VDOT right of way or easement.

   The Contractor shall prevent or minimize any stormwater or non-stormwater discharge that will have a reasonable likelihood of adversely affecting human health or public and/or private properties.

2. Certification Requirements

   In addition to satisfying the Section 107.16(a) personnel certification requirements, the Contractor shall certify his activities by completing, signing, and submitting Form C-45 VDOT SWPPP Contractor Certification Statement to the Engineer at least 7 days prior to commencing any project-related, land-disturbing activities, both within the project limits and any support facilities located on VDOT rights of way or easements outside the project limits.

3. SWPPP Requirements for Support Facilities

   VDOT will secure VSMP Construction Permit coverage for support facilities located on VDOT rights of way or easements according to IIM-LD-242. The Contractor shall be responsible for securing separate VSMP Construction Permit coverage for support facilities that are not located on VDOT rights of way or easements.

Support facilities shall include, but not be limited to, borrow and disposal areas, construction and waste material storage areas, equipment and vehicle washing, maintenance, storage and fueling areas, storage areas for fertilizers, fuels or chemicals, concrete wash out areas, sanitary waste facilities, and any other areas that may generate a stormwater or non-stormwater discharge directly related to the construction site.

Support Facilities located on VDOT rights of way or easements:

a. For those support facilities located within the project limits but not included in the construction plans for the project, the Contractor shall develop a SWPPP according to IIM-LD-246 which shall include, where applicable, an erosion and sediment control plan according to IIM-LD-11, a stormwater management plan according to IIM-LD-195, and a pollution prevention plan according to these Specifications and the SWPPP General Information Sheet notes in the construction plans or other such Contract documents. All plans developed shall be reviewed and approved by appropriate personnel certified through DEQ's ESC and SWM Certification program and shall be developed according to Section 105.10 and shall be submitted to the Engineer for review and approval. Once approved, the Engineer will notify the Contractor in writing that the plans are accepted as a component of the Project's SWPPP and VPDES Construction Permit coverage (where applicable) and shall be subject to all conditions and requirements of the VPDES Construction Permit and all other Contract documents. No land disturbing activities can occur in the support area(s) until written notice to proceed is provided by the Engineer.

b. For support facilities located outside the project limits and not included in the construction plans for the project, the Contractor shall develop a SWPPP according to IIM-LD-246 which shall include, where applicable, an erosion and sediment control plan according to IIM-LD-11, a stormwater management plan (where applicable) according to IIM-LD-195, a pollution prevention plan according to these specifications and the SWPPP General Information Sheet notes in the construction plans or other such Contract documents and all necessary documents for obtaining VPDES Construction Permit coverage according to IIM-LD-242. All plans developed shall be reviewed and approved by appropriate personnel certified through DEQ's ESC and SWM Certification program and shall be developed according to Section 105.10 and shall be submitted to the Engineer for review and approval. Once approved by the Engineer, VDOT will secure VPDES Construction Permit coverage according to IIM-LD-242. After VDOT secures VPDES Construction Permit coverage for the support facility, the Engineer will notify the Contractor in writing. The support facility shall be subject to all conditions and requirements of the VPDES Construction Permit and all other Contract documents. No land disturbing activities can occur in the support area(s) until written notice to proceed is provided by the Engineer.

4. Inspection Procedures

a. Inspection Requirements

The Contractor shall be responsible for conducting site inspections in accordance with the requirements herein. Site inspections shall include erosion and sediment control and pollution prevention practices and facilities. The Contractor shall document such inspections by completion of Form C-107, Construction Runoff Control Inspection Form, in strict accordance with the directions contained within the

form. Inspections shall include all areas of the site disturbed by construction activity, all on-site support facilities and all off site support facilities within VDOT right of way or easement. Inspections shall be conducted at least once every 7 calendar days (equivalent to once every 5 business days) and within 48 hours following any measureable storm event. In the event a measureable storm event occurs when there are more than 48 hours between business days, the inspection shall occur no later than the next business day. A business day is defined as Monday through Friday excluding State holidays. A measurable storm event is defined as one producing 0.25 inches of rainfall or greater over a 24 hour time period. The Contractor shall install a rain gage at a central location on the project site for the purposes of determining the occurrence of a measureable storm event. Where the project is of such a length that one rain gage may not provide an accurate representation of a the occurrence of a measurable storm event over the entire project site, the Contractor shall install as many rain gages as necessary to accurately reflect the amount of rainfall received over all portions of the project. The rain gage shall be observed no less than once each business day at the time prescribed in the SWPPP General Information Sheet notes in the construction plans or other Contract documents to determine if a measureable storm event has occurred. The procedures for determining the occurrence of a measurable storm event are identified in the SWPPP General Information Sheet notes in the construction plans or other Contract documents. For those areas of the site that have been temporarily stabilized or where land disturbing activities have been suspended due to continuous frozen ground conditions and stormwater discharges are unlikely, the inspection schedule may be reduced to once per month. If weather conditions (such as above freezing temperatures or rain or snow events) make stormwater discharges likely, the Contractor shall immediately resume the regular inspection schedule. Those definable areas where final stabilization has been achieved will not require further inspections provided such areas have been identified in the project's Stormwater Pollution Prevention Plan.

b. Corrective Actions

If a site inspection identifies an existing control measure that is not being maintained properly or operating effectively; an existing control measure that needs to be modified; locations where an additional control measure is necessary; or any other deficiencies in the erosion and sediment control and pollution prevention plan, corrective action(s) shall be completed as soon as practical and prior to the next anticipated measurable storm event but no later than 7 days after the date of the site inspection that identified the deficiency.

5. Unauthorized Discharges and Reporting Requirements

The Contractor shall not discharge into state waters sewage, industrial wastes, other wastes, or any noxious or deleterious substances nor shall he otherwise alter the physical, chemical, or biological properties of such waters that render such waters detrimental for or to domestic use, industrial consumption, recreational, or other public uses.

a. Notification of non-compliant discharges

The Contractor shall immediately notify the Engineer upon the discovery of or the potential of any unauthorized, unusual, extraordinary, or non-compliant discharge from the land construction activity or any of support facilities located on VDOT right

of way or easement. Where immediate notification is not possible, such notification shall be not later than 24 hours after said discovery.

b. Detailed report requirements for non-compliant discharges

The Contractor shall submit to the Engineer within 5 days of the discovery of any actual or potential non-compliant discharge a written report describing details of the discharge to include a description of the nature and location of the discharge; the cause of the discharge; the date of occurrence; the length of time that the discharge occurred, the volume of the discharge; the expected duration and total volume if the discharge is continuing; a description of any apparent or potential effects on private and/or public properties and state waters or endangerment to public health; and any steps planned or taken to reduce, eliminate, and prevent a recurrence of the discharge. A completed Form C-107 shall be included in such reports.

6. Changes and Deficiencies

The Contractor shall report to the Engineer when any planned physical alterations or additions are made to the land disturbing activity or deficiencies in the project plans or Contract are discovered that could significantly change the nature of or increase the potential for pollutants discharged from the land disturbing activity to surface waters and that have not previously been addressed in the SWPPP.

7. Amendments, Modifications, Revisions and Updates to the SWPPP

a. The Contractor shall amend the SWPPP whenever site conditions, construction sequencing or scheduling necessitates revisions or modifications to the erosion and sediment control plan, the pollution prevention plan, or any other component of the SWPPP for the land disturbing activity or onsite support facilities,

b. The Contractor shall amend the SWPPP to identify any additional or modified erosion and sediment control and pollution prevention measures implemented to correct problems or deficiencies identified through any inspection or investigation process.

c. The Contractor shall amend the SWPPP to identify any new or additional person(s) or Contractor(s) not previously identified that will be responsible for implementing and maintaining erosion and sediment control and pollution prevention devices.

d. The Contractor shall update the SWPPP to include:

1) A record of dates when major grading activities occur, construction activities temporarily or permanently cease on a portion of the site, and stabilization measures are initiated.

2) Documentation of replaced or modified erosion and sediment control and pollution prevention controls where periodic inspections or other information have indicated that the controls have been used inappropriately or incorrectly.

3) Identification of areas where final stabilization has occurred and where no further SWPPP or inspection requirements apply.

4) The date of any prohibited discharges, the discharge volume released, and what actions were taken to minimize the impact of the release.

5) A description of any measures taken to prevent the reoccurrence of any prohibited discharge.

6) A description of any measures taken to address any issues identified by the required erosion and sediment control and pollution prevention inspections.

e. The Contractor shall update the SWPPP no later than 7 days after the implementation and/or the approval of any amendments, modifications, or revisions to the erosion and sediment control plan, the pollution prevention plan, or any other component of the SWPPP.

f. Revisions or modifications to the SWPPP shall be approved by the Engineer and shall be documented by the Contractor on a designated plan set (Record Set) according to IIM-LD-246. All updates to the SWPPP shall be signed by the Contractor and the VDOT Responsible Land Disturber (RLD).

g. The record set of plans shall be maintained with other SWPPP documents on the project site or at a location convenient to the project site where no onsite facilities are available.

107.17—Construction Safety and Health Standards

(a) In the performance of this Contract the Contractor shall comply with all applicable Federal, State, and local laws governing safety, health, and sanitation (23 CFR 635). The Contractor, subcontractors at any tier, and their respective employees, agents and invitees, shall at all times while in or around the project site comply with all applicable laws, regulations, provisions, and policies governing safety and health under the Virginia Occupational Safety and Health (VOSH) Standards adopted under the Code of Virginia, and any laws, regulations, provisions, and policies incorporated by reference including but not limited to the Federal Construction Safety Act (Public Law 91-54), 29 CFR Chapter XVII, Part 1926, Occupational Safety and Health Regulations for Construction, and the Occupation Safety and Health Act (Public Law 91-596), 29 CFR Chapter XVII, Part 1910 Occupational Safety and Health Standards for General Industry, and subsequent publications updating these regulations.

(b) The Contractor shall provide all safeguards, safety devices and protective equipment, and take any other needed actions as it determines, or as the Engineer may determine, to be reasonably necessary to protect the life and health of employees on the job and the safety of the public, and to protect property in connection with the performance of the Work. The Contractor shall be responsible for maintaining and supervising all safety and health protections and programs to ensure compliance with this Section. The Contractor shall routinely inspect the project site for safety and health violations. The Contractor shall immediately abate any violations of the safety and health requirements or duties at no cost to the Department.

(c) It is a condition of this Contract, and shall be made a condition of each subcontract, which the Contractor enters into pursuant to this Contract, that the Contractor and any subcontractor shall not permit any employees, in performance of the Contract, to work in surroundings or under

conditions which are unsanitary, hazardous, or dangerous to their health or safety, as determined by the Virginia Work Area Protection Manual or under construction safety and health standards (29 CFR 1926) promulgated by the Secretary of Labor, in accordance with Section 107 of the Contract Work Hours and Safety Standards Act (40 U.S.C. 3704).

(d) VOSH personnel, on all Federal-aid construction contracts and related subcontracts, pursuant to 29 CFR 1926.3, the Secretary of Labor or authorized representative thereof, shall have right of entry to any site of contract performance to inspect or investigate the matter of compliance with the construction safety and health standards and to carry out their duties.

107.18—Sanitary Provisions

The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of employees as may be necessary to comply with the requirements of the state and local Board of Health or other bodies or tribunals having jurisdiction.

107.19—Railway-Highway Provisions

If the Contractor's work requires hauling materials across the tracks of a railway, he shall make arrangements with the railway for any new crossing(s) required. Access to existing rail crossings with off-road heavy equipment shall also be arranged by the Contractor. Charges made by the railway company for the construction or use of new or existing crossings and their subsequent removal and for watchperson or flagger service at such crossings shall be reimbursed by the Contractor directly to the railway company under the terms of their separate individual arrangements before final acceptance.

Work to be performed by the Contractor in construction on or over the railway right of way shall be performed at times and in a manner that will not unnecessarily interfere with the movement of trains or traffic on the railway track. The Contractor shall use care to avoid accidents, damage, or unnecessary delay or interference with the railway company's trains or other property. If any interruption of railway traffic is required by the Contractor's actions, he shall obtain prior written approval from the railway company.

The Contractor shall conduct operations that occur on or over the right of way of any railway company fully within the rules, regulations, and requirements of the railway company and in accordance with the requirements of any agreements made between the Department and the railway company that are a part of the Contract. Said agreements are included within the Contract.

(a) **Flagger or Watchperson Services:** Flagger or watchperson services required by the railway company for the safety of railroad operations because of work being performed by the Contractor or incidental thereto will be provided by the railway company. The cost for such services as required for work shown on the plans will be borne by the Department. Any cost of such services resulting from work not shown on the plans or for the Contractor's convenience shall be borne by the Contractor and shall be paid directly to the railway company(s) under the terms of their separate individual agreement.

No work shall be undertaken on or over the railway right of way until the watchpersons or flaggers are present at the project site. The Contractor shall continuously prosecute the affected work to completion to minimize the need for flagger or watchperson services. Costs for such services that the Engineer determines to be unnecessary because of the Contractor's failure to give notice as required herein before; initially starting, intermittently continuing, or discon-

tinuing work on or over the railway right of way shall be borne by the Contractor and will be deducted from monies due him.

(b) **Approval of Construction Methods on Railway Right of Way:** The Contractor shall submit to the Department a plan of operations showing the design and method of proposed structural operations and shall obtain its approval before performing any work on the railway company's right of way unless otherwise indicated in the railroad agreement. The plan shall be clear and legible, and details shall be drawn to scale. The plan shall incorporate any stipulations or requirements the railroad may impose for the evaluation of the Contractor's contemplated operations. The plan shall show, but not be limited to, the following:

1. proximity of construction operations to tracks.

2. depth of excavation with respect to tracks.

3. description of structural units.

4. vertical and horizontal clearances to be afforded the railroad during installation and upon completion of excavation.

5. sheeting and bracing.

6. method and sequence of operations.

Approval shall not relieve the Contractor of any liability under the Contract. The Contractor shall arrange the work so as not to interfere with the railway company's operation except by agreement with the railway company.

(c) **Insurance:** In addition to insurance or bonds required under the terms of the Contract, the Contractor shall carry insurance covering operations affecting the property of the railway company. The original railroad protective liability insurance policy and certificate of insurance showing insurance carried by the Contractor and any subcontractors shall be submitted to the railway company for approval and retention.

Neither the Contractor nor any subcontractor shall begin any work affecting the railway company until the railway company has received the insurance.

Notice of any material change in or cancellation of the required policies shall be furnished the Department and the railway company at least 30 days prior to the effective date of the change or cancellation. The insurance shall be of the following kinds and amounts:

1. **Contractor's public liability and property damage insurance:** The Contractor shall furnish evidence to the Department with respect to the operations to be performed that he carries regular contractor's public liability insurance. The insurance shall provide for a limit of at least the dollar value specified in the Contract for all damages arising out of bodily injuries to or the death of one person, and subject to that limit for each person, a total limit of at least the dollar value specified in the Contract for all damages arising out of bodily injuries to or death of two or more persons in any one occurrence, and regular contractor's property damage insurance providing for a limit of at least the dollar value specified in the Contract for all damages arising out of bodily injury to or destruction of property in any one occurrence, and subject to that limit per occurrence, a total or aggregate limit of at least the dollar value specified in the Contract for all damages arising out of injury to or destruction

of property during the policy period. The Contractor's public liability and property damage insurance shall include explosion, collapse, and underground damage coverage. If the Contractor subcontracts any portion of the work, he shall secure insurance protection in his own behalf under the Contract's public liability and property damage insurance policies to cover any liability imposed on him by law for damages because of bodily injury to, or death of persons and injury to, or destruction of property as a result of work undertaken by the subcontractors. In addition, the Contractor shall provide similar insurance protection for and on behalf of any subcontractors to cover their operation by means of separate and individual contractor's public liability and property damage policies. As an alternative, he shall require each subcontractor to provide such insurance in his own behalf.

2. **Railroad protective insurance and public liability and property damage:** The policy furnished the railway company shall include coverage for contamination, pollution, explosion, collapse, and underground damage. The policy shall be of the type specified hereinafter and shall be expressed in standard language that may not be amended. No part shall be omitted except as indicated hereinafter or by an endorsement that states an amendment or exclusion of some provision of the form in accordance with the provisions of a manual rule. The form of the endorsement shall be approved as may be required by the supervising authority of the state in which the policy is issued. A facsimile of the Policy Declarations form as shown in the proposal shall be made a part of the policy and shall be executed by an officer of the insurance company. The several parts of the requirements and stipulations specified or inferred herein may appear in the policy in such sequence as the company may elect.

   a. **For a policy issued by one company:**

      (NAME AND LOCATION OF INDEMNITY COMPANY), a _____ (Type of Company) Insurance Company, herein called the Company, agrees with the insured named in the Policy Declarations made a part hereof, in consideration of the payment of the premium and in reliance upon the statements in the Policy Declarations made by the named insured and subject to all of the terms of his policy.

      For a policy issued by two companies:

      (NAME AND LOCATION OF INDEMNITY COMPANY) and(NAME AND LOCATION OF INDEMNITY COMPANY),each a _____ Insurance Company (Type of Company), herein called the Company, severally agree with the insured named in the Policy Declarations made a part hereof, in consideration of the payment of the premium and in reliance upon the statements in the Policy Declaration made by the named insured and subject to all of the terms of this policy, provided the named Indemnity Company shall be the insured with respect to Coverage _____ and no other and the named Insurance Company shall be the insurer with respect to Coverage _____ and no other.

   b. **Insuring agreements:**

      1) **Coverages: Coverage A—Bodily injury liability:** To pay on behalf of the insured all sums that the insured shall become legally obligated to pay as damages because of bodily injury, sickness, or disease including death at any time resulting therefrom (hereinafter called bodily injury) either (1) sustained by any person arising out of acts or omissions at the designated job site that are related

to or are in connection with the work described in Item 6 of the Policy Declarations; or (2) sustained at the designated job site by the Contractor, any employee of the Contractor, any employee of the governmental authority specified in Item 5 of the Policy Declarations, or any designated employee of the insured, whether or not arising out of such acts or omissions.

Coverage B—Property damage liability: To pay on behalf of the insured all sums the insured shall become legally obligated to pay as damages because of physical injury to or destruction of property, including loss of use of any property because of such injury or destruction (hereinafter called property damage) arising out of acts or omissions at the designated job site that are related to or are in connection with the work described in Item 6 of the Policy Declarations.

Coverage C—Physical damage to property: To pay for direct and accidental loss of or damage to rolling stock and other contents, mechanical construction equipment, or motive power equipment (hereinafter called loss) arising out of acts or omissions at the designated job site that are related to or are in connection with the work described in Item 6 of the Policy Declarations; provided such property is owned by the named insured or is leased or entrusted to the named insured under a lease or trust agreement.

2) **Definitions:**

Insured means and includes the named insured and any executive officer, director, or stockholder thereof while acting within the scope of his duties as such.

Contractor means the Contractor designated in Item 4 of the Policy Declarations and includes all subcontractors of the Contractor but not the named insured.

Designated employee of the insured means (1) any supervisory employee of the insured at the job site; (2) any employee of the insured while operating, attached to, or engaged on work trains or other railroad equipment at the job site that is assigned exclusively to the Contractor; or (3) any employee of the insured not within (1) or (2) who is specifically loaned or assigned to the work of the Contractor for prevention of accidents or protection of property, the cost of whose services is borne specifically by the Contractor or governmental authority.

Contract means any contract or agreement to carry a person or property for a consideration or any lease, trust, or interchange contract or agreement respecting motive power, rolling stock, or mechanical construction equipment.

3) **Defense and settlement supplementary payments:** With respect to such insurance as is afforded by this policy under Coverages A and B, the Company shall defend any suit against the insured alleging such bodily injury or property damage and seeking damages that are payable under the terms of this policy, even if any of the allegations of the suit are groundless, false, or fraudulent. However, the Company may make such investigation and settlement of any claim or suit as it deems expedient.

In addition to the applicable limits of liability, the Company shall pay (1) all expenses incurred by the company, all costs taxed against the insured in any

such suit, and all interest on the entire amount of any judgment therein that accrues after entry of the judgment and before the Company has paid or tendered or deposited in court that part of the judgment that does not exceed the limit of the Company's liability thereon; (2) premiums on appeal bonds required in any such suit and premiums on bonds to release attachments for an amount not in excess of the applicable limit of liability of this policy, but without obligation to apply for or furnish any such bonds; (3) expenses incurred by the insured for first aid to others that shall be imperative at the time of the occurrence; and (4) all reasonable expenses, other than loss of earnings, incurred by the insured at the Company's request.

4) **Policy period and territory:** This policy applies only to occurrences and losses during the policy period and within the United States, its territories or possessions, or Canada.

c. **Exclusions:** This policy does not apply to the following:

1) liability assumed by the insured under any contract or agreement except a contract as defined herein.

2) bodily injury or property damage caused intentionally by or at the direction of the insured.

3) bodily injury, property damage, or loss that occurs after notification to the named insured of the acceptance of the work by the governmental authority, other than bodily injury, property damage, or loss resulting from the existence or removal of tools, uninstalled equipment, and abandoned or unused materials.

4) under Coverage A(1), B, and C, to bodily injury, property damage, or loss, the sole proximate cause of which is an act or omission of any insured.

5) under Coverage A, to any obligation for which the insured or any carrier as his insurer may be held liable under any workers' compensation, employment compensation, or disability benefits law or under any similar law; provided that the Federal Employer's Liability Act, U.S. Code (1946) Title 45, Sections 51-60, as amended, shall for the purpose of this insurance be deemed not to be any similar law

6) under Coverage B, to injury to or destruction of property owned by the named insured or leased or entrusted to the named insured under a lease or trust agreement.

7) under any liability coverage, to injury, sickness, disease, death, or destruction (1) with respect to which an insured under the policy is also an insured under a nuclear energy liability policy issued by the Nuclear Energy Liability Insurance Association, Mutual Atomic Energy Liability Underwriters, or Nuclear Insurance Association of Canada or would be an insured under any such policy but for its termination upon exhaustion of its limit of liability; or (2) resulting from the hazardous properties of nuclear material and with respect to which any person or organization is required to maintain financial protection pursuant to the Atomic Energy Act of 1954 or any law amendatory thereof or the insured is (or had this policy not been issued would be) entitled to indemnity from the

United States or any agency thereof under any agreement entered into by the United States, or any agency thereof, with any person or organization.

8) under any Medical Payments Coverage or any Supplementary Payments provision relating to immediate medical or surgical relief or to expenses incurred with respect to bodily injury, sickness, disease, or death resulting from the hazardous properties of nuclear material and arising out of the operation of a nuclear facility by any person or organization.

9) under any liability coverage, to injury, sickness, disease, death, or destruction resulting from the hazardous properties of nuclear material if (1) the nuclear material is at any nuclear facility owned or operated by or on behalf of an insured or has been discharged or dispersed therefrom; (2) the nuclear material is contained in spent fuel or waste at any time possessed, handled, used, processed, stored, transported, or disposed of by or on behalf of an insured; or (3) the injury, sickness, disease, death, or destruction arises out of the furnishing by an insured of services, materials, or parts for equipment in connection with the planning, construction, maintenance, operation, or use of any nuclear facility; if such facility is located in the United States, its territories or possessions, or Canada, this exclusion applies only to injury to or destruction of property at such nuclear facility.

10) under Coverage C, to loss attributable to nuclear reaction, nuclear radiation, or radioactive contamination or to any act or condition incident to any of the foregoing.

11) As used in exclusions (7), (8), and (9), the following definitions apply:

Disposable material means material containing byproduct material and resulting from the operation by any person or organization of any nuclear facility included in the definition of nuclear facility under (i) or (ii) below.

Hazardous properties include radioactive, toxic, or explosive properties.

Injury or destruction with respect to injury to or destruction of property, includes all forms of radioactive contamination of property

Nuclear facility means:

a) any nuclear reactor.

b) any equipment or device designed or used for separating the isotopes of uranium or plutonium; processing or utilizing spent fuel; or handling, processing, or packaging waste.

c) any equipment or device designed or used for the processing, fabricating, or alloying of special nuclear material if at any time the total amount of such material in the custody of the insured at the premises where such equipment or device is located consists of or contains more than 25 grams of plutonium or uranium 233 (or any combination thereof) or more than 250 grams of uranium 235.

d) any structure, basin, excavation, premises, or place prepared or used for the storage or disposal of waste (includes the site on which any of the foregoing is located, all operation conducted on such site, and all premises used for such operations).

Nuclear material means source material, special nuclear material, or byproduct material.

Nuclear reactor means any apparatus designed or used to sustain nuclear fission in a self-supporting chain reaction or to contain a critical mass of fissionable material.

Source material, special nuclear material, and byproduct material have the meanings given them in the Atomic Energy Act of 1954 or in any law amendatory thereof.

Spent fuel means any fuel element or fuel component (solid or liquid) that has been used or exposed to radiation in a nuclear reaction.

d. **Conditions:** The following conditions, except conditions (3) through (12), apply to all coverages. Conditions (3) through (12) apply only to the coverage noted thereunder.

1) **Premium:** The premium bases and rates for the hazards described in the Policy Declarations are stated therein. Premium bases and rates for hazards not so described are those applicable in accordance with the requirements of the manuals used by the Company. The term "Contract cost" means the total cost of all work described in Item 6 of the Policy Declaration. The term "rental cost" means the total cost to the Contractor for rental or work trains or other railroad equipment, including the remuneration of all employees of the insured while operating, attached to, or engaged thereon. The advance premium stated in the Policy Declarations is an estimated premium only. Upon termination of this policy, the earned premium shall be computed in accordance with the Company's rules, rates, rating plans, premiums, and minimum premiums applicable to this insurance. If the earned premium thus computed exceeds the estimated advance premium paid, the Company shall look to the Contractor specified in the Policy Declarations for any such excess. If the earned premium is less than the estimated advance premium paid, the Company shall return to the Contractor the unearned portion paid. In no event shall payment or premium be an obligation of the named insured.

2) **Inspection:** The named insured shall make available to the Company records of information relating to the subject matter of this insurance. The Company shall be permitted to inspect all operations in connection with the work described in Item 6 of the Policy Declarations.

3) **Limits of liability, Coverage A:** The limit of bodily injury liability stated in the Policy Declarations as applicable to "each person" is the limit of the Company's liability for all damages (including damages for care and loss of services) arising out of bodily injury sustained by one person as the result of any one occurrence. The limit of such liability stated in the Policy Declarations as applicable to "each occurrence" is (subject to the provision respecting each person) the

total limit of the Company's liability for all such damage arising out of bodily injury sustained by two or more persons as the result of any one occurrence.

4) **Limits of liability, Coverages B and C:** The limit of liability under Coverages B and C stated in the Policy Declarations as applicable to "each occurrence" is the total limit of the Company's liability for all damages and all loss under Coverages B and C combined arising out of physical injury to, destruction of, or loss of all property of one or more persons or organizations, including the loss or use of any property attributable to such injury or destruction under Coverage B, as the result of any one occurrence. Subject to the provision respecting "each occurrence", the limit of liability under Coverages B and C stated in the Policy Declaration as "aggregate" is the total limit of the Company's liability for all damages and all loss under Coverages B and C combined arising out of physical injury to, destruction of, or loss of property, including the loss or use of any property attributable to such injury or destruction under Coverage B.

   Under Coverage C, the limit of the Company's liability for loss shall not exceed the actual cash value of the property, or if the loss is a part thereof, the actual cash value of such part, at time of loss, nor what it would then cost to repair or replace the property of such part thereof with other of like kind and quality.

5) **Severability of interests, Coverages A and B:** The term the insured is used severally and not collectively. However, inclusion herein of more than one insured shall not operate to increase the limits of the Company's liability.

6) **Notice:** In the event of an occurrence or loss, written notice containing particulars sufficient to identify the insured and also reasonably obtainable information with respect to the time, place, and circumstances thereof and the names and addresses of the injured and of able witnesses shall be given by or for the insured to the Company or any of its authorized agents as soon as is practicable. If a claim is made or a suit is brought against the insured, he shall immediately forward to the Company every demand, notice, summons, or other process received by him or his representative.

7) **Assistance and cooperation of the insured, Coverages A and B:** The insured shall cooperate with the Company and upon the Company's request attend hearings and trials and assist in making settlements, securing and giving evidence, obtaining the attendance of witnesses, and conducting suits. Except at his own cost, the insured shall not voluntarily make any payment, assume any obligations, or incur any expense other than for first aid to others that shall be imperative at the time of an accident.

8) **Action against Company, Coverages A and B:** No action shall lie against the Company unless as a condition precedent thereto the insured shall have fully complied with all the terms of this policy, nor until the amount of the insured's obligation to pay shall have been finally determined either by judgment against the insured after actual trial or by written agreement of the insured, the claimant, and the Company. Any person or organization or the legal representative thereof who has secured such judgment or written agreement shall thereafter be entitled to recover under this policy to the extent of the insurance afforded by this policy. No person or organization shall have any

right under this policy to join the Company as a part to any action against the insured to determine the insured's liability. Bankruptcy or insolvency of the insured or of the insured's estate shall not relieve the Company of any of its obligations hereunder.

9) **Action against Company, Coverage C:** No action shall lie against the Company unless as a condition precedent thereto there shall have been full compliance with all the terms of this policy nor until 30 days after proof of loss is filed and the amount of loss is determined as provided in this policy.

10) **Insured's duties in event of loss, Coverage C:** In the event of loss, the insured shall protect the property, whether or not the loss is covered by this policy. Any further loss attributable to the insured's failure to protect shall not be recoverable under this policy. Reasonable expenses incurred in affording such protection shall be deemed incurred at the Company's request.

    The insured shall also file with the Company, as soon as practicable after loss, his sworn proof of loss in such form and including such information as the Company may reasonably require and shall, upon the Company's request, exhibit the damaged property.

11) **Appraisal, Coverage C:** If the insured and the Company fail to agree as to the amount of loss, either may demand an appraisal of the loss within 60 days after the proof of loss is filed. In such event the insured and the Company shall each select a competent appraiser, and the appraisers shall select a competent and disinterested umpire. An award in writing or any two shall determine the amount of loss. The insured and the Company shall each pay his chosen appraiser and shall bear equally the other expenses of the appraisal and umpire. The Company shall not be held to have waived any of its rights by any act relating to appraisal.

12) **Payment of loss, Coverage C:** The Company may pay for the loss in money, but there shall be no abandonment of the damaged property to the Company.

13) **No benefit to bailee coverage:** The insurance afforded by this policy shall not enure directly or indirectly to the benefit of any carrier or bailee (other than the named insured) liable for loss to the property.

14) **Subrogation:** In the event of any payment under this policy, the Company shall be subrogated to all of the insured's rights of recovery therefor against any person or organization. The insured shall execute and deliver instruments and papers and do whatever else is necessary to secure such rights. The insured shall do nothing after loss to prejudice such rights.

15) **Application of insurance:** The insurance afforded by this policy is primary insurance. If the insured has other primary insurance against a loss covered by this policy, the Company shall not be liable under the policy for a greater proportion of such loss than the applicable limit of liability stated in the Contract bears to the total applicable limit of all valid and equitable insurance against such loss.

16) **3-year policy:** A policy period of 3 years is comprised of three consecutive annual periods. Computation and adjustment of earned premium shall be made

at the end of each annual period. Aggregate limits of liability as stated in this policy shall apply separately to each annual period.

17) **Changes:** Notice to any agent of knowledge possessed by any agent or by any other person shall not affect a waiver or a change in any part of this policy or stop the Company from asserting any right under the terms except by endorsement issued to form a part of this policy signed by *_____ provided, however, changes may be made in the written portion of the Policy Declaration by *_____ when initialed by such *_____ or by endorsement issued to form a part of this policy signed by such *_____. [*Insert titles of authorized company representatives.]

18) **Assignment:** Assignment of interest under this policy shall not bind the Company until its consent is endorsed hereon.

19) **Cancellation:** This policy may be cancelled by the named insured by mailing to the Company written notice stating when the cancellation shall become effective. This policy may be cancelled by the Company by mailing to the named insured, Contractor, and governmental authority at the respective addresses shown in this policy written notice stating when such cancellation shall be effective (not less than 30 days thereafter). The mailing of notice shall be sufficient proof of notice. The effective date and hour of cancellation stated in the notice shall become the end of the policy period. Delivery of such written notice either by the named insured or the Company shall be equivalent to mailing. If the named insured cancels, the earned premium shall be computed in accordance with the customary short rate table and procedure. If the Company cancels, the earned premium shall be computed pro rata. The premium may be adjusted either at the time cancellation is effected or as soon as practicable after the cancellation becomes effective, but payment or tender of unearned premium is not a condition of cancellation.

20) **Policy Declarations:** By acceptance of this policy, the named insured agrees that such statements in the Policy Declarations as are made by him are his agreements and representations, that his policy is issued in reliance on the truth of such representations, and that this policy embodies all agreements existing between himself and the Company or any of its agents relating to this insurance.

e. **For a policy issued by one company:**

In witness whereof, the _____ Indemnity Company has caused this policy to be signed by its president and a secretary at _____ and countersigned on the Policy Declarations page by a duly authorized agent of the Company.

(Facsimile of Signature)	*(Facsimile of Signature)*
Secretary	*President*

For a policy issued by two companies:

In witness whereof, the _____ Indemnity Company has caused this policy with respect to Coverages _____ and such other parts of the policy as are applicable thereto to be signed by its presi-

dent and a secretary at _____ and countersigned on the Policy Declarations page by a duly authorized agent of the Company.

(Facsimile of Signature)	*(Facsimile of Signature)*
Secretary	*President*

(d) **Submitting Copies of Insurance Policies:** Prior to beginning construction operations on or over the railway right of way, the Contractor shall submit to the Department evidence of the railway company's approval and a copy of the required insurance policies. The Commonwealth will not be responsible for any claims from the Contractor resulting from delay in the acceptance of any of these policies by the railway company other than consideration of an extension of time. If the delay is caused by the failure of the Contractor or his insurer to file the required insurance policies promptly, an extension of time will not be granted.

(e) **Beginning Construction:** Preliminary contingent work or other work by the railway company may delay the starting or continuous prosecution of the work by the Contractor. The Contractor shall be satisfied as to the probable extent of such work and its effect on the operations prior to submitting a bid for the work. The Commonwealth will not be responsible for any claims by the Contractor resulting from such delays except that an extension of time may be considered.

(f) **Arranging for Tests:**

1. **Railroad specifications:** When ordering materials that are to conform to railroad specifications, the Contractor shall notify the railway company, who will arrange for tests. The Contractor shall specify in each order that the materials are to be tested in accordance with the requirements of the railroad specifications and not those of the Department.

2. **Highway Specifications:** When ordering materials that are to conform to highway Specifications, the Contractor shall specify in each order that the materials are to be tested in accordance with the requirements of Department Specifications.

107.20—Construction Over or Adjacent to Navigable Waters

The Department will obtain a permit from the U.S. Coast Guard for the anticipated construction and/or demolition activities of structures on Department projects that cross a waterway(s) under the jurisdiction of the U.S. Coast Guard. As the permit holder, the Department must apply to the U.S. Coast Guard for approval of permit modifications to the original Department permit that the Contractor requests.

Prior to starting demolition or construction operations the Contractor shall meet with the Engineer and the U.S. Coast Guard (U.S. Coast Guard Coordination Meeting) to present its planned operations and the potential impacts those operations may pose to water traffic. As part of this meeting, the parties shall establish in writing the proper protocol for emergency closures and be governed accordingly.

(a) **Activities subject to Coast Guard regulation under the Permit.** Following the U.S. Coast Guard Coordination meeting, the Contractor shall submit its proposed schedule of operations in writing to the Engineer. The Engineer shall review and provide written comments, if applicable, to the Contractor within 7 days following receipt of the Contractor's schedule of operations. The Contractor shall incorporate the Engineer's comments and submit its notice of scheduled operations to the Engineer and to the U.S. Coast Guard at least 30 days prior to commencement of any permitted construction or demolition operations. U.S. Coast Guard

acceptance of the Contractor's written schedule of operations is a condition precedent to the Contractor's commencement of those operations.

(b) **Activities that require channel closures or restrictions.** In addition to the submittal of its proposed schedule of operations as described in (a) above, Contractor shall submit plans that comply with the Permit for falsework, cofferdams, floating equipment and other obstructions to the channel or channels to the Engineer. The Contractor's attention is directed to the possibility that advance notification for consideration of approval may vary depending on the type and duration of proposed closures, the time of year for requested closure(s), and location of existing bridge(s) and waterway(s) involved, and the impact to entities served along or through the waterway(s). The Engineer shall review and provide written comments, if applicable, to the Contractor within 30 days following receipt of the Contractor's plans. The Contractor shall incorporate the Engineer's comments and submit its plans to the Engineer and to the U.S. Coast Guard at least 30 days prior to commencement of any permitted construction or demolition operations. The Contractor may not commence activities that require channel closures or restrictions without the prior written approval of the Department and the U.S. Coast Guard. The Contractor shall be responsible for complying with all operational requirements that the U.S. Coast Guard may place on the Contractor as conditions of approval.

In addition, the Contractor shall request and obtain Department and U.S. Coast Guard approval in writing before commencing any operations that deviate from the Contractor's schedule of operations when these operations interfere or have the potential to interfere with navigation of water traffic outside of timeframes previously approved by the Department and the U.S. Coast Guard.

Notices shall be sent to the U.S. Coast Guard, Fifth District Bridge Office (OBR), 431 Crawford Street, Portsmouth, VA 23704-5004. Payment of any penalty or fine that may be levied by the U.S. Coast Guard for Contractor violations of bridge regulations found in 33 CFR Parts 114, 115, 116, 117 and 118 shall be the responsibility of the Contractor. Further, any delay to the Contract as a result of actions or inaction by the Contractor relative to the requirements herein that are determined by the Department to be the fault of the Contractor will be a non-compensable and non-excusable delay.

The cost to comply with the requirements of this provision and to provide and maintain temporary navigation lights, signals and other temporary work associated with the structure(s) under this Contract required by the U.S. Coast Guard for the protection of navigation during construction or demolition operations shall be included in the bid price for other appropriate pay items.

107.21—Size and Weight Limitations

(a) **Hauling or Moving Material and Equipment on Public Roads Open to Traffic:** The Contractor shall comply with legal size and weight limitations in the hauling or moving of material and equipment on public roads open to traffic unless the hauling or moving is covered by a hauling permit.

(b) **Hauling or Moving Material and Equipment on Public Roads Not Open to Traffic:** The Contractor shall comply with legal weight limitations in the hauling or moving of material and equipment on public roads that are not open to traffic unless the hauling or moving is permitted elsewhere herein or is otherwise covered by a hauling permit. The Contractor shall be liable for damage that results from the hauling or moving of material and equipment. The hauling or moving of material and equipment on the pavement structure or across any structure during

various stages of construction shall be subject to additional restrictions as specified or directed by the Engineer.

(c) **Furnishing Items in Component Parts of Sections:** If the size or weight of fabricated or manufactured items together with that of the hauling or moving vehicle exceeds the limitations covered by hauling permit policies and other means of transportation are not available, permission will be given to furnish the items in component parts of sections with adequately designed splices or connections at appropriate points. Permission for such adjustments shall be requested in writing, and approval in writing shall be secured from the Department prior to fabrication or manufacture of the items. The request shall state the reasons for adjustment and shall be accompanied by supporting data, including working drawings where necessary.

(d) **Construction Loading of Structures:** In the construction, reconstruction, widening, or repair of bridge, culvert, retaining wall, and other similar type structures including approaches, the Contractor shall consider construction loads during the planning and prosecution of the work. If the loading capacity of these type structure(s) is not shown in the Contract, the Contractor is responsible for contacting the office of the appropriate district bridge engineer to obtain the loading capacity information. Construction loads include but are not limited to the weight of cranes, trucks, other heavy construction, or material delivery equipment, as well as the delivery or storage of materials placed on or adjacent to the structure or parts thereof during the various stages (phases) of the work in accordance with the Contractor's proposed work plan. The Contractor shall consider the effect(s) of construction loads on the loading capacity of these type structure(s) in his sequencing of the work and operations, including phase construction. At the Engineer's request the Contractor shall be prepared to discuss or review his proposed operations with the Engineer with regard to construction loads to demonstrate he has taken such into consideration in the planning and execution of the work.

SECTION 108—PROSECUTION AND PROGRESS OF WORK

108.01—Prosecution of Work

The Contractor shall provide sufficient labor, materials, equipment, and tools; and shall prosecute the Work with such means and methods and with such diligence as is required to attain and maintain a rate of progress necessary to ensure completion of the project within the Contract time limit in accordance with the plans, specifications, and other requirements of the Contract.

Once the Contractor has begun work, the Contractor shall prosecute the Work continuously and to the fullest extent possible except for suspensions authorized or ordered by the Engineer according to Section 108.05. If approval is given to suspend the work temporarily, the Contractor shall notify the Engineer at least 24 hours in advance of resuming operations.

The Contractor shall notify the Engineer at least 24 hours in advance of any changes in the Contractor's planned operations or work requiring inspection.

108.02—Limitation of Operations

(a) **General**

The Contractor shall conduct the work in a manner and sequence that will ensure its expeditious completion with the least interference to traffic and shall have due regard for the location of detours and provisions for handling traffic. The Contractor shall not open any work to the prejudice or detriment of work already started. The Engineer may require the Contractor to finish a section of work before work is started on any other section.

(b) **Holidays**

Except as is necessary to maintain traffic, work shall not be performed on Sundays or the following holidays without the permission of the Engineer: January 1, Easter, Memorial Day, July 4, Labor Day, Thanksgiving Day, and Christmas Day.

If any of these holidays occurs on a Sunday, the following Monday shall be considered the holiday.

In addition to the Sunday or Holiday work limitations, mobile, short duration, short-term stationary, or intermediate-term stationary temporary traffic control zone (as defined in the VWAPM) lane closures on mainline lanes, shoulders, or ramps shall not be performed during the following Holiday time periods without the written permission of the Engineer. Additionally, a long-term stationary temporary traffic control zone (as defined in the VWAPM) shall not be initially put in place, adjusted, or removed during the following Holiday time periods without the written permission of the Engineer:

- **January 1:** From Noon on the preceding day until Noon on the following day, except as indicated below for Holidays occurring on a Friday/Saturday or Sunday/Monday.
- **Easter:** As indicated below for Holidays occurring on a Sunday.
- **Memorial Day:** As indicated below for Holidays occurring on a Monday.
- **July 4:** From Noon on the preceding day until Noon on the following day, except as indicated below for Holidays occurring on a Friday/Saturday or Sunday/Monday.
- **Labor Day:** As indicated below for Holidays occurring on a Monday.
- **Thanksgiving Day:** From Noon on the Wednesday preceding Thanksgiving Day until Noon on the Monday following Thanksgiving Day.
- **Christmas Day:** From Noon on the preceding day until Noon on the following day, except as indicated below for Holidays occurring on a Friday/Saturday or Sunday/Monday.

If the Holiday occurs on a Friday or Saturday: From Noon on the preceding Thursday to Noon on the following Monday.

If the Holiday occurs on a Sunday or Monday: From Noon on the preceding Friday to Noon on the following Tuesday.

108.03—Progress Schedule

Unless otherwise indicated in the Contract, the Contractor shall, at a minimum, be governed by the following:

(a) **General Requirements**

The Contractor shall plan and schedule the work and shall submit his overall work plan in the form of a written Progress Schedule, as described herein, for the Engineer's review and acceptance. The accepted Progress Schedule will be used by the Engineer for planning and coordination of the Department activities, resources, and expenditures, and for evaluation of the Contractor's rate of progress and the effects of time-related impacts on the project.

When preparing the Progress Schedule, the Contractor shall consider all known constraints and restrictions such as holidays, seasonal, weather, traffic, utility, railroad, right-of-way, environmental, permits, or other known or specified limitations to the work.

At the Pre-Construction Conference the Contractor shall be prepared to discuss his planned or contemplated operations relative to the Contract requirements.

Delays resulting from the Contractor's failure to provide the Progress Schedule will not be considered just cause for extension of the Contract time limit or for additional compensation.

(b) **Progress Schedule Submission Requirements**

The Contractor shall submit to the Engineer three (3) copies of the written Baseline Progress Schedule at least 7 calendar days prior to beginning work. The Progress Schedule shall represent the Contractor's overall work plan to accomplish the entire scope of work in accordance with the requirements of the Contract. The Progress Schedule shall include all work including, as applicable, the work to be performed by sub-contractors, the Department, or others. The Progress Schedule submittal shall consist of a written Narrative to:

- Describe the Contractor's proposed general sequence to accomplish the work;

- Indicate the general schedule of work to be completed each month in terms of the major operations, routes, or segments of work as delineated in the Contract or in the absence of such delineations, as agreed to by the Contractor and the Engineer. A bar-chart schedule may be substituted at the Contractor's option.

The Progress Schedule, including the Initial and any subsequent Revised Progress Schedules requested by the Engineer or originated by the Contractor, will not be measured or paid for separately. All associated costs to prepare, update, revise, and/or furnish the Progress Schedule in accordance with the requirements herein shall be considered incidental to the work.

1. **Two Week Look-ahead (TWLA) Progress Schedule.** At least 7 calendar days prior to beginning work, the Contractor shall submit to the Engineer, an initial written TWLA Progress Schedule for any work planned for the first two weeks. Every week thereafter, on a day agreed to by the Contractor and the Engineer, the Contractor shall submit to the Engineer, a written TWLA Progress Schedule for the following two-week period. The TWLA schedule shall provide a detailed list of operations to indicate the type of operation, locations of the work, proposed working days and hours, and the start and finish dates for any work planned, started, in progress, or scheduled for completion during the two-week period. The TWLA Progress Schedule shall also indicate any critical stages of work requiring VDOT oversight or inspection. The Contractor shall submit 3 copies of the TWLA Progress Schedule to the Engineer in any legible format.

The Contractor may revise his TWLA Progress Schedule at his discretion. However, the Contractor shall notify the Engineer at least 48 working hours in advance of any changes in the Contractor's planned operations or critical stage work requiring Department oversight or inspection. In the event of extenuating circumstances deemed by the Engineer to be beyond the Contractor's control, the Engineer may grant verbal concurrence of changes in the Contractor's planned operations with less advance notice, as the need arises.

2. **Progress Schedule Revisions.** The Contractor may revise his overall plan of operations at any time; however, the Contractor shall submit a Revised Progress Schedule to reflect any changes in his overall sequence of operations or general schedule. The Contractor may be required, as determined by the Engineer, to submit a Revised Progress Schedule. Circumstances that may prompt the Engineer's decision to request a Revised Progress Schedule may include deviations from the overall sequence of operations or if the actual progress of work varies by one month or more from the currently accepted Progress Schedule.

   When required by the Engineer, the Revised Progress Schedule shall be submitted within 7 calendar days of receipt of the Engineer's written request. The Revised Progress Schedule shall be submitted in the form of the Progress Schedule as defined herein, to reflect the changes in the Contractor's overall work plan. The accepted Revised Progress Schedule will replace any previously accepted Progress Schedule for the remainder of the work.

(c) **Submittal and Reporting Format**

If requested by the Engineer, the Contractor shall submit its progress schedule in the following manner.

1. A transmittal letter to the Engineer listing the items, date, and number of copies of items being submitted.

2. Three printed legible paper copies of the progress schedule and progress schedule narrative.

3. One compact disk (CD) containing electronic "PDF" copies of the progress schedule, progress schedule narrative, and an electronic back-up file copy of the working progress schedule. Each electronic file submittal shall have a unique file name indicating the Contract ID, submission number, submittal type, and data date of the submission (e.g. C00012345C01_B01_Narrative_6-04-12.pdf).

(d) **Engineer's Review and Acceptance**

The Engineer will review the Baseline or subsequent Revised Progress Schedule submittals for acceptance within 7 calendar days of receipt of the Contractor's complete submittal. Review and acceptance by the Engineer will be based on conformance with the requirements of this provision and the Contract.

Review and acceptance by the Engineer will not constitute a waiver of any Contract requirements and will in no way assign responsibilities of the work plan, scheduling assumptions, and validity of the work plan or schedule to the Department. Failure of the Contractor to include in the Progress Schedule any element of work required by the Contract for timely completion of the Contract shall not excuse the Contractor from his contractual obligations.

(e) **Failure to Comply with Progress Schedule Submission Requirements**

With the exception of project start-up activities approved in writing by the Engineer, the Contractor shall not commence work, until 7 days after the date the Contractor submits a complete Baseline Progress Schedule, unless otherwise approved by the Engineer in writing.

If the Contractor fails to comply with any of the Progress Schedule submissions within the time and in the manner specified, the Engineer may withhold approval of the Contractor's ensuing monthly progress estimates until the Contractor has satisfied the submission requirements. If the Contractor fails to submit the Final As-Built Schedule in the time and manner required, the Engineer may withhold approval of the final payment until the Contractor satisfies the submission requirement.

The Department shall not be responsible for any delays, costs or damages resulting from the Contractor's failure to submit the schedule submittals in accordance with the requirements of the Contract.

108.04—Determination and Extension of Completion Date

The Department will specify the Completion Date in the Contract. The Department will not consider any request for an extension of time that is based on a claim that the Completion Date as originally established is insufficient to complete the Work.

When Contract execution is not within 60 calendar days after the opening of bids, or when the Contractor is unable to commence work because of any failure of the Department, the Contractor will be given an extension of time based on the number of days delayed beyond the 60 calendar days. No time extension will be allowed for a delay in the date of Contract execution when the delay is the fault of the Contractor.

The Engineer will determine if an extension of the Contract time limit for completion is warranted by additions to the Contract. The Contractor shall inform the Department, in writing, of a request for time extensions in his Work Order in accordance with the applicable portion(s) of Section 104 or 109. The Contractor shall provide written supporting data for any request for extension of time due to quantity additions and or additional or altered work.

During prosecution of the work, the Contractor shall identify the causes for any delays attributable to conditions he deems to be beyond his control and shall identify the particular construction operations affected, their criticality to project milestones or overall Contract completion, and the significant dates that encompass the periods of delay. The Contractor shall furnish all such information necessary for the Department to make an adequate evaluation of any request received from the Contractor for an extension of the Contract time limit within 3 days of experiencing such a delay.

(a) **Fixed Date:** Unless otherwise indicated in the Contract, the Contract time limit will be specified as a fixed date for completion. The Contractor shall take into consideration normal conditions considered unfavorable for the prosecution of the work, and shall place sufficient workers and equipment on the project to complete the work in accordance with the specified Contract time limit.

If the Contract identifies a contract-specific Notice to Proceed date and the Contract is not executed by that date, the Contractor will receive an extension of time equal to the number of days between the contract-specific Notice to Proceed date and the eventual date of Contract execution.

If the Notice to Proceed date is selected by the Contractor and after prior approval the Engineer directs the Contractor not to begin work on that date, the Contractor will receive an extension of time equal to the number of days between the Contractor's selected Notice to Proceed date and the eventual date the Engineer informs the Contractor that he may commence the work.

The Engineer may give consideration for extension of time when a delay occurs due to unforeseen causes beyond the control of or without the fault or negligence of the Contractor. However, consideration will not be given to extensions of time attributable to normal adverse weather conditions or conditions resulting from normal adverse weather.

For the purposes of this Section normal adverse weather is defined as that which is not considered extraordinary or catastrophic and is not reasonably conducive to the Contractor progressively prosecuting critical path work under the Contract. Weather events considered extraordinary or catastrophic include, but are not limited to tornados, hurricanes, earthquakes, and floods that exceed a 25-year storm event as defined by National Oceanic and Atmospheric Administration (NOAA) for the NOAA data gathering location that is nearest the project site.

If there is a delay in the progress of the work due to unforeseen causes described within these Specifications, and the delay extends the Contract time limit into the period between November 30 of one year and April 1 of the following year and working conditions during such period are unsuitable for the continuous prosecution or completion of the work, then consideration may only be given to granting an extension of time that will encompass a suitable period during which such work can be expeditiously and acceptably performed.

108.05—Suspension of Work Ordered by the Engineer

(a) If the Engineer orders the Contractor in writing to suspend performance of all or any portion of the Work for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation or Contract time is due as a result of such suspension, the Contractor shall submit to the Engineer a written request for adjustment according to Section 108.04 within 7 days after receipt of the notice to resume work. The Contractor's request shall set forth the reasons and support for such adjustment.

(b) Upon receipt, the Engineer will review the Contractor's documentation and evaluate the Contractor's request. If the Engineer agrees that the cost or time required for the performance of the Contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, his suppliers, or subcontractors at any tier, and was not caused by weather, the Engineer will make an adjustment (excluding profit and consequential damages) and modify the Contract in writing accordingly. The Engineer will notify the Contractor of the determination regarding whether or not an adjustment of the Contract is warranted.

(c) No Contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time and in the manner prescribed.

(d) No Contract adjustment will be allowed under this Section to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided for or excluded under any other term or condition of the Contract.

108.06—Failure to Complete on Time

(a) **General**

For each calendar day that any work remains incomplete after the Contract time limit specified for the completion of the work, the Department will assess liquidated damages against the Contractor. Liquidated damages will be assessed at the rate applicable to the Contract in accordance with the Schedule of Liquidated Damages, Table I-1, or as otherwise specified in the Contract provisions. Liquidated damages will be deducted from any monies due the Contractor for each calendar day of additional time consumed until final completion and acceptance of the Work, subject to such adjustments as provided in accordance with the requirements of Section 108.04, not as a penalty, but as liquidated damages. The Contractor waives any defense as to the validity of any liquidated damages stated in the Contract or these Specifications and assessed by the Department against the Contractor on the grounds that such liquidated damages are void as penalties or are not reasonably related to actual damages.

(b) **Liquidated Damages**

The following Schedule of Liquidated Damages, representing the cost of administration, engineering, supervision, inspection and other expenses, will be charged against the Contractor for each calendar day beyond the Contract time limit that the Contract remains in an incomplete state:

TABLE I-1

Schedule of Liquidated Damages

Original Contract Amount in Dollars	Daily Charge in Dollars
0.00 - 500,000.00	350
500,000.01 - 2,000,000.00	600
2,000,000.01 - 8,000,000.00	1,350
8,000,000.01 - 15,000,000.00	2,500
15,000,000.01 or more	3,100

108.07—Default of Contract

The Contractor may be declared in default if he does any one of the following:

(a) fails to begin the Work within 10 days after the notice to proceed date, except as otherwise permitted by specific Contract language, or the provisions of Section 105.01 or Section 108.02;

(b) fails to perform the Work with sufficient workers and equipment or with sufficient materials to ensure prompt completion of the Work;

(c) performs the Work in such manner that it is unacceptable, or fails, neglects or refuses to promptly remove and replace materials or work that are unacceptable;

(d) discontinues prosecution of the Work without an order to do so from the Engineer;

(e) fails to resume work that has been discontinued within a reasonable time after notice to do so;

(f) becomes insolvent, is declared bankrupt, or commits any act of bankruptcy or insolvency;

(g) allows any final judgment to stand against him unsatisfied for a period of 10 days;

(h) makes an assignment for the benefit of creditors;

(i) fails for any other cause whatsoever to carry on the work in accordance with the Contract or to perform contractual obligations in an acceptable manner;

(j) disregards laws, regulations, ordinances, the Engineer's written instructions, or otherwise remains in substantial violation of any provision of the Contract.

If any of these conditions exists, the Engineer will give notice in writing to the Contractor and his surety of the delay, neglect, or default. If within 10 days after the date of such notice the Contractor or his surety has not taken measures that will, in the judgment of the Engineer, ensure satisfactory progress of the work or give assurances satisfactory to the Engineer that the provisions of the Contract will be fully carried out and instructions complied with, the Commissioner may then, or at any time thereafter, declare the Contractor in default. Without violating the Contract, the Commissioner may call upon the Contractor's surety for the satisfactory and expeditious completion of all work under the Contract, the removal and replacement of any unacceptable or unauthorized work, or may otherwise terminate the Contract in accordance with the provisions of Section 108.08. If the Commissioner declares the Contractor in default, payments to the Contractor will be withheld and may be made directly to the Contractor's surety. Further negotiations regarding the remaining work will be conducted with the Contractor's surety.

If the Contractor's surety fails or refuses to proceed in accordance with the Commissioner's instructions, the Commissioner will appropriate and use any or all materials and equipment on the project site that are suitable and acceptable and will enter into an agreement with others for the completion of the work, or he will use such other methods as he deems necessary to ensure the completion of the work.

Costs and charges incurred by the Department, including the cost of completing the Work under the Contractor the cost of removal and replacement of any unacceptable or unauthorized work, will be deducted from any monies due or that will become due the Contractor and his surety. If the expense incurred by the Department is less than the sum that would have been payable under the Contract had the work been completed by the Contractor, the Contractor and his surety will be entitled to receive the difference. If the expenses exceed the sum that would have been payable under the Contract, the Contractor and his surety shall be liable for and shall pay to the Commonwealth the amount of the excess.

108.08—Termination of Contract

(a) **Conditions for Termination:** The Department may terminate the Contract or any portion thereof because of any of the following conditions:

1. Default.

2. National emergency.

3. Action by the Commonwealth, U.S. government, or court order.

4. Conditions beyond the control of the Department.

5. For the convenience of the Department.

Termination of the Contract or a portion thereof shall not relieve the Contractor of his responsibilities for completed Work, nor shall it relieve his surety of its obligation for and concerning any just claims arising out of the Work performed or remaining to be performed.

(b) **Termination for Convenience:** The Engineer will deliver to the Contractor and surety written notice of termination for convenience specifying the extent of the termination and the effective date. A termination for convenience may be directed at any time after the notice of award of the Contract. Termination for convenience will be accomplished in accordance with the following:

1. **Procedure:** The Contractor shall immediately upon receipt of the notice of termination do the following:

   a. Stop work as directed in the notice.

   b. Promptly place disturbed areas in an acceptable condition as directed by the Engineer.

   c. Place no further subcontracts or orders for materials, services, or equipment, unless necessary for any part of the Work not terminated or to protect any part of the Work completed.

   d. Terminate all subcontracts or orders to the extent related to the terminated work, unless instructed otherwise by the Department.

   e. Settle all outstanding liabilities with subcontractors and suppliers arising from the termination.

   f. Transfer title and deliver to the Department any work in progress, completed work, materials, supplies, equipment, drawings, plans, information, warranties, or other property that were purchased, acquired, fabricated, produced, supplied, or constructed for the Work, whether completed or terminated, and would be required to be furnished to the Department on completion of the Contract.

   g. Complete performance of Work not terminated, if any.

   h. Inventory along with the Engineer any acceptable materials obtained, but not incorporated into the Work.

   i. Take any action necessary or that the Engineer may direct for the protection and preservation of the site or other property that is in the Contractor's possession or control in which the Department has or may acquire an interest.

2. **Payment:** Within 30 days after the Contractor receives the Department's notice of termination for convenience, or within such time as the Contractor and the Engineer mutually agree, the Contractor shall submit a request for payment due for work performed through the effective date of termination and as a result of the termination for convenience. The Contractor shall submit with the request sufficient cost records to substantiate the payment amount requested.

   The Department shall pay and the Contractor shall accept, as full payment for all work and materials provided, a sum mutually agreed to by the Contractor and the Department determined as follows:

a. Work on Contract pay items performed prior to termination for which the Contractor has not been paid will be paid at the Contract price according to Section 109.03, or in the absence of Contract unit prices, in accordance with the requirements of Section 109.05 (Extra and Force Account Work). Items eliminated entirely by termination will be paid for as provided in Section 109.07. No claim for loss of anticipated profits will be considered, and the provisions of Section 104.02 will not apply for costs that are then incurred as a result of the termination.

b. Reimbursement for organizing the Work when not specified in the Contract and moving equipment to and from the project site will be considered where the volume of work completed is too small to compensate the Contractor for these expenses under the Contract unit prices.

c. At the option of the Engineer, materials the Contractor obtains for the Work that have been inspected, tested, and accepted by the Engineer and that have not been incorporated in the Work may be purchased from the Contractor at actual costs as shown by receipted bills, purchase orders, bills of lading, paid invoices, or other similar actual cost records at such points of delivery as will be designated by the Engineer.

d. The Contractor shall be reimbursed for any actual costs incurred to terminate sub contracts or purchase orders, as shown by receipted bills, bills of lading, paid invoices, or other similar actual cost records at such points of delivery as will be designated by the Engineer.

e. If a sum cannot be agreed upon, the Contractor shall be paid by unilateral change order and may seek recourse for the disputed amount in accordance with Section 105.19.

f. When requested by the Department, the Contractor shall furnish itemized statements of the cost of the work performed and shall give the Department (and/or the Department's Auditors) access to any and all financial and/or project records and documents, relating thereto. Unless the Contractor, when requested to do so, furnishes such itemized statements and access to any and all financial and/or project records and documents, the Contractor shall not be entitled to payment for work for which such information is sought by the Department.

3. The Contractor shall incorporate the provisions of this Section as provisions in its contracts with each of their subcontractors.

(c) **Termination for Default:** In the event the Commissioner declares the Contractor in default as provided in Section 108.07, the Department may terminate the Contract in accordance with the following:

1. Upon such termination becoming effective, the Department shall provide written notice to the surety confirming that the Contract is terminated, and that the Department is proceeding to finish the Work as set forth in the Contract performance bond, Form C-18A, and the terms and conditions therein if the Surety declines to complete the project. The Department will also take possession of the project site and of all materials purchased for the project thereon. If the expense of completing the Work, including compensation for additional managerial and administrative services, exceeds the unpaid balance of the Contract amount and the penal amount of the Contract performance bond, the Contractor

shall pay the difference to the Department, together with any other costs and expenses of terminating the Contract and having it completed by others.

2. If it should be judicially determined that the Department's termination for default was improper or in error, then the termination shall be deemed to be a termination for convenience and the Contractor's rights and remedies shall be limited exclusively to those provided under Section 108.08(b).

3. Termination for default as provided herein is in addition to and without prejudice to the Department's other rights or remedies. Any of the Department's actions permitted herein shall not be deemed a waiver of any other right or remedy of the Department under the Contract or under the law. The Department may offset any claims it may have against the Contractor against the amounts due or to become due to the Contractor under any other contract the Contractor may have with the Commonwealth. The provisions of this Section shall survive termination of the Contract.

4. When the Contractor is terminated for default, any claims timely identified in a written notice of intent may be submitted in accordance with provisions of Section 105.19 or the Code of Virginia as amended and as applicable, except that the Contractor shall submit the required claim within 60 days after the Department's notice of termination for default to the Contractor. Failure on the part of the Contractor to submit a claim within such 60-day period shall constitute a waiver and release of such claim.

108.09—Acceptance

(a) **Contractor's Responsibility for Work:** Until final acceptance of the work by the Engineer in accordance with the requirements of this Section, the Contractor shall have charge and care thereof and shall take every precaution against damage to any part thereof by action of the elements or from any other cause. The Contractor shall rebuild, repair, restore, and make good on damage to any portion of the work occasioned by any of the foregoing causes before final acceptance and shall bear the expense thereof. The Department may reimburse the Contractor for repair of damage to work attributable to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor as determined by the Engineer.

In case of suspension of work, the Contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the work, provide for erosion control and drainage, and erect any necessary temporary structures, signs, or other facilities as determined by the Engineer. During the suspension of work, the Contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seedings, and soddings furnished under the Contract and shall take adequate precautions to protect new tree growth and other important vegetation against damage.

(b) **Partial Acceptance:** If at any time during the prosecution of the project the Contractor completes a unit or portion of the project, such as a structure, an interchange, slopes, pavement, or a section of a roadway in its entirety, he may ask the Engineer to make final inspection of such work. If the Engineer finds upon inspection that the work conforms to the requirements of the Contract and that acceptance is in the best interest of the public, he may accept the work as being completed, and the Contractor will be relieved of further responsibility for the work. Partial acceptance shall in no way void or alter any terms of the Contract.

If any damage is sustained by an accepted unit or portion of the project attributable to causes beyond the control of the Contractor, the Engineer may authorize the Contractor to make the necessary repairs. These repairs will be paid for at the Contract price for the items requiring repair. In the absence of Contract prices covering the items of repair, the repair work will be paid for in accordance with the requirements of Section 109.05.

(c) **Final Acceptance:** Upon receipt of a written notice from the Contractor of presumptive completion of the entire project, the Engineer will make an inspection. If all work specified in the Contract has been completed, the inspection will constitute the final inspection and the Engineer will make the final acceptance. The Contractor will be notified in writing, of the determination of final acceptance within five days of the date of the Engineer's final acceptance.

If the Engineer's inspection discloses that any work, in whole or in part, is incomplete or unacceptable, the Contractor shall immediately correct the deficiency. A written list of deficiencies will be provided to the Contractor by the Engineer. Upon completion or correction of the work, another inspection will be made of the deficient work. If the work is then satisfactory, the Engineer will notify the Contractor in writing within 5 days of the Engineer's final acceptance. In any event, the Contractor shall be responsible for and maintain the project until final acceptance except under conditions that may be specifically exempted by the Specifications or other Contract documents.

108.10—Termination of Contractor's Responsibilities

The Contract will be considered fully complete upon final acceptance. The Contractor's responsibility for the Work will then cease except as set forth in his bonds, and Sections 107.12, 109.08, 109.10, and other provisions of the Contract that extend the Contractor's responsibility beyond final acceptance.

SECTION 109—MEASUREMENT AND PAYMENT

109.01—Measurement of Quantities

(a) **General:** Work specified in the Contract will be measured by the Engineer in accordance with U.S. Standard Measure. The methods of measurement and computations to be used to determine quantities of material furnished and work performed will be those generally recognized as conforming to good engineering practice.

Specific methods of measurement shall be as indicated in the specific Section for the Contract item.

Longitudinal measurements for surface area computations will be made along the surface, and transverse measurements will be the surface measure shown on the plans or ordered in writing by the Engineer. Individual areas of obstructions with a surface area of 9 square feet or less will not be deducted from surface areas measured for payment.

Structures will be measured in accordance with the neat lines shown on the plans.

Items that are measured by the linear foot will be measured parallel to the base or foundation upon which they are placed.

Allowance will not be made for surfaces placed over an area greater than that shown on the plans or for any material moved from outside the area of the cross-section and lines shown on the plans.

When standard manufactured items are specified and are identified by weights or dimensions, such identification will be considered nominal. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

(b) **Measurement by Weight:** Materials that are measured or proportioned by weight shall be weighted on accurate scales as specified in this Section. When material is paid for on a tonnage basis, personnel performing the weighing shall be certified by the Department and shall be bonded to the Commonwealth of Virginia in the amount of $10,000 for the faithful observance and performance of the duties of the weighperson required herein. The bond shall be executed on a form having the exact wording as the Weighpersons Surety Bond Form furnished by the Department and shall be submitted to the Department prior to the furnishing of the tonnage material.

The Contractor shall have the weighperson perform the following:

1. Furnish a signed weigh ticket for each load that shows the date, load number, plant name, size and type of material, project number, schedule or purchase order number, and the weights specified herein.

2. Maintain sufficient documentation so that the accumulative tonnage and distribution of each lot of material, by Contract, can be readily identified.

3. Submit by the end of the next working day a summary of the number of loads and total weights for each type of material by Contract.

Trucks used to haul material shall be equipped with a cover suitable to protect the material and to protect the traveling public.

The truck tare to be used in the weighing operation shall be the weight of the empty truck determined with full tank(s) of fuel and the operator seated in the cab. The tare weight of trucks shall be recorded to the nearest 20 pounds. At the option of the Contractor, a new tare may be determined for each load. When a new tare is obtained for each load, the requirement for full tank(s) of fuel will be waived.

Net rail shipment weights may be used for pay quantities when evidenced by railroad bills of lading. However, such weights will not be accepted for pay quantities of materials that subsequently pass through a stationary mixing plant.

Scales shall conform to the requirements for accuracy and sensitivity as set forth in the National Institute of Standards and Technology Handbook No. 44 for Specification Tolerances and Requirements for Commercial and Weighing Devices. Scales used in the weighing of materials paid for on a tonnage basis shall be approved and sealed in accordance with the requirements of the policies of the Bureau of Weights and Measures of the Department of Agriculture and Consumer Services, or other approved agencies, at least once every six months and upon being moved. Hopper and truck scales shall be serviced and tested by a scale service representative at least once every six months. Hopper scales shall be checked with a minimum 500 pounds of test weights and truck scales shall be checked with a minimum 20,000 pounds of test weights.

Copies of scale test reports shall be maintained on file at the scale location for at least 18 months, and copies of all scale service representative test reports shall be forwarded to the Department.

The quantity of materials paid for on a tonnage basis shall be determined on scales equipped with an automatic printer. Truck scale printers shall print the net weight and either the gross or tare weight of each load. Hopper scale printers shall print the net weight of each load. The weigh ticket shall also show the legal gross weight for material weighed on truck scales and the legal net weight for material weighed on hopper scales.

If the automatic printer becomes inoperative, the weighing operation may continue for 48 hours provided satisfactory visual verification of weights can be made. The written permission of the District Materials Engineer shall be required for the operation of scales after 48 hours.

If significant discrepancies are discovered in the printed weight, the ultimate weight for payment will be calculated on volume measurements of the materials in place and unit weights determined by the Engineer or by other methods deemed appropriate to protect the interests of the Commonwealth.

(c) **Measurement by Cubic Yard:** Material that is measured by the cubic yard, loose measurement or vehicular measurement, shall be hauled in approved vehicles and measured therein at the point of delivery. Material measured in vehicles, except streambed gravel, silt cleanout, or other self-consolidating material will be allowed at the rate of 2/3 the volume of the vehicle. The full volume of the vehicle will be allowed for streambed gravel. Such vehicles may be of any size or type acceptable to the Engineer provided the body is of such shape that the actual contents can be readily and accurately determined. Unless all approved vehicles are of uniform capacity, each vehicle shall bear a plainly legible identification mark indicating the specific approved capacity. Each vehicle shall be loaded to at least its water level capacity.

When approved by the Engineer in writing, material specified to be measured by the cubic yard may be weighed and such weights converted to cubic yards for payment purposes. Factors for conversion from weight to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before they are used.

(d) **Measurement by Lump Sum:** When used as an item of payment, the term lump sum will mean full payment for completion of the corrrsponding item of work described in the Contract. When a complete structure or structural unit is specified as a Contract item, the unit of measurement will be lump sum, and shall include all necessary fittings and accessories. The quantities may be shown on the plans for items for which lump sum is the method of measurement. If shown, the quantities are approximate and are shown for estimating purposes only and no measurement of quantities will be made for payment. Items that are to be measured as complete units will be counted by the Inspector in the presence of a representative of the Contractor.

(e) **Measurement for Specific Materials:**

1. **Concrete (Measured by Volume Measure):** Concrete will be measured and computed by dividing the work into simple geometrical figures and adding their volumes.

2. **Concrete (Measured by Square or Lineal Measure):** Concrete will be measured and computed by dividing the work into simple geometrical figures and adding their areas or measuring linearly along the item's surface.

3. **Excavation, embankment, and borrow:** In computing volumes of excavation, embankment, and borrow, methods having general acceptance in the engineering profession will be used. When the measurement is based on the cross-sectional area, the average end area method will be used.

4. **Asphalt:** Asphalt will be measured by the gallon, volumetric measurement, based on a temperature of 60 degrees F using the following correction factors:

   a. 0.00035 per degree F for petroleum oils having a specific gravity 60/60 degrees F above 0.966

   b. 0.00040 per degree F for petroleum oils having a specific gravity 60/60 degrees F between 0.850 and 0.966

   c. 0.00025 per degree F for emulsified asphalt

   Unless volume correction tables are available, the following formula shall be used in computing the volume of asphalt at temperatures other than 60 degrees F:

   $$V1 = V \times [1 - K(T - 60)]$$

   Where:
   V = volume of asphalt to be corrected;
   V1 = volume of asphalt at 60 degrees F;
   K = correction factor (coefficient of expansion); and
   T = temperature in degrees F of asphalt to be corrected.

   When asphalt is delivered by weight, the volume at 60 degrees F will be determined by dividing the net weight by the weight per gallon at 60 degrees F.

   When specified in the Contract, asphalt will be measured by weight. Net certified scale weights, or weights based on certified volumes in the case of rail shipments, will be used as a basis of measurement, subject to correction when asphalt has been lost from the car or the distributor, disposed of, or otherwise not incorporated in the work.

   When asphalt is shipped by truck or transport, net certified weights or volumes subjected to correction for loss or foaming may be used to compute quantities.

   Only the quantity of asphalt actually placed in the work and accepted will be considered in determining the amount due the Contractor.

5. **Timber:** Timber will be measured in units of 1,000 foot board measure actually incorporated in the structure. Measurement will be based on nominal widths and thicknesses and the extreme length of each piece.

109.02—Plan Quantities

When specified in the Contract, Contract items will be measured and paid for on the basis of plan quantities. The quantities allowed for compensation will be those shown on the plans with deductions from or authorized additions to such quantities resulting from authorized deviations from the plans.

In the case of excavation, only excavation within the cross section prism will be paid for on a plan quantity basis.

If the Contractor believes that any plan quantity is incorrect, he may solicit, at his own expense, the aid of a Professional Engineer liscensed to practice engineering in the Commonwealth of Virginia to check the quantity or he may ask the Department in writing to check computations of the quantity. Written requests for a quantity check by the Department shall be accompanied by calculations, drawings, or other evidence indicating why the plan quantity is believed to be in error. If any item of the Contract is found to be in error and so verified by the Engineer, payment will be made in accordance with the corrected plan quantity.

If the Department determines during construction that there is an error in the plan quantity, or that conditions vary from those anticipated in the design to the extent that an actual measurement of a plan quantity item is warranted, the Department will make such measurement and will notify the Contractor, in writing, of the rationale for adjustment. Payment will then be based on the measured quantity in lieu of the plan quantity.

109.03—Scope of Payment

Payments to the Contractor will be made for the actual quantities of Contract items performed in accordance with the plans and the requirements of the Specifications and other Contract documents. If, upon completion of the Work, the actual quantities vary, either by an increase or decrease from the estimated quantities shown in the Contract, the Contract unit prices shall prevail and payment will be made for actual quantities performed at such unit prices, unless the unit prices have been modified by written change orders according to Sections 104 and 109.04, as determined by the Engineer.

Quantities appearing on the Proposal are estimated quantities for the basic design shown on the plans. With the Engineer's approval, the Contractor may furnish other design(s) that may involve changes in quantities or the use of different materials. However, payment will be made for the original quantities listed in the Contract only and in the units of measure given in the Contract for the basic design unless the dimensions for the basic design are changed by an authorized change order to conform to field conditions encountered. In this event, the original quantities listed will be modified based on the change in dimension, and the modified quantities will be used for pay quantities at Contract unit prices for the items listed on the Proposal.

The Contractor shall accept the compensation provided for in the Contract as full payment for the following:

(a) Furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the Work according to the Contract.

(b) Performing all work specified in the Contract.

(c) All loss or damage arising from the nature of the Work or from action of the elements or any other unforeseen difficulties that may be encountered during prosecution of the Work and until its final acceptance.

(d) Any license, use, or infringement of a patent, trademark, or copyright.

(e) The completion of the Work in accordance with the Contract requirements.

If the payment clause in the Specifications relating to any unit price in the Contract requires that the unit price cover and be considered compensation for certain work or material essential to the item, the

work or material will not be measured or paid for under any other item except as provided in Section 106.05.

The payment of any partial estimate, the final estimate, or any retainage shall in no way affect the obligation of the Contractor to repair or replace any unacceptable, unauthorized or defective work or materials, or to be responsible for all damages attributable to such unacceptable, unauthorized or defective work or materials.

109.04—Payment for Non-Significant Changes and Additional Units of In-scope Work

When the accepted quantities of work vary from the estimated quantities set forth in the Contract, whether or not there have been any alterations in the plans, the quantities of work, or the character of work, the Contractor shall accept as payment in full, so far as Contract items are concerned, payment at the original Contract unit prices for the accepted quantities of work performed, except where such variance is a significant change as set forth in Section 104.02. No allowance or other adjustment except as provided for a significant change in Section 104.02 will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting directly from such variance, or from the Contractor's unbalanced allocation among the Contract items of overhead expense and subsequent loss of expected reimbursements therefor, or from any other cause.

109.05—Payment for Contract Changes

The Department will pay the Contractor for adjustments to the Contract amount based on one of the following methods.

(a) **Payment for Extra Work**

The Department may add any extra work that in the judgment of the Engineer is necessary for the satisfactory fulfillment of the Contract within its intended scope. Extra work may be accomplished by change order if the scope is defined as provided in this Section (a), or on a force account basis, if the scope is not defined as provided in Section 109.05(b). Where possible, the Department and Contractor will each proceed to secure any information, documentation, or plans to assist in detailing the extent and character of such work, if known, in sufficient detail to define, analyze, and estimate the cost and time required to perform such work. Extra work does not include overruns of Contract items according to 104.02.

1. The Engineer may notify the Contractor in writing that extra work is necessary. When no such notice is given, but the Contractor believes extra work is necessary, he shall notify the Engineer in writing within 2 days of such a determination or before performing any such work. If the Engineer agrees with the Contractor, the Engineer will notify the Contractor that extra work is necessary. Within 7 days of the Engineer notifying the Contractor of extra work, or within such time as mutually decided with the Engineer, the Contractor shall submit a proposal that includes a determination of the extent of such work, and the additional compensation and/or time he seeks, if any, relative to his determination. The Contractor's request shall be in sufficient detail to enable the Engineer to determine the basis for and extent of the Contractor's entitlement to additional compensation or time. Failure on the part of the Contractor to furnish sufficient documentation or to qualify his reason for failure to do so will delay the determination of entitlement for such work. If such delay occurs, it will in no way relieve the Contractor of his obligation to meet the

Contract time limits or other Contract requirements or constitute basis for a Contractor to make a delay claim.

2. If the Contractor requests a time extension based on extra work, the requested time extension will only be considered if the extra work impacts the critical path, a controlling work item, or an interim milestone established in the Contract to the extent that it extends the Completion Date of the project beyond the lattermost of the Contract Completion Date or its most recent extension. The Contractor shall submit detailed documents and information showing how the extra work or interim milestone impacted the critical path in accordance with Section 108.04. Any time extension given, including time extensions in accordance with Section 108.04, must be included in the executed change order.

3. Upon receipt and review of the Contractor's costs for the proposed extra work, if it is found that the Contractor's prices or the time differ considerably from the Department's estimate, the Engineer may request the Contractor to provide support for his prices or his requested time extension. Where the Department and the Contractor can determine and agree upon an accurate cost and time estimation for the proposed work, the Engineer will issue a Bilateral Change Order to authorize the work. When the Contractor and the Department cannot agree upon the cost or the time estimation for the extra work after the Engineer's analysis and subsequent discussion with the Contractor, or where due to issues of emergency, safety, environmental damage, other similar critical factors as determined by the Department, the Engineer will act unilaterally and issue a Unilateral Change Order to authorize the work. The issuance of a Unilateral Change Order by the Engineer shall in no way invalidate or relinquish the Contractor's rights under Section 105.19.

(b) **Payment by Force Account**

The Department will require the Contractor to proceed with extra work on a force account basis when neither the Department nor the Contractor can firmly establish a reliable estimate for the cost of the extra work because either the scope or the quantity of work is unknown, is of such character that a price cannot be determined to a reasonable degree of accuracy, or the level of effort required to perform and complete the extra work is unknown or not quantifiable at the time of discovery or start of the extra work, and will be determined as work progresses. The compensation provided for in this Section for force account work applies only to extra work the Engineer orders in writing to be performed on a force account basis, and does not apply to any other work performed under the Contract or to claims.

The Contractor shall be paid for all labor, materials, equipment, services, supplies, taxes, overhead, profit and miscellaneous costs or expenses, for extra work performed on a force account basis in the following manner:

1. **Labor:** Unless otherwise approved, the Contractor will receive the rate of wage or scale as set forth in his most recent payroll for each classification of laborers, forepersons, and superintendent(s) who are in direct charge of the specific operation. The time allowed for payment will be the number of hours such workers are actually engaged in the work. If overtime work is authorized, payment will be at the normal overtime rate set forth in the Contractor's most recent payroll. If workers performing the class of labor needed have not been employed on the project, mutually agreed on rates will be established. However, the rates shall be not less than those predetermined for the project, if applicable. An amount equal to 45 percent of the approved force account payroll will be included in the payment

for labor to cover administrative costs, profit, and benefits and/or deductions normally paid by the Contractor.

2. **Insurance and Tax:** The Contractor will receive an amount equal to 25 percent of the approved force account payroll exclusive of additives of administrative cost as full compensation for property damage and liability, workers' compensation insurance premiums, unemployment insurance contributions, and social security taxes of force account work.

3. **Materials:** The Contractor will receive the actual cost of materials accepted by the Engineer that are delivered and used for the work including taxes, transportation, and handling charges paid by the Contractor, not including labor and equipment rentals as herein set forth, to which 15 percent of the cost will be added for administration and profit. The Contractor shall make every reasonable effort to take advantage of trade discounts offered by material suppliers. Any discount received shall pass through to the Department. Salvageable temporary construction materials will be retained by the Department, or their appropriate salvage value shall be credited to the Commonwealth, as agreed on by the Department.

4. **Equipment:** The Contractor shall provide the Engineer a list of all equipment to be used in the work. For each piece of equipment, the list shall include the serial number; date of manufacture; location from which equipment will be transported; and, for rental equipment, the rental rate and name of the company from which it is rented. The Contractor will be paid rental rates for pieces of machinery, equipment, and attachments necessary for prosecution of the work that are approved for use by the Engineer. Equipment rental will be measured by time in hours of actual time engaged in the performance of the work and necessary traveling time of the equipment within the limits of the project or source of supply and the project. Hourly rates will not exceed 1/176 of the monthly rates of the schedule shown in the Rental Rate Blue Book modified in accordance with the Rental Rate Blue Book rate adjustment tables that are current at the time the force account is authorized. Equipment rental rates not modified by the adjustment factors or rate modifications indicated in the Rental Rate Blue Book will not be considered. Hourly rates for equipment on standby will be at 50 percent of the rate paid for equipment performing work. Operating costs shall not be included in the standby rate. For the purposes herein "standby time" is defined as the period of time equipment ordered to the jobsite by the Engineer is available on-site for the work but is idle for reasons not the fault of the Contractor or normally associated with the efficient and necessary use of that equipment in the overall operation of the work at hand.

   Payment will be made for the total hours the equipment is performing work. When equipment is performing work less than 40 hours for any given week and is on standby, payment for standby time will be allowed for up to 40 hours, minus hours performing work. Payment will not be made for the time that equipment is on the project in excess of 24 hours prior to its actual performance in the force account work. An amount equal to the Rental Rate Blue Book estimated operating cost per hour will be paid for all hours the equipment is performing work. This operating cost shall be full compensation for fuel, lubricants, repairs, greasing, fueling, oiling, small tools, and other incidentals. No compensation will be paid for the use of machinery or equipment not authorized by the Engineer.

   The Contractor will be paid freight cost covering the moving of equipment to and from the specific force account operation provided such cost is supported by an invoice showing

the actual cost to the Contractor. However, such payment will be limited to transportation from the nearest source of available equipment. If equipment is not returned to the nearest equipment storage lot but is moved to another location, the freight cost paid will not exceed the cost of return to the nearest storage lot.

The rates for equipment not listed in the Rental Rate Blue Book schedule shall not exceed the hourly rate being paid for such equipment by the Contractor at the time of the force account authorization. In the absence of such rates, prevailing rates being paid in the area where the authorized work is to be performed shall be used.

If the Contractor does not possess or have readily available equipment necessary for performing the force account work and such equipment is rented from a source other than a company that is an affiliate of the Contractor, payment will be based on actual invoice rates, to which 15 percent of the invoice cost will be added for administrative cost and profit. If the invoice rate does not include the furnishing of fuel, lubricants, repairs, and servicing, the invoice rate will be converted to an hourly rate, and an amount equal to the Rental Rate Blue Book estimated operating cost per hour will be added for each hour the equipment is performing work.

5. **Miscellaneous:** No additional allowance will be made for attachments that are common accessories for equipment as defined in the Rental Rate Blue Book, general superintendents, timekeepers, secretaries, the use of small hand held tools or other costs for which no specific allowance is herein provided. The Contractor will receive compensation equal to the cost of the bond, special railroad insurance premiums, and other additional costs necessary for the specific force account work as determined by the Department. The Contractor shall supply documented evidence of such costs.

6. **Compensation:** The compensation as set forth in this Section shall be accepted by the Contractor as payment in full for work performed on a force account basis. At the end of each day, the Contractor's representative and the Inspector shall compare and reconcile records of the hours of work and equipment, labor and materials used in the work as ordered on a force account basis. Such accounting may not include actual costs or labor rates where these are not available but shall be used to verify quantities, types of materials or labor, and number and types of equipment.

   If all or a portion of the force account work is performed by an approved subcontractor, the Contractor will be paid 10 percent of the subcontract net force account costs to cover the Contractor's profit and administrative cost. The amount resulting will not be subject to any further additives. The itemized statements of costs as required below shall be submitted on a form that separates the subcontracted portions of the force account labor, materials, and equipment from the other force account costs.

7. **Statements:** Payments will not be made for work performed on a force account basis until the Contractor has furnished the Engineer duplicate itemized statements of the cost of such work detailed as follows:

   a. payroll indicating name, classification, date, daily hours, total hours, rate, and extension of each laborer, foreperson, and superintendent.

   b. designation, dates, daily hours, total hours, rental rate, and extension for each unit of equipment.

c. quantities of materials, prices, and extensions.

d. transportation of materials.

Statements shall be accompanied and supported by invoices for all materials used and transportation charges. However, if materials used on the force account work are not specifically purchased for such work but are taken from the Contractor's stock, then in lieu of the invoices, the Contractor shall furnish an affidavit certifying that such materials were taken from his stock; that the quantity claimed was actually used; and that the price, transportation, and handling claimed represented his actual cost.

(c) **Payment for Significant Changes**

When the Contractor alleges that there is a significant change as defined in Section 104.02, then, within a mutually agreed upon timeframe, he shall submit a request for the additional compensation, excluding anticipated profits for reduced or eliminated work, for such significant change. The Contractor's request shall be in sufficient detail to enable the Engineer to determine the basis for and extent of the Contractor's entitlement to additional compensation.

Failure on the part of the Contractor to furnish sufficient documentation or to qualify his reason for failure to do so will delay the determination of entitlement to additional compensation. If such delay occurs, it will in no way relieve the Contractor of his obligation to meet milestone dates, the Contract time limit, or other Contract requirements, or constitute the basis for a claim of any kind.

(d) **Payment for Differing Site Conditions**

When the Contractor encounters a differing site condition as defined in Section 104.03, then, within a mutually agreed upon timeframe, he shall submit a written request for the additional compensation, excluding anticipated profits, he seeks as a result of such condition. The Contractor's request shall be in sufficient detail to enable the Engineer to determine the basis for and extent of the Contractor's entitlement to additional compensation.

Failure on the part of the Contractor to furnish sufficient documentation or to qualify his reason for failure to do so will delay the determination of entitlement to additional compensation. If such delay occurs, it will in no way relieve the Contractor of his obligation to meet the Contract time limits or other Contract requirements or constitute basis for a claim of any kind.

If the Engineer determines that the conditions materially differ and cause an increase or decrease in the cost required for the performance of any of the Work, an adjustment, excluding anticipated profits, will be made and the Contract may be modified accordingly.

(e) **Payment for Compensable Delay**

The Contractor is entitled to compensation for a compensable delay. Compensable delays are critical delays that are not the Contractor's fault or responsibility and are the Department's fault or responsibility. Compensable delays may include, but are not limited to:

- Delays due to alteration of quantities or character of work according to 104.02.
- Delays due to differing site conditions according to 104.03.
- Delays due to an Engineer-ordered suspension according to 108.05.

- Delays due to the acts or omissions of the Department or its failure to act in a timely manner.

The following delays are not compensable:

- Acts or omissions of the Contractor, its agents, employees, subcontractors or suppliers or causes within their control; or conditions that the Contractor could reasonably have foreseen or avoided.

- Floods, tidal waves, tornadoes, hurricanes, lightning strikes, earthquakes, fires, epidemics, or similar natural phenomena.

- Normal adverse weather.

- Extraordinary, unforeseen, and unavoidable delays in material deliveries.

- Acts of government entities other than the Department.

- Unforeseen and unavoidable industry-wide labor strikes affecting the Contractor or its subcontractors' or suppliers' workforce that are beyond the Contractor's control.

- Actions of third parties that are not the responsibility of the Contractor or within it's or the Department's control.

- Civil disturbances or sovereign acts of the State, including but are not limited to states of emergency or epidemic or quarantine restrictions.

To request payment for a compensable delay, the Contractor shall within 14 days after the end date of a delay event, unless directed otherwise in writing by the Engineer, submit a written request for a change order for the Engineer's approval. With the request, the Contractor shall submit a Schedule Impact Analysis (SIA) and all supporting data to objectively substantiate its request. The Engineer will evaluate the Contractor's SIA and all supporting data to determine entitlement and the appropriate amount of compensation, according to the following:

1. **Field Office Overhead (FOOH)**

   a. FOOH is the extended project field office overhead and site costs and expenses that are not attributable to specific Contract pay items, but are incurred in support of the project as a result of a delay, which include:

      (1) Extended site supervision costs such as salaries for project field superintendent and administrative staff.

      (2) Extended site office costs such as utilities, trailers, field office, office equipment, and sanitary and toilet facilities.

      (3) Extended site equipment and tool costs for support equipment and tools that are not used for specific Contract pay items.

   b. The Contractor is entitled to FOOH only for compensable delays for which the Engineer has granted a Contract time extension. The Contractor is not entitled to additional compensation for FOOH for delays that are caused by extra work performed on a Force Account basis or for increased quantities.

c. The Contractor's agreed amount of compensation for FOOH shall be based on the project daily FOOH rate derived from the Contractor's Itemized Project FOOH Costs set out on the Department's form or other format acceptable to the Engineer. The Contractor shall submit the form to the Engineer no later than 30 days after the Notice to Proceed date or on a date approved by the Engineer. On the form, the Contractor shall list each project FOOH item, the total estimated costs or expenses for each FOOH item for the original Contract time, the total project FOOH, and the project daily FOOH rate based on the total project FOOH divided by the original Contract duration. The compensation for FOOH will be calculated as follows:

(Daily FOOH Rate) x (No. of Days of Compensable Delay) = (Amount of FOOH Liquidated Damages)

2. **Home Office Overhead (HOOH)**

HOOH is the Contractor's allowable home office overhead costs and expenses that cannot be attributed and are not billed to a particular project, but are incurred in support of all of the Contractor's projects, including but not limited to rent, office equipment and furnishings, insurance, office supplies, depreciation, taxes, and utilities, as well as executive salaries, administrative staff salaries, project support staff salaries, and accounting and payroll services.

a. The Contractor is entitled to payment of HOOH only for compensable delays for which the Engineer has granted a Contract time extension and only when the Contractor could not reasonably recoup its HOOH while its workforce was idled by the delay because the Contractor was required to remain on standby, ready to resume work, and unable to perform other work at the project or elsewhere during the delay. The Contractor is not entitled to compensation for HOOH for delays that are caused by extra work performed on a Force Account basis or by increased quantities.

b. The agreed amount of compensation for extended or unabsorbed HOOH for a compensable delay will be determined as follows:

$$\frac{(A \times C)}{B} = D$$

$$D \times E = F$$

Where:

A = Original total Contract amount
B = Original Contract duration (number of calendar days between and inclusive of the Contract Notice to Proceed (NTP) date and the original Contract Completion Date)
C = 6% (Agreed allowable HOOH percentage)
D = Daily allowable HOOH rate
E = Number of days of compensable delay
F = Agreed amount of compensation for HOOH

3. **When to Audit to Determine FOOH and HOOH**

The Contractor may propose a higher rate determined according to Federal Acquisition Regulations 48 CFR § 31 or other accounting standard if the Contractor determines that the agreed allowable HOOH percentage is insufficient.

The Itemized Project FOOH Costs (IPFC) and FOOH shall be subject to field verification and Department audit, at any time, as determined by the Engineer, if the Engineer determines that the rate the Contractor submits is not an accurate representation of the Contractor's actual FOOH at the time of occurrence of the delay. If the Engineer determines the daily FOOH rate is not an accurate representation of the Contractor's actual FOOH, the Contractor shall submit its actual project FOOH records at the time of occurrence of the delay, as requested by the Engineer. The Department may perform an audit of the Contractor's records as necessary to verify the Contractor's actual project FOOH. Adjustments to the daily FOOH rate may be made upon verification or Department audit of the Contractor's actual project FOOH. The project daily FOOH rate will then be calculated utilizing the rate determined by the audit. The Department may also elect to perform an audit of the Contractor's actual project FOOH at the completion of the Contract, as determined by the Engineer, in which case the project FOOH paid previously by change order may be adjusted based on the rate determined by the audit.

The Contractor's actual extended FOOH are defined to be those costs and expenses incurred from the original Contract time limit to the actual final acceptance of the project as documented by timesheets, payroll records, accounting records, contracts, invoices, bills, receipts, tickets, cancelled checks, and similar business records showing the costs and expenses actually incurred for the project field supervision and administrative staff, project field office, and overhead items submitted in accordance with this provision; and the records must be accurate and auditable.

If the total sum of the extended project FOOH and unabsorbed or extended HOOH for all approved change orders exceeds 20 percent of the original Contract amount, the Department may at its option calculate the amount of FOOH and HOOH based on a Department audit of the Contractor's actual project FOOH and HOOH records. In such event, the Department will perform the audit according to Section 103.08 at the Department's expense. The Department audit may begin on 10-days notice to the Contractor, its subcontractors, and suppliers. The Contractor, subcontractors, and suppliers shall make a good faith effort to cooperate with the auditors.

4. **Other Delay Costs**

The Contractor may incur costs attributable to compensable delays in addition to FOOH and HOOH. These costs include, but are not limited to, labor cost escalation, material costs escalation, idle equipment costs, and idle labor costs. These costs shall be determined according to the applicable provisions herein.

109.06—Common Carrier Rates

The common carrier rates and taxes thereon that are current on the date of the opening of bids shall be considered applicable to all items subject to transportation charges thereunder. If such rates or taxes are thereafter increased by public authority on any materials entering into and forming a part of the Contract, an amount equal to the sum of all such increases, when evidenced by receipted common carrier bills, will be paid the Contractor by the Department. Requests for such payments shall be made not later than 60 days after final acceptance. If, after the date of the opening of bids, such rates or taxes are reduced by public authority on any materials entering into and forming a part of the Contract, an amount equal to the sum of all such decreases, when evidenced by receipted common carrier bills, will be deducted by the Department from the monies due the Contractor for the work performed under the Contract.

The carrier rates for petroleum tank truck carriers, as defined in the Code of Virginia, that are in effect on the date of the opening of bids for the project shall be considered effective for at least one year after that date. After one year from that date, the Department will pay the Contractor additional compensation equal to the cost of any carrier rate increases, subject to a maximum of eight percent of the original carrier rate for any materials ordered, delivered, and actually incorporated into the work after the one year period. However, the Contractor shall advise the Engineer in writing of his intent to request additional compensation attributable to carrier rate changes at the time of occurrence and shall submit receipted carrier bills and all relative information concerning the original and current carrier rates as they pertain to the project. If carrier rates are decreased after the one year period, the Department will deduct from monies due the Contractor an amount equal to the cost of any carrier rate decreases, subject to a maximum of eight percent of the original carrier rate, for any materials ordered, delivered, and actually incorporated into the work, based on receipted carrier bills that shall be furnished by the Contractor. On each succeeding year of the Contract, a maximum difference of eight percent of the original rate will be considered for increases or decreases in compensation under these terms and conditions.

Except for the aforementioned carriers, additional compensation attributable to changes in hauling rates of other contract carriers will not be allowed.

109.07—Eliminated Items

If all or a part of any Contract item is determined to be unnecessary for the proper completion of the Work, the Department may, upon written notice to the Contractor and issuance of an appropriate change order, eliminate all or part of such item from the Contract. Payment will not be made for such item except that the Contractor will be compensated for the actual cost of any work performed for such item and the net cost of materials purchased, including freight and tax costs, as evidenced by invoice. No additional compensation will be made for overhead or anticipated profit.

109.08—Partial Payments

(a) **General**

Partial payments will be based on a monthly progress estimate consisting of approximate quantities and value of work performed as determined by the Engineer. When the method of measurement for a Contract item is in units of each or lump sum, the value of work accomplished for partial payment will be determined on a pro rata basis. Partial payments will be made once each month for the work performed in accordance with the Contract requirements. The Contractor will be given the opportunity to review the monthly progress estimate prior to each partial payment. Upon final acceptance, one last monthly estimate will be prepared and any additional payment due will be vouchered for payment.

The monthly progress estimates will be prepared in accordance with the following schedule:

1. **Contractor companies whose name begins with the letter A through F:** The monthly progress estimate will be prepared on the 4th day of each month, beginning on the first 4th day following the date of the Contract execution, and on the same day of the succeeding months as the work progresses.

2. **Contractor companies whose name begins with the letter G through P:** The monthly progress estimate will be prepared on the 11th day of each month, beginning on the first

11th day following the date of the Contract execution, and on the same day of the succeeding months as the work progresses.

3. **Contractor companies whose name begins with the letter Q through Z:** The monthly progress estimate will be prepared on the 20th day of each month, beginning on the first 20th day following the date of the Contract execution, and on the same day of the succeeding months as the work progresses.

For contracts without a payment bond, the Contractor shall submit to the Engineer a letter from each materials supplier and subcontractor involved stating that the Contractor has paid or made satisfactory arrangements for settling all bills for materials and subcontracted work that was paid on the previous month's progress estimate. The Department will use the source of supply letter and approved subletting request to verify that certifications have been received for work that was paid on the previous monthly estimate. The Contractor shall furnish these and other certificates as are required as a prerequisite to the issuance of payment for the current monthly estimate.

The Department may withhold the payment of any partial or final estimate voucher or any sum(s) thereof from such vouchers if the Contractor fails to make payment promptly to all persons supplying equipment, tools, or materials; or for any labor he uses in the prosecution of the Contract work. Unless otherwise provided under the terms of the Contract, interest shall accrue at the rate of one percent per month.

(b) **Payment to Subcontractors**

Upon Department payment of the subcontractor's portion of the work as shown on the monthly progress estimate and the receipt of payment by the Contractor for such work, the Contractor shall make compensation in full to the subcontractor. For the purposes of this Section, payment of the subcontractor's portion of the Work shall mean that payment has been issued for that portion of the Work that was identified on the monthly progress estimate for which the subcontractor has performed service.

Payment to subcontractors shall be in accordance with the provisions of Code of Virginia §2.2-4354 and § 2.2-4355. The Contractor shall take one of the following two actions within 7 days after receipt of payment from the Department for the subcontractor's portion of the Work as shown on the monthly progress estimate:

1. Pay the subcontractor for the proportionate share of the total payment received from the agency attributable to the Work performed by the subcontractor; or

2. Notify the Department and subcontractor, in writing, of his intention to withhold all or a part of the subcontractor's payment along with the reason for nonpayment.

In the event payment is not made as required, the Contractor shall pay interest at the rate of one percent per month, unless otherwise provided in the Contract, to the subcontractor on all amounts that remain unpaid after 7 days, except for the amounts withheld as provided in this Section. The Contractor shall include in each of its subcontracts a provision requiring each subcontractor to include or otherwise be subject to the same payment and interest requirements with respect to each lower tier subcontractor.

If the Contractor fails to make payment to the subcontractor within the time frame specified herein, the subcontractor shall notify the Engineer and the Contractor's bonding company

in writing. The Contractor's bonding company shall be responsible for insuring payment in accordance with this Section and Section 107.01.

(c) **Retainage**

If the Engineer determines the Contractor's progress is unsatisfactory according to Section 108.03 or other applicable Contract documents, the Engineer will send a notice of unsatisfactory progress to the Contractor advising him of such determination. This notification will also advise the Contractor that five percent retainage of the monthly progress estimate is being withheld and will continue to be withheld for each month the Contractor's actual progress is determined to be unsatisfactory.

When the Engineer determines that the Contractor's progress is satisfactory in accordance with these requirements, the 5 percent retainage previously withheld because of unsatisfactory progress will be released in the next monthly progress estimate, and the remaining monthly progress estimates will be paid in full provided the Contractor's progress continues to be satisfactory.

109.09—Payment for Material on Hand

When requested in writing by the Contractor, payment allowances may be made for materials secured for use on the project and required to complete the project. Such material payments will be made for only those actual quantities of materials identified in the Contract, approved change orders, or otherwise authorized and documented by the Engineer based on delivery tickets, bills of lading, or paid invoices. All such payments shall be in accordance with the following terms and conditions:

(a) **Structural Steel or Reinforcing Steel:** An allowance of 100 percent of the cost to the Contractor for structural steel **or reinforcing steel** materials secured for fabrication not to exceed 60 percent of the Contract price may be made when such material is delivered to the fabricator and has been adequately identified for exclusive use on the project. The provisions of this section for steel reinforcement will only apply where the quantity of steel reinforcement is identified as a separate and distinct bid item for payment. An allowance of 100 percent of the cost to the Contractor for superstructure units and reinforcing steel, not to exceed 90 percent of the Contract price, may be made when fabrication is complete. Prior to the granting of such allowances, the materials and fabricated units shall have been tested or certified and found acceptable to the Department and shall have been stored in accordance with the requirements specified herein. Allowances will be based on invoices, bills, or the estimated value as approved by the Engineer and will be subject to the retainage requirements of Section 109.08. For the purposes of this section fabrication is defined as any manufacturing process such as bending, forming, welding, cutting or coating with paint or anti-corrosive materials which alters, converts, or changes raw material for its use in the permanent finished work.

(b) **Other Materials:** For aggregate, pipe, guardrail, signs and sign assemblies, and other nonperishable material, an allowance of 100 percent of the cost to the Contractor for materials, not to exceed 90 percent of the Contract price, may be made when such material is delivered to the project and stockpiled or stored in accordance with the requirements specified herein. Prior to the granting of such allowances, the material shall have been tested and found acceptable to the Department. Allowances will be based on invoices, bills, or the estimated value of the material as approved by the Engineer and will be subject to the retainage provisions of Section 109.08.

(c) **Excluded Items:** No allowance will be made for fuels, form lumber, falsework, temporary structures, or other work that will not become an integral part of the finished construction. Additionally, no allowance will be made for perishable material such as cement, seed, plants, or fertilizer.

(d) **Storage:** Material for which payment allowance is requested shall be stored in an approved manner in areas where damage is not likely to occur. If any of the stored materials are lost or become damaged, the Contractor shall repair or replace them at no additional cost to the Department. Repair or replacement of such material will not be considered the basis for any extension of Contract time. If payment allowance has been made prior to such damage or loss, the amount so allowed or a proportionate part thereof will be deducted from the next progress estimate payment and withheld until satisfactory repairs or replacement has been made.

When it is determined to be impractical to store materials within the limits of the project, the Engineer may approve storage on private property or, for structural units and reinforcing steel, on the manufacturer's or fabricator's yard. Requests for payment allowance for such stored material shall be accompanied by a release from the owner or tenant of such property or yard agreeing to permit the removal of the materials from the property without cost to the Commonwealth. The Department must be allowed access to the materials for inspection during normal business hours.

(e) **Materials Inventory:** If the Contractor requests a payment allowance for properly stored material, he shall submit a certified and itemized inventory statement to the Engineer no earlier than 5 days and no later than 2 days prior to the progress estimate date. The statement shall be submitted on forms furnished by the Department and shall be accompanied by supplier's or manufacturer's invoices or other documents that will verify the material's cost. Following the initial submission, the Contractor shall submit to the Engineer a monthly-certified update of the itemized inventory statement within the same time frame. The updated inventory statement shall show additional materials received and stored with invoices or other documents and shall list materials removed from storage since the last certified inventory statement, with appropriate cost data reflecting the change in the inventory. If the Contractor fails to submit the monthly-certified update within the specified time frame, the Engineer will deduct the full amount of the previous statement from the progress estimate.

At the conclusion of the project, the cost of material remaining in storage for which payment allowance has been made will be deducted from the progress estimate.

109.10—Final Payment

When final acceptance has been duly made by the Engineer as provided for in Section 108.09 the Engineer will prepare the final statement of the quantities of the items of work performed. Thereafter, the Contractor will be afforded 10 days in which to review the final estimate before payment. The time may be extended by mutual agreement, and the extension added to the 90-day criteria set forth within this Section.

Prior partial estimates and payments shall be subject to correction in the final estimate and payment.

For Contracts not requiring a payment bond, the Contractor shall certify to the Department that he has paid or made satisfactory arrangements for settling all bills for materials, labor, equipment, supplies, and other items entering into or used on the work and shall furnish other certificates as are required by the Department as a prerequisite to the issuance of final payment.

Failure by the Contractor to provide required information and certifications will extend the 90-day period for final payment by the number of days equivalent to the delay attributable to the Contractor.

Upon review of the final estimate by the Contractor and approval by the Engineer, the Contractor will be paid the entire sum due after previous payments are deducted and other amounts are retained or deducted under the provisions of the Contract. Final payment will become due within 90 days after final acceptance.

Interest will accrue on the amount the Department owes to the Contractor that remains unpaid after 7 days following the 90-day payment date. The rate of interest will be the base rate on corporate loans (prime rate) at large U.S. money center commercial banks as reported daily in The Wall Street Journal. When a split rate is published, the lower of the two rates shall be used. The rate effective on the 91st day following final acceptance will be applicable throughout the period of time for which interest is paid. However, in no event shall the rate of interest paid exceed the rate of interest established pursuant to the Code of Virginia. The period subject to payment of interest will begin on the 91st calendar day after final acceptance and will extend through the date of the payment of the final estimate.

When the payment date is delayed beyond the 90-day period by the fault of the Contractor and monies are due the Commonwealth, the Contractor will be assessed annual interest on the balance due the Commonwealth for the time delay attributable to the Contractor. The rate of interest will be determined as specified hereinbefore. The Department may deduct monies owed to the Commonwealth from the final payment. If the final payment is insufficient, monies owed to the Commonwealth will become due and payable within 30 days of Contractor's receipt of a certified letter giving notification of the amount owed. The Contractor will be assessed annual interest at the rate determined as specified within this Section for any balance that remains unpaid after 37 days from receipt of the letter.

After final acceptance and prior to final payment, the Contractor may request reimbursement for additional performance and payment bond premiums, but only to the extent that the final Contract amount exceeds the original Contract amount. If the Contractor requests reimbursement on such additional bond premiums the Contractor shall submit to the Department a written request for reimbursement, together with a notarized statement from the surety, or its agent that certifies the Contractor's actual bond premium rate for any increase in the amended Contract amount above the original Contract amount. Such request shall also contain the Contractor's calculation of the additional premium requested for reimbursement as verified by the surety or its agent.

Upon submission of such request from the Contractor, the Department will calculate the additional bond premium payment due the Contractor by multiplying the difference between the final Contract amount, including all change orders, overruns, and adjustments, and the original Contract amount, times the percentage bond premium rate provided by the Contractor and certified by the surety or its agent. The additional premium amount will be paid to the Contractor on the final estimate.

Division II
MATERIALS

SECTION 200—GENERAL

200.01—Description

These specifications cover general sampling and testing requirements and procedures, certifications for aggregate acceptance, and certifications and responsibilities of technicians and batchers for asphalt and hydraulic cement concrete.

200.02—Conformance with Specifications

Materials shall conform to these specifications in accordance with Section 106.06. Whenever a reference to a material is followed by a reference to a specification, the material shall conform to the referenced specification.

Material that is required to conform to these specifications shall not be used until it has been approved by the Engineer.

Where maximum and minimum limits are given for a characteristic of a material, material whose specified characteristic approximates the mean value shall be furnished. The specified limits shall not be exceeded.

When a material is fabricated of or treated with another material or when any combination of materials is assembled to form a product, the failure of any component to comply with the applicable specification shall be sufficient cause for rejection of the whole unless the combination of components will produce a product satisfactory to the Engineer.

If the Contractor desires to substitute another material for that specified, he shall submit proof that the substitute material is equal in all respects to the material specified. Proof shall be in the form of specifications for the proposed substitution that may be readily compared with the specifications for the original material.

200.03—General Sampling and Testing Procedures

Materials shall be evaluated for compliance according to the requirements of standard AASHTO, ASTM, or federal test methods or methods devised by the Department as specified in the applicable specifications or as approved by the Engineer. At the discretion of the Engineer, the Contractor may furnish a certification of conformity from the manufacturer in lieu of testing.

The Engineer reserves the right to retest any material that has previously been tested or accepted on certification and reject that material if it is found to be defective.

The Department has developed test methods for the evaluation of certain materials or their properties. These test methods are identified by the prefix VTM (Virginia Test Method) followed by a number that will identify the specific VTM to be used. Copies of the Department's test methods may be obtained from the Department's Materials Division.

Sampling of materials shall be performed in accordance with the standard methods of the Department. When required, samples submitted to the Department's laboratories shall be accompanied by an MSDS. Failure by the Contractor to submit an MSDS will be cause for rejection of the material.

When a material is to be tested prior to delivery to the project, the Contractor shall furnish complete identification of the material and its specific intended use in the proposed construction, including references to the plans or specifications calling for the material.

Material will be inspected at the original or intermediate source of supply whenever it is economically advantageous to the Department. This inspection does not relieve the Contractor of the responsibility to furnish materials that conform to the specifications. The Department's representative will be provided ready access to all parts of any processing plant furnishing material for a project. Access for sampling and inspecting materials or plant equipment shall include secure, sturdy platforms conforming to local, state, and federal safety regulations.

The Department may discontinue the use of a plant laboratory for acceptance testing in the event of a mechanical malfunction of the laboratory equipment and in cases of emergency involving plant inspection personnel. In such event, acceptance testing will be performed at the district or central office laboratory until the malfunction or emergency has been satisfactorily corrected or resolved.

200.04—Acceptance Procedures for Aggregates

Aggregates conforming to the requirements of Section 207 (for Type I) and Section 208 will be accepted under a quality assurance program that uses statistical concepts. Aggregate materials shall conform to such requirements prior to the addition of any admixtures.

Acceptance procedures for other aggregates will be according to the requirements of an approved production control plan conforming to the policies of the Department with regard to sampling and testing. Shipments of aggregates accepted under such a production control plan shall be accompanied by the following certification:

Aggregate Certification

Aggregate shipped under this certification has been tested and conforms to VDOT's requirements.

_____

Signature and Title

The certification may be printed or stamped on the delivery ticket or affixed by a gummed label thereto. The certification shall be signed by an authorized representative of the aggregate supplier and given to the Engineer upon delivery of the aggregate.

The No. 10 sieve shall be the dividing sieve for soils, select material, aggregate subbase material, and aggregate base material. The No. 8 sieve shall be the dividing sieve for asphalt concrete aggregates. That portion of the total aggregate retained on the sieves is defined as *coarse aggregate,* and that portion passing the sieves is defined as *fine aggregate.* Soundness tests will be performed according to the requirements of AASHTO T104 without regard to these definitions of fine and coarse aggregate. Fine and coarse aggregates for hydraulic cement concrete are distinguishable by their conformity to the series of grading requirements specified in Section 202 and Section 203, respectively.

The term *nonpolishing aggregate* shall mean aggregate that the Department has determined will result in a surface of acceptable skid resistance when it is used and exposed as part of a roadway or bridge deck wearing surface. The Department reserves the right to evaluate and determine the acceptability of polishing characteristics of aggregate proposed for use in pavement and bridge deck surfaces.

Crushed glass may be used for construction in drainage, embankment and backfilling applications, except for undercutting and foundation support for bridges, abutments, retaining walls and box culverts. The substitution of crushed glass is limited to applications using material of size 3/8 inch and smaller where allowed for use in the Specifications.

200.05—Handling and Storing Aggregates

Stockpiles of aggregate shall be constructed on areas that are hard, well drained, and denuded of vegetation. The different sizes and kinds of aggregates shall be kept separate during handling and storage and until batched. Care shall be taken to prevent segregation of coarse and fine particles during handling and storing.

Aggregates placed directly on the ground shall not be removed from the stockpiles within 1 foot of the ground until final cleanup. The Engineer will only permit the use of clean aggregates removed from within 1 foot of the ground.

200.06—Technician and Batcher Certification

Certification for technicians and batchers will be awarded by the Department upon a candidate's satisfactory completion of an examination.

(a) **Central Mix Aggregate Technician:** A Central Mix Aggregate Technician designs and makes necessary adjustments in job mixtures at the aggregate plant based on an analysis of the specified material. The technician also samples materials and conducts any tests necessary to put the aggregate plant into operation and produce a mixture in accordance with the applicable Specifications.

(b) **Asphalt Plant Level I Technician:** An Asphalt Plant Level I Technician samples materials to be used in asphalt production.

(c) **Asphalt Plant Level II Technician:** An Asphalt Plant Level II Technician samples material to be used in asphalt production and is capable of conducting any tests necessary to put the asphalt plant into operation.

(d) **Concrete Plant Technician:** A Concrete Plant Technician performs necessary adjustments in the proportioning of material used to produce the specified concrete mixtures.

(e) **Concrete Batcher:** A Concrete Batcher performs the batching operation of materials used to produce the specified concrete mixtures. The batcher implements adjustments only at the direction of a certified Concrete Plant Technician unless the batcher's certification authorizes otherwise.

(f) **Asphalt Field Level I Technician:** An Asphalt Field Level I Technician provides quality control of the placement operations of Asphalt Concrete.

(g) **Asphalt Field Level II Technician:** An Asphalt Field Level II Technician inspects asphalt concrete placement to ensure and verify conformance with applicable requirements.

(h) **Concrete Field Technician:** A Concrete Field Technician provides quality control of placement operations for hydraulic cement concrete in accordance with applicable requirements.

(i) **Asphalt Mix Design Technician:** An Asphalt Mix Design Technician is responsible for designing and adjusting asphalt mixes as needed, reviewing and approving all test results, having direct communication with the asphalt plant for making recommended adjustments and is capable of conducting any tests necessary to put the asphalt plant into operation.

(j) **Aggregate Properties Technician:** An Aggregate Properties Technician conducts all aggregate tests on aggregate used in asphalt concrete and verify conformance to applicable requirements.

(k) **Slurry Surfacing Technician:** A Slurry Surfacing Technician inspects the placement of emulsified asphalt slurry seal and latex modified emulsion treatment (Micro-surfacing) and verify conformance with applicable requirements.

(l) **Surface Treatment Technician:** A Surface Treatment Technician inspects the placement of single seal and modified (blotted) seal coats to ensure and verify conformance to applicable requirements.

SECTION 201—MINERAL FILLER

201.01—Description

These specifications cover inorganic material such as lime or fly ash, usually of very fine grading, added to soil or asphalt to produce a desired effect.

201.02—Detail Requirements

Mineral filler shall conform to the requirements of AASHTO M17. Tests to verify conformance will be performed in accordance with AASHTO T37.

SECTION 202—FINE AGGREGATE

202.01—Description

These specifications cover material for use as fine aggregate in the production of hydraulic cement concrete, mortar, asphalt concrete, and asphalt surface treatments.

202.02—Materials

Fine aggregate is classified herein in according to its natural occurrence or method of manufacture as natural sand or stone sand. Natural sand shall consist of grains of hard, sound material, predominantly quartz, occurring in natural deposits or in loosely bound deposits, such as sandstone conglomerate. Stone sand shall consist of sound crushed particles of approved Grade A stone, essentially free from flat or elongated pieces, with sharp edges and corners removed.

Fine aggregates for use in hydraulic cement concrete that are obtained from more than one source shall not be used alternately or mixed without the Engineer's approval.

202.03—Detail Requirements

(a) **Grading:** Grading shall conform to the requirements of Table II-1. Tests to verify conformity shall be performed according to the requirements of AASHTO T27.

(b) **Soundness:** Soundness shall conform to the requirements of Table II-2. Tests to verify conformity shall be performed according to the requirements of AASHTO T103 or T104.

(c) **Organic Impurities:** When fine aggregate is to be used in hydraulic cement concrete, the percentage of organic impurities shall conform to the requirements of AASHTO T21; however, material producing a darker color than that specified in AASHTO T21 may be accepted in accordance with AASHTO M6.

(d) V**oid Content:** Void content shall be tested to verify conformity according to the requirements of VTM-5.

(e) **Deleterious Material:** The amount of deleterious material in sands shall be not more than the following:

Material	% by Weight	AASHTO Test Method
Clay lumps	0.25	T112
Shale, mica, coated grains, soft or flaky particles	1.0	T113
Organic material	0	T21
Total material passing No. 200 sieve by washing[1]		T11 and T27
For use in concrete subject to abrasion	3	
For other concrete	5	

[1]In the case of stone sand, if the material passing the No. 200 sieve is dust of fracture, essentially free from clay and shale, the percentages shown for use in concrete subject to abrasion and in other concrete may be increased to 5.0 percent and 7.0 percent, respectively.

TABLE II-1
Fine Aggregate

	Amounts Finer Than Each Laboratory Sieve (Square Opening) (% by Weight)							
Grading	**3/8 in.**	**No. 4**	**No. 8**	**No. 16**	**No. 30**	**No. 50**	**No. 100**	**No. 200**
A	Min. 100	95-100	80-100	50-85	25-60	5-30	Max. 10	
B	Min. 100	94-100					Max. 10	
C	Min. 100	94-100				Max. 25		

TABLE II-2
Soundness

	Max. Soundness Loss (%)	
Use	**Magnesium Sulphate (5 Cycles)**	**Freeze and Thaw (100 Cycles)**
Hydraulic cement concrete	18	8
Asphalt concrete surfaces and surface treatments	25	15
Asphalt concrete bases	30	15

SECTION 203—COARSE AGGREGATE

203.01—Description

These specifications cover material used as coarse aggregate in the production of hydraulic cement concrete, asphalt concrete, asphalt surface treatments, and in drainage.

203.02—Materials

Coarse aggregate shall consist of crushed stone, crushed slag, crushed or uncrushed gravel with clean, hard, tough, and durable pieces free from adherent coatings and deleterious amounts of friable, thin, elongated, or laminated pieces; soluble salts; or organic materials.

(a) **Crushed hydraulic cement concrete** will be permitted for use as a coarse aggregate provided it conforms to the physical requirements specified herein and shows no adverse chemical reaction. Crushed hydraulic cement concrete will not be permitted in the following: (1) reinforced cement concrete, (2) in combination with other materials in contact with geotextile fabric when such fabric is used as a drainage item, and (3) in backfill or bedding for perforated pipe.

(b) **Crushed gravel** shall consist of particles of which at least 80 percent by weight shall have at least one face fractured by artificial crushing. Tests to verify conformance shall be performed in accordance with VTM-15.

(c) **Blast furnace slag** shall be relatively free from foreign minerals and glassy or spongy pieces. It shall weigh at least 70 pounds per cubic foot, dry rodded, for size No. 68 and smaller and at least 65 pounds per cubic foot, dry rodded, for larger sizes. Tests to verify conformance shall be performed in accordance with AASHTO T19. When used in asphalt surface treatments, blast furnace slag shall contain not more than 10 percent nonporous material and shall have an absorption of at least 3 percent. Tests to verify conformance will be performed in accordance with AASHTO T85.

(d) **Crushed glass** shall consist of particles of curbside-collected or waste glass. It shall be free from sources of glass that include automotive glass, lead crystal, TV monitors, lighting fixtures and electronics applications. Non-glassy material associated with curbside collection (paper, capping materials, etc.), excluding fragments of broken ceramics and pottery, shall be limited to 5 percent by weight using a gravimetric determination, and including loss on ignition performed in accordance with ASTM D2974. One hundred percent (100%) of the crushed glass shall pass the 9.5 mm (3/8 inch) sieve with less than 5 percent passing the No. 200 sieve. Crushed glass shall not be used in hydraulic cement concrete, asphalt, base/subbase, or exposed shoulder applications.

203.03—Detail Requirements

(a) **Grading:** Open-graded aggregates shall conform to the requirements of Table II-3. Tests to verify conformance shall be performed in accordance with AASHTO T27.

(b) **Soundness:** Soundness shall conform to the requirements of Table II-4. Tests to verify conformance shall be performed in accordance with AASHTO T103 or T104. The requirement for soundness test for crushed glass is waived due to its preclusion from the applications shown in Table II-4.

TABLE II-3
Sizes of Open-Graded Coarse Aggregates

Va. Size No.	Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Weight)														
	4 in.	3½ in.	3 in.	2½ in.	2 in.	1½ in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 16	No. 50	No. 100
1	Min. 100	90-100		25-60		Max. 15		Max. 5							
2			Min. 100	90-100	35-70	Max. 15		Max. 5							
3				Min. 100	90-100	35-70	0-15		Max. 5						
357				Min. 100	95-100		35-70		10-30		Max. 5				
5						Min. 100	90-100	20-55	Max. 10	Max. 5					
56						Min. 100	90-100	40-85	10-40	Max. 15	Max. 5				
57						Min. 100	95-100		25-60		Max. 10	Max. 5			
67							Min. 100	90-100		20-55	Max. 10	Max. 5			
68							Min. 100	90-100		30-65	5-25	Max. 10	Max. 5		
7								Min. 100	90-100	40-70	Max. 15	Max. 5			
78								Min. 100	90-100	40-75	5-25	Max. 10	Max. 5		
8									Min. 100	85-100	10-30	Max. 10	Max. 5		
8P									Min. 100	75-100	5-30	Max. 5			
9										Min. 100	85-100	10-40	Max. 10	Max. 5	
10										Min. 100	85-100				10-30

TABLE II-4
Soundness

Use	Max. Soundness Loss (%)	
	Magnesium Sulphate (5 Cycles)	Freeze and Thaw (100 Cycles)
Hydraulic cement concrete	12	5
Asphalt surfaces courses	15	6
Asphalt and aggregate bases	20	7
Select material (Type I) and subbase	30	12

(c) **Abrasion Loss:** Abrasion loss shall conform to the requirements of Table II-5. Tests to verify conformance shall be performed in accordance with AASHTO T96 on aggregate with a grading the most nearly identical with the grading to be used in the work.

TABLE II-5
Abrasion

Use	Max. Los Angeles Abrasion Loss (%)	
	100 Rev.	500 Rev.
Grade A stone	9	40
Grade B stone	12	45
Grade C stone	14	50
Slag	12	45
Gravel	12	45

(d) **Deleterious Material**: The amount of deleterious material shall be not more than the following:

Material	% by Weight	AASHTO Test Method
Coal and lignite	0.25	T113
Clay lumps	0.25	T112
Material passing No. 200 sieve by washing[1]	1.00	T11

[1]When the material passing the No. 200 sieve by washing is dust of fracture, the percentage of deleterious material may be increased to 1.50 percent.

(e) **Flat and Elongated Particles:** Coarse aggregate to be used as a temporary riding surface during construction activities or as the final riding surface after construction shall contain not more than 30 percent by mass of aggregate particles retained on and above the 3/8-inch sieve having a maximum to minimum dimensional ratio greater than 5 as determined in accordance with ASTM D4791.

SECTION 204—STONE FOR MASONRY, RIPRAP, POROUS BACKFILL, AND GABIONS

204.01—Description

These specifications cover aggregate materials used in the construction of masonry items and stone gabions, to protect ground slopes from erosion or wave action and to facilitate drainage, generally behind a backwall or abutment.

204.02—Detail Requirements

(a) **Stone for rubble or mortar rubble masonry** shall be sound, durable, and free from seams, cracks, and other structural defects and shall be minimum Grade C free from rounded, worn, or weathered surfaces.

(b) **Stone for riprap and bedding** shall be sound, durable, and free from seams, cracks, and other structural defects. Riprap stone and bedding exposed to the wave action of water shall be of igneous or metamorphic origin. Riprap bedding shall be crushed stone, minimum Grade B.

(c) **Porous backfill** shall be aggregate size No. 78 or No. 8, a minimum Grade B. Crushed glass meeting the gradation requirements specified in Section 203.02(d) may be directly substituted for size No. 78 and 8 aggregates.

(d) **Gabion stone** shall be durable and free from seams and cracks. Weathered stone shall not be used. Stone shall weigh between 4 and 30 pounds except that approximately 5 percent of the individual stones may weigh less than 4 or more than 30 pounds. At least 50 percent of the stone shall weigh more than 10 pounds.

SECTION 205—CRUSHER RUN AGGREGATE

205.01—Description

These specifications cover crushed aggregate used for backfilling and bedding pipe and box culverts, maintaining traffic, and repairing and constructing all-weather private access pavements.

205.02—Materials

Crusher run aggregate shall be crushed from stone, slag, or gravel and shall contain all of the sizes produced when the original aggregate is reduced through a series of crushers to the maximum size specified. It shall be essentially free from deleterious substances in accordance with Section 203.

(a) **Crushed hydraulic cement concrete** will be permitted for use as crusher run aggregate provided it conforms to the physical requirements of Section 203 and shows no adverse chemical reaction. It shall not be used in a subsurface drainage application in combination with perforated pipe or as a base material where geotextile fabric is to be used.

(b) **Crushed gravel** shall consist of particles of which at least 90 percent by weight of material retained on the No. 10 sieve shall have at least one face fractured by artificial crushing. Tests to verify acceptance shall be performed in accordance with VTM-15.

(c) **Crushed glass** will be permitted for use as crusher run aggregate provided it conforms to the physical requirements of Section 203.02(d). Crushed glass having the gradation specified in Section 203.02(d) may be directly substituted for size No. 25 and 26 aggregates in pipe bedding and backfilling applications only.

205.03—Detail Requirements

(a) **Grading:** Grading shall conform to the following requirements when tested in accordance with AASHTO T27:

% by Weight of Materials Passing Sieve

Size No.	2½ in	2 in	1½ in	1 in	¾ in	No. 4
24	Min. 100	95±5				32±18
25			Min. 100	95±5		32±18
26				Min. 100	95±5	38±22

(b) **Atterberg Limits:** The liquid limit shall be not more than 25. The plasticity index shall be not more than 3. Tests to verify acceptance shall be performed in accordance with VTM-7.

(c) **Soundness:** Soundness shall conform to the requirements of Table II-4. Tests to acceptance shall be performed in accordance with AASHTO T103 or T104. The requirement for soundness test for crushed glass is waived due to its preclusion from the applications shown in Table II-4.

(d) **Abrasion Loss:** Abrasion loss shall be not more than 45 percent. Tests to verify acceptance shall be performed in accordance with AASHTO T96.

(e) **Flat and Elongated Particles:** Crusher run aggregate to be used as a temporary riding surface during construction activities or as the final riding surface after construction shall contain not more than 30 percent by mass of aggregate particles retained on and above the 3/8-inch sieve having a maximum to minimum dimensional ratio greater than 5 as determined in accordance with ASTM D4791.

SECTION 206—LIGHTWEIGHT AGGREGATE

206.01—Description

These specifications cover lightweight aggregate used in the production of hydraulic cement concrete and asphalt surface treatment.

206.02—Detail Requirements

Lightweight aggregate shall consist of clay, shale, or slate expanded through a sintering or rotary kiln.

(a) **Lightweight aggregate used in hydraulic cement concrete** shall conform to AASHTO M195.

(b) **Lightweight aggregate used for asphalt surface treatment** shall conform to AASHTO M195 except that Sections 3, 6, and 8 will not apply. Grading shall conform to Table II-3 except that the maximum percentage by weight of material passing the No. 8 sieve shall be 16 percent and passing the No. 16 sieve shall be 9 percent.

SECTION 207—SELECT MATERIAL

207.01—Description

These specifications cover nonplastic material obtained from roadway cuts, borrow areas, or commercial sources used as foundation for subbase, shoulder surfacing, fill, backfill, or other specific purposes.

TABLE II-6
Design Range: Select Material, Type I

% by Weight of Material Passing Sieve					
3 in	**2 in**	**No. 10**	**No. 40**	**No. 200**	**ASTM D4791 Flat & Elongated 5:1**
100	95-100	25-55	16-30	4-14	30% max.

207.02—Detail Requirements

Select material shall consist of approved local or commercial materials free from roots, muck, and debris.

(a) **Grading:**

1. **Type I:** Grading for Type I shall conform to the job-mix formula selected from within the design range specified in Table II-6, subject to the applicable tolerances specified in Table II-7 when tested in accordance with VTM- 25.

2. **Type II and Type III:** Grading for Types II and III shall conform to the following when tested in accordance with VTM-25:

	% by Weight of Material Passing Sieve		
Type	**3 in**	**2 in**	**No. 200**
II	Min. 100	Min. 100	Max. 25
III[1]			Max. 20

[1]A maximum of 25 percent of material retained on the No. 200 sieve will be allowed for Type III if the liquid limit is less than 25 and the plasticity index is less than 6.

TABLE II-7
Process (P) and Range (R) Tolerance: Select Material, Type I

	Tolerance on Each Laboratory Sieve (%)									
	3 in		2 in		No. 10		No. 40		No. 200	
No. Test	P	R	P	R	P	R	P	R	P	R
1	0.0		±4.0		±15.0		±10.0		±6.0	
2	0.0	0.0	±3.0	5.0	±10.5	18.5	±7.0	13.0	±4.0	8.5
3	0.0	0.0	±2.5	5.5	±8.5	22.0	±5.5	15.0	±3.5	10.0
4	0.0	0.0	±2.0	6.0	±7.5	23.5	±5.0	16.5	±3.0	10.5
8	0.0	0.0	±1.5	7.0	±5.5	26.5	±3.0	18.5	±2.0	12.0

(b) **Atterberg Limits:**

1. **Type I:** The mean of the Atterberg limits shall conform to Table II-8 when tested to verify acceptance in accordance with VTM-7.

2. **Types II and III:** Atterberg limits shall conform to the following values when tested in accordance with VTM-7:

Type	Max. Liquid Limit	Max. Plasticity Index
II	30	9
III1	30	9

(c) **California Bearing Ratio (CBR):** Tests for CBR shall be performed in accordance with VTM-8 for conformance to the specified value.

(d) **Soundness:** Soundness for Type 1 shall conform to Table II-4. Tests shall be performed in accordance with AASHTO T103 or T104.

(e) **Flat and Elongated Particles:** Select materials to be used as a temporary riding surface during construction activities or as the final riding surface after construction shall contain not more than 30 percent by mass of aggregate particles retained on and above the 3/8-inch sieve having a maximum to minimum dimensional ratio greater than 5 as determined in accordance with ASTM D4791.

(f) **Crushed glass** that conforms to the physical requirements set forth in the Specifications shall be limited to Type II and Type III applications to exclude those applications listed in Section 203.02(d).

207.03—Job-Mix Formula for Select Material, Type I

The Contractor shall submit or shall have the source of supply submit a job-mix formula for each mixture for the Engineer's approval through the "Producer Lab Analysis and Information Details" (PLAID) website https://plaid.vdot.virginia.gov prior to starting work. The formula shall establish a single percentage of aggregate passing each required sieve size denoted in Table II-6 and shall be in effect until a modifica-

tion is approved by the Engineer. If unsatisfactory results or other changed conditions make it necessary, the Contractor shall prepare and submit a new job mix formula for the Engineer's approval.

207.04—Mixing

The Contractor shall provide a laboratory as specified in Section 106.07. Select material shall be produced at optimum moisture ±2 percentage points.

The Contractor shall have a certified Central Mix Aggregate Technician present at the aggregate plant during initial setup and subsequent production.

207.05—Acceptance of Select Material, Type I

The Contractor shall perform sampling and testing for determination of grading, moisture, and Atterberg limits. The Contractor shall provide such test results within 48 hours of sampling to the Department through the "Producer Lab Analysis and Information Details" (PLAID) website https://plaid.vdot.virginia.gov. The Contractor shall maintain appropriate, current quality control charts. The Department will perform independent monitor tests. If there is a statistically significant difference between the two sets of results, the Department will conduct an investigation to determine the reason for the difference. If it is determined that the material does not conform to the requirements of the Contract, the Engineer will reject the material or make an adjustment in payment adjustment in accordance with Section 207.07.

Determination of gradation and Atterberg limits will be based on a mean of the results of tests performed on four samples taken in a stratified random manner from each lot. The Engineer may use lots of 2000 tons or 4000 tons at the Engineer's discretion when warranted by annual plant shipping quantity and past performance. If visual examination reveals that the material is obviously contaminated or segregated, the material will be rejected without additional sampling or testing. If it is necessary to determine the gradation and Atterberg limits of the material in an individual location, one sample taken from the material in question will be tested and the results will be compared to the job-mix formula with the tolerances specified in Table II-7 and Table II-8 for one test. The results obtained will apply only to the material in question.

A lot will be considered acceptable for grading if the mean of the test results falls within the allowed deviation from the job-mix formula and the difference between the maximum and minimum results does not exceed the range values specified in Table II-7.

A lot will be considered acceptable for Atterberg limits if the mean of the test results is less than the maximum allowed for the liquid limit and plasticity index values specified in Table II-8.

TABLE II-8
Process (P) and Range (R) Tolerance: Select Material, Type I

No. Tests	Max. Liquid Limit	Max. Plasticity Index
1	25.0	6.0
2	23.9	5.4
3	23.2	5.1
4	23.0	5.0
8	22.4	4.7

If the liquid limit exceeds 30 or the plasticity index exceeds 9 on any individual sample, that portion of the lot from which the sample was taken will be considered a separate part of the lot and shall be removed from the road.

If the Contract specifies less than 2,000 tons of material, the amount of material necessary to complete the last lot is less than 2,000 tons (or 4,000 tons, if applicable), the job-mix formula is modified within a lot, or a portion of the lot is rejected on the basis of individual test results, the mean results of the tests on the samples taken will be compared to the job-mix formula with the applicable process tolerances specified in Table II-7 and Table II-8 for the number of tests performed.

207.06—Referee System for Select Material, Type I

If the test results obtained for one of the four samples is questionable or the mean of the four samples tested to evaluate a particular lot is questionable, the Engineer will apply the referee system specified in Section 208.07 except that the final mean results will be compared to the job-mix formula with the tolerances given in Table II-7 and Table II-8 for the mean of eight tests.

207.07—Payment Adjustment System for Select Material, Type I

If a lot of material does not conform to the acceptance requirements stated herein, adjustment points, determined as follows, will be applied for each 1 percent or part thereof that the grading or Atterberg limits are outside the job-mix formula with the tolerances given in Table II-7 and Table II-8.

	Adjustment Points	
Sieve Size	**Process**	**Range**
3-in	1	1
2-in	1	1
No. 10	1	1
No. 40	3	3
No. 200	5	5

Atterberg Limits	Adjustment Points
Liquid limit	3
Plasticity index	7

If it is determined the total adjustment (excluding the range adjustment) for the lot is more than 25 points, the failing material shall be removed from the roadway. If the total adjustment (excluding the range adjustment) is 25 points or less and the Contractor does not elect to remove and replace the material, the Contract unit price for the material will be reduced by 1 percent for each adjustment point. The total adjustment will be applied to the tonnage in the Contract represented by the sample(s).

SECTION 208—SUBBASE AND AGGREGATE BASE MATERIAL

208.01—Description

These specifications cover material used to form a foundation for base or surface pavement.

208.02—Materials

(a) **Subbase material** shall consist of mixtures of natural or crushed gravel, crushed stone or slag, and natural or crushed sand, with or without soil mortar.

(b) **Aggregate base material** will be designated as Type I or Type II as follows:

Type I shall consist of crushed stone, crushed slag, or crushed gravel, with or without soil mortar or other admixtures. Crushed gravel shall consist of particles of which at least 90 percent by weight of the material retained on the No. 10 sieve shall have at least one face fractured by artificial crushing.

Type II shall consist of gravel, stone, or slag screenings; fine aggregate and crushed coarse aggregate; sand-clay-gravel mixtures; or any combination of these materials; with or without soil mortar or other admixtures.

208.03—Detail Requirements

(a) **Grading:** Grading shall conform to the requirements of the job-mix formula selected from within the design range specified in Table II-9, subject to the applicable tolerances specified in Table II-10 when tested to verify acceptance in accordance with VTM-25.

TABLE II-9
Design Range for Dense-Graded Aggregates

	Amounts Finer Than Each Laboratory Sieve (Square Openings[1]) (% by Weight)						
Size No.	**2 in**	**1 in**	**3/8 in.**	**No. 10**	**No. 40**	**No. 200**	**ASTM D4791 Flat & Elongated 5:1**
21A	100	94-100	63-72	32-41	14-24	6-12	30% max.
21B	100	85-95	50-69	20-36	9-19	4-7	30% max.
22	---	100	62-78	39-56	23-32	8-12	30% max.

[1]In inches, except where otherwise indicated. Numbered sieves are those of the U.S. Standard Sieve Series.

TABLE II-10
Process Tolerances for Each Laboratory Sieve (%)

No. Tests	Top Size	1 in	3/4 in.	3/8 in.	No. 10	No. 40	No. 200
1	0.0	±10.0	±14.0	±19.0	±14.0	±8.0	±4.0
2	0.0	±7.1	±10.0	±13.6	±10.0	±5.7	±2.9
3	0.0	±5.6	±7.8	±10.6	±7.8	±4.4	±2.2
4	0.0	±5.0	±7.0	±9.5	±7.0	±4.0	±2.0
8	0.0	±3.6	±5.0	±6.8	±5.0	±2.9	±1.4

TABLE II-11
Atterberg Limits

Max. Liquid Limit		Max. Plasticity Index	
No. Tests	Subbase and Aggregate Base Type I and II	Subbase Sizes No. 21A, 22, and Aggregate Base Type II	Aggregate Base Type I and Subbase Size No. 19
1	25.0	6.0	3.0
2	23.9	5.4	2.4
3	23.2	5.1	2.1
4	23.0	5.0	2.0
8	22.4	4.7	1.7

(b) **Atterberg Limits:** Atterberg limits shall conform to Table II-11 when tested to verify acceptance in accordance with VTM-7.

(c) **Soundness:** Soundness shall conform to the requirements of Table II-4 when tested to verify acceptance in accordance with AASHTO T103 or T104.

(d) **Abrasion Loss:** Abrasion loss shall be not more than 45 percent when tested to verify acceptance in accordance with AASHTO T96.

(e) **Optimum Moisture:** Material shall be produced at optimum moisture ±2 percentage points.

(f) **Admixtures:** Admixtures shall conform to the applicable Specifications for the use specified.

(g) **Flat and Elongated Particles:** Subbase and aggregate base materials to be used as a temporary riding surface during construction activities or as the final riding surface after construction shall contain not more than 30 percent by mass of aggregate particles retained on and above the 3/8-inch sieve having a maximum to minimum dimensional ratio greater than 5 as determined in accordance with the testing requirements of ASTM D4791.

208.04—Job-Mix Formula

The Contractor shall submit, or shall have the source of supply submit a job-mix formula for each mixture for the Engineer's approval through the "Producer Lab Analysis and Information Detail" (PLAID) website https://plaid.vdot.virginia.gov prior to starting work. The formula shall be within the design range specified in Table II-9. If unsatisfactory results or other conditions make it necessary, the Contractor shall prepare and submit a new job-mix formula for approval.

208.05—Mixing

Subbase or aggregate base materials shall be mixed in an approved central mixing plant of a pugmill or other mechanical type. Materials shall be blended prior to or during mechanical mixing in a manner that will ensure conformance to the specified requirements.

Preparation of subbase and aggregate base material will be subject to Department inspection at the plant. The Contractor shall provide a laboratory as specified in Section 106.07.

During the initial setup and subsequent production, the Contractor shall have a certified Central Mix Aggregate Technician present at the plant.

208.06—Acceptance

The Contractor shall provide the quality assurance necessary for the Engineer to determine conformance to the required grading and Atterberg limits of subbase and aggregate base material.

Sampling and testing for determination of grading, moisture, and Atterberg limits shall be performed by the Contractor. The Contractor shall provide such test results within 48 hours of sampling to the Department through "the Producer Lab Analysis and Information Details" (PLAID) website https://plaid.vdot.virginia.gov. The Contractor shall maintain appropriate current quality control charts. The Department will perform independent monitor tests at a laboratory of its choice. If there is a statistically significant difference between the two sets of results, an investigation will be made to determine the reason for the difference. If it is determined that the material does not conform to the requirements of the Contract, the material will be rejected or a payment adjustment will be made in accordance with Section 208.08.

Determination of gradation and Atterberg limits will be based on a mean of the results of tests performed on four samples taken in a stratified random manner from each lot. Lots of 2000 tons or 4000 tons may be used at the discretion of the Engineer when warranted by annual plant shipping quantity and past performance. Samples shall be obtained by methods approved by the Engineer. Any statistically acceptable method of randomization may be used to determine the time and location of the stratified random sample to be taken. The Department shall be advised of the method to be used prior to the beginning of production.

A lot will be considered acceptable for grading if the mean of the test results is within the deviation from the job-mix formula specified in Table II-10.

A lot will be considered acceptable for Atterberg limits if the mean of the test results is less than the maximum for the liquid limit and plasticity index specified in Table II-11.

If the liquid limit exceeds 30 or the plasticity index exceeds 6 for Type I base material or 19 for subbase material; or the plasticity index exceeds 9 for Type II base material or subbase materials No. 20, 21, 21A, 21B, or 22 on any individual sample; that portion of the lot from which the sample was taken will be considered a separate part of the lot and the Contractor shall remove that portion from the roadway.

If either the amount of material in the lot is less than 2,000 tons (4,000 tons if applicable), the job-mix formula is modified within a lot, or the Engineer rejects a portion of the lot on the basis of individual test results, the mean test results of the samples taken will be compared to the job-mix formula with the tolerances given in Tables II-10 and II-11 for the number of tests performed.

If a visual examination by the Engineer reveals that material in any load is obviously contaminated or segregated, the Engineer will reject that load without additional sampling or testing of the lot. If it is necessary to determine grading or Atterberg limits of material in an individual load, one sample (taken from the load) will be tested and the results compared to the job-mix formula with the tolerances given in Tables II-10 and II-11 for one test. Results obtained in the testing of a specific individual load will apply only to the load in question.

208.07—Referee System

If the Engineer determines test results obtained for one of the four samples taken to evaluate a particular lot is questionable, the Contractor may request that the results of the questionable sample be disregarded. The Contractor shall then perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed. If the Engineer determines that one of the four test results is questionable, the Department will perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed. The Engineer will average the test results of the three original (unquestioned) samples with the tests results of the five road samples, and the mean of the test values obtained for the eight samples will be compared to the job-mix formula with the tolerances specified in Table II-10 and Table II-11 for the mean of eight tests.

If the Contractor questions the mean of the four original test results obtained for a particular lot, the Contractor may request approval to perform additional testing of that lot. If the Engineer approves the Contractor's request for further tests, the Contractor shall sample and test the material in accordance with procedures approved by the Engineer. If the Engineer determines that the mean of the four original test results is questionable, the Department will perform additional testing of that lot. The Department will average the test results of the original four samples with the test results of the four additional samples taken from randomly selected locations in the roadway where the lot was placed, and the mean of test values obtained for the eight samples will be compared to the job-mix formula with the tolerances specified in Tables II-10 and II-11 for the mean result of eight tests.

If the mean of the test values obtained for the eight samples conforms to the requirements for the mean of the results of eight tests, the Engineer will consider the material to be acceptable; if the mean does not conform, the Engineer will adjust the lot according to the payment adjustment rate specified in Section 208.08.

The provisions of this Section will not apply to mixtures containing cement or other admixtures that alter the characteristics of the material.

208.08—Payment Adjustment System

If a lot of material does not conform to the acceptance requirements of Section 208.06, the Engineer will determine payment adjustment points as follows:

Sieve No.	Adjustment Points for Each 1% Grading Is Outside Tolerance Permitted in Table II-10
2 in	1
1 in	1
3/4 in	1
3/8 in	1
No. 10	1
No. 40	3
No. 200	5

Atterberg Limits	Adjustment Points for Each 1% Atterberg Limits Exceed Maximum Permitted in Table II-11
Liquid limit	3
Plasticity index	7

TABLE II-12
Standard Deviation

Sieve Size	1 Adjustment Point for Each Sieve Size	2 Adjustment Points for Each Sieve Size	3 Adjustment Points for Each Sieve Size
2 in	0.6-1.5	1.6-2.5	2.6-3.5
1 in	4.6-5.5	5.6-6.5	6.6-7.5
3/4 in	5.6-6.5	6.6-7.5	7.6-8.5
3/8 in	7.1-8.0	8.1-9.0	9.1-10.0
No. 10	5.6-6.5	6.6-7.5	7.5-8.5
No. 40	3.6-4.5	4.6-5.5	5.6-6.5
No. 200	3.1-4.0	4.1-5.0	5.1-6.0

The Engineer will require the Contractor to remove the failed material from the roadway if the total adjustment for the lot is more than 25 points. The Engineer will reduce the unit price of the material by 1 percent for each adjustment point if the total adjustment is 25 points or less and the Contractor does not elect to remove and replace the material. The Engineer will apply the adjustment to the tonnage represented by the sample(s).

The Contractor shall minimize the variability of the Contractor's product in order to furnish a consistent, well-graded mixture. When the quantity of any one type of material furnished for a project exceeds 4,000 tons, the variability of the total quantity furnished will be determined on the basis of the standard deviation for each sieve size. The Engineer will adjust the Contract unit price for the material as indicated herein if the standard deviation is within the limits specified in Table II-12. The Engineer will not make standard deviation computations separately on more than two job mixtures for the same type of material.

The Contract unit price will be reduced by 0.5 percent for each adjustment point applied for standard deviation.

The Engineer will instruct the Contractor on the disposition of material having standard deviations larger than those specified in Table II-12.

SECTION 209—OPEN-GRADED SHOULDER MATERIAL

209.01—Description

These specifications cover the requirements for open-graded material used on roadway shoulders where designated on the plans or other Contract documents.

209.02—Detail Requirements

Open-graded shoulder material shall be aggregate material No. 18 and shall consist of mixtures of natural or crushed gravel, crushed stone, or sand, without soil mortar.

(a) **Grading:** Grading shall conform to the following when tested to verify acceptance in accordance with VTM-25:

% by Weight of Materials Passing Sieve

2 in	**1 in**	**3/8 in**	**No. 10**	**No. 40**	No. 200
100	90 ± 10	55 ± 15	20 ± 10	8 ± 5	3 ± 3

(b) **Atterberg Limits:** Material shall be nonplastic, and the liquid limit shall be not more that 25 when tested to verify acceptance in accordance with VTM-7.

(c) **Soundness:** Soundness shall conform to the requirements of Table II-7 for subbase material when tested to verify acceptance in accordance with AASHTO T103 or T104.

(d) **Abrasion Loss:** Abrasion loss shall be not more than 45 percent when tested to verify acceptance in accordance with AASHTO T96.

209.03—Mixing

Pugmill mixing will not be required for aggregate shoulder material No. 18. The Contractor shall provide a laboratory for Department use as specified in Section 106.07.

SECTION 210—ASPHALT MATERIALS

210.01—Description

These specifications cover the manufacturing and material requirements for asphalt material consisting of asphalt, asphalt cement, asphalt cutback, or asphalt emulsion as defined in ASTM D8.

210.02—Materials

Asphalt material shall be homogeneous and shall conform to the following:

(a) **Rapid curing and medium curing liquid asphalts used as surface treatments** shall contain a heat-stable additive conforming to Section 211.

(b) **Liquid asphalt material** will be tested for coating ability in accordance with AASHTO T182, with the following modifications:

1. Material that can coat 95 percent of a shady dolomite will be classified Type I.

2. Material that can coat 95 percent of a siliceous gravel wetted with 2 percent water by weight will be classified Type II.

(c) **Rapid curing cutback asphalts** shall conform to AASHTO M81.

(d) **Medium curing cutback asphalts** shall conform to AASHTO M82.

(e) **Cements** shall be viscosity graded and shall conform to AASHTO M226, Table 2, except that the loss on heating shall be not greater than 1.0 for AC-5, 0.8 for AC-20, and 0.5 for all other grades.

(f) **Emulsions** shall conform to AASHTO M208 and shall be Type I as specified herein except that CRS-2 shall be Type II as specified herein. CRS-1h shall conform to AASHTO M208 for CRS-1 except that the penetration shall be 40 to 110. Emulsions will be sampled and tested in accordance with AASHTO T59 except that viscosity will be tested in accordance with VTM-64.

(g) **Polymer Modified Cationic Emulsified Asphalt** shall conform to AASHTO M316.

(h) **Non-tracking tack** will be tested in accordance with Section 210.07.

210.03— Virginia Asphalt Acceptance Program (VAAP)

Acceptance into the VAAP

(a) Asphalt materials will be accepted under the Virginia Asphalt Acceptance Program (VAAP). Acceptance involves sampling, testing, documentation, and certification of the product by the manufacturer in combination with a Department monitoring effort. Performance Graded Binder suppliers shall conform to AASHTO R-26, and Emulsion suppliers shall conform to AASHTO PP-71 to be added to the VAAP, with provisions listed below.

(b) To have a new facility added to the VAAP, producers shall submit a split sample of each material to be approved to Materials Division for testing.

(c) Approved shipping facilities from the VAAP that need to add a material to the Materials Division Approved Products List shall submit a split sample of the material to be approved to Materials Division for testing.

210.04—VDOT Asphalt Acceptance Program Requirements and Compliance

The Contractor shall ensure the following are preformed:

(a) Sample and test asphaltic materials in accordance with the specified methods in Section 210.07 at a minimum frequency of once a month and whenever additional or different components materials are added to existing materials, and tested in accordance with the specified methods in Section 210.07. If the manufacturer is supplying to multiple VDOT jobs, they shall only be required to submit one sample per month per type/grade.

(b) Maintain a file or certified test reports representing the asphaltic material.

(c) Provide a copy of the certified test report to the Materials Division within 30 days of sampling. Failure to comply with this requirement may result in removal from the VAAP and the Materials Division Approved Products List.

(d) Supply the Materials Division a summary sheet of quantities shipped to state work annually in January of the following year. This summary sheet shall show the number of gallons of each type/grade of material shipped to Virginia addresses.

(e) Submit a detailed plan of action describing the procedures to be taken to ensure tracking of sample test results and the material represented by these results to the Department.

210.05—Sampling

(a) Samples shall be taken in the presence of VDOT personnel or a VDOT representative.

(b) Samples taken for testing of asphaltic materials are to be not less than one quart (one liter) of materials, (0.5 gallons (2 liters) for asphalt emulsions).

(c) Care is to be taken to ensure that the samples are not contaminated and the sample containers are perfectly clean and dry before filling.

(d) Immediately after filling, sample containers are to be tightly closed, and properly marked for identification on the container itself.

210.06—Testing

(a) The Contractor shall ensure the standard control tests on asphaltic materials, as detailed in Section 210.07, are conducted.

(b) The Contractor shall require all testing for certified test reports to be performed by the Manufacturer's personnel in the Manufacturer's VDOT approved laboratory or by a VDOT approved commercial testing facility.

(c) The Department will conduct acceptance testing at a frequency of a minimum of 1 test per month per type/grade of asphaltic material that has been supplied to VDOT projects during the previous month at the Materials Division during the construction season. The frequency will be less during the remainder of the year.

(d) Laboratories conducting quality control must be certified by VDOT as meeting the following requirements:

1. All Binder Laboratories shall hold AASHTO Accreditation and provide VDOT with a copy of accreditation.

2. All Emulsion Laboratories shall be AASHTO Accredited, and shall provide VDOT with a copy of their accreditation.

3. Test Reports

   a. The Contractor shall ensure the manufacturer maintains a file of certified test reports for all asphaltic materials ultimately shipped to them.

   b. Test Reports shall indicate that the material shipped meets the requirements for that type/grade of asphaltic material and shall show the test results that were obtained to determine compliance with the applicable specifications.

   c. The Contractor shall ensure records are maintained for at least 12 months by the manufacturer, and available for verification by VDOT personnel upon request.

d. Copies of certified test results shall also be sent to the Materials Division.

e. Certified Test Reports shall be a company's standard form containing the following information:

(1) Manufacturer's name and address

(2) Type and grade of asphaltic material

(3) Testing performed (AASHTO or Virginia Test Method designation)

(4) Test results and date obtained

(5) Quantity represented

(6) Tank Number

(7) Unique Report Identifier

(8) Statement indicating that the manufacturer "certified that these are the test results obtained on the material tested under the VAAP program".

210.07—Tests

(a) **PG Asphalt Binders:**

1. Certified Test Reports for PG Asphalt Binders shall be based upon the results of tests performed in accordance with AASHTO M332, Table 1. The manufacturer is not required to perform the Direct Tension Test, AASHTO T314.

2. Certified test results for Superpave PG Asphalt Binders are to be based upon the results of tests performed in accordance with AASHTO R 29, as specified below:

a. Original Material

Flash Point °C	AASHTO T 48
Viscosity @ 135°C/100°C	AASHTO T316
Dynamic Shear, 10 Rad/sec	AASHTO T 315

b. RTFO (AASHTO T 240) Material

Mass Loss %	AASHTO T 240
Dynamic Shear, 10 Rad/sec	AASHTO T 315
Multiple Stress Creep Recovery (MSCR) Test	AASHTO T 350

c. Pressure Aging Vessel, Residue at 100°C (AASHTO R 28)

Dynamic Shear, 10 Rad/sec	AASHTO T 315
Creep Stiffness, 60 sec	AASHTO T 313
M-Slope	AASHTO T 313

3. For asphalt binders tested in accordance with AASHTO T 350, indication of elastic response shall be determined using Figure X1.1 Nonrecoverable Creep Compliance Versus Percent Recovery in AASHTO M 332.

(b) **Cutback Asphalts:**

1. Certified Test Reports for Cutback Asphalts shall be based upon the results of tests per formed in accordance with AASHTO M81 and M82. The manufacturer is not required to perform the Flash Point, Ductility, and Solubility tests unless the Engineer directs the Contactor to require it. VDOT will perform Ductility and Solubility tests on all acceptance samples. Flash Point tests will be performed by VDOT periodically. When performed by VDOT, failure of either sample on Flash Point, Ductility, and Solubility will be considered sufficient reason for the Engineer to direct the Contractor to require the manufacturer to perform this testing. If the manufacturer elects to conduct these tests to better control production, the results shall be included on the certified test report.

2. When used in surface treatments, the Coating Ability test shall be conducted subject to the specifications listed in Section 210.02.

(c) **Emulsified Asphalts:**

1. Certified Test Reports for Emulsified Asphalts shall be based upon the results of tests performed in accordance with AASHTO M208 or AASHTO M316, as specified below:

a. Cationic Emulsions - Table 1 (from AASHTO M208 or M316, as applicable), specifically

(1) Tests on Emulsions:

- Saybolt Furol Viscosity
- Sieve Test (if necessary)
- Demulsibility or Classification test
- Particle Charge Test
- Residue by Distillation

(2) Tests on residue from distillation:

- Penetration

b. CSS-1h (Quick Set) shall be tested the same as Cationic Emulsions, with the addition of "Quick set Emulsified Asphalt Setting Time (VTM-89)."

c. Latex Modified Cationic Emulsions (Quick Set)

(1) CQS-1h Latex Modified (CQS-1hLM)

(a) Tests on Emulsions
- Saybolt Furol Viscosity
- Sieve Test (if necessary)
- Particle Charge Test
- Residue by Evaporation (VTM-78)

(b) Tests on residue

- Penetration
- Ring and Ball Softening Point

(2) CRS-2 Latex

(a) Tests on Emulsions

- Saybolt Furol Viscosity
- Sieve Test (if necessary)
- Particle Charge Test
- Residue by Distillation

(b) Tests on residue by Distillation

- Penetration
- Ring and Ball Softening Point
- Elastic Recovery

2. The manufacturer is not required to perform the Flash Point, Ductility, and Solubility tests unless the Engineer directs the Contractor to require it. VDOT will perform Ductility and Solubility tests on all independent assurance (monitor) and Q.A. samples. Flash Point tests will be performed by VDOT periodically. When performed by VDOT, failure of either sample on Flash Point, Ductility, and Solubility will be considered sufficient reason to require the manufacturer to perform this testing. If the manufacturer elects to conduct these tests to better control production, the results shall be included on the certified test report.

(d) **Non-Tracking Tack:**

Certified Test Reports for Non-Tracking Tack shall be based upon the results of tests performed, as specified below:

1. Tests on Non-Tracking Tack:

- Saybolt Furol Viscosity
- Residue by Distillation

2. Tests on residue by distillation:

- Ring and Ball Softening Point

210.08—Storing and Shipping

(a) **Shipping:**

1. Shipments of asphalt material shall be made in transporting media that are free from contamination. Tank trucks or trailers shall be equipped with an Engineer approved sampling device. The device shall have an inside diameter of 1/2 to 1 inch and a gate valve or petcock. The device shall be built into the tank or the recirculating or discharge line so that a sample can be drawn during circulation or discharge.

2. All shipping documents shall contain sufficient information such that at any point, the material may be traceable back to the original test results. If the material is mixed with other approved material for storage, the record system will be such as to assure the traceability of all the material which is being mixed.

3. All shipping documents shall be accompanied by a statement similar to "We certify that all material being shipped on this invoice/bill of lading has been tested and approved under the Virginia Asphalt Acceptance Program and that the material has been loaded under the supervision of our representative into carriers that are suitable for shipment of this material."

4. All shipping documents shall be kept by the recipient of the material for at least 12 months from the date of receipt, and are available for verification by VDOT personnel.

5. Only material tested and certified in accordance with the VAAP shall be mixed and shipped to VDOT projects.

(b) **Storing:** Asphalt material shall be placed in storage tanks that are free from contamination.

210.09—Payment Adjustment System

If the asphalt material represented by any one sample does not conform to the requirements herein and the material is a pay item, the Engineer will reduce the Contract unit price for the item by 4 percent for each property that does not conform to the Specifications for the quantity represented by the sample that was used on the project. The Engineer will reject any unused material represented by the failing sample.

The Engineer will consider any failed sampled asphalt material that is not a pay item unacceptable and subject to the provisions of Section 105.18 and Section 106.10.

SECTION 211—ASPHALT CONCRETE

211.01—Description

Asphalt concrete shall consist of a combination of mineral aggregate and asphalt material mixed mechanically in a plant specifically designed for such purpose.

An equivalent single-axle load (ESAL) will be established by the Engineer, and SUPERPAVE mix types may be specified as one of the types listed as follows:

Mix Type	Equivalent Single-Axle Load (ESAL) Range (millions)	Minimum Asphalt Performance Grade (PG)[2]	Aggregate Nominal Maximum Size[1]
SM-9.0A	0 to 3	64S-16	3/8 in
SM-9.0D	3 to 10	64H-16	3/8 in
SM-9.0E	Above 10	64E-22	3/8 in
SM-9.5A	0 to 3	64S-16	3/8 in
SM-9.5D	3 to 10	64H-16	3/8 in
SM-9.5E	Above 10	64E-22	3/8 in
SM-12.5A	0 to 3	64S-16	1/2 in
SM-12.5D	3 to 10	64H-16	1/2 in
SM-12.5E	Above 10	64E-22	1/2 in
IM-19.0A	Less than 10	64S-16	3/4 in
IM-19.0D	10 to 20	64H-16	3/4 in
IM-19.0E	20 and above	64E-22	3/4 in
BM-25.0A	All ranges	64S-16	1 in
BM-25.0D	Above 10	64H-16	1 in

[1]**Nominal Maximum Size** is defined as one sieve size larger than the first sieve to retain more than 10 percent aggregate.

[2]**Minimum Asphalt Performance Grade (PG)** is defined as the minimum binder performance grade for the job mixes as determined by AASHTO T170 or AASHTO M332.

Asphalt concrete shall conform to the requirements for the mix type designated on the plans or elsewhere in the Contract for use.

At the Contractor's option, an approved Warm Mix Asphalt (WMA) additive or process may be used to produce the asphalt concrete (AC) mix type designated.

211.02—Materials

(a) **Asphalt materials** shall conform to the requirements of Section 210 except asphalt cement materials shall be performance graded (PG) in accordance with AASHTO M332. In addition, asphalt mixtures with the E designation shall meet the asphalt cement requirements in Section 211.04(e)1.

(b) **Coarse aggregate** shall be Grade A or B conforming to the requirements, except for grading, of Section 203 for quality. In addition, the coarse aggregate sizes retained on and above the No. 4 sieve shall comply with the coarse aggregate requirements in Table II-12A. Flat and elongated (F&E) particles shall be tested in accordance with ASTM D 4791, and coarse aggregate angularity (CAA) shall only be tested on crushed gravel in accordance with ASTM D 5821.

(c) **Fine aggregate** shall conform to the requirements, except for grading, of Section 202 for quality and the fine aggregate requirements in Table II-12A. Fine aggregate angularity (FAA)

shall be tested in accordance with AASHTO T 304 (Method A) and the sand equivalent (SE) shall be tested in accordance with AASHTO T 176.

(d) After a gradation test is performed:

1. If 10 percent or more of the material is retained on the No. 4 sieve, that portion shall be tested in accordance with the requirements for coarse aggregate.

2. If 10 percent or more of the material passes the No. 4 sieve, that portion shall be tested for SE.

3. If 10 percent or more of the material passes the No. 8 sieve, that portion shall be tested for FAA.

(e) Fine or coarse aggregates that tend to polish under traffic will not be permitted in any final surface exposed to traffic except in areas where the two-way average daily traffic is less than 750 vehicles per day and as permitted elsewhere in these Specifications.

(f) **Mineral filler** shall conform to the requirements of Section 201.

(g) **Aggregate for asphalt concrete** shall be provided in sufficient sizes and amounts to produce a uniform mixture. The Contractor shall indicate on the proposed job-mix formula the separate approximate sizes of aggregate to be used.

Where segregation or nonuniformity is evident in the finished pavement, the Engineer reserves the right to require the Contractor to discontinue the use of crusher run or aggregate blends and to furnish separate sizes of open-graded aggregate material.

TABLE II-12A
Standard Deviation

	Coarse Aggregate Properties			Fine Aggregate Properties	
	CAA		ASTM D4791		
Mix Type	**1 fractured face**	**2 fractured faces**	**F & E "(5:1) % by weight**	**SE**	**FAA**
SM-9.0 A	85% min.	80% min.	10% max.[1]	40% min.	40% min.
SM-9.0 D	85% min.	80% min.	10% max.[1]	45% min.	45% min.
SM-9.0 E	95% min.	90% min.	10% max.[1]	45% min.	45% min.
SM-9.5 A	85% min.	80% min.	10% max.[1]	45% min.	45% min.
SM-9.5 D	85% min.	80% min.	10% max.[1]	45% min.	45% min.
SM-9.5 E	95% min.	90% min.	10% max.[1]	45% min.	45% min.
SM-12.5 A	85% min.	80% min.	10% max.[1]	45% min.	45% min.
SM-12.5 D	85% min.	80% min.	10% max.[1]	45% min.	45% min.
SM-12.5 E	95% min.	90% min.	10% max.[1]	45% min.	45% min.
IM-19.0 A	85% min.	80% min.	10% max.[1]	45% min.	45% min.
IM-19.0 D	95% min.	90% min.	10% max.[1]	45% min.	45% min.
IM-19.0 E	95% min.	90% min.	10% max.[1]	45% min.	45% min.
BM-25.0 A	80% min.	75% min.	10% max.[1]	45% min.	45% min.
BM-25.0 D	80% min.	75% min.	10% max.[1]	45% min.	45% min.

[1]10 percent measured at 5:1 on maximum to minimum dimensions

(h) An antistripping additive shall be used in all asphalt mixes. It may be hydrated lime or a chemical additive from the Materials Division Approved Products List No. 7 or a combination of both. The approved chemical additive shall be added at a rate of not less than 0.30 percent by weight of the total asphalt content of the mixture.

The mixture shall produce a tensile strength ratio (TSR) of not less than 0.80 for the design and production tests. The TSR shall be determined in accordance with AASHTO T283, including a freeze-thaw cycle (4-inch specimens compacted with a Marshall Hammer or 3.5 by 6-inch specimens when compacted with a gyratory compactor); except that the 16-hour curing time requirement and the 72 to 96-hour storage period will not be enforced.by the Department. Design tests shall use the same materials that are to be used in the production mix and shall be conducted in a laboratory approved by the Department.

When a chemical additive is used, it shall be added to the asphalt cement prior to the introduction of the cement into the mix. Any chemical additive or particular concentration of chemical additive found to be harmful to the asphalt material or that changes the original asphalt binder performance grade (PG) shall not be used.

(i) **Hydrated lime** shall conform to the requirements of ASTM C977. Hydrated lime shall be added at a rate of not less than 1 percent by weight of the total dry aggregate.

A separate bin or tank and feeder system shall be provided to store and accurately proportion the dry or slurried lime into the aggregate. The lime and aggregate shall be mixed by pugmill or other Department approved means to achieve a uniform lime coating of the aggregate prior to entering the drier. If lime is added in dry form, the aggregate shall contain at least 3 percent free moisture. The Department will not permit the stockpiling of lime treated aggregate.

The feeder system shall be controlled by a proportioning device, which shall be accurate to within ±10 percent of the specified amount. The proportioning device shall have a convenient and accurate means of calibration. A flow indicator or sensor shall be provided with the proportioning device and interlocked with the plant controls, aggregate feed or weigh system, such that production of the mixture shall be consistently maintained and, if there is a stoppage of the lime feed, interrupted.

The method of introducing and mixing the lime and aggregate shall be subject to approval by the Engineer prior to beginning production.

(j) **Reclaimed Asphalt Pavement (RAP)** material may be used as a component material of asphalt mixtures in conformance with the following:

1. Asphalt surface, intermediate and base mixtures containing RAP (but without RAS) should use the performance grade (PG) of asphalt cement as indicated in Table II-I4A, however, the choice of PG to use in the mix shall be the responsibility of the Contractor in order to meet the requirements of Section 211.01.

2. The final asphalt mixture shall conform to the requirements for the type specified.

3. During the production process, RAP material shall not be allowed to contact open flame.

4. RAP material shall be handled, hauled, and stored in a manner that will minimize contamination. Further, the material shall be stockpiled and used in such manner that variable

asphalt contents and asphalt penetration values will not adversely affect the consistency of the mixture.

5. RAP shall be processed in such a manner as to ensure that the maximum top size particle of material introduced into the mix shall be 2 inches. The Engineer may require smaller sized particles to be introduced into the mix if the reclaimed particles are not broken down or uniformly distributed throughout the mixture during heating and mixing.

(k) **Reclaimed Asphalt Shingles (RAS) – Tear-off RAS Material**s in Asphalt Concrete

1. Asphalt surface, intermediate, and base mixtures containing **Tear-off RAS Materials** shall meet the requirements of Section 211.01 and 211.03.

2. Tear-off RAS Materials shall be discarded shingle scrap from the re-roofing of domestic buildings. These tear-offs shall have been produced by the manufacturing process for roofing shingles.

   Tear-off RAS materials shall contain less than 3.0 percent foreign materials such as paper, roofing nails, wood, or metal flashing. Materials shall be shredded prior to being incorporated in the AC mixture so that at least 99 percent of the shredded pieces pass the 1/2 inch (12.5 mm) sieve and at least 80 percent pass the #4 (4.75 mm) sieve.

   Tear-off RAS materials shall not have asbestos containing material (ACM) as defined by the National Emission Standards for Hazardous Air Pollutants (NESHAP), which is less than 1 percent asbestos. The Contractor shall furnish a certification obtained from the recycler tat Polarized Light Microscopy (PLM) tests were performed on random samples of RAS at the rate of 1 test per 100 tons or if operating under a Virginia DEQ permit the rate will be the 1 test per 750 tons. The test results shall reveal no detectable level of ACM. Copies of the test results from the recycler shall be available upon request.

3. Asphalt Binder of the asphalt concrete mixture shall be Performance Grade (PG) of asphalt conforming to the requirements specified in Section 211.

4. RAS tear-offs in asphalt concrete shall be mixed mechanically in a plant specifically designed for asphalt concrete production.

5. Contractors shall store tear-off RAS materials by stockpiling either whole or as partial shingles which have not been shredded or shredded shingles that meet the maximum size requirements. Stockpiled RAS shall not be contaminated by dirt or other objectionable foreign materials. Blending of the shingles with fine aggregate may be necessary to prevent conglomeration of shingle particles. When fine aggregate is used for this purpose, this material shall be accounted for in the mix design.

(l) **Reclaimed Asphalt Shingles (RAS) – Tabs RAS Materials** in Asphalt Concrete

1. Asphalt surface, intermediate, and base mixtures containing **Tabs RAS Materials** shall meet the requirements of Section 211.01 and 211.03.

2. Tabs RAS Materials shall be produced by the manufacturing process for domestic roofing shingles. Blending or mixing of Tabs and Tear-offs shall not be permitted.

Tabs RAS Materials shall be shredded prior to being incorporated into the asphalt concrete mixture so that one hundred percent of the shredded pieces are less than ½ inches (12.5mm) in any dimension.

Tabs RAS Materials shall not contain asbestos fibers. The Contractor shall furnish the Department a certification from the manufacturer of the shingles stating that the shingles are free of asbestos. If a certification cannot be obtained then the Contractor shall furnish test results of RAS sample analysis for Polarized Light Microscopy (PLM) on the shingles which certify the material to be used is free of asbestos. Testing is required at the specified rate of 1 per manufacturer per type of RAS prior to processing and results shall be submitted prior to or during the stockpile approval process.

3. Asphalt Binder of the asphalt concrete mixture shall be Performance Grade (PG) of asphalt conforming to the requirements specified in Section 211.

4. Tabs RAS Materials in asphalt concrete shall be mixed mechanically in a plant specifically designed for asphalt concrete production.

5. Contractors shall store Tabs RAS materials by stockpiling either whole or as partial shingles which have not been shredded or shredded shingles that meet the maximum size requirements. Stockpiled RAS shall not be contaminated by dirt or other objectionable foreign materials. Blending of the shingles with fine aggregate may be necessary to prevent conglomeration of shingle particles. When fine aggregate is used for this purpose, this material shall be accounted for in the mix design.

(m) **Warm Mix Asphalt (WMA)** additives or processes shall be approved by the Department prior to use and shall be obtained from the Department's approved list which is included in the Materials Division's Manual of Instructions.

211.03—Job-Mix Formula

The Contractor shall submit a job-mix formula for each mixture planned for use on the project for the Department's evaluation and approval through the "Producer Lab Analysis and Information Details" (PLAID) website. Paper copies of the job mix formula along with supporting documentation shall also be submitted to the Department. The job-mix formula shall be within the design range specified. The job-mix formula shall establish a single percentage of aggregate passing each required sieve, a single percentage of asphalt material to be added to the aggregate, a temperature at which the mixture is to be produced, and a temperature at which the mixture is to be compacted for SUPERPAVE testing in accordance with AASHTO R35. Each approved job-mix formula shall remain in effect provided the results of tests performed on material currently being produced consistently comply with the requirements of the job-mix formula for grading, asphalt content, temperature, and SUPERPAVE compaction results and the requirements of Section 315.

(a) SUPERPAVE mixes shall be designed and controlled in accordance with AASHTO R35 and as specified herein. The Contractor shall have available all of the equipment outlined in AASHTO T312 (Section 4-6) and a Department-certified Asphalt Mix Design Technician. The SUPERPAVE mixture shall be compacted in a gyratory compactor with an internal angle of 1.16 + 0.02 degrees. **The internal angle shall be measured and calibrated using a cold (non-mix) device.** The SUPERPAVE Gyratory Compactor (SGC) shall be one from the Department's approved list of devices found in the Materials Division's Manual of Instructions.

The SUPERPAVE mixes shall conform to the requirements of Table II-13 and Table II-14. Section 7.1.2 of AASHTO R30 shall be modified such that the compaction temperature is as specified in (d) 6 herein.

(b) In conjunction with the submittal of a job-mix formula, the Contractor shall submit complete SUPERPAVE design test data, ignition furnace calibration data in accordance with VTM-102 prepared by an approved testing laboratory, and viscosity data or supplier temperature recommendations for the asphalt cement if different from (d) 6 herein.

(c) Three trial blends for gradation shall be run at one asphalt content.

(d) The SUPERPAVE design test data shall include, but not be limited to, the following information:

1. Grading data for each aggregate component of three trial blends shall be submitted to the Department. The data for the mixture shall show percent passing for the following sieves: 2 inch, 1 1/2 inch, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, No. 4, No. 8, No. 16, No. 30, No. 50, No. 100, and No. 200. The grading shall be reported to the nearest 1.0 percent except the No. 200 sieve shall be reported to the nearest 0.1 percent.

2. The test data shall include, but not be limited to, the percentage of each aggregate component as compared to the total aggregate in the asphalt mixture. The specific gravity and aggregate properties for coarse and fine aggregates defined in Section 211.02 (b) and (c), including flat and elongated properties, for each aggregate component or for the total aggregates used in the mixture shall be reported. Aggregate properties, except sand equivalent, shall be reported for RAP portions of a mixture. The aggregate specific gravity of RAP shall be the effective aggregate specific gravity calculated from the results of tests conducted in accordance with AASHTO T 209 and VTM-102.

TABLE II-13
Asphalt Concrete Mixtures: Design Range[1]

Mix Type	2 in.	1 1/2 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 30	No. 50	No. 200
SM-9.0 A,D,E					100[2]	90-100	90 max.	47-67			2-10
SM-9.5 A,D,E					100[2]	90-100	80 max.	38-67			2-10
SM-12.5 A,D,E				100	95-100	90 max.	--	34-50			2-10
IM-19.0 A,D,E			100	90-100	90 max.	--	--	28-49			2-8
BM-25.0 A,D		100	90-100	90 max.	--	--	--	19-38			1-7
C (Curb Mix)					100	92-100	70-75	50-60	28-36	15-20	7-9

[1]SM = Surface Mixture; IM = Intermediate Mixture; BM = Base Mixture; C = Curb Mixture.
[2]A production tolerance of 1% will be applied to this sieve regardless of the number of tests in the lot.

TABLE II-14
Mix Design Criteria

Mix Type	VFA (%) Production (Note 1)	VFA (%) Design	VFA (%) Production (Note 2)	Min. VMA %	Fines/Asphalt Ratio (Note 3)	No. of Gyrations N Design
SM-9.0A Notes 1,2,3	2.0-5.0	75-80	70-85	16	0.6-1.3	65
SM-9.0D Notes 1,2,3	2.0-5.0	75-80	70-85	16	0.6-1.3	65
SM-9.0E Notes 1,2,3	2.0-5.0	75-80	70-85	16	0.6-1.3	65
SM-9.5A Notes 1,2,3	2.0-5.0	73-79	68-84	15	0.6-1.2	65
SM-9.5D Notes 1,2,3	2.0-5.0	73-79	68-84	15	0.6-1.2	65
SM-9.5E Notes 1,2,3	2.0-5.0	73-79	68-84	15	0.6-1.2	65
SM-12.5A Notes 1,2,3	2.0-5.0	70-78	65-83	14	0.6-1.2	65
SM-12.5D Notes 1,2,3	2.0-5.0	70-78	65-83	14	0.6-1.2	65
SM-12.5E Notes 1,2,3	2.0-5.0	70-78	65-83	14	0.6-1.2	65
IM-19.0A Notes 1,2,3	2.0-5.0	69-76	64-81	13	0.6-1.2	65
IM-19.0D Notes 1,2,3	2.0-5.0	69-76	64-81	13	0.6-1.2	65
IM-19.0E Notes 1,2,3	2.0-5.0	69-76	64-81	13	0.6-1.2	65
BM-25.0A Notes 2,3,4	1.0-4.0	67-87	67-92	12	0.6-1.3	65
BM-25.0D Notes 2,3,4	1.0-4.0	67-87	67-92	12	0.6-1.3	65

[1]SM = Surface Mixture; IM = Intermediate Mixture; BM = Base Mixture.
Note 1: Asphalt content should be selected at 4.0 % Air Voids,
Note 2: During production of an approved job mix, the VFA shall be controlled within these limits.
Note 3: Fines-asphalt ratio is based on effective asphalt content.
Note 4: Base mix shall be designed at 2.5% air voids. BM-25.0A shall have a minimum asphalt content of 4.4% unless otherwise approved by the Engineer. BM-25.0D shall have a minimum asphalt content of 4.6% unless otherwise approved by the Engineer.

3. The aggregate grading in the asphalt mixture shall be determined by igniting or extracting the asphalt from a laboratory-prepared sample. The laboratory sample shall be batched on the basis of component percentages as indicated in (d) 2. herein and at the proposed job-mix asphalt content. The aggregate shall be obtained in accordance with VTM-102 or VTM-36, when approved. Sieves specified in (d) 1. herein shall be reported, beginning with the top size for the mix.

4. The following volumetric properties of the compacted mixture, calculated on the basis of the mixture's maximum specific gravity determined in accordance with AASHTO T-209, shall be reported to the Engineer. The mixture shall be aged in accordance with AASHTO R30 and the bulk specific gravity of the specimens determined in accordance with AASHTO T-166, Method A, for each asphalt content tested. Properties shall be determined and reported in accordance with AASHTO R35.

   a. Voids in total mix (VTM)

   b. Voids in mineral aggregate (VMA)

   c. Voids filled with Asphalt (VFA)

   d. Fines/Asphalt ratio (F/A)

5. The value of the maximum specific gravity of the asphalt mixture used in (c) 4. herein shall be reported to three decimal places.

6. The mixing and compaction temperature for testing shall be as follows:

   a. For mixes designation A, the mix temperature shall be 300 degrees F to 310 degrees F and the compaction temperature shall be 285 degrees F to 290 degrees F.

   b. For mixes designation D, the mix temperature shall be 310 degrees F to 320 degrees F and the compaction temperature shall be 295 degrees F to 300 degrees F.

   c. In cases involving PG 64E-22 or modified binders, the temperatures shall be based on documented supplier's recommendations.

7. The field correction factor as determined by subtracting the bulk specific gravity of the aggregate from the effective specific gravity of the aggregate at the design asphalt content.

8. For surface mixes, permeability test data shall be submitted in accordance with VTM 120 using either single point verification or the regression method for each surface mix having a different gradation. If the average of the permeability results from the single point verification method exceeds 150 x 10^{-5} cm/sec, or if the regression method predicts a permeability exceeding 150 x 10^{-5} cm/sec at 7.5% voids, the Contractor shall redesign the mixture to produce a permeability number less than 150 x 10^{-5} cm/sec.

(e) The SUPERPAVE design binder content test data shall be plotted on graphs as described in AASHTO R 35 and shall show that the proposed job-mix formula conforms to the requirements of the designated mix type.

(f) A determination will be made to verify if any asphalt concrete mixture being produced conforms to the job-mix formula approved by the Department. The Department and Contractor will test the mixture using samples removed from production. The following tests will be conducted to determine the properties listed:

Property	Test
Asphalt content	VTM-102, (VTM-36 when approved)
Gradation	AASHTO T-30
SUPERPAVE properties	AASHTO R35
Asphalt cement material	AASHTO T316 or T-201

For Warm Mix Asphalt (WMA), SUPERPAVE properties for mixing and compaction temperatures will be determined by the Department and Contractor based on the mix designations in Section 211.03(d)6.

The Department will perform rut testing in accordance with the procedures detailed in VTM-110. If the results of the rut testing do not conform to the following requirements, the Engineer reserves the right to require adjustments to the job-mix formula:

Mix Designation	Maximum Rut Depth, mm
A	7.0
D	5.5
E, (S)	3.5

TABLE II-14A
Recommended Performance Grade of Asphalt Cement

Mix Type	Percentage of Reclaimed Asphalt Pavement (RAP) in Mix		
	%RAP ≤ 25.0%	**25.0% < %RAP ≤ 30.0%**	**25.0% < %RAP ≤ 35.0%**
SM-4.75A, SM-9.0A, SM-9.5A, SM-12.5A	PG 64S-22	PG 64S-22	
SM-4.75D, SM-9.0D, SM-9.5D, SM-12.5D	PG 64H-22	PG 64S-22	
IM-19.0A	PG 64S-22	PG 64S-22	
IM-19.0D	PG 64H-22	PG 64S-22	
BM-25.0A	PG 64S-22		PG 64S-22
BM-25.0D	PG 64H-22		PG 64S-22

After calibration of the gyratory compactor is completed, the Engineer may require the Contractor to make adjustments to the job-mix formula.

If the Department determines that the mixture being produced does not conform to the approved job-mix formula and volumetric properties specified in Table II-14 based on the Department's or Contractor's test results, the Contractor shall immediately make corrections to bring the mixture into conformance with the approved job-mix formula or cease paving with that mixture.

Subsequent paving operations using either a revised or another job-mix formula that has not been verified as described herein shall be limited to a test run of 100 to 300 tons of mixture if such material is to be placed in Department project work. No further paving for the Department using that specific mixture shall occur until the acceptability of the mixture being produced has been verified using the 100 to 300 ton constraint.

Based on rut testing performed by the Department and/or field performance of the job mix, the Engineer reserves the right to require the Contractor to make adjustments to the job-mix formula.

(g) When using **RAS Materials (Tear-off or Tabs)**, the Contractor shall submit material samples to include the RAS stockpiled tear-off shingles, reclaimed asphalt pavement (RAP) and PG Binder.

The amount of RAS material used in the recycled mixture shall be no more than five percent of the total mixture weight. However, the combined percentages of RAS and RAP shall not contribute more than 30 percent (by weight) of the total asphalt content of the mixture, according to the following equation:

$$\frac{\left(\%RAS_{mix} \times \%AC_{RAS}/100\right) + \left(\%RAP_{mix} \times \%AC_{RAP}/100\right)}{\%AC_{JMF}} \leq 30.0\%$$

Where:
$\% RAS_{mix}$ = Percent RAS in the Job Mix Formula
$\% AC_{RAS}$ = Average Percent AC in the RAS
$\% RAP_{mix}$ = Percent RAP in the Job Mix Formula
$\% AC_{RAP}$ = Average Percent AC in the RAP
$\% AC_{JMF}$ = Design AC content of the JMF

The Contractor shall determine the asphalt content of the RAS using AASHTO T-164, Method B, or VTM-102 and report the average results to the nearest 0.1 percent. When the ignition furnace is used, a correction factor shall be applied for the non-asphalt combustible materials in the RAS. Unless the actual correction factor is determined by comparing the test results on paired samples from AASHTO T-164 Method B and VTM-102, the estimated correction factor for the RAS shall be 5 percent.

Used separately or with RAP, RAS can be used to stiffen the asphalt concrete mixture binder to meet the requirements in Section 211. Asphalt surface, intermediate, and base mixtures containing RAS in order to meet the asphalt concrete mixture stiffness of PG 64H-16 should use PG 64S-22 asphalt cement. Further, mixes using RAS shall not exceed the 30 percent (by weight) and are required to use the maximum binder replacement criteria noted here:

- 5% RAS and 0% RAP
- 4% RAS and 5% RAP minimum
- 3% RAS and 10% RAP minimum
- 2% RAS and 20% RAP minimum

Interpolation shall be used to determine combinations between the whole number RAS/RAP usage figures shown herein, subject to review and approval by the Engineer.

211.04—Asphalt Concrete Mixtures

Asphalt concrete mixtures shall conform to the requirements of Table II-14 and the following:

(a) **Types SM-9.0A, SM-9.0D, SM-9.0E, SM-9.5A, SM-9.5D, SM-9.5E, SM-12.5A, SM-12.5D, and SM-12.5E asphalt concrete** shall consist of crushed stone, crushed slag, or crushed gravel and fine aggregate, slag or stone screenings, or a combination thereof combined with asphalt cement.

NOTE: For all surface mixes, except where otherwise noted, no more than 5 percent of the aggregate retained on the No. 4 sieve and no more than 20 percent of the total aggregate may be polish susceptible. At the discretion of the Engineer, SM-9.5AL or SM-12.5AL may be specified and polish susceptible aggregates may be used (without percentage limits).

NOTE: Unless Type C (curb mix) is specified by the Engineer in the Contract, SM9.0, SM-9.5, and SM-12.5 mix types are acceptable for use in the construction of asphalt curbing.

(b) **Types IM-19.0A, IM-19.0D, and IM-19.0E asphalt concrete** shall consist of crushed stone, crushed slag, or crushed gravel and fine aggregate, slag or stone screenings, or a combination thereof combined with asphalt cement.

NOTE: At the discretion of the Engineer, an intermediate mix may be designated as either SM-19.0A, SM-19.0D or SM-19.0E. When designated as such, no more than 5 percent of the aggregate retained on the No. 4 sieve may be polish susceptible. All material passing the No. 4 sieve may be polish susceptible.

(c) **Types BM-25.0A and BM-25.0D asphalt concrete** shall consist of crushed stone, crushed slag, or crushed gravel and fine aggregate, slag or stone screenings, or a combination thereof combined with asphalt cement.

(d) **Type C (curb mix) asphalt concrete** shall consist of a blend of No. 78 or No. 8 crushed aggregate, No. 10 crushed aggregate, fine aggregate, mineral filler, and a stabilizing additive from the Department's approved list found in the Materials Division's Manual of Instructions combined with 6.0 to 9.0 percent of PG 64S-22. This mix does not require a volumetric mix design or volumetric testing under the SUPERPAVE system.

(e) **Type SM-9.5, SM-12.5, IM-19.0 and BM-25.0 asphalt concrete** may be designated E (polymer modified), or stabilized (S). Asphalt concrete mixtures with the E designation may not be stabilized.

1. **Type E asphalt mixtures** shall consist of mixes incorporating a neat asphalt material with polymer modification complying with the requirements of PG 64E-22 and have a rolling thin film oven test residue elastic recovery at 77 degrees F of a minimum of 70 percent when tested in accordance with ASTM D 6084 procedure A. E designated mixtures shall not contain more than 15 percent reclaimed asphalt pavement (RAP) material (by weight) or 3 percent recycled asphalt shingles (RAS) (by weight).

2. **Type (S) asphalt mixtures** shall consist of mixes incorporating a stabilizing additive from the Department's approved list found in the Materials Division's Manual of Instructions. These mixes shall be designated with an (S) following the standard mix designation. The minimum required additive shall be as specified on the Department's approved list found in the Materials Division's Manual of Instructions.

3. **Type L asphalt mixtures** will be allowed to contain a 100 percent polishing course and fine aggregate. These mixes shall be designated with a L following the standard mix designation.

211.05—Testing

The Contractor shall provide the quality control and quality assurance necessary for the Department to determine conformance with the required grading, asphalt content, and temperature properties for asphalt concrete.

The Contractor shall have a Department-certified Asphalt Mix Design Technician for designing and adjusting mixes as necessary. The Asphalt Mix Design Technician or Asphalt Plant Level II Technician may perform testing of asphalt mixes. The Asphalt Mix Design Technician shall be responsible for reviewing and approving the results of all testing. The Asphalt Mix Design Technician shall be available and have direct communication with the plant for making necessary adjustments in the asphalt concrete mixes at the mixing plant. The Asphalt Mix Design Technician and Asphalt Plant Level II Technician shall each be capable of conducting any tests necessary to put the plant into operation; however, the Asphalt Mix Design Technician shall be responsible for producing a mixture that complies with the requirements of these Specifications. The Department will award certification.

The Contractor shall maintain all records and test results associated with the material production and shall maintain appropriate current quality control charts. Test results and control charts shall be available for review by the Engineer.

The Contractor shall execute a quality control plan of process inspections and tests, including the determination of SUPERPAVE properties. The results of the SUPERPAVE tests shall be used, along with the results of other quality control efforts, to achieve and maintain the quality of the mixture being produced.

The Contractor shall perform at least one field SUPERPAVE test per day per mix or per 1,000 tons per mix if more than 1,000 tons of a mix is produced per day. Aging as described in AASHTO R30 shall not be performed. If less than 300 tons of asphalt mixture is produced under a single job-mix formula in a day, field SUPERPAVE testing will not be required on that day. That day's tonnage shall be added to subsequent production. When the accumulated tonnage exceeds 300 tons, minimum testing frequency shall apply. Field SUPERPAVE test results shall be plotted and displayed in control chart form in the plant immediately following the completion of each individual test. The tests shall determine asphalt content in percentages to the nearest 0.01. The tests shall determine VTM, VMA, VFA, and F/A in percentages to the nearest 0.1 percent. The Department will conduct on-site inspections so the Contractor's Asphalt Mix Design Technician can demonstrate knowledge of the SUPERPAVE mix design and production requirements on Department-supplied mixtures.

Aggregate specific gravity and aggregate property tests shall be conducted by a Department-certified Aggregate Properties Technician or Asphalt Mix Design Technician on each aggregate component (including RAP) or total aggregate mixture once at mix design stage and once prior to beginning production in each calendar year. Sand equivalent shall not be determined on RAP. In addition, for each 50,000 tons of each aggregate size used at each plant, aggregate specific gravity and the results of aggregate property tests shall be reported for each aggregate component or the total aggregate mixture. Otherwise, if the total blend (cold feed) is used to determine aggregate specific gravity and aggregate properties, these tests shall be run for each 50,000 tons of the total blend.

Field SUPERPAVE tests shall be performed to N_{design} gyrations as specified in Table II-14.

For surface mixes, permeability test data shall be submitted in accordance with VTM 120 using either single point verification or the regression method for each surface mix having a different gradation.

A minimum of one permeability samples will be taken and test run in the first lot, and every other lot thereafter, and results submitted to the District Materials Engineer.

211.06—Tests

The Department may sample materials entering into the composition of the asphalt concrete, the mixture, or the completed pavement. The Contractor shall cooperate with the Engineer in obtaining these samples. When samples are obtained from the pavement by coring, the resulting voids shall be filled and refinished by the Contractor without additional compensation.

Abson recovery samples shall be PG graded according to the requirements of AASHTO M 322-14. Samples meeting the required grades specified in Section 211.01 shall be acceptable.

When the Department performs PG grading on the asphalt in a Contractor's liquid asphalt storage tank, the Engineer will notify the asphalt concrete producer and binder supplier if tests indicate that the binder properties of the asphalt material differ from those of the approved job-mix. The asphalt concrete producer and binder supplier shall determine what corrective action must be taken with the approval of the Engineer.

211.07—Plant Inspection

The Department will accept the preparation of asphalt concrete mixtures under a quality assurance plan. The Contractor shall provide a laboratory as specified in Section 106.07.

In addition, the Contractor shall have all laboratory scales and gyratory compactors calibrated once a year by an independent source. The Contractor shall maintain the calibration records for 3 years from the date of the last calibration.

211.08—Acceptance

Acceptance will be made under the Department's quality assurance program, which includes the testing of production samples by the Contractor and of monitor samples by the Department. Sampling and testing for the determination of grading, asphalt cement content, and temperature shall be performed by the Contractor, and the Department will perform independent monitor checks at a laboratory of its choosing. The Contractor shall input such test results within 24 hours of sampling to the Department through the "Producer Lab Analysis and Information Details" (PLAID) website https://plaid.vdot.virginia.gov, unless otherwise approved by the appropriate District Materials Engineer. Where the Contractor's test results indicate that the mixture conforms to the gradation, asphalt cement content, and mix temperature requirements of the Specifications, the mixture will be acceptable for these properties; however, nothing herein shall be construed as waiving the requirements of Section 106.06, Section 200.02, Section 200.03, and Section 315 or relieving the Contractor of the contractual obligation to furnish and install a finished functional product that conforms to the requirements of the Contract. If a statistical comparative analysis of the Contractor's test results and the Department's monitor tests indicate a statistically significant difference in the results and either of the results indicates that the material does not conform to the grading and asphalt cement content requirements of the Specifications, the Department and the Contractor will make an investigation to determine the reason for the difference. If it is determined from the investigation that the material does not conform to the requirements of the Contract, price adjustments will be made in accordance with Section 211.09.

Acceptance for gradation and asphalt cement content will be based on the mean of results of eight tests performed on samples taken in a stratified random manner from each 4,000-ton lot (8,000-ton lots may be used when the normal daily production of the source from which the material is being obtained is in excess of 4,000 tons). The Contractor shall take samples from the approximate center of the truckload of material unless otherwise approved by the Engineer. Any statistically acceptable method of randomization may be used to determine when to take the stratified random sample; however, the Department shall be advised of the method to be used prior to the beginning of production.

A lot will be considered to be acceptable for gradation and asphalt content if the mean of the test results obtained is within the tolerance allowed for the job-mix formula as specified in Table II-15.

The temperature of the mixture at the plant shall be controlled to provide load-to-load uniformity during changing weather conditions and surface temperatures. The maximum temperature of mix designations A and D and base mixes shall not exceed 350 degrees F unless otherwise directed by the Engineer. The maximum temperature as recommended by the supplier shall not be exceeded for a mix designated E or (S).

If the job-mix formula is modified within a lot, the mean test results of the samples taken will be compared to the applicable process tolerance shown in Table II-15.

Asphalt content will be measured as extractable asphalt or weight after ignition.

TABLE II-15
Process Tolerance

No. Tests	Top Size[1]	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8	No. 30	No. 50	No. 200	A.C.
1	0.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	5.0	2.0	.60
2	0.0	5.7	5.7	5.7	5.7	5.7	5.7	5.7	4.3	3.6	1.4	0.43
3	0.0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	3.3	2.8	1.1	0.33
4	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	2.5	1.0	0.30
5	0.0	3.6	3.6	3.6	3.6	3.6	3.6	3.6	2.7	2.2	0.9	0.27
6	0.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	2.4	2.0	0.8	0.24
7	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.3	1.9	0.8	0.23
8	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.1	1.8	0.7	0.21
12	0.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	1.7	1.4	0.6	0.17

[1]Defined as the sieve that has 100% passing as defined in Table II-13.

Field SUPERPAVE tests will be performed by the Department in accordance with AASHTO R35 during the production of the approved job mixes designed by the SUPERPAVE method. Aging, as described in AASHTO R30, will not be performed. Should any field SUPERPAVE test fail with regard to the limits specified in Table II-14, the Department may require that production be stopped until necessary corrective action is taken by the Contractor. The Engineer will investigate and determine the acceptability of material placed and represented by failing field SUPERPAVE test results.

Should visual examination by the Engineer reveal that the material in any load or portion of the paved roadway is obviously contaminated or segregated, that load or portion of the paved roadway will be rejected without additional sampling or testing of the lot. If it is necessary to determine the gradation or asphalt content of the material in any load or portion of the paved roadway, samples will be taken and tested and the results will be compared to the requirements of the approved job-mix formula. The results obtained in the testing will apply only to the material in question.

211.09—Adjustment System

If a lot of material does not conform to the acceptance requirements of Section 211.08, the Department will determine adjustment points as follows:

Adjustment Points for Each 1% the Gradation Is Outside the Process Tolerance Permitted In Table II-15

Sieve Size	(Applied in 0.1% increments)
1 1/2 in	1
1 in	1
3/4 in	1
1/2 in	1
3/8 in	1
No. 4	1
No. 8	1
No. 30	2
No. 50	2
No. 200	3

TABLE II-16
Standard Deviation

Sieve Size and A.C.	Standard Deviation 1 Adjustment Point for Each Sieve Size and A.C.	2 Adjustment Points for Each Sieve Size and A.C.	3 Adjustment Points for Each Sieve Size and A.C.
1/2 in.	3.8-4.7	4.8-5.7	5.8-6.7
3/8 in.	3.8-4.7	4.8-5.7	5.8-6.7
No. 4	3.8-4.7	4.8-5.7	5.8-6.7
No. 8	3.0-3.9	4.0-4.9	5.0-5.9
No. 30	2.2-3.1	3.2-4.1	4.2-5.1
No. 50	1.5-2.4	2.5-3.4	3.5-4.4
No. 200	1.1-2.0	2.1-3.0	3.1-4.0
A.C.	0.27-0.36	0.37-0.46	0.47-0.56

One adjustment point will be applied for each 0.1 percent that the material is out of the process tolerance for asphalt content.

If the total adjustment for a lot is greater than 25 points, the Contractor shall remove the failing material from the road. If the total adjustment is 25 points or less and the Contractor does not elect to remove and replace the material, the unit price for the material will be reduced 1 percent of the unit price bid for each adjustment point the material is outside of the process tolerance. The Engineer will apply this adjustment to the tonnage represented by the sample(s). If the Engineer applies adjustment points against two successive lots, the Contractor shall ensure plant adjustment is made prior to continuing production.

The Contractor shall control the variability of the Contractor's product in order to furnish a consistently uniform mix. When the quantity of any one type of material furnished to a project exceeds 4,000 tons, the variability of the total quantity furnished will be determined on the basis of the standard deviation for each sieve size and the asphalt content. If the standard deviation is within the ranges specified in Table II-16, the Engineer will adjust the unit bid price for the material as indicated herein. The Engineer will not make adjustments for standard deviation computations on more than two job mixes for the same type of material.

The Engineer will reduce the unit bid price by 0.5 percent for each adjustment point applied for standard deviation.

211.10—Referee System

(a) If the test results obtained from one of the eight samples taken to evaluate a particular lot appear to be questionable, the Contractor may request in writing that the results of the questionable sample be disregarded, whereupon the Contractor shall have either an AASHTO-accredited lab or a Department lab perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed.

If the Engineer determines that one of the 8 test results appears to be questionable, the Department will perform tests on five additional samples taken from the randomly selected locations in the roadway where the lot was placed. The test results of the seven original, i.e. unquestioned, samples will be averaged with the test results of the five road samples, and the mean of the test values obtained for the twelve samples will be compared to the requirements for the mean of twelve tests as specified in Table II-15.

(b) If the Contractor questions the mean of the eight original test results obtained for a particular lot, the Contractor may request in writing approval to have either an AASHTO-accredited lab or a Department lab perform additional testing of that lot.

If the Engineer determines that the mean of the eight original test results are questionable, the Department will perform additional testing of that lot. The test results of the eight samples will be averaged with the test results of four additional samples taken from randomly selected locations in the roadway where the lot was placed, and the mean of the test values obtained from the twelve samples will be compare to the requirements for the mean of twelve tests as specified in Table II-15.

If the Contractor requests additional tests, as described in (a) or (b) herein, the Contractor shall sample the material and have either an AASHTO-accredited lab or Department lab test the material in accordance with Department-approved procedures. The Engineer may observe the sampling and testing.

If the mean of the test values obtained for the twelve samples conforms to the requirements for the mean of twelve tests, the material will be considered acceptable. If the mean of the test values obtained for the twelve samples does not conform to the requirements for the mean result of twelve tests, the lot will be adjusted in accordance with the adjustment rate specified in Section 211.09.

Samples of the size shown herein shall be saw cut by the Contractor for testing without the use of liquids:

Application Rate	Minimum Sample Size
125 lb/yd^2	8 by 8 in
150 lb/yd^2	7 by 7 in
200 lb/yd^2	6 by 6 in
300 lb/yd^2	5 by 5 in

211.11—Handling and Storing Aggregates

Aggregates shall be handled, hauled, and stored in a manner that will minimize segregation and avoid contamination. Aggregates shall be stockpiled in the vicinity of the plant and on ground that is denuded of vegetation, hard, well drained, or otherwise prepared to protect the aggregate from contamination. Placing aggregate directly from the crusher bins into the cold feed may be permitted provided the material is consistent in gradation. When different size aggregates are stockpiled, the stockpiles shall be separated to prevent commingling of the aggregates.

211.12—Asphalt Concrete Mixing Plant

Plants used for the preparation of asphalt concrete mixtures shall conform to the following requirements:

(a) **Certification for Plant Operation and Sampling:** A Certified Asphalt Plant Level I Technician or a Certified Asphalt Plant Level II Technician shall sample material at the plant.

(b) **Plant Scales:** Scales shall be approved in accordance with Section 109.01.

(c) **Drier:** The plant shall include a drier(s) that continuously agitates the aggregate during the heating and drying process. The aggregate shall be dried to a point at which the moisture content of the completed mixture does not exceed 1 percent as determined from samples taken at the point of discharge from the mixing operation.

(d) **Feeder for Drier:** The plant shall be equipped with accurate mechanical means for uniformly feeding the aggregate into the drier so that a consistent production and temperature are reached and maintained. Where different size aggregates are required to comply with grading specifications, they shall be proportioned by feeding into the cold elevator through a multiple compartment feeder bin, one bin for each size used, equipped with positive action gates that can be securely locked to maintain desired proportioning.

(e) **Bins:** When bins are used, adequate and convenient facilities shall be provided to make possible the sampling of representative aggregate material from each bin. Each compartment shall be provided with an overflow pipe of such size and location to prevent contamination of the aggregate in adjacent compartments. Bins shall be provided with individual outlet gates that, when closed, will allow no leakage.

(f) **Thermometric Equipment:** The plant shall be equipped with a thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate or the completed mix if a drier drum mixing plant is used.

A thermometric device shall be fixed in the asphalt feed line at a suitable location near the charging valve at the mixer unit.

Thermometric devices shall be maintained in good working condition and shall be subject to checking against the laboratory thermometer. Any thermometric devices that do not operate or accurately register temperatures shall be removed and repaired or replaced.

(g) **Pollution Control:** Pollution control shall conform to the requirements of Section 107.16.

(h) **Equipment for Preparation of Asphalt Material:** Tanks for the storage of asphalt material shall be equipped with a heating system capable of heating and holding the material at the required temperatures. A separate storage tank or a storage tank having separate compartments shall be available for each grade of asphalt cement being used on the project. The heating system shall be designed to heat the contents of the tank by means of steam, electricity, or other approved means so that no flame is in direct contact with the heating surface of the tank. The circulating system for the asphalt material shall be designed to assure proper and continuous circulation during the operating period and to minimize oxidation. Pipelines shall be steam jacketed or insulated to prevent undue loss of heat. Storage facilities for asphalt material shall be sufficient capacity for at least one day's operation or an equivalent means of supply shall be provided that will ensure continuous operation. Provisions shall be made for measuring and sampling asphalt within storage tanks. When asphalt material is proportioned by volume, the temperature of the asphalt material in storage shall be uniformly maintained at ±20 degrees F during operation of the plant by means of an automatic temperature control device. A sampling valve shall be provided for sampling of each asphalt storage tank used in production of the mix. If there are multiple storage tanks, a dedicated valve for each tank shall be provided.

(i) **Asphalt Control:** Asphalt material shall be accurately proportioned by volume or weight. When volumetric methods are used, measurements shall be made by means of meters or

pumps, calibrated for accuracy. The section of the asphalt line between the charging valve and the spray bar shall be provided with an outlet valve for checking the meter.

When proportioned by weight, the asphalt material shall be weighed on approved scales. Dial scales shall have a capacity of not more than 15 percent of the capacity of the mixer. The value of the minimum graduation shall not be greater than 2 pounds.

Except when a drier-drum mixing plant is used, the asphalt material bucket and its valves and spray bar shall be steam jacketed or heated by other Department approved means. The bucket shall have a capacity of at least 115 percent of the weight of the asphalt material required in any mixture and shall be supported by fulcrums.

The asphalt shall be delivered to the mixer in multiple uniform streams for the full width of the mixer.

(j) **Proportioning Aggregates:** Mineral filler and any bag house fines the Contractor uses shall be metered or introduced by means of an approved device for uniform proportioning by weight or by volume.

The weigh hopper shall be of sufficient size to hold the maximum required weight of aggregate for one batch without hand raking or running over. Sufficient clearance between the weigh hopper and supporting devices shall be provided to prevent accumulation of foreign materials.

The discharge gate of the weigh hopper shall be situated in such a manner that the aggregates will not segregate when dumped into the mixer. Gates on the bins and weigh hopper shall be constructed to prevent leakage when closed.

(k) **Drum Mixer:** The aggregate shall be proportioned by a positive weight control at the cold aggregate feed by use of a belt scale that will automatically regulate the supply of material being fed and permit instant correction of variations in load. The cold feed flow shall be automatically coupled with the asphalt flow to maintain the required proportions.

(l) **Batch Mixer:** The batch mixer shall be of a twin pugmill or other approved type, steam jacketed or heated by other approved means, and capable of producing uniform mixtures within the specified tolerances. It shall be equipped with a sufficient number of paddles or blades operating at such speeds as to produce a properly and uniformly mixed batch. The number and arrangement of the mixer paddles shall be subject to the Engineer's approval. Worn or defective blades shall not be used in mixing operations.

The mixer shall be provided with an approved time lock that will lock the discharge gate after the aggregates and asphalt have been placed in the mixer and will not release the gate until the specified time for mixing has elapsed.

Batch-type mixing plants used to produce asphalt concrete shall be equipped with approved automatic proportioning devices. Such devices shall include equipment for accurately proportioning batches of the various components of the mixture by weight or volume in the proper sequence and for controlling the sequence and timing of mixing operations. The automated system shall be designed to interrupt and stop the batching operation at any time batch quantities are not satisfied for each of the materials going into the mix. A means shall be provided for observing the weight of each material during the batching operation.

The aggregate may be proportioned by cold feed controls in lieu of plant screens provided the cold aggregate feed conforms to the requirements specified in (j) herein.

Should the automatic proportioning devices become inoperative, the plant may be allowed to batch and mix asphalt materials for a period of not more than 48 hours from the time the breakdown occurs provided alternate proportioning facilities are verbally approved by the Engineer. Written permission of the Engineer will be required for operation without automatic proportioning facilities for periods longer than 48 hours.

(m) **Continuous Mixing Plant:** A continuous mixing plant shall include a means for accurately proportioning each size of aggregate either by weighing or volumetric measurement. When gradation control is by volume, the unit shall include a feeder mounted under the compartment bins. Each bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each respective bin compartment. The orifice shall be rectangular, with one dimension adjustable by positive mechanical means, and shall be provided with a lock. Indicators shall be provided to show the individual gate opening in inches. The plant shall be equipped with a satisfactory revolution counter.

The plant shall include a means for calibrating gate openings by weight. The materials fed out of the bins through individual orifices shall be bypassed to a suitable test box, with each component material confined in a separate section. The plant shall be equipped to conveniently handle test samples weighing up to 200 pounds per bin with accurate platform scales provided for this purpose.

Positive interlocking control shall be provided between the flow of aggregate from the bins and the flow of asphalt material from the meter or other proportioning device. This shall be accomplished by approved interlocking devices or other approved positive means.

Accurate control of the asphalt material shall be obtained by weighing, metering, or volumetric measurement.

The aggregate may be proportioned by cold feed controls in lieu of plant screens provided the cold aggregate feed conforms to the requirements specified in (j) herein.

The plant shall include a continuous mixer of an approved type that is steam jacketed or heated by other approved means. The paddles shall be of any adjustable type for angular position on the shafts and reversible to retard the flow of the mixture.

Interlock cutoff circuits shall be included to interrupt and to stop the proportioning and mixing operations when the aggregate level in the plant or the asphalt material in storage falls below that necessary to produce the specified mixture.

(n) **Trucks, Truck Scales, and Automatic Printer System:** These shall conform to the requirements of Section 109.01.

211.13—Preparation of Mixture

The asphalt and aggregate shall be introduced into the mixer at a temperature that will produce a mixture that conforms to the requirements of the job-mix formula.

After the required amounts of aggregate and asphalt material have been introduced into the mixer, the materials shall be mixed until a uniform coating of asphalt and a thorough distribution of the aggregate throughout the mixture are secured that comply with the requirements of the Ross count procedure in AASHTO T195.

The wet mixing time, based on the procedures in AASHTO T195, shall be determined by the Contractor at the beginning of production and will be approved by the Engineer for each individual plant or mixer and for each type of aggregate used; however, in no case shall the wet mixing time be less than 20 seconds. The wet mixing time is the interval of time between the start of introduction of the asphalt material into the mixer and the opening of the discharge gate. A wet mixing time that results in fully coating a minimum of 95 percent of the coarse particles, based on the average of the three samples is acceptable, provided that none of the three sample results has a coating less than 92 percent of the coarse particles shall be the minimum wet mixing time requirement.

A dry mixing time of up to 15 seconds may be required by the Engineer to accomplish the degree of aggregate distribution necessary to obtain complete and uniform coating of the aggregate with asphalt.

211.14—Storage System

If the Contractor elects to use a storage system, the system shall be capable of conveying the mix from the plant to the storage bins and storing the mix without a loss in temperature or segregation or oxidation of the mix. Storage time shall be limited by the ability of the bins to maintain the mix within the quality requirements specified herein with a maximum time limit not to exceed 10 days. Material may be stored in bins for no more than 24 hours without a Department approved heating system.

The conveyor system may be a continuous or skip bucket type. Continuous type conveyors shall be enclosed so that the mix temperature is maintained.

The storage bins shall be designed in a manner to prevent segregation of the mix during discharge from the conveyor into the bins and shall be equipped with discharge gates that will not cause segregation of the mix while the mix is being loaded into the trucks.

Approval for the use of storage bins may be withdrawn by the Engineer if the amount of heat loss, segregation, or oxidation of the mix is excessive.

211.15—Initial Production

(a) **Warm Mix Asphalt (WMA):** At the start of production, the Contractor shall place no more than 500 tons or up to one day's production as directed by the Engineer at an approved site, which may be the project site, so the Engineer can examine the process control of the mixing plant, the Contractor's placement procedures, surface appearance of the mix, compaction patterns of the Contractor's roller(s), and correlation of the nuclear density device.

(b) **Hot Mix Asphalt (HMA):** At the start of production of a mix not previously used on a state roadway, the Contractor shall place 100 to 300 tons or up to one day's production as directed by the Engineer at an approved site, which may be the project site, so the Engineer can examine the process control of the mixing plant, the Contractor's placement procedures, surface appearance of the mix, compaction patterns of the Contractor's roller(s), and correlation of the nuclear density device.

The material shall be placed at the specified application rate. The Engineer will determine the disposition of material that was not successfully produced and/or placed due to negligence in planning, production, or placement by the Contractor.

SECTION 212—JOINT MATERIALS

212.01—Description

These specifications cover resilient products made from various materials that are designed to accommodate the movement of rigid structures, such as component parts of hydraulic cement concrete, and seal the joint from intrusion of water or incompressibles.

212.02—Detail Requirements

(a) **Hot-poured joint sealer** shall be heated in accordance with the manufacturer's recommendations.

1. **Asphalt sealer** shall conform to ASTM D6690, Type II.

2. **Elastomeric joint sealer** shall conform to ASTM D3406 and shall only be used for longitudinal joints.

(b) **Silicone sealants** shall be furnished in a one- or two-part formulation. The sealant shall be compatible with the surface to which it is applied. Acid-cure sealants are not acceptable for use on hydraulic cement concrete. Bond breakers shall be chemically inert and resistant to petroleum products, solvents, and primers.

Silicone sealants are identified in the following manner:

1. **Class A:** A low-modulus non-sag silicone for use in sealing horizontal and vertical joints in hydraulic concrete pavements and structures. Tooling is required.

2. **Class B:** A very-low-modulus self-leveling silicone used to seal horizontal joints in hydraulic cement concrete pavements and structures. Tooling is not normally required.

3. **Class C:** An ultra-low-modulus self-leveling silicone used to seal horizontal joints in hydraulic cement concrete pavements and structures. It can also be used to seal the joints between hydraulic cement concrete pavement and asphaltic concrete shoulders. Tooling is not normally required.

4. **Class D:** An ultra-low-modulus self-leveling rapid-curing two-part silicone used to seal expansion joints on bridge decks. It can also be used to seal joints subject to dynamic movements where rapid curing is necessary. Tooling is not normally required.

Silicone sealants shall conform to the following physical requirements:

Properties	Test Method	Sealant Class A	B	C	D
Tensile stress at 150% strain (max. psi) (Note 1)	ASTM C1135	45	40	15	25
Durometer hardness, Shore (0° and 77° ± 3°F) (Note 1)	ASTM D2240	"A" 10-25	"00" 40-80	"00" 20-80	"00" 40-80
Bond to concrete mortar (min. psi) (Notes 1 and 3)	VTM-90	50	40	35	35
Tack-free time (skin-over) (max. min) (Note 2)	VTM-90 (Note 4)	180	180	180	30
Extrusion rate (min. g/min)	VTM-90	75	90	100	200
Non-volatile (min. %) specific gravity	VTM-90 ASTM D792 (Method A)	90 1.1-1.5	90 1.1-1.5	90 1.1-1.5	90 1.2-1.5
Shelf life (from date of shipment)		6 mo	6 mo	6 mo	6 mo
Movement capability and adhesion (Note 1)	VTM-90	No adhesive or cohesive failure after 10 cycles at 0°F			
Ozone and UV resistance (Note 1)	ASTM C-793-75	No chalking, cracking, or bond loss after 5,000 hr			

Note 1: The cure time for these specimens shall be 21 days for Class A and 28 days for Classes B and C. Specimens shall be cured at 77° ± 3°F and 50 ± 5% relative humidity.
Note 2: At conditions of 77° ± 3°F and 50 ± 5% relative humidity.
Note 3: Class C silicone shall also attain its bond strength requirement to asphalt concrete.
Note 4: In cases of dispute, ASTM D2377 shall be used as a referee test. The exposure period in Section 7, Procedure, shall be the tack-free time requirement of this specification.

Bond breakers: The bond breaker shall not stain or adhere to the sealant. Bond breakers shall be either a backer rod or tape identified and used in accordance with the following:

1. **Backer Rods:**

Type L: A closed-cell expanded polyethylene foam backer rod. This backer rod may only be used with Class A silicone and is suitable for roadway and structure joints.

Type M: A closed-cell polyolefin foam backer rod that has a closed-cell skin over an open-cell core. This backer rod may be used with all three types of sealants and is suitable for use in roadway and structure joints.

Backer rods shall conform to the following requirements:

Property	Test Procedures	Physical Requirements
Density	ASTM D1622	Min. 2.0 lb/ft^3
Tensile strength	ASTM D1623	Min. 25 psi
Water absorption	ASTM C509	Max. 0.5% by volume

2. **Bond Breaking Tape:** Type N: Bond breaking tape shall be made from extruded polyethylene and shall have a pressure-sensitive adhesive on one side. Bond breaking tape may be used with all three types of sealants but is suitable for structure joints only.

   Bond breaking tape shall be not less than 0.005-inch thick.

   The manufacturer of the joint sealant shall furnish certified test results on each lot of sealant furnished to a project. The certified test results shall include all test results except the bond to concrete mortar and shore durometer hardness at 0 degrees F.

   The Engineer will only approve for use those silicone sealants that appear on the latest Approved Products list published by the Department's Materials Division.

   The Department will not approve silicone sealants meeting the material requirements of this specification submitted for initial approval for general use until field evaluations are completed. The material shall be installed in roadway or bridge joints and must go through two winters without failure before being approved. After such evaluation and approval, the material will be placed on the Department's Approved Products list.

   The Department will reject any sealant or bond breaker that fails to perform adequately in actual use even though a sealant or bond breaker has been previously evaluated and approved.

(c) **Preformed expansion joint filler** shall conform to AASHTO M213.

(d) **Expanded rubber joint filler** shall conform to ASTM D1056. Unless otherwise specified, Grades 2A3, 2A4, or 2A5 shall be furnished.

(e) **Preformed neoprene (polychloroprene) seals** shall conform to ASTM D1056, Grade 2B3. (Modification requires that material be manufactured from neoprene.)

(f) **PVC and PE joint fillers** shall conform to ASTM D1667. Grades VE-43 BL to VE-45 BL shall be furnished. The manufacturer shall recommend adhesives for use with this material.

(g) **Sponge rubber joint filler** shall conform to AASHTO M153, Type I. When used in conjunction with bridge bearings, the load required to compress the test specimen to 50 percent of its thickness before the test shall be not more than 100 pounds per square inch.

(h) **Gaskets for pipe** shall conform to the following: Rubber gaskets for ductile iron pipe and fittings shall conform to AWWA C111. Rubber gaskets for concrete and metal pipe shall conform to ASTM C443 and the ozone cracking resistance described in Section 237.02. Rubber gaskets for plastic pipe shall conform to ASTM F 477.

(i) Preformed flexible joint sealants for concrete pipe, manholes and box culvert sections for use in storm sewers or culverts not intended to operate under pressure or subject to infiltration or exfiltration limits shall conform to ASTM C990.

(j) **Preformed elastomeric joint sealer** shall be a vulcanized elastomeric compound in which noncrystallizing neoprene is used as the sole polymer. Sealer shall be resilient and resistant to heat, oil, and ozone.

The seal shall conform to the following as evidenced by samples cut from the finished product:

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	2,000 psi min.
Elongation at break	ASTM D412	250% min.
Hardness (durometer, Shore A)	ASTM D2240	55 ± 5
Tensile strength (change) After Oven aging (70 hr at 212°F) IAW ASTM D573	ASTM D412	–30% max.
Elongation (change) After Oven aging at 212°F) IAW ASTM D573	ASTM D412	–40% max.
Hardness (points change) After Oven aging (70 hr at 212°F) IAW ASTM D573	ASTM D2240	+10% max.
Ozone resistance (20% strain, 100 pphm in air, 300 hr at 104°F) (wipe with solvent to remove surface contamination)	ASTM D1149	No cracks
High-temperature recovery (72 hr at 212°F under 50% deflection)	VTM-3	85% (no web adhesion or cracks)
Low-temperature recovery (72 hr at 14°F under 50% deflection)	VTM-3	87%
Low-temperature recovery (22 hr at –20°F under 50% deflection)	VTM-3	82%

When tested at a temperature of 70 ± 5 degrees F, the seal shall also conform to the following:

Use	Deflection Based on Nominal Width (%)	Pressure (psi)
Pavement	20	Min. 3
	50	Max. 15
Structure	20	Min. 4
	50	Max. 40

After aging at 212 degrees F for 70 hours at 50 percent deflection, the seal shall conform to the following:

Use	Deflection Based on Nominal Width (%)	Pressure (psi)
Pavement	20	Min. 1.0
	50	Max. 15
Structure	20	Min. 1.5
	50	Max. 40

Lubricant adhesive shall be a one-component polyurethane compound with an aromatic hydrocarbon solvent and shall conform to the physical properties of ASTM D4070.

Lubricant for pavement seals shall conform to ASTM D2835.

(k) **Elastomeric Expansion Dam and Tooth Expansion Joint:** The elastomeric sheet gland material shall be virgin ethylene propylene diene monomer (EPDM) or virgin polychloroprene. The elastomeric material shall have the following physical properties:

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	1,500 psi min.
Elongation at break	ASTM D412	175% min.
Low-temperature brittleness	ASTM D746	Not brittle at –40°F
Oil deterioration (no requirement for EPDM material), volume increase after 70-hr immersion in ASTM Oil No. 3 at 212°F	ASTM D471	120% max.
Ozone resistance: exposure to 100 pphm ozone in air for 70 hr at 100°F under 20% strain	ASTM D1149	No cracks
Hardness, Durometer A	ASTM D2240	50-60

The elastomeric strip seal gland material shall be preformed, non-reinforced, polychloroprene and shall have the following properties:

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	2,000 psi min.
Elongation at break	ASTM D412	250% min.
Hardness, Durometer A, points	ASTM D2240 (Modified)[1,2]	60 ± 5
Tensile strength, loss after Oven aging, 70 hr at 212°F IAW ASTM D573	ASTM D412	20% max.
Elongation, loss after Oven aging, 70 hr at 212°F IAW ASTM D573	ASTM D412	20% max.
Hardness, Durometer A, points After Oven aging (70 hr at 212°F) IAW ASTM D573	ASTM D2240 (Modified)[1,2]	0 to +10
Oil swell, ASTM Oil No. 3, 70 hr at 212°F (100°C), weight change	ASTM D471	45% max.
Ozone resistance, 20% strain, 300 pphm in air, 70 hr at 104°F (40°C)	ASTM D1149 (Modified)[3]	No cracks
Low-temperature stiffening, 7 days at 14°F (10°C), hardness, Durometer A, points change	ASTM D2240 (Modified)[1,2]	0 to +15
Compression set, 70 hr at 212°F (100°C)	ASTM D395 (Modified)[1]	40% max.

[1]The term modified relates to the specimen preparation. The use of the strip seal as the specimen source requires that more plies than specified in either modified test procedure be used. Such specimen modification shall be agreed upon by the purchaser and producer or supplier prior to testing.
[2]The hardness test shall be performed with the durometer in a durometer stand as specified in ASTM D2240.
[3]Test in accordance with ASTM D518, Procedure A. Ozone concentration is expressed in pphm.

1. **Steel portion of expansion dam** shall conform to ASTM A709, Grade 36.

2. **Deformed reinforcing steel bars** shall conform to ASTM A615, Grade 60.

3. **Lubricant adhesive** shall be a one-part moisture-curing polyurethane compound conforming ASTM D4070.

4. **Fabric reinforcement** shall be nonwicking woven polyester material.

5. **Bolts, nuts, and washers** shall conform to ASTM A276, Type 304 Stainless Steel.

6. **Flathead screws** shall conform to ASTM F 738, Type 304 Stainless Steel.

7. **Stud anchors** shall conform to Section 226.02(d).

8. **Special configurations such as doglegs, tees, and crosses in the elastomeric strip seal gland** shall be shop fabricated in a mold under heat and pressure.

(l) **Pressure relief joint material** shall conform to ASTM D3204.

(m) **Waterstops** shall conform to the following:

1. **Metal:** Sheet copper shall conform to Section 230.

2. **Nonmetallic Waterstops:** Nonmetallic waterstops shall be manufactured from neoprene or PVC. Manufacturer's shop splices shall be fully vulcanized.

a. **Neoprene waterstops** shall be manufactured from a vulcanized elastomeric compound containing neoprene as the sole elastomer and shall conform to the following:

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	Min. 2,000 psi
Elongation at break	ASTM D412	Min. 300%
Ozone resistance (20% strain, 100 hr at 100 ± 2°F)	ASTM D1149 (except (except 100 ± 20 pphm)	No cracks
Oil swell (ASTM No. 3 Oil, 70 hr at 212oF, volume change)	ASTM D471	Max. 80%

After accelerated aging in accordance with ASTM D573 for 70 hours at 212 degrees F, the elastomer shall not show a change in tensile strength of more than 15 percent or a change in the elongation at break of more than 40 percent.

b. **PVC waterstops** shall be manufactured from PVC conforming to the U.S. Corps of Engineers Specification CRD-C 572 and shall conform to the ozone resistance as required for neoprene waterstops. The manufacturer shall furnish a certificate verifying compliance with the performance requirements specified under paragraph 6 of CRD-C 572 with the test sample supplied.

(n) **Traffic loop sealant** material shall be an epoxy-resin system, a polyester system, or rubberized asphalt designed specifically to conform to the physical properties for sealing traffic loop pavement cuts. The system shall bond to either hydraulic cement concrete or asphalt concrete, be unaffected by environmental conditions, and have a dielectric strength sufficient to allow the traffic loop to operate as intended. The viscosity of the mixture shall be such that the mixture is easily pourable into the saw slot and sufficiently flowable to encase the electrical wiring.

1. **The epoxy-resin system** shall be a two-component material conforming to the following based on the epoxy without sand, except for the cure time requirement:

Property	Test Procedures	Physical Requirements
Pot life at 77°F	ASTM C881, Para. 11.2	Min. 12 min
Initial cure time at 77°F		Max. 60 min
Hardness, Shore D	ASTM D2240	25-65
Elongation	ASTM D638	Min. 50%
Water absorption (24 hr)	ASTM D570	Max. 0.5%
3% NaCl absorption (24 hr)	ASTM D570	Max. 0.5%
ASTM No. 3 Oil absorption (24 hr)	ASTM D570	Max. 0.1%
Gasoline absorption (24 hr)	ASTM D570	Max. 1.0%

The sand used in the epoxy-resin system shall conform to the following grading requirements:

Sieve No.	% Passing
16	100
30	95 ± 5
100	Max. 10
200	Max. 3

2. **The polyester system** shall be a two-component material conforming to the following:

Property	Test Procedures	Physical Requirements
Pot life at 77°F	ASTM C881, Para. 11.2	Min. 12 min
Initial cure time at 77°F		Max. 45 min
Hardness, Shore D	ASTM D2240	25-65
Elongation	ASTM D638	Min. 15%
Water absorption (24 hr)	ASTM D570	Max. 0.2%
3% NaCl absorption (24 hr)	ASTM D570	Max. 0.2%
ASTM No. 3 Oil absorption (24 hr)	ASTM D570	Max. 0.02%
Gasoline absorption (24 hr)	ASTM D570	Max. 0.8%

3. **Rubberized asphalt** (two-component) shall conform to the following:

Property	Test Procedures	Physical Requirements
Pot life at 77°F		Min. 25 min
Initial cure time at 77°F		Max. 60 min
Hardness, Shore A	ASTM D2240	Max. 20
Flow at 140°F (5 hr)	ASTM D1851	No flow
Bond at 0°F (3 cycles)	ASTM D1851	Min. 50% of original width
Water absorption (72 hr)		Max. 0.1%
ASTM No. 3 Oil absorption (24 hr)		Max. 0.1%

SECTION 213—DAMP-PROOFING AND WATERPROOFING MATERIALS

213.01—Description

These specifications cover materials, generally asphalt based, that are intended to prevent or delay the passage of water, usually through a section of hydraulic cement concrete.

213.02—Detail Requirements

(a) **Asphalt** shall conform to ASTM D312 Type II and shall be free of asbestos. Primer shall conform to AASHTO M140, Types SS-1h, QS-1H, or AASHTO M208, Types CSS-1h, CQS-1h.

(b) **Fabric** shall conform to AASHTO M288. When cotton fabric is used, it shall be saturated with asphalt. Glass fiber shall conform to ASTM D1668.

(c) **Joint sealers** for horizontal joints shall be a viscosity grade, AC-40 asphalt cement, conforming to Section 210. Sealers for vertical joints shall have fiber added, 20 percent by weight. The manufacture shall provide a factory mixed vertical joint sealer to ensure a uniform mixture.

(d) **Membrane** shall conform to ASTM D6153.

SECTION 214—HYDRAULIC CEMENT

214.01—Description

These specifications cover cements that harden when mixed with water. The various types have special characteristics to be used as denoted in other parts of these specifications and on the plans or in other Contract documents.

214.02—Detail Requirements

(a) **Blended hydraulic cement** shall conform to AASHTO M240 and only used as approved by the Engineer.

(b) **Portland cements** shall conform to AASHTO M85 except as follows:

1. The Department will permit SO3 content as specified in AASHTO M85 provided supporting data specified in AASHTO M85 are submitted to the Department for review and acceptance prior to use of the material.

2. Type I and Type II cement shall contain not more than 1.0 percent alkalies (% Na2O + % 0.658K20).

(c) **Expansive hydraulic cement** shall conform to ASTM C 845, Type K.

SECTION 215—HYDRAULIC CEMENT CONCRETE ADMIXTURES

215.01—Description

These specifications cover materials that are chemical or organic elements that may be added to a hydraulic cement concrete mixture, when permitted elsewhere in these specifications, to achieve some desired effect.

215.02—Materials

(a) **Air-entraining admixtures** shall conform to AASHTO M154.

(b) **Water-reducing and retarding admixtures** shall conform to AASHTO M194, Type D, and shall be free from water-soluble chlorides.

The Department will not permit the use of water-reducing and retarding admixtures that have not been tested for compatibility with the brand, type, source, and quantity of cement proposed for use until tests have been performed in accordance with VTM-16 and the test results verify conformance to the requirements of Table I therein.

(c) **Water-reducing admixtures** shall conform to AASHTO M194, Type A, and shall be free from water-soluble chlorides.

(d) **Accelerating admixtures** shall conform to AASHTO M194, Type C or Type E.

(e) **High-range water-reducing and high-range water-reducing and retarding admixtures** shall conform to AASHTO M194, Type F or Type G, and shall be free from water-soluble chlorides.

(f) **Calcium chloride** shall conform to AASHTO M144, Type 2.

(g) **Pozzolan** shall conform to Section 241.

(h) **Granulated iron blast-furnace slag** shall conform to ASTM C989, Grade 100 or 120.

(i) **Silica fume** shall conform to AASHTO M307.

(j) **Corrosion inhibitor** shall contain a minimum 30 percent solution of calcium nitrate or other Department approved material.

(k) **Metakaolin** shall conform to AASHTO M321.

215.03—Detail Requirements

Approved admixture(s) shall be used in concrete in the proportions recommended by the manufacturer to obtain the optimum effect where seasonal, atmospheric, or job conditions dictate its use.

The Contractor shall use only admixtures (a) through (e) that appear on the Materials Division Approved Products List. The Department will base its' initial approval of such admixtures on independent laboratory data submitted by the manufacturer verifying conformance to the specific admixture requirements.

Thereafter, the manufacturer shall annually provide the Engineer a written certification that the material currently being furnished is identical in both composition and chemical concentrations to that tested by the independent laboratory.

The manufacturer shall also supply a certification stating that that the chemical composition of the material is essentially the same as that of the approved mixture if the Contractor proposes to use an admixture that differs in concentration from the acceptance sample.

The Department will permit the use of pump-aid admixtures when the Engineer authorizes placing concrete by pumping, provided these are used in accordance with the manufacturer's recommendations.

SECTION 216—WATER FOR USE WITH CEMENT OR LIME

216.01—Description

These specifications cover water for use in mixing with cement or lime.

216.02—Detail Requirements

Water shall be clean, clear, and free from oil, acid, salt, alkali, organic matter, or other deleterious substances.

Water that has been approved for drinking purposes (potable) may be accepted without testing for use in hydraulic cement concrete, cement, or lime stabilization. The Engineer must approve water from other sources as well as pumping methods planned by the Contractor before use.

The acidity or alkalinity of water will be determined colorimetrically or electrometrically. Water shall have a pH between 4.5 and 8.5. When subjected to the mortar test in accordance with AASHTO T26, water shall produce a mortar having a compressive strength of at least 90 percent of a mortar of the same design using distilled water.

The Engineer will permit the use of wash water from hydraulic cement concrete mixer operations in the concrete mixture provided it is metered and it is 25 percent or less of the total water required. The total water shall conform to the acceptance criteria of ASTM C1602, Tables 1 and 2. The Contractor shall use a uniform amount of wash water in consecutive batches, with subsequent admixture rates adjusted accordingly to produce a workable concrete conforming to the Specification requirements for the concrete mixture.

SECTION 217—HYDRAULIC CEMENT CONCRETE

217.01—Description

These specifications cover materials, design criteria, mixing, and testing procedures for hydraulic cement concrete.

217.02—Materials

Hydraulic cement concrete shall consist of hydraulic cement, fine aggregate, coarse aggregate, water, and admixture(s) mixed in the approved proportions for the various classes of concrete by one of the methods designated hereinafter.

The Contractor shall be responsible for the quality control and condition of materials during handling, blending, and mixing operations and for the initial determination and necessary adjustments in the proportioning of materials used to produce the concrete.

(a) **Cementitious materials** shall be a blend of mineral admixtures and portland cement. In overlay concretes, expansive hydraulic cement is permitted in lieu of portland cement. Portland cement (Types I, II, III), blended cements or expansive cement (Type K) shall comply with Section 214. Blended and Type K cements shall be used only as approved by the Engineer unless otherwise specified. Flyash, ground granulated iron blast-furnace slag (GGBFS), silica fume or metakaolin shall conform to Section 215. The table below lists the minimum percentage of specific mineral admixtures, required by mass, as a portion of the cementitious material depending on the alkali content of the cement. Any other mineral admixture or any other amount or combination of mineral admixtures may be used if approved by the Engineer. The fly ash content shall not exceed 30 percent for Class F, the ground granulated blast-furnace slag content shall not exceed 50 percent and the silica fume content shall not exceed 10 percent as a portion of the cementitious material unless approved by the Engineer. Class C Flyash or other mineral admixtures may be used provided the Contractor demonstrates that the percent usage of Class C Flyash or other mineral admixtures have a maximum expansion of 0.15% at 56 days according to ASTM C227 using borosilicate glass as aggregate.

Minimum percent mineral admixtures required by mass of cementitious material as a portion of the total cementitious materials and is based upon the alkali content of the cement in accordance with the following:

Mineral Admixtures	Total Alkalies of Cement is less than or equal to 0.75%	Total Alkalies of Cement is greater than 0.75% and less than or equal to 1.0%
Class F Flyash	20%	25%
GGBF Slag	40%	50%
Silica Fume	7%	10%
Metakaolin	7%	10%

(b) **Formulated latex modifier** shall be a nontoxic, film-forming, polymeric emulsion of which 90 percent of the nonvolatiles are styrene butadiene polymers. It shall be homogeneous and uniform in composition and free from chlorides. Latex modifier shall conform to the chemical and physical properties specified hereinafter when tested in accordance with FHWA's Report RD-78-35. Initial approval of the modifier by the Department will be based on an analysis of the results of tests performed by an independent laboratory. After initial acceptance, material will be accepted upon certification subject to periodic testing by the Department. A copy of the initial test report shall be submitted to the Department and shall show the following chemical and physical properties:

Property	Value
Butadiene content (%)	30-40
Solids (%)	46-53
pH	8.5-12
Coagulum (%)	Max. 0.10
Surface tension	Max. 50 dynes/cm
Particle size	
Mean Angstrom	1,400-2,500
Median Angstrom	1,400-2,500
Distribution	Unimodal
95% range Angstrom	Max. 2,000
Freeze-thaw stability (% coagulum after 2 cycles)	Max. 0.10
Concrete slump	Greater than standard
Concrete air content	Max. 9%
Time for 50% slump loss	±25% standard
Concrete compressive strength (24 hr and 28 days)	Min. 75% standard
Compressive strength loss (28-42 days)	Max. 20%
Concrete flexural strength (24 hr and 28 days)	Greater than standard
Flexural strength loss (28-42 days)	Max. 25%
Bond strength/slant shear (% monolithic latex concrete cylinder)	Min. 45
Deicer scaling (50 cycles)	
Median grading	Max. 3
Worst rated	Below 5
Chloride permeability (95% absorbed)	
1/16-1/2 in (% Cl-)	Max. 0.320
1/2-1 in (% Cl-)	Max. 0.064

Values for viscosity and density spectrographs of the solid portion and volatile portion shall be provided in the report.

Type I, Type II, Type III or Type K cement shall be used without mineral admixtures for latex-modified concrete.

(c) **Fine aggregate** shall conform to Section 202 for Grading A.

(d) **Coarse aggregate** shall conform to Section 203 for the class of concrete being produced.

(e) **Water** shall conform to Section 216.

(f) **Admixtures** shall conform to Section 215.

(g) **White Portland cement concrete** shall conform to the requirements herein except as follows:

1. **Cement** shall be white portland cement conforming to Section 214 for Type I portland cement except that it shall contain not more than 0.55 percent by weight of Fe2O3.

2. **Fine aggregate** shall consist of clean, hard, durable, uncoated particles of quartz composed of at least 95 percent silica; shall be free from lumps of clay, soft or flaky material, loam, organic material, or other deleterious material; and shall conform to Section 202. It shall contain not more than 3 percent inorganic silt by actual dry weight when tested in accordance with AASHTO T11. Stone sands that produce an acceptable white concrete may also be used.

3. **Coarse aggregate** shall be crushed stone or crushed or uncrushed gravel conforming to Section 203.

(h) **Fly ash** shall conform to Section 241.

(i) **Granulated iron blast-furnace slag** shall conform to Section 215.

(j) **Concrete to which a high-range water reducer is to be added** shall conform to Table II-17. Concrete shall be mixed 70 to 100 revolutions at mixing speed.

(k) **Silica fume** shall conform to Section 215.

(l) **Concrete Repair Materials** shall be from the Materials Division Approved List 31 and shall be in accordance with VTM 132.

217.03—Handling and Storing Materials

(a) **Aggregate** shall be kept separated by size until batched. Aggregates shall be clean and shall be maintained in at least a saturated, surface-dry condition.

Fine aggregate that has been washed shall not be used within 24 hours after being placed in the stockpile or until surplus water has disappeared and the material has a consistent free moisture content. Stockpiles shall be located and constructed so that surplus water will drain from stockpiles and the batcher.

(b) **Cement** that is reclaimed or that shows evidence of hydration, such as lumps or cakes, shall not be used.

Loose cement shall be transported to the mixer either in tight compartments for each batch or between the fine and coarse aggregate. Cement in original shipping packages may be transported on top of the aggregates, with each batch containing the number of bags required.

(c) **Latex modifier** shall be kept in enclosures that will protect it from exposure to temperatures below 40 degrees F or above 85 degrees F. Containers of latex modifier shall be protected from direct sunlight.

(d) **Admixtures** shall be stored and handled so that contamination and deterioration will be prevented. Liquid admixtures shall be thoroughly agitated before use. Admixtures that are frozen or partially frozen shall not be used.

(e) **Aluminum forms, chutes, buckets, pump lines, and other conveying devices** shall not be used if the aluminum comes in contact with concrete.

217.04—Measurement of Materials

Measuring devices shall be subject to the approval of the Engineer.

(a) **Stationary Production Plant:**

1. **Cement** shall be measured by weight. Cement in standard packages of 94 pounds net per bag need not be weighed, but bulk cement and fractional packages shall be weighed within an accuracy of 1 percent.

2. **Mixing water** shall be measured by volume or weight. The water-measuring device shall be readily adjustable and capable of accurately delivering the required amount. The device shall have an accuracy of within 1 percent of the quantity of water required for the batch under all operating conditions.

3. **Aggregates** shall be measured by weight within an accuracy of 2 percent. Fine and coarse aggregate shall be weighed separately. Prior to mixing concrete, the moisture content of aggregates shall be determined and proper allowance made for the water content. The moisture content shall be determined prior to the start of mixing and thereafter as changes occur in the condition of aggregates. The Contractor shall perform moisture determinations and tests for slump and air content and provide necessary testing equipment.

4. **Admixtures** shall be dispensed and used according to the manufacturer's recommendations or instructions. Admixtures shall be added within a limit of accuracy of 3 percent by means of an approved, graduated, transparent, measuring device before they are introduced into the mixer. If more than one admixture is used, they shall be released in sequence rather than in the same instant. The sequence of dispensing admixtures shall not be altered once established. However, when the amount of admixture required to achieve the specified results deviates appreciably from the manufacturer's recommended dosage, use of the material shall be discontinued and the Engineer shall be notified of the change.

(b) **Mobile Production Plant:** Aggregates, cement, and water shall be measured by weight or volume. If ingredients are measured by volume, the Contractor shall furnish, at his expense, approved scales and containers suitable for checking the calibration of the equipment's measuring system. The manufacturer's recommendations shall be followed in operating the equipment

and calibrating the gages and gate openings. Mixing water shall be measured by a calibrated flow meter. The introduction of mixing water to the mixer shall be properly coordinated with the introduction of cement and aggregates. Ingredients shall be proportioned within the following tolerances, which are based on the volume/weight relationship established by calibration of the measuring devices:

Ingredients	Tolerance
Cement	0 to +4%
Fine aggregate	±2%
Coarse aggregate	±2%
Admixtures	±3%
Water	±1%

Tolerances will be applied to Department approved mixture design quantities.

Means shall be provided whereby samples of the various ingredients can be taken from the feed prior to blending and mixing to test the calibration of the equipment.

217.05—Equipment

Equipment and tools necessary for handling materials and performing all parts of the work will be approved by the Engineer before use and must be in accordance with one of the following procedures:

1. having a current National Ready Mix Concrete Association Plant and Truck Certification, or

2. having a Department approved self-certification program in-place prior to the production of concrete for the Department.

Failure to comply with one or the other of these procedures will result in the Department not approving the concrete and the work requiring concrete will not be allowed to proceed.

(a) **Batching Equipment:** Bins with separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Bins for bulk cement shall be arranged so that cement is weighed on a scale separate from those used for other materials and in a hopper free and independent of hoppers used for weighing aggregates. The weighing hopper shall be properly sealed and vented to preclude dusting during operation. Each compartment shall be designed to discharge aggregate efficiently and freely into the weighing hopper. A means of control shall be provided so that material may be added slowly and shut off with precision. A port or other opening shall be provided to remove any overrun of any of the several materials from the weighing hopper. Weighing hoppers shall be constructed to prevent accumulation of materials and to discharge fully.

Scales used for weighing aggregates and cement shall be approved and sealed in accordance with Section 109.01.

When beam scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The indicator shall indicate at least the last 200 pounds of load. Weighing and indicating devices shall be in full view of the operator while the hopper is charged, and the operator shall have convenient access to all controls.

(b) **Mixers and Agitators:** Mixers may be stationary or truck mixers. Agitators may be truck mixers or truck agitators. Each mixer and agitator shall have a metal plate(s) attached in a prominent place by the manufacturer on which the following are marked: the various uses for which the equipment is designed, capacity of the drum or container in terms of the volume of mixed concrete, and speed of rotation of the mixing drum or blades. Each stationary mixer shall be equipped with an approved timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. Each truck mixer shall be equipped with an approved counter by which the number of revolutions of the drum or blades may be readily verified.

The mixer shall be capable of combining ingredients of concrete into a thoroughly mixed and uniform mass and of discharging concrete with a satisfactory degree of uniformity.

The agitator shall be capable of maintaining mixed concrete in a thoroughly mixed and uniform mass and of discharging concrete within a satisfactory degree of uniformity.

Mechanical details of the mixer or agitator, such as the water measuring and discharge apparatus, condition of the blades, speed of rotation of the drum, general mechanical condition of the unit, and cleanliness of the drum, shall be checked by the Contractor and operator before use of the unit is permitted by the Engineer. Consistency tests of individual samples at approximately the beginning, midpoint, and end of the load shall be conducted upon request by the Engineer. If consistency measurements vary by more than 2 inches for slump between high and low values, the mixer or agitator shall not be used until the inconsistency is corrected.

(c) **Mobile Production Plants:** The Contractor may produce Class A3 general use hydraulic cement concrete for incidental construction items from a mobile production plant. The Engineer will not allow the use of mobile production plants to produce concrete used in bridges, except overlays; box culverts; pavements, except patching; or retaining walls. If the Contractor elects to use a mobile production plant as permitted, the equipment requirements specified hereinbefore will not apply and the concrete shall be mixed at the point of delivery by a combination materials transport and mixer unit conforming to the following:

1. The unit shall be capable of carrying ingredients needed for concrete production in separate compartments and of mixing ingredients at the point of delivery. The unit shall be equipped with calibrated proportioning devices to vary mixture proportions of dry ingredients and water. The unit shall be capable of changing the slump at any interval of continuous discharge of concrete.

2. The mixing mechanism shall be a part of the transportation unit carrying dry ingredients. The mixer may be any type capable of combining ingredients for concrete production into a thoroughly mixed and uniform mass and of discharging concrete with a satisfactory degree of uniformity within the specified time of mixing.

3. Each unit shall have a metal plate(s) attached in a prominent place by the manufacturer on which the following are plainly marked: the gross volume of the transportation unit in terms of mixed concrete, discharge speed, and weight-calibrated constant of the machine in terms of an indicator revolution counter.

4. During discharge, the consistency, determined by the slump cone method (ASTM C143), of representative samples taken from the discharge of the mixer at random intervals shall not vary by more than 1 inch.

(d) **High Performance Volumetric Mixers (HPVMs):** The Contractor may produce the specified class of hydraulic cement concrete in Table II-17 in accordance with Section 217.02(a) provided that the manufacturer's equipment meets the tolerance requirements of Section 217.04(a) and has a stamped plate from the Volumetric Mixers Manufacturers Bureau stating that the equipment conforms to ASTM C685.

This combination materials transport and mixer unit shall conform to the following:

1. The unit shall be equipped with calibrated proportioning devices for each ingredient added to the concrete mix. The unit shall be equipped with a working recording meter that is visible at all times and that furnishes a ticket printout with the calibrated measurement of the mix being produced. If the mixer fails to discharge a uniform mix at any time, production of concrete shall halt until any problems are corrected.

2. Each unit shall have a metal plate(s) attached in a prominent place by the manufacturer on which the following are plainly marked: the gross volume of the transportation unit in terms of mixed concrete, the discharge speed and the mass calibrated constant of the machine in terms of volume.

3. HPVMs shall be calibrated by a Department approved testing agency in accordance with the manufacturer's recommendations at an interval of every 6 months or a maximum production of 2500 cubic yards, whichever occurs first. The yield shall be maintained within a tolerance of ±1 percent and verified using a minimum 2 cubic feet container every 500 cubic yards or a minimum once per week.

4. The three cubic feet initially discharged from the truck shall be discarded and not used for concrete placement. Acceptance of the specified class of concrete shall comply with Section 217.08 except that the sample secured for acceptance testing will be taken after four cubic feet is discharged from the delivery vehicle. During discharge, the consistency as determined by ASTM C143 on representative samples taken from the mixer discharge at random intervals shall not vary more than 1 inch. Acceptance tests shall be performed on each load. If test data demonstrates that consistent concrete properties are being achieved, the Engineer may reduce testing requirements.

5. The HPVM shall be operated by a person who is a certified operator by the HPVM manufacturer. Any equipment adjustments made during the on-site production of concrete shall be done under the direct on-site supervision of the producer's VDOT Concrete Plant and Field Certified Technician.

Each load of HPVM produced concrete shall be accompanied by a Form TL-28 signed by the producer's VDOT Certified Concrete Plant Technician or a designated company representative working under the direct on-site supervision of the producer's VDOT Certified Concrete Plant Technician. The form shall be delivered to the Inspector at the site of the work. Loads that do not carry such information or do not arrive in satisfactory condition shall not be used.

217.06—Classification of Concrete Mixtures

Classes and uses of concrete are specified in Table II-17.

TABLE II-17
Requirements for Hydraulic Cement Concrete

Class of Concrete	Design Min. Laboratory Compressive Strength at 28 Days (f'c) (psi)	Aggregate Size No.[6]	Design Max. Laboratory Permeability at 28 Days (Coulombs)[5]	Design Max. Laboratory Permeability at 28 Days - Over tidal water (Coulombs)[5]	Nominal Max. Aggregate Size (in)	Min. Grade Aggregate	Min. Cementitious Content (lb./cu yd)	Max. Water /Cementitious Mat. (lb. Water /lb. Cement)	Consistency (in of slump)	Air Content (percent)[1]
A5 Prestressed and other special designs[2]	5,000 or as specified on the plans	57, 68, 78, or 7	1,500	1,500	1	A	635	0.40	0-4	4 1/2 ± 1 1/2
A4 General	4,000	56 or 57	2,500	2,000	1	A	635	0.45	2-4	61/2 ± 1 1/2
Low Shrinkage A4 Mod.	4,000	56 or 57	2,500	2,000	1	A	N.A.	0.45	2-4	61/2 ± 1 1/2
A4 Post & rails	4,000	7, 8 or 78	2,500	2,000	0.5	A	635	0.45	2-5	7 ± 2
A3 General	3,000	56 or 57	3,500	2,000	1	A	588	0.49	1-5	6 ± 2
A3a Paving	3,000	56 or 57	3,500	3,500	1	A	564	0.49	0-3	6 ± 2
A3b Paving	3,000	357	3,500	3,500	2	A	N.A.	0.49	0-3	6 ± 2
B2 Massive or lightly Reinforced	2,200	57	N.A.	N.A.	1	B	494	0.58	0-4	4 ± 2
C1 Massive Unreinforced	1,500	57	N.A.	N.A.	1	B	423	0.71	0-3	4 ± 2
T3 Tremie seal	3,000	56 or 57	N.A.	N.A.	1	A	635	0.49	3-6	4 ± 2
Latex hydraulic cement concrete overlay[3]	3,500	7, 8 or 78	1,500	1,500	0.5	A	658	0.40	4-6	5 ± 2
Silica fume, silica fume / Class F Fly Ash or silica fume / slag concrete overlay[4]	5,000	7, 8 or 78	1,500	1,500	0.5	A	658	0.40	4-7	6 ± 2
Class F Fly Ash or slag overlay	4,000	7, 8 or 78	1,500	1,500	0.5	A	658	0.40	4-7	6 ± 2

(TABLE II-17 Notes)

[1] When a high-range water reducer is used, the upper limit for entrained air may be increased by 1% and the slump shall not exceed 7 inches. The lower limit for entrained air remains unchanged.

[2] When Class A5 concrete is used as the finishing bridge deck riding surface, or when it is to be covered with asphalt concrete with or without waterproofing, the air content shall be 5 1/2 ± 1 1/2 percent. Prestressed concrete structures over tidal water, beams and slabs within 15 feet of mean high tide and exposed piles shall contain a minimum 2.0 gallons per cubic yard of calcium nitrite with the calcium nitrite conforming to Section 215.

[3] The latex modifier content shall be 3.5 gallons per bag of cement. Slump shall be measured approximately 4.5 minutes after discharge from the mixer.

[4] Silica fume with a minimum of 7% by weight of cementitious material; silica fume with a range of 2.5-5 % shall be combined with Class F Fly Ash in range of 15-20% and minimum cement of 77.5% by weight of cementitious material; silica fume with a range of 2.5-5% shall be combined with Ground Granulated Blast Furnace Slag in the range of 30-35% and a minimum cement of 67.5% by weight of cementitious material.

[5] The permeability testing does not apply to concrete structures and incidental concrete as described in Sections 219, 232, 302, 415, 502, 504, 506 and 519. Curing and testing of test cylinders for permeability will be in accordance with VTM 112.

[6] The Contractor may use different aggregate sizes or a combination of sizes to increase the coarse aggregate content of the concrete as approved by the Engineer. The maximum size of the coarse aggregate shall not exceed 2.5 inches.

Note: The Contractor may substitute a higher class of concrete for that specified at the Contractor's expense with the approval of the Engineer.

217.07—Proportioning Concrete Mixtures

The Contractor is responsible for having a VDOT Certified Concrete Plant Technician available during batching operations, and a VDOT Certified Concrete Field Technician present during placing operations.

A VDOT Certified Concrete Plant Technician is that person who is capable of performing adjustments to the proportioning of materials used to produce the specified concrete should adjustments become necessary.

A VDOT Certified Concrete Field Technician is the person employed by the Contractor responsible for quality control of concrete work at the project site. The Contractor shall have at least one VDOT Certified Concrete Field Technician on the project for single or multiple incidental concrete placements. The Contractor shall have at least one VDOT Certified Concrete Field Technician present at each site during the placement of pavements, bridge decks, bridge piers and abutments, box culverts, and any placement of 50 or more cubic yards.

The VDOT Certified Concrete Field Technician shall provide control over methods used for discharging, conveying, spreading, consolidating, screeding, finishing, texturing, curing, and protecting the concrete. Deficiencies in conformance to specification requirements and good concreting practices shall be corrected by or under the direction of the VDOT Certified Concrete Field Technician as soon as they begin to occur.

The concrete producer shall plan batching operations so that delays do not occur because of the absence of certified personnel.

Concrete shall be proportioned to secure the strength and durability required for the pavement or the part of the structure in which it is to be used.

The Contractor shall submit, or shall have his supplier submit, concrete mixture design(s) conforming to the specifications for the class of concrete specified for the Engineer's approval prior to the start of concrete mixing operations.

The Contractor shall furnish and incorporate a Department approved water-reducing and retarding admixture in bridge deck concrete and in other concrete when conditions are such that the initial set may occur prior to completion of approved finishing operations. The Contractor shall supply and incorporate only an approved water-reducing admixture in lieu of both the water-reducing and retarding admixtures normally required in the bridge deck concrete to provide the required slump without exceeding the maximum water/cement ratio when the Engineer elects not to enforce the requirement for both admixtures. The Contractor shall demonstrate to the Engineer that use of the admixture will not cause segregation. The two admixtures shall not be used together in the same concrete batch unless tests indicate the admixtures are compatible in accordance with Section 215.02(b). Costs for admixture(s) shall be included in the Contract unit price for the respective concrete item.

Concrete shall be air entrained. The air content shall conform to Table II-17.

Except for latex hydraulic cement concrete, concrete mixtures shall be developed and/or verified by any one of the following three options listed below.

The mix design(s) as determined by the respective option below shall be valid provided there is no change in sources of aggregate, chemical admixtures, mineral admixtures, or hydraulic cement. All concrete mixtures shall contain the minimum amount of mineral admixtures or combination thereof expressed as a percent of the total cementitious materials in accordance with Section 217.02(a). All quantities of materials shall be weighed in accordance with tolerances specified in Section 217.04. The quantities of coarse and fine aggregates used in concrete production shall not deviate by more than ±5% by weight from the batch weights of the approved mix design.

When low permeability concrete is specified, two 4 X 8 inch specimens shall be molded from concrete representing the proposed mix design and tested in accordance with VTM 112 to validate conformance. For trial batches, the tested permeability value shall be considered satisfactory provided it is 500 coulombs less than the specified maximum value for the class of concrete specified.

Option 1 - Prescriptive Method:

Mix proportions for normal, heavy weight, and lightweight concrete shall be established by the methods described in ACI 211, on an absolute volume basis, for the respective aggregate size and meeting all Table II-17 requirements for the class of concrete indicated. Aggregate properties obtained from the aggregate producer shall be used for design purposes.

Once the proposed mix design has been established, the Contractor or their concrete supplier shall produce one 3-cubic yard production verification batch using the same type of equipment intended for use in supplying concrete to the Department. The proposed mix design will be considered acceptable provided that the plastic properties of the concrete are within the Department's specification limits for the given class of concrete. Strength tests of the verification batch must equal or exceed f'c for the intended class of concrete.

Option 2 - Trial Batch Mix Design Method:

The minimum cementitious content requirement in Table II-17 shall be waived provided that the maximum water-cementitious ratio requirement of Table II-17 is met for the respective

class of concrete. The required grading for fine and coarse aggregate shall be waived provided the coarse aggregate meets the nominal maximum size as required in Table II-17 for the respective class of concrete.

The Contractor or their concrete supplier shall prepare a minimum of 3 trial concrete batches with differing cementitious materials contents over a range anticipated to encompass the design strength, f'c, plus overdesign, and water-cementitious ratios encompassing the range permitted for the classes of concrete being evaluated. Trial batches may be produced in either:

Option 2A: Small scale laboratory batches, or

Option 2B: Truck batches with a minimum batch volume of 3 cubic yards each.

The plastic properties of the trial concrete batches shall meet the requirements for consistency and air content in Table II-17 and meet the additional requirements listed below:

- The concrete temperature of the trial batches, as batched and sampled, shall be a minimum of 68 degrees F.
- Air content of the trial batches shall within a range of -1.0 to + 1.5 percentage points of the median design air content for the classes of concrete being evaluated.
- Slump of the trial batches shall be within ± 1 inch of the maximum slump permitted for the class of concrete.

Three 4 X 8 inch test specimens shall be molded from each batch, cured in accordance with ASTM C 31 for acceptance specimens, and then compression tested at an age of 28 days. The strength results of these tests shall be plotted on a graph to establish the relationship between the water-cementitious ratio and the compressive strength. Alternately, the relationship can be established between the cementitious content and the compressive strength. The design water-cementitious ratio, or design cementitious content, can then be derived from the graph to satisfy the required design strength plus an appropriate overdesign to be designated as f'cr. The required cementitious materials content determined from these tests can be interpolated from the established graph. If desired, the design water-cementitious ratio or cementitious content can be determined from a polynomial regression analysis of the plotted strength data.

Test results from prior trial concrete batches are acceptable for use provided that they represent the same material sources proposed for the Department work, meet the requirements for trial concrete batches as stated above and are less than 18 months old.

The required cementitious content to satisfy the strength requirement for the respective class of concrete shall be determined in accordance with either of the two following procedures:

1. When the concrete production facility has sufficient data to establish a production standard deviation (s), as described in **Documentation of Previous Field Experience or Production Standard Deviation(s).** The cementitious content required to meet the design strength requirement, f'cr, then the f'cr shall be based upon the following equation:

$$f'cr = f'c + 3s$$

2. When the concrete production facility does not have a production standard deviation established the cementitious content required to meet the design strength requirement, f'cr, then the f'cr shall be based upon the following equation:

$$f'cr = f'c + 1700 \text{ psi.}$$

Once the proposed mix design has been established, the Contractor or their concrete supplier shall produce one 3-cubic yard production verification batch using the same type of equipment intended for use in supplying concrete to the Department. The proposed mix design will be considered acceptable provided that the plastic properties of the concrete are within the Department's specification limits for the given class of concrete. Strength tests of the verification batch must equal or exceed f'c for the intended class of concrete. The requirement for a production verification batch shall be waived when the trial batching is performed by Option 2B -Truck batches.

Option 3 - Documented Field Experience Method:

The minimum cementitious content requirement in Table II-17 shall be waived provided that the maximum water-cementitious ratio requirement of Table II-17 is met for the respective class of concrete. The required grading for fine and coarse aggregate shall be waived provided the coarse aggregate meets the nominal maximum size as required in Table II-17 for the respective class of concrete.

An existing concrete mixture shall be considered acceptable for use provided that the Contractor or their concrete supplier has a satisfactory test record of pervious field experience as described in:

Documentation of Previous Field Experience or Production Standard Deviation(s), and that the proposed concrete mixture meets the following requirements:

1. The water cementitious ratio of the proposed concrete mixture is less than or equal to the maximum water cementitious ratio specified for the respective class of concrete.
2. The documented average strength, f'cr, equals or exceeds the design compressive strength f'c for the respective class of concrete in accordance with the following equation: $f'cr = f'c + 3s$.
3. The proposed concrete mixture contains the same aggregate sources, supplementary cementitious materials type, and admixture type as those used to establish the previous field experience test record.
4. The consistency (slump) and air content are within the specification limits for the respective class of concrete.

Documentation of Previous Field Experience or Production Standard Deviation(s)

An acceptable test record to document previous field experience and/or to establish a production facility standard deviation shall represent a minimum of 30 consecutive compressive strength tests results, encompass a production period of at least 45 days and test data not more than 18 months old. A test record of less than 30 tests, but not less than 15 tests, shall be permitted provided a modification factor is applied to the production facility sample standard deviation as shown below:

Multiply Standard Deviation by Modification Factor

Number of Test	Modification Factor
15	1.16
20	1.08
25	1.03
30	1.00

The test record does not necessarily have to be based on Department projects provided that documentation of the source(s) of concrete strength test results accompanies the submittal.

For latex hydraulic cement content, the dry weight ratio of cement/fine aggregate/coarse aggregate shall be 1:2.5:2. With the Engineer's approval a maximum adjustment of 10 percent may be made in aggregate weights to compensate for grading changes and variable specific gravity.

The Contractor shall adjust batch quantities during the course of the work to compensate for changes in workability caused by differences in the characteristics of aggregates and cements permitted within the specification requirements. Such adjustments shall be made only by the Contractor and shall not change the yield.

If concrete cannot be obtained with the required workability or consistency or within the maximum design water content with the materials furnished, the Contractor shall make changes to secure the desired properties subject to the limiting requirements specified in Table II-17 and the Engineer's approval. The Contractor shall use a fine aggregate having a void content of less than 50.5 percent when the void content of the fine aggregate is more than 50.5 percent and the concrete does not have the desired properties. In lieu of changing the fine aggregate, the Contractor may take one or more of the following actions:

(a) Use a Department approved water-reducing admixture.

(b) Increase the cement content.

(c) Change the source of coarse aggregate.

(d) In hot weather, add ice or otherwise reduce the temperature to increase the workability.

(e) Submit other recommendations to the Engineer for approval.

The Contractor shall make trial batches under the observation of the Engineer to verify that concrete of the required workability and consistency is obtained within the specified water content when any of the actions is exercised. At least one trial batch shall be made with the concrete temperature at approximately 90 degrees F to verify that the concrete mixture has sufficient workability and consistency without exceeding the specified water content. The concrete mixture shall be redesigned when the fineness modulus of the fine aggregate changes more than 0.2 from the original design and the concrete does not have the desired properties. Costs incurred because of adjustments of concrete mixture design(s) and for trial batches shall be borne by the Contractor with no additional compensation being made.

217.08—Acceptance

(a) **Air Consistency Tests:** Air and consistency tests will be performed by the Department prior to discharge of concrete into the forms to ensure that specification requirements are consistently being complied with for each class of concrete supplied. The sample secured for the tests shall be taken after at least two cubic feet of concrete has been discharged from the delivery

vehicle. The two cubic feet discharged is not to be used as part of the test sample. The Engineer must authorize any deviation from sampling and testing procedures. The Contractor shall provide a receptacle conforming to ASTM C31 for the Department's use in obtaining the sample. If either determination yields a result that is outside of the allowable range for air content or consistency, the Engineer will use the following procedure:

1. The Engineer will immediately perform a recheck determination. If the results confirm the original test results, the load will be rejected.

2. The Contractor's representative will be immediately informed of the test results.

3. The Contractor's representative shall notify the concrete producer of the test results through a pre-established means of communication.

The Engineer may perform any additional tests deemed necessary and reject all remaining material that fails the tests.

Entrained air content will be determined in accordance with ASTM C231 or ASTM C173. Acceptance or rejection will be based on the results obtained from these tests.

In general, a mixture that contains the minimum amount of water consistent with the required workability shall be used. Consistency will be determined in accordance with ASTM C143. The Engineer will not allow adding cement to loads previously rejected for excessive water content or unsatisfactory consistency.

(b) **Strength Tests:** The 28-day compressive strengths (f'_c) specified in Table II-17 are the strengths used in the design calculations. The Engineer will verify design strengths by tests made during the progress of the work in accordance with ASTM C31 (Standard Practice for Making and Curing Concrete Test Specimens in the Field) and ASTM C39 (Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens) except that the fresh concrete sample used for testing is to be secured after at least two cubic feet has been discharged from the delivery vehicle. The two cubic feet discharged is not to be used as part of the test sample or in the work. The Engineer must pre authorize any deviation from sampling and testing procedures. The use of ASTM C42 (Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete) will be at the Engineer's discretion. If the 28-day design compressive strength (f'_c) test results do not conform to the strength requirements specified in Table II-17, the Contractor shall take immediate steps to adjust the mixture design. In addition, the Engineer may require removal of or corrective measures be applied to any concrete that does not meet the requirements of Table II-17. If the concrete cylinder strength, f'cyl, is less than the specified compressive strength found in Table II-17, the criteria in Table II-17A shall apply:

TABLE II-17A
Price Reduction or Action Taken due to f'_{cyl}
not meeting the specification value f'_c listed in Table II-17

Condition	Concrete is a Pay Item	Concrete is Not a Pay Item
f'_{cyl} is greater than or equal to 98% f'_c	A	A
f'_{cyl} is greater than or equal to 90% f'_c and less than 98% f'_c	B	C
f'_{cyl} is less than 90% f'_c	D	D
f'_{cyl} is not available due to the Contractor's inappropriate handling and storage of specimens in accordance with ASTM C31	D	D

f'_c is the 28-day design compressive strength requirement found in Table II-17.

f'_{cyl} is the actual average tested strength of the standard-cured concrete cylinder made and tested in accordance with ASTM C31 and ASTM C39.

A = full payment

B = pay reduction = $[((f'_c - f'_{cyl})/f'_c)$ x Contract unit price for concrete per yd^3 x number of yds^3 the concrete represents] or $500, whichever is greater.

C = pay reduction = $[((f'_c - f'_{cyl})/f'_c)$ x 5 x Contractor's invoice price for concrete per yd^3 x number of yds^3 the concrete represents] or $500, whichever is greater.

D = The Contractor shall submit an investigative plan stamped by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia outlining how the Contractor shall demonstrate that the in-place concrete meets the structural strength requirements for the design. The Engineer will not permit any reduction in concrete strength below $0.9f'_c$ for barriers, parapets, railings, etc. The Engineer will approve the investigative plan for all other applications prior to the execution of the investigation. All costs associated with this investigation shall be borne by the Contractor. After the investigation is completed, the Contractor shall submit a report to the Engineer showing the results of the Professional Engineer's analysis, testing and conclusions as well as any recommended actions proposed by the Contractor to be taken with the concrete that did not meet the strength requirements. The Department retains all rights to determine if the action proposed with regard to the concrete in question is acceptable. If the Department concurs with the proposed action and the concrete meets the structural strength requirements of the design and remains in place, any price reduction will be taken by Method B if the concrete is a pay item or Method C if the concrete is not a pay item. If the concrete does not meet the structural requirements of the design, the concrete shall be removed and replaced at no cost to the Department. The maximum penalty assessed for low strength concrete left in place will be 10% as specified in Table II-17A, not including the cost of the investigation and any corrective measures taken by the Contractor.

The Department will not assess a calculated penalty less than $500. The Contractor shall have the right to remove and replace concrete failing to meet specifications at the Contractor's cost.

Before concrete is placed, the Contractor shall provide a storage chamber at his expense for temporary storage of the Department's concrete cylinders. The Contractor shall be responsible for maintaining the chamber so that the concrete test cylinders are kept in a continuously moist condition and within a temperature range of 60 degrees F to 80 degrees F. The chamber shall be equipped with a continuously recording thermometer accurate to ± 2 degrees F for the duration of concrete cylinder curing. The Contractor shall provide the data from the continuously recording thermometer within time frames as approved by the Engineer. The chamber shall be located in an area where the test cylinders will not be subject to vibration and shall be of sufficient size or number to store, without crowding or wedging, the required number of test cylinders as determined by the Contractor based on his plan of operations. The Engineer will approve the location of the chamber prior to its placement.

When use of high-early-strength hydraulic cement concrete is required, it shall conform to Table II–17 except that the 28-day compressive strength requirement shall be obtained in 7 days.

The Contractor may use up to 800 pounds per cubic yard of Type I, Type II or Type III cement to produce high-early-strength concrete.

(c) **Concrete Temperature** shall be measured in accordance with ASTM C1064.

(d) **Quality Assurance for Low Permeability Concrete:**

General:

The Contractor shall prepare and cast test specimens on at least two trial batches using job materials, with permissible combination of cementitious materials, for testing by the Department for permeability and strength at least 5 weeks before the field application. The permeability samples shall be cylindrical specimens with a 4-inch diameter and at least 4-inches in length. Cylinders will be tested at 28 days in accordance with VTM 112. The test value shall be the result of the average values of tests on two specimens from each batch. Permeability values obtained from trial batches shall be 500 coulombs below the maximum values specified in Table II-17 to be acceptable.

Acceptance Tests:

For each set of cylinders made for compressive strength tests, two additional cylinders shall be made for the permeability test. The Department will be responsible for making and testing all permeability test specimens.

If the average permeability test result is equal to or less than the value for the specified class of concrete in Table II-17, then full payment will be made for the lot the average permeability test result represents. However, if the average permeability test result exceeds the coulomb value in Table II-17, the percent reduction in payment for that lot of concrete shall be calculated by multiplying 0.005 by each coulomb above the coulomb value in Table II-17 by the concrete item Contract unit price times the number of cubic yards or cubic meters of concrete in the lot. The reduction in price will not exceed 5 percent of the concrete item Contract unit price. The Engineer will reject any concrete with a coulomb value that exceeds the maximum required in Table II-17 by 1000 coulombs. However, bridge deck concrete with any coulomb value exceeding the maximum required value by over 1000 coulomb may be accepted by the Engineer at 95 percent of the Contract unit price if the concrete in question has the required strength, meets the other specification requirements and the Contractor applies, at his own expense, an approved epoxy concrete overlay to the top of the entire deck. In such cases deck grooving will not be required. The Engineer will not allow the placement of epoxy overlays over latex overlays. The Contractor shall make the adjustment to the roadway grade as required by the Engineer at the Contractor's expense.

Similarly, concrete in abutments and pier caps with coulomb value exceeding the maximum required in Table II-17, by more than 1000 coulomb may be accepted at 95 percent of the Contract unit price if it has the required strength, meets the other specification requirements and the Contractor applies, at his own expense, one coat of epoxy Type EP 3B and one coat of epoxy EP 3T in conformance with Section 243.02, on top of the pier caps or abutment seats.

(e) **Bond Strength for Silica fume concrete, latex-modified concrete and very-early-strength latex-modified concrete overlays:**

Bond Strength, minimum at 7 days, VTM 92: 150 psi or failure in the substrate concrete at a depth > 0.5-in over > 50 percent of the test area. The Contractor shall perform the bond strength

testing. Tests shall be performed one or more days after the overlay is placed and at a time when the lane can be closed to traffic with a minimum of inconvenience to the public. A minimum of one test result (based upon the average of three test specimen results) shall be conducted on each placement.

217.09—Mixing

The Engineer must approve the Contractor's method of mixing prior to the start of concrete work.

The volume of concrete mixed per batch shall be at least 15 but not more than 110 percent of the mixer's rated capacity.

Concrete that becomes nonplastic, unworkable, or outside the limits of the slump specified shall not be used. Retempered concrete shall not be used. The Contractor shall regulate concrete delivery so that placement is at a continuous rate. Intervals between deliveries of batches shall not be so great as to allow concrete in place to begin its initial set.

(a) **Mixing at Job Site:** Concrete shall be mixed in a batch mixer designed to ensure a uniform distribution of materials throughout the mass. When bag cement is used, batches shall be proportioned on the basis of integral bags of cement.

Mixing shall be performed in accordance with the requirements herein.

The mixer shall be thoroughly cleaned upon cessation of mixing for more than 30 minutes.

(b) **Ready-Mixed Concrete:** Ready-mixed concrete shall be delivered to the designated point ready for use.

Each load of transit or shrink-mixed concrete shall be accompanied by Form TL-28 signed by the VDOT Certified Concrete Plant Technician or a designated company representative working under the direction of the VDOT Certified Concrete Plant Technician. The form shall be delivered to the Inspector at the site of the work. Additional TL-28's shall be delivered as needed on the project such as when additional space is needed on the form or there is a change in mix design. The Engineer will reject loads that do not carry such information or that do not arrive in satisfactory condition.

The mixer shall be thoroughly cleaned upon cessation of mixing for more than 30 minutes.

Each batch of concrete shall be delivered to the site of work and discharged within 90 minutes of the time the cement is introduced into the mixture unless the Engineer approves otherwise.

Mixing and delivery shall be in accordance with the following:

1. **Transit mixing:** Concrete shall be mixed in a truck mixer. Mixing shall begin immediately after all ingredients are in the mixer and shall continue for at least 70 revolutions of the drum or blades at the rate of at least 14 but no more than 20 revolutions per minute.

   Additional rotations of the drum or blades shall be at the rated agitating speed. The mixer shall be operated within the capacity and speed of rotation designed by the manufacturer.

2. **Shrink mixing:** Materials, including water, shall be partially mixed in a stationary mixer for at least 30 seconds. Mixing shall be completed in a truck mixer with at least 60 but not more than 100 revolutions of the drum or blades at the rated mixing speed. Additional rotations of the drum or blades shall be at the rated agitating speed. Mixers shall be operated within the capacity and speed of rotation designated by the manufacturer of the equipment.

3. **Central mixing:** Concrete shall be completely mixed in a stationary mixer and transported in agitator equipment to the point of delivery. The Engineer will approve the use of nonagitator equipment only when the plant is in the immediate vicinity of the project.

   Mixing time for mixers having a capacity of 1 cubic yard or less shall be at least 60 seconds. Mixing time for mixers having a capacity of more than 1 but less than 10 cubic yards shall be at least 75 seconds. Mixing times for mixers having a capacity of more than 10 cubic yards shall be as determined by the Engineer. Performance tests to verify mixing time shall be conducted in accordance with VTM-17 by an approved commercial laboratory at the Contractor's expense. The Engineer will only approve shorter mixing times if the producer of the concrete is in conformance with VTM-17. In any event, mixing time shall be not less than 40 seconds.

   VTM-17 shall not be construed as a nullification of the requirements of Table II-17. If subsequent evaluation check tests indicate that the reduced mixing time is not satisfactory, the Contractor shall reestablish the necessary mixing time.

   The Engineer will reject concrete mixed for less than the specified time. Mixing time starts when solid materials are in the mixing compartment and ends when any part of the concrete begins to discharge. The mixer shall be operated at the drum speed specified on the nameplate of the approved mixer.

   Bodies of nonagitating equipment used to transport concrete shall be smooth, mortar tight, non-aluminum metal containers capable of discharging concrete at a controlled rate without segregation. Upon discharge of concrete, the body of the equipment shall be free from concrete. Concrete shall be delivered to the work site in a thoroughly mixed and uniform mass. Upon the request of the Engineer, consistency tests of individual samples at approximately the beginning, midpoint, and end of a load shall be conducted. If consistency measurements vary by more than 2 inches for slump between high and low values, mixer or agitator equipment shall be used in lieu of nonagitating equipment.

(c) **Automatic Mobile Continuous Mixers:** Mobile continuous mixers shall be calibrated to proportion the mixture accurately and shall have been certified prior to their use on the project for the type of material specified. Certifications will be valid for 6 months or until the source of materials changes or the grading or moisture changes significantly so as to affect the consistency of the concrete mixture. Evaluation and certification of the mixer will be performed by the Department or an approved testing agency to verify that the true yield is within a tolerance of ±1.0 percent. A recording meter, visible at all times and equipped with a ticket printout, shall indicate the calibrated measurement.

(d) **Hand Mixing:** Hand mixing will be permitted only in case of emergency and with the Engineer's permission. Batches shall be not more than 1/2 cubic yard and shall be mixed in a watertight container in a manner approved by the Engineer. Ingredients shall be measured by placing them in any suitable, rigid container in the volumetric proportions of 1 part cement to

2 parts fine aggregate to 2 1/2 parts coarse aggregate. The container shall be filled and leveled with each ingredient to ensure the proportions specified are as near to their prescribed amounts as possible. Water shall then be added to produce a mixture having a slump of not more than 3 inches.

217.10—Placement Limitations

The Contractor shall be responsible for the quality of concrete placed in any weather or atmospheric condition. At the time of placement, concrete shall have a temperature in accordance with the following:

(a) **Class A3 general use concrete used in the construction of incidental items specified in Division V, except retaining walls,** shall have a temperature of at least 40 degrees F but not more than 95 degrees F.

(b) **Class A3 paving concrete placed by the slipform method and containing an approved water reducer** shall have a temperature of at least 40 degrees F but not more than 95 degrees F.

(c) **Concrete used in the construction of bridge decks** shall have a temperature of at least 40 degrees F but not more than 85 degrees F.

(d) **Retaining walls and other concrete not specified in (a), (b), or (c) herein** shall have a temperature of at least 40 degrees F but not more than 90 degrees F.

In cold weather, water and aggregates may be heated to not more than 150 degrees F to maintain concrete at the required temperature. The heating apparatus shall be such that materials will be heated uniformly and the possibility of the occurrence of overheated areas that might damage materials will be precluded. Steam shall not come in contact with aggregates. Cement shall not be heated. Heating equipment or methods that alter or prevent entrainment of the required amount of air in concrete shall not be used. Materials containing frost, lumps, crusts, or hardened material shall not be used to produce concrete.

In hot weather, aggregates or the mixing water shall be cooled as necessary to maintain the temperature of the concrete within the specified maximum temperature.

217.11—Self Consolidating Concrete (SCC)

When specified or designated on the plans, SCC shall be designed as the Class of Concrete specified in Table II-17 and conform to all the requirements herein except as outlined below. Combined aggregate grading and viscosity modifying admixture (VMA) may be used. The viscosity-modifying admixture shall conform to ASTM C494, Type S. Synthetic fibers from the Materials Division Approved Products List 35 may be added to control cracking. Shrinkage-reducing admixture may be added to control shrinkage with the approval of the Engineer. The maximum size of aggregate shall be 3/4-inch. Further, the maximum size shall, not be larger than 1/5 the narrowest dimension between the sides of the forms, not be larger than 1/3 the slab depth and not be larger than 3/4 of the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, individual tendons, bundled tendons or ducts.

The Contractor shall furnish the Engineer a mix design for the SCC to be used in accordance with the following:

Proportion the mixture according to the project specific criteria for compressive strength, air content, slump flow, VSI, J-Ring value, and segregation factor. The maximum water-cementitious materials ratio shall be 0.45 unless otherwise approved by the Engineer.

Use the same components in the trial batches as are to be used in the project including coarse and fine aggregates, water, source and type of cement, supplementary cementitious materials, and admixtures; including any site-added admixtures intended to be used.

Laboratory and field testing of SCC shall conform to the following:

(a) **Slump Flow:**

The slump flow shall be measured in accordance with ASTM C 1611. The slump flow shall be 26 +/- 3 inches, and there shall be no visible segregation of the mix in the spread. The slump flow shall be compared to the slump flow with the J-ring in accordance with ASTM C 1621.

(b) **Visual Stability Index (VSI):**

VSI Rating in accordance with ASTM C 1611 shall not exceed 1.

(c) **J-Ring Flow:**

The difference between slump flow and J-Ring flow as measured by ASTM C 1621 shall not be more than 2 inches.

(d) **Stability (performed on trial batches):**

The stability of the concrete shall be determined in the laboratory prior to approval of the SCC mixture using test method ASTM C 1610. Concrete mixtures shall have a maximum static segregation (segregation factor) of 15 percent.

(e) **Strength and Permeability Test Specimens:**

Test specimens for strength and permeability (if specified) shall be sampled in accordance with Section 217.08(b) and fabricated in accordance with ASTM C 1758.

217.12—Low Shrinkage Class A4 Modified Concrete

Low shrinkage Class A4 modified concrete shall conform to either of the following:

(a) The cementitious materials content shall be < 600 pounds per cubic yard. High-early-strength hydraulic cement concrete as described in Section 217.08 (b) shall not be used.

The 28 day drying shrinkage shall be < 0.035% (based on average of three specimens) when tested in accordance with ASTM C 157. Specimens shall be moist cured for 7 days prior to testing for drying shrinkage. A shrinkage reducing admixture shall be used unless the 28 day drying shrinkage is < 0.035% without the admixture. With appropriate documentation, a fixed amount of SRA dosage can be used without additional drying shrinkage testing if approved by the Engineer.

The Contractor, at the Contractor's expense, shall prepare a minimum 3 cubic yard trial batch of the mix at least 5 weeks prior to the proposed start date of production. The trial batch will be used to verify compliance with the shrinkage requirements listed herein and the minimum compressive strength, permeability, air void content, and slump listed in Table II-17. The Contractor shall prepare the trial batch with the same equipment to be used on the project. The Contractor shall obtain the services of a Department approved independent laboratory to perform the trial batch testing. Test results shall be furnished to the Engineer for review and approval. The Engineer will not authorize the Contractor to proceed with production of low shrinkage Class A4 modified concrete for the work required by the Contract until the test results verify conformance with the requirements stated herein.

(b) Use lightweight concrete with lightweight aggregates in conformance with AASHTO M195 (ASTM C330).

The maximum cementitious materials content shall be 650 pounds per cubic yard. All other requirements shall conform to those listed in Table II-17 for Low Shrinkage Class A4 Modified concrete.

Maximum density of freshly mixed lightweight concrete, when tested according to ASTM C138, shall be 120 lbs./cu.yd., or as specified on the plans.

217.13—Latex-modified Concrete, Very-Early-Strength (LMCVE), for Bridge Deck Overlays

LMCVE shall conform to the requirements herein, except as follows:

Cement shall be approximately 1/3 calcium sulfoaluminate (C4A3S) and 2/3 dicalcium silicate (C2S) or other hydraulic cement that will provide a Latex-Modified Concrete that meets the physical requirements indicated in this section.

The LMCVE shall contain a minimum 658 lbs per cubic yard of rapid hardening cement, 15% styrene butadiene latex by weight of cement, water not to exceed a water-cement ratio of 0.40, and aggregates as proposed by the Contractor for the mixture. The compressive strength minimum shall be 2500 psi at 3 hours and 3500 psi at 24 hours. Compressive strength specimens shall be cured in the molds in the same environment as the in-place LMCVE tested. Specimens shall remain undisturbed at the site for 2 hours and shall be transported to the testing lab for testing.

Prior to placing overlay the Contractor shall calibrate the mobile concrete mixers. Once the mixers are calibrated, the mixtures shall be sampled and tested for slump and air content. The Contractor shall prepare and test specimens to demonstrate that the concrete mixture shall obtain a compressive strength of at least 2500 psi within 3 hours at the curing temperatures in which the overlay will be placed, and a compressive strength of at least 3500 psi at an age of 24 hours. All trial batching and prepatory work prior to placing LMCVE shall be at the Contractor's expense. During the placement of the overlay the Contractor shall take samples for testing for compressive strength. Permeability, slump and air content measurements will not be required, but may be performed by the Engineer.

217.14—High Early Strength Latex Modified Concrete (HESLMC) for Bridge Deck Overlays

High Early Strength Latex Modified Concrete (HESLMC) shall conform to the requirements herein and Table II-17, Latex hydraulic cement concrete overlay, except as follows:

The compressive strength minimum shall be 3500 psi in 7 days.

Prior to placing overlay the Contractor shall calibrate the mobile concrete mixers. Once the mixers are calibrated, the mixtures shall be sampled and tested for slump and air content. The Contractor shall prepare and test specimens to demonstrate that the concrete mixture will obtain a compressive strength of at least 3500 psi at an age of 7 days. All trial batching and preparatory work prior to placing HESLMC shall be at the Contractor's expense. Permeability, slump and air content measurements will not be required, but may be performed by the Engineer.

SECTION 218—HYDRAULIC CEMENT MORTAR AND GROUT

218.01—Description

These specifications cover hydraulic cement mortar and grout used in bonding units together, filling voids, and making surface repairs.

218.02—Materials

(a) **Hydraulic cement** shall conform to Section 214.

(b) **Fine aggregate** shall conform to Section 202.

(c) **Water** shall conform to Section 216.

(d) **Admixtures** shall conform to Section 215.

218.03—Detail Requirements

Hydraulic cement mortar and grout shall consist of a mixture of hydraulic cement, fine aggregate, water, and admixtures as specified herein.

Hydraulic cement mortar and grout shall contain from 3 to 7 percent entrained air. Air-entrained hydraulic cement may be used. The Contractor or supplier shall mix hydraulic cement mortar and grout with the minimum amount of water necessary to obtain the required consistency.

(a) **Hydraulic cement mortar** shall consist of 1 part hydraulic cement, 2 1/2 parts fine aggregate by weight, and sufficient water to produce a stiff mixture. Grading C fine aggregate shall be used.

(b) **Nonshrink mortar** shall consist of 1 part hydraulic cement, 2 parts fine aggregate by weight, a set retarder or other admixture that will reduce the amount of required mixing water, and sufficient water to produce a stiff mixture. Grading C fine aggregate shall be used.

(c) **Hydraulic cement grout** shall consist of 1 part hydraulic cement, 2 parts fine aggregate by weight, and sufficient water to produce a free-flowing mixture. Grading A or C fine aggregate shall be used.

(d) **High-strength grout and mortar** shall consist of a commercially produced prepackaged, non shrink, hydraulic cement mixture conforming to ASTM C1107 modified by the following:

The grout/mortar shall develop a 7-day compressive strength of at least 4,000 pounds per square inch when tested in accordance with ASTM C109, and a 7-day bond strength of at least 1,000 pounds per square inch when tested in accordance with VTM-41, except that epoxy shall not be used to develop the bond.

SECTION 219—RIGHT-OF-WAY MONUMENTS

219.01—Description

These specifications cover concrete and metal markers used to designate right-of-way boundaries.

219.02—Detail Requirements

Right-of-way monuments shall be manufactured from reinforced concrete or metal conforming to the dimensions and details shown in the Standard Drawings, and in accordance with these specifications.

(a) **Concrete Monuments:** Concrete shall be Class A3 conforming to Section 217, except that the Department will allow the use of Type I cement and a change in the aggregate size.

Steel reinforcement shall conform to Section 223 and shall be placed as shown on the Standard drawings.

Monuments shall be cast in one piece with smooth and uniform surfaces.

Monuments shall withstand a cracking load of at least 4,000 pounds and a destruction load of 5,000 pounds when tested transversely on a 24-inch span and shall have an absorption value of not more than 10 percent. Tests will be performed in accordance with AASHTO T177.

(b) **Metal Monuments:** Material for steel pins shall conform to Section 223.

Material for locator posts shall conform to Section 226 or Section 229.

Steel posts or pins shall be galvanized in accordance with ASTM A123.

SECTION 220—CONCRETE CURING MATERIALS

220.01—Description

These specifications cover materials used to maintain the humidity and temperature of freshly placed concrete to ensure satisfactory hydration and proper hardening of the concrete.

220.02—Detail Requirements

Concrete curing materials shall consist of waterproof paper, polyethylene (PE) film, a combination of burlap and PE film, liquid membrane-forming compound, or water. Concrete curing materials shall be free from impurities that may be detrimental to the surface of concrete or the proper curing of concrete.

(a) **Waterproof paper** shall conform to AASHTO M171. One side shall be composed of white, light-reflecting paper.

(b) **PE film** shall conform to AASHTO M171 except that its nominal thickness shall be 3.0 mils. The thickness at any point shall be at least 2.5 mils.

(c) **Burlap and PE film** may be used in combination. They shall be bonded securely so that they cannot be easily separated in a dry or saturated condition. White PE film shall conform to the reflectance requirements of AASHTO M171. Burlap shall conform to AASHTO M182, Class 3. The combination product shall have a total weight of 11 ounces per square yard with 11 threads of burlap per inch.

(d) **Liquid membrane-forming compounds** shall be used on concrete masonry except bridge substructure elements. Fugitive dye compounds shall be used on bridge substructure elements. The Contractor shall protect concrete surfaces or remove liquid membrane-forming compound from concrete surfaces to which a bonding compound, joint sealer, or waterproofing material is to be applied.

Liquid membrane-forming compounds will be tested in accordance with VTM-2 and shall conform to the following:

1. Liquid membrane-forming compounds shall contain an easily dispersed opaque, white, finely ground pigment or a fugitive dye. They shall not react with the components of concrete and shall not contain oils, waxes, or other materials that would prevent bonding of traffic paints or applied pavement markings. The resulting film shall be continuous, uniform, and free from pinholes, bubbles, or blisters and shall not darken the hardened concrete. The dye shall have sufficient color to be distinctly visible for at least 30 minutes after application and designed to disappear within 7 days.

2. The membrane shall not peel. It shall be designed to disappear by gradual disintegration from exposure to the elements over a period of at least 30 days but not more than 1 year. Within 60 days after application, the membrane shall be capable of being readily removed by means of steel wire brushes or another abrasive that will not damage the concrete surface.

3. When applied by pressure spray to a troweled, vertical, damp concrete surface at the rate specified, material shall adhere to the surface in a continuous, tenacious film without running off or sagging appreciably.

4. Shipping containers shall identify the trade name of the material and a lot or batch number except for small, locally repackaged containers bearing the Department's seal.

5. The average moisture loss at 24 hours shall be not more than 0.20 kilograms per square meter of exposed surface. At 72 hours, it shall be not more than 0.30 kilograms per square meter.

6. When applied to the test specimen, white pigmented material shall have a daylight reflectance of at least 60 percent of that of magnesium oxide.

(e) **Water** used for curing concrete shall be clean, clear, and free from oil and other deleterious substances and shall have a pH of at least 4.5.

SECTION 221—GUARDRAIL

221.01—Description

These specifications cover material requirements for components of guardrail systems.

221.02—Detail Requirements

Guardrail shall consist of rail or cable elements and fastenings fabricated to develop continuous beam or cable strength when installed.

(a) **Steel beam** shall conform to AASHTO M180, Class A, Type 1. Where guardrail is to be constructed on curves that have a radius of 150 feet or less, rail elements shall be shop curved to the proper radius, with the roadside of the rail either concave or convex as required.

(b) **Wire rope (cable)** shall conform to AASHTO M30, Type I, Class A.

(c) **Brackets, turnbuckles, compensating assemblies, and attachment hardware** shall be of sufficient design and section to develop the full strength of the cable guardrail and shall be galvanized in accordance with ASTM A153. The spring compensating device shall have a spring constant of 450 ± 50 pounds and shall permit a travel of 6 ± 1 inches.

(d) **Concrete for precast reinforced concrete posts** shall conform to Section 217 for Class A3, except that Type I cement and a smaller size of aggregate may be used.

(e) **Steel posts** shall be galvanized in accordance with AASHTO M111.

1. **Structural rolled shapes** shall conform to ASTM A709, Grade 36.

2. **Sheet steel for fabricated shapes** shall conform to ASTM A1011, Grade 36.

3. **Weld-fabricated shapes** shall conform to ASTM A769.

(f) **Wood posts** shall conform to Section 236 and shall be pressure treated.

(g) **Anchor bolts** shall conform to Section 226.02(c) for high-strength bolts.

(h) **Offset blocks** shall conform to either of the following:

1. Shall be pressure treated wood conforming to Section 236; or

2. Shall be made of plastic or rubber and contain a minimum of 40 percent recycled post-consumer and post-industry waste. Block attachment shall be in accordance with the

details and dimensions of the Standard Drawings for wooden posts, Standard GR-2, 2A W-Beam guardrail. The size tolerance in the direction of the bolt hole shall not be more than 1/4 inch. The blocks shall present a neat appearance and have planed surfaces.

The manufacturer of the recycled blocks shall provide independent test results showing that the material complies with the velocity, acceleration, and post-impact trajectory requirements of National Cooperative Highway Research Program (NCHRP) Report 350 or Manual for Assessing Safety Hardware (MASH).

The manufacturer shall certify that the material components of the completed blocks are weather resistant and manufactured to prevent ultra-violet (UV) degradation. The manufacturer shall also certify that the material components of the completed blocks are resistant to the subterranean termites during its theoretical lifetime when tested according to ASTM D3345. The theoretical lifetime is considered to be at least 20 years. Any block that varies from the materials herein or from the dimensions and tolerances in the Road and Bridge Standards shall be submitted for approval.

SECTION 222—MASONRY UNITS

222.01—Description

These specifications cover masonry units manufactured of regular or lightweight concrete or brick made from clay or shale in a plant specifically designed for such a purpose.

222.02—Detail Requirements

(a) **Wall Units:**

1. **Hollow load-bearing units** shall conform to ASTM C90, Grade N-I.

2. **Hollow non-load bearing units** shall conform to ASTM C129, Type I.

3. **Solid load-bearing units** shall conform to ASTM C145, Grade N-I.

4. **Building bricks** shall conform to either:

   a. ASTM C62 Grade SW, or

   b. ASTM C55, except that the average compressive strength of 5 bricks shall be a minimum 3000 psi and no individual brick shall be less than 2500 psi.

(b) **Catch Basins and Manholes:**

1. **Masonry blocks** shall conform to ASTM C139.

2. **Bricks** shall conform to either:

a. ASTM C32, Grade MS, or

b. ASTM C55, except that the average compressive strength of 5 bricks shall be a minimum 3000 psi and no individual brick shall be less than 2500 psi.

(c) **Sewer Bricks** shall conform to ASTM C32, Grade SM.

SECTION 223—STEEL REINFORCEMENT

223.01—Description

These specifications cover steel items designed to give added flexural strength to hydraulic cement concrete or to control and reduce cracking in such applications.

223.02—Detail Requirements

(a) **Reinforcement:**

1. **Deformed bars** shall conform to ASTM A615, Grade 40 or 60. Longitudinal bars for continuous reinforced hydraulic cement concrete pavement shall be Grade 60.

2. **Plain bars** shall conform to ASTM A615, Grade 40 or 60, deformation waived. When used as a dowel, material may be a plain bar conforming to the requirements of ASTM A615, Grade 40 or 60, or a plain dowel conforming to the requirements of ASTM A709, Grade 36.

3. **Welded wire fabric** shall conform ASTM A185. When used in continuously reinforced hydraulic cement concrete pavement wire fabric shall be deformed, furnished in flat sheets, and shall conform to ASTM A497, high yield of 70,000 pounds per square inch.

4. **Structural steel** shall conform to Section 226.

5. **Bar mats** shall conform to ASTM A184.

6. **Spiral wire** shall conform to AASHTO M32 or ASTM A82.

7. Wire mesh for use in gabions shall be made of galvanized steel wire at least 0.105 inch, 12 gage, in diameter. The tensile strength of the wire shall be at least 60,000 pounds per square inch. Wire mesh shall be galvanized in accordance with ASTM A641, Class 3. When PVC coating is specified, it shall be at least 0.015 inch in thickness and shall be black.

   Wire shall be welded to form rectangular openings or twisted to form hexagonal openings of uniform size. The linear dimension of the openings shall be not more than 4 1/2 inches. The area of the opening shall be not more than 9 square inches. The unit shall be nonraveling. Nonraveling is defined as the ability to resist pulling apart at any of the twists or connections forming the mesh when a single wire strand in a section is cut.

(b) **Prestressing Tendons** shall be seven-wire stress-relieved strands, stress-relieved wire, and low-relaxation strands shall conforming to ASTM A416, Grade 270; ASTM A421; and ASTM A416, Supplement I, respectively, with the following modifications:

1. Strands or wires used in units of any one-bed layout shall be manufactured by the same plant.

2. A manufacturer's certification and load-elongation curve in accordance with ASTM A416 or ASTM A421 shall be obtained by the prestressed concrete fabricator for each lot of strand planned for use in fabrication. The strand or wire manufacturer shall submit the data in permanent record form to the Engineer for approval prior to fabrication.

(c) **Reinforcing Steel to Be Epoxy Coated:** Steel shall conform to the requirements herein and shall be coated in accordance with AASHTO A775.

1. Plants that epoxy coat reinforcing steel shall be CRSI certified for epoxy coating. CRSI inspection reports shall be on file at the plant and shall be available to the Engineer for review.

2. Handling and storage of the coated bars shall conform to AASHTO A775.

3. Visible damage to the epoxy coating shall be patched or repaired with materials compatible with the existing coating in accordance with AASHTO A775.

(d) **Reinforcing Steel to Be Galvanized:** Steel shall conform to the requirements herein and shall be galvanized in accordance with ASTM A767.

(e) **Corrosion Resistant Reinforcing Steel, Class I** shall conform to ASTM A1035/A1035M – Standard Specification for Deformed and Plain, Low-carbon, Chromium, Steel Bars for Concrete Reinforcement Alloy Type 1035 CS with a minimum chromium content of 9.0%; or shall conform to ASTM A955/A955M – Standard Specification for Deformed and Plain, Solid Stainless Steel Bars for Concrete Reinforcement, UNS* Designation(s):S24100.

(f) **Corrosion Resistant Reinforcing Steel, Class II** shall conform to AASHTO Designation: MP 13M/MP 13-04, Standard Specification for Stainless Steel Clad Deformed and Plain Round Steel Bars for Concrete Reinforcement; or shall conform to ASTM A955/A955M - Standard and Specification for Deformed and Plain Solid Stainless Steel Bars for Concrete Reinforcement. UNS* Designations: S32101. Stainless steel clad bars may only be provided if domestically produced except for projects designated as experimental in the plans.

(g) **Corrosion Resistant Reinforcing Steel, Class III** shall conform to ASTM A955/A955M - Standard Specification for Deformed and Plain Solid Stainless Steel Bars for Concrete Reinforcement. UNS* Designations: S24000, S30400, S31603, S31653, S31803, S32304.

* Unified Numbering System for Metals and Alloys

SECTION 224—CASTINGS

224.01—Description

These specifications cover items cast from metal to a specific design in a manufacturing plant.

224.02—Materials

All casting suppliers/manufacturers shall have an approved QA/QC plan on file with the Department. Junction boxes that are to be installed within that portion of the roadway not protected by a guardrail or barrier shall be designed in accordance with AASHTO M306 and M105, Class 35B.

(a) **Malleable castings** shall conform to ASTM A47, Grade 32510.

(b) **Gray iron castings** used in that portion of the roadway not protected by a guardrail or barrier shall conform to AASHTO M306 and M105, Class 35B. All other castings shall conform to AASHTO M105, Class 35B.

(c) **Ductile iron castings** used in that portion of the roadway not protected by a guardrail or barrier shall conform to AASHTO M306. All other ductile iron castings shall conform to ASTM A536, Grade 60-40-18.

(d) **Steel castings** shall conform to the following:

1. **Carbon steel** shall conform to ASTM A27, Grade 65-35.

2. **Chromium alloy steel** shall conform to ASTM A296, Grade CA-15.

(e) **Steel castings** for bridges shall conform to ASTM A486, Class 70, or ASTM A27, Grade 70-36.

224.03—Detail Requirements

If castings are supplied from materials conforming to Sections 224.02 (a), (d), and (e), all tolerances and workmanship requirements for castings shall conform to AASHTO M306. If used in that portion of the roadway not protected by a guardrail or barrier, the load testing shall conform to AASHTO M306. When the alternate load test is used, test bars shall be present and fully identifiable with regard to the casting lot. Each casting in a lot must have the same markings as all of the other castings in the lot; if not, each group of castings with the same markings within the original lot, becomes a new lot.

SECTION 225—STEEL FORGINGS AND STEEL SHAFTING

225.01—Description

These specifications cover steel items specifically designed for a particular bridge structure and generally used where movement of a part of the structure is involved.

225.02—Detail Requirements

(a) **Steel forgings** shall conform to ASTM A668, Class D, for use with structural carbon steel and Class F for use with high-strength low-alloy steel.

(b) **Steel shafting** shall conform to ASTM A108, Grades 1016 through 1030.

SECTION 226—STRUCTURAL STEEL

226.01—Description

These specifications cover steel structural shapes furnished to specific dimensions and associated hardware and fasteners.

226.02—Detail Requirements

(a) **Bridge Structural Steel** shall conform to ASTM A709 for the grade specified except that stud shear connectors shall conform to (e) herein. Steel for tensile flanges and webs of plate girders, rolled beams, cover and splice plates, and any other components designated as main load-carrying components subject to tensile stress shall conform to the supplemental requirements of ASTM A709 for the Charpy V-Notch tests for Zone Two.

Steel used for tubular structural members in bridges including, but not limited to, ASTM A500, A501, A847 and ASTM A1085 (HSS), whether for vehicular or pedestrian bridges, shall meet the requirements for Charpy V-notch testing for Zone 2 in accordance with ASTM A709. Welding shall conform to AWS D1.1 for cycically loaded tubular structures, except that all NDT (Non Destructive Testing) shall be in conformance with applicable Virginia Test Methods and paid for by the Contractor. Tubular steel structures shall be protected from corrosion in accordance with Section 233.

Fracture-critical bridge steel members designated on the plans shall conform to the AASHTO Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members.

One copy of the mill analysis for bridge steel shall be submitted to the Engineer.

(b) Other Structural Steel shall conform to ASTM A36 unless otherwise specified. Piles shall conform to Section 228. One copy of the mill analysis shall accompany steel piles shipped to the project site. Three copies of the mill analysis for structural steel members shall be submitted to the Engineer.

(c) **Anchor Bolts:**

1. Anchor bolts for general use shall conform to AASHTO M314, Grade 36. Nuts shall conform to ASTM A563, and washers shall conform to ASTM F844. Threads shall be coarse series.

2. **High-strength anchor bolts** shall conform to AASHTO M314, Grade 55, with supplemental requirements of S1. Nuts and washers shall conform to ASTM A563, Grade DH and ASTM F436 respectively.

3. Galvanization of steel anchor bolts, nuts, and washers shall conform to ASTM A153.

4. Anchor bolts for railings shall conform to (c)1. herein, and shall be hot-dipped galvanized.

(d) **Stud Shear Connectors** shall conform to AWS D1.1 Structural Welding Code or AWS D1.5 Bridge Welding Code as applicable. Stud shear connectors that conform to these requirements and that are on the Materials Division Approved Products List, No. 15, may be used without further testing.

(e) **Steel for Structural Supports for Light Poles and Traffic Control Devices** shall be suitable for the design requirements of the Contract and shall conform to the following:

Characteristic	Value
Min. yield strength	36,000 psi
Min. tensile strength	58,000 psi
Min. elongation (in 8 inches)	18%
Min. elongation (in 2 inches)	20%
Carbon equivalent (as determined by AWS D1.1/D1.5)	Max. 0.45%

Charpy V-notch values of 25 foot-pounds at 10 degrees F may be substituted for elongation requirements. Tubing conforming to ASTM A500, A501, A847 and A1085 shall have Charpy V-notch values of 25 foot-pounds at 10 degrees F.

Steel conforming to ASTM A709, Grade 50W, and ASTM A847 shall not be used unless specified.

(f) **Steel for Timber Connectors** shall conform to ASTM A711 or AISI No. 1015.

(g) **Bolts, Nuts, and Washers:** Bolts shall conform to ASTM A307, except where high-strength or other special types of bolts are required. ASTM A307 bolts shall have nuts conforming to ASTM A563, and washers shall conform to ASTM F844. Lock washers shall conform to ANSI B18.21.1.

(h) **High-Strength Bolts, Nuts, Washers, and Direct Tension Indicators** shall conform to the following respective ASTM specifications:

High-Strength Bolts	Nuts for Use with High-Strength Bolts, Heavy Hex	Washers (Hardened)	Direct Tension Indicators
ASTM A325, Type 1 (galvanized)	ASTM A563, Grade DH	ASTM F436	ASTM F959
ASTM A325, Type 3	ASTM A563, Grade DH3	ASTM F436	ASTM F959
ASTM A449, Type 1 (galvanized)	ASTM A563, Grade DH	ASTM F436	ASTM F959
ASTM A449 Type 3	ASTM A563, Grade DH3	ASTM F436	ASTM F959
ASTM A490, Types 1	ASTM A563, Grade DH ASTM A194, Grade 2H	ASTM F436	ASTM F959
ASTM A490, Type 3	ASTM A563, Grade DH3	ASTM F436	ASTM F959

1. Bolts, nuts, and washers conforming to ASTM A490 shall not be galvanized. Bolts, nuts, and washers conforming to ASTM A325, Type 1 or ASTM A449, Type 1, shall be galvanized. High-strength bolts used with unpainted weathering steel shall conform to ASTM A325, Type 3; ASTM A449, Type 3; or, when specified, ASTM A490, Type 3. All use of high-strength bolts conforming to ASTM A449 shall be approved, in writing, by the Engineer. ASTM A449 bolts shall conform to the rotational capacity testing requirement in ASTM A325 and these specifications.

2. The maximum hardness for bolts conforming to ASTM A325 shall be 33Rc. The maximum tensile strength for such bolts shall be 150 kips per square inch for bolts 1 inch or less in diameter and 120 kips per square inch for larger bolts.

3. High-strength fasteners (plain and coated) shall pass a rotational-capacity test as detailed in Virginia Test Method 135.

   a. Bolts shall be proof-load tested in accordance with ASTM F606, Method I. Full-size bolts shall be wedge tested in accordance with ASTM F606. Nuts shall be proof-load tested in accordance with ASTM F606. Galvanized bolts shall be wedge tested after galvanizing. Galvanized nuts shall be proof-load tested in accordance with ASTM F606 only after overtapping, galvanizing, and lubricating operations are completed.

   b. Galvanized bolts, nuts and washers shall be hot-dipped galvanized in accordance with ASTM A153. The Contractor may use mechanically galvanized bolts, nuts, and washers that conform to ASTM B695, Class 50 if the bolts are to be topcoated with paint.

      When galvanized nuts conforming to ASTM A563 are specified, the amount of over-tapping may be less than specified; however, all nuts in each lot shall be overtapped by the same amount. Galvanized nuts shall be lubricated in accordance with ASTM A563 using a lubricant sufficiently tinted so as to be readily visible.

      Galvanized bolts, nuts, and washers shall have the galvanization measured for thickness. Measurements for bolts shall be taken on the wrench flats or top of the bolt head. Measurements for nuts shall be taken on the wrench flats.

      When galvanized washers are specified, hardness testing shall be performed after galvanizing. The coating shall be removed prior to testing.

   c. All bolts, nuts, and washers shall be furnished with a marking that readily identifies their manufacturer. The Contractor shall provide the Engineer with an example of such marking and the manufacturer's certification for each bolt, nut, and washer supplied to the project. The Contractor shall ensure that two samples from each rotational capacity lot, each sample consisting of one bolt, nut, washer, and DTI (if used on the project), are submitted to the Department for testing, and are accompanied by all documentation.

      Documentation shall indicate the results of all tests and processes performed on the hardware, the name of the testing facility, address where the tests were performed and the date of testing. Test results of bolts and nuts shall also indicate the lot number of the product. Bolts, nuts, and washers from different rotational-capacity lots shall not be shipped in the same container. In addition, shipping containers shall be marked with the rotational-capacity test lot number of the product supplied.

SECTION 227—STEEL GRID FLOORING

227.01—Description

These specifications cover plant-fabricated steel for use as a portion of a bridge deck.

227.02—Materials

(a) **Steel** shall conform to ASTM A709, Grade 36, except that material which is not galvanized shall have a copper content of at least 0.2 percent.

(b) **Concrete** for filling steel grid floors shall conform to Section 217 for Class A3, maximum aggregate size No. 7.

227.03—Detail Requirements

(a) **Open flooring** shall be galvanized in accordance with ASTM A123.

(b) **Painting,** when specified or permitted by the Engineer, shall be performed in accordance with Section 411 except that the Department will allow dipping to coat the flooring.

SECTION 228—STEEL PILES

228.01—Description

These specifications cover steel fabricated to a shape that will act as a foundation for a structure. The Contractor shall ensure one copy of each applicable mill analysis accompanies the corresponding steel piles shipped to the project and shall supply the Engineer three additional copies of the mill analysis.

228.02—Detail Requirements

(a) **H-piles:** H-piles shall be structural carbon steel conforming to ASTM A709, Grade 36.

(b) **Shell Piles:** Welded shells shall be fabricated with butt welds only.

End plates and other fittings shall be fabricated from the same material used for the shell or from steel conforming to ASTM A709, Grade 36.

1. **Steel for Type A shells** shall be classification SAE 1010 with a yield point of at least 50,000 pounds per square inch. Shells shall be fluted and consist of a cylindrical upper section(s) and a lower section having a diameter diminishing at the rate of at least 1/8 but not more than 1/4 inch per foot. The lower section shall have a welded point with a diameter of at least 8 inches.

2. **Steel for Type B shells** shall conform to ASTM A252, Grade 1, 2, or 3. Shells shall be straight pipe having bottoms closed with end plates at least 3/4 inch in thickness and a diameter not more than 1/2 inch greater than the outside diameter of the shell.

3. **Steel for Type C shells** shall conform to ASTM A569 or A366. Shells shall be helically corrugated and cylindrical in the section and shall diminish in diameter toward the point by stepping at regular intervals at the rate of approximately 1 inch per step or at an average rate of at least 1/8 but not more than 1/4 inch per foot. The lower section shall have a welded point with a diameter of at least 8 inches.

4. **Steel for Type D shells** shall be classification SAE 1010 with a yield point of at least 50,000 pounds per square inch. Shells shall be helically corrugated and of a constant cylindrical section or shall diminish uniformly in diameter at the rate of at least 1/8 but not more than 1/4 inch per foot. Bottoms shall have ends closed with plates at least 3/4 inch in thickness and not more than 1/2 inch greater in diameter than the outside diameter of the shell. Shells diminishing in diameter shall have welded points with a diameter of at least 8 inches.

(c) **Steel Sheet Piles:** Steel sheet piles shall conform to ASTM A328.

SECTION 229—ALUMINUM ALLOY

229.01—Description

These specifications cover aluminum alloy products designed in shapes and compositions to serve a specific purpose, such as a sign panel, post, or conduit, including necessary fasteners.

229.02—Detail Requirements

(a) **Sheets and plates** shall conform to ASTM B209, alloy 6061 T6, 6061 T651, 5052-H32, 5052-H34, 3003-H14, or 5086-H116/H32. Aluminum sign panels shall be alloy 5052-H32, 5052-H34, 5052-H38, or 6061-T6.

(b) **Bars, rods, and wire** shall conform to ASTM B211, alloy 6061-T6 or 6061-T651.

(c) **Extruded bars, rods, shapes, and tubes** shall conform to ASTM-B221, alloy 6061-T6 or 6063-T6.

Aluminum alloy extrusions, extruded tubes, drawn tubes, or pipes that are to be bent on a radius of less than 3 feet may be made from alloy having a temper condition of 0.

(d) **Drawn tubes** shall conform to ASTM B210, alloy 6061-T6.

(e) **Pipe** shall conform to ASTM B429 or ASTM B241, alloy 6061-T6 or 6063-T6.

(f) **Bolts, studs, nuts, set screws, washers, and rivets** shall be furnished as commercial items suitable for the application.

(g) **Permanent-mold castings** for items other than rail posts shall conform to ASTM B108, alloy 356.0-T6. Cast aluminum alloy rail post shall conform to ASTM B108, alloy A444.0.

(h) **Sand castings** shall conform to ASTM B26, alloys 319-F, 319.0-T6, 356.0-F, 356.0-T6, or 535.0-F.

(i) **Shims** shall be made from a sheet or plate conforming to ASTM B209, alloy 1100-O.

(j) **Aluminum filler metal for welding** shall conform to AWS 1.2.

(k) **Rolled or extruded structural shapes** shall conform to ASTM B308, alloy 6061-T6.

(l) **Breakaway support couplings for light poles and sign posts** shall conform to ASTM B209 or ASTM B221, alloy 6061-T6.

(m) **Frangible bases for light and signal poles** shall conform to ASTM B26 or ASTM B108, alloy 319 or 356.0-T6.

(n) **Aluminum alloy for controller, control center, and flasher cabinets** shall conform to ASTM B209, alloy 5052-H32.

(o) **Aluminum alloy for lighting and pedestal poles** shall conform to ASTM B221, ASTM B241, or B429, alloy 6063-T6.

SECTION 230—BRONZE AND COPPER ALLOY

230.01—Description

These specifications cover the fabrication of specific bronze or copper alloys, usually in the construction of a bridge structure or for electrical purposes.

230.02—Detail Requirements

(a) **Cast bronze** shall conform to ASTM B22.

(b) **Copper alloy** shall conform to ASTM B100, copper alloy No. 51000.

(c) **Copper sheets and strips** shall conform to ASTM B370.

SECTION 231—PAINT

231.01—Description

These specifications cover a mixture of pigment in a liquid vehicle that, when applied, will dry to an opaque solid film. Use of paint in these specifications refers to the requirements for highway construction.

Paint materials not specified herein shall be as specified by the manufacturer and recommended specifically for or compatible with the intended application.

231.02—Materials

Paint shall not be formulated with any compounds of the heavy metals listed in 40 CFR 261.24, Table 1, except that barium sulfate is allowed. Except for barium sulfate, total heavy metal levels shall not exceed 20 times the specified regulatory limits. Volatile organic compound (VOC) content shall not exceed 2.8 pounds per gallon as applied, except zinc rich primers shall not exceed 3.5 pounds per gallon as applied.

When Federal Standard (FS) color numbers are specified, they refer to color only and not to gloss requirements.

(a) **Paint vehicles** shall conform to the following requirements:

Vehicle	Specification
Acrylic resin	100% straight acrylic polymer dispersed in water
Alkyd resin	FS TT-R-266, Type I, Class A or B
Linseed oil	
Boiled	ASTM D260, Type I
Heat bodied	FS TT-L-201
Raw	ASTM D234
Methyl ethyl ketone	ASTM D740
Mineral spirits	ASTM D235
Soybean oil	
Refined	ASTM D1462
Degummed	ASTM D124
Spar varnish	FS TT-V-121
Toluene	ASTM D841
Tricresyl-phosphate	ASTM D363
Volatile thinners	ASTM D235
2-ethoxyethanol acetate	ASTM D3728

(b) **Paint pigments** shall conform to the following requirements:

Pigment	Specification
Aluminum paste	ASTM D962
Carbon black	ASTM D561, Type I
Lamp black	ASTM D209
Magnesium silicate	ASTM D605
Micaceous iron oxide	Processed specular hematite ore with lamellar structure that conforms to ASTM D 5532, Type I
Organo montmorillonite	Fine, creamy white powder with high gelling efficiency in a wide range of organic liquids; water content less than 30% and fineness less than 5% retained on No. 200 (75 µm sieve)
Raw Sienna	ASTM D765
Titanium dioxide	ASTM D476, Rutile
Yellow iron oxide	ASTM D768
Zinc dust	ASTM D520, Type II
Zinc oxide	ASTM D79

231.03—Detail Requirements

Paint shall not settle excessively or cake in the container. Paint shall be readily broken up with a paddle or power mixer to form a smooth uniform paint of acceptable consistency and working properties having a minimum of foaming. Paint shall not thicken, liver, skim, or curdle and retain all of these properties while in storage for at least 12 months.

When applied according to standard practice, paint shall show good leveling properties; be free from laps, brush marks, orange peel, sags, or other surface defects; and shall flow out to a uniform, smooth finish.

Paints will be inspected, sampled, and tested in accordance with Federal Test Method Standard No. 141.

Paint containers shall be plainly marked with the name of the material, date of manufacture, lot number and/or batch number, Department color, quantity contained therein, and name and address of the manufacturer. A manufacturer's product data sheet shall also be provided with each shipment for each type of paint product supplied. The Engineer will reject any package or container not provided as specified.

(a) **Zinc-rich paint systems** (System B) shall consist of a zinc-rich primer; an intermediate coat when recommended by the manufacturer; and a topcoat, which shall be selected from the Materials Division Approved Products List, List No. 13. Zinc-acrylic-acrylic systems shall be tested in accordance with VTM-73. Zinc-rich-epoxy-urethane paint systems approved by the Northeast Protective Coating Committee (NEPCOAT) or those systems tested in accordance with AASHTO R-31 will be evaluated for inclusion to the Qualified Low Volatile Organic Compound Zinc Rich Paint Systems List.

Primer for shop application shall be inorganic zinc and shall conform to the slip coefficient requirements of AASHTO 1995 Interim Provision, Division I, Design, Table 10.32.3C, Class B.

(b) **No. 14 paint, aluminum epoxy mastic,** (System F) shall be a two-component, modified epoxy coating, aluminum in color.

1. **Composition:** Pigment shall be flake metallic aluminum and shall contain rust-inhibiting and inert pigments.

   The paint vehicle shall be a modified epoxy resin and curing agent and shall not contain coal tar. Paint shall be supplied as a two-package material with a 1:1 mixture ratio by volume.

2. **Physical Requirements:** The epoxy mastic shall contain at least 90 percent solids by weight when tested in accordance with ASTM D1644, modified to a drying time of 72 hours at 100 degrees F.

   The shelf life of epoxy mastic components shall be at least 6 months. There shall be no skinning, gelling, or hard settling that does not disperse when agitated.

   The viscosity of mixed paints measured immediately after the blending and mixing of components shall be from 80 to 140 Kreb units at 77 ± 2 degrees F.

The weight per gallon of mixed paint shall be at least 10.8 pounds at 77 ± 2 degrees F.

The appearance of the dry applied film shall be bright aluminum.

The epoxy mastic shall be suitable for use over properly prepared, inorganic zinc-rich primers. A mist coat may be required to minimize bubbling.

Mixed paint, when thinned in accordance with the manufacturer's recommendations for application over wire-brushed rusty steel, shall be capable of being spray applied in one coat at a wet film thickness of 10 mils without runs or sags.

The epoxy mastic, when applied in a dry film thickness of 5 mils and air dried at 75 degrees F, shall be dry to the touch within 24 hours; dry enough to handle in 48 hours; and provide a hard tough film after 5 days.

The usable pot life of the mixture of components reduced as recommended shall be at least 3 hours at 70 degrees F and 1 1/2 hours at 90 degrees F.

The epoxy-mastic coating shall possess such flexibility that when applied in a dry film thickness of 5 mils to a 1/8-inch steel panel that has been blast cleaned according to SSPC-5 and cured for 2 weeks at 75 degrees F, shall not display signs of cracking or loss of adhesion when the panel is uniformly bent 180 degrees around a mandrel 8 inches in diameter.

3. **Resistance:** Steel test panels conforming to ASTM D609 shall be abrasive blasted in accordance with SSPC-SP 5, exposed to the atmosphere for 30 days so that a uniform rusting occurs, and then hand cleaned with a wire brush in accordance with SSPC-SP 2. The panel shall then be spray applied with epoxy mastic to achieve a dry film thickness of 5 mils and cured in accordance with the manufacturer's recommendations.

   a. **Fresh Water:** Coated panels shall be scribed down to base metal with an X having at least 2-inch legs and immersed in fresh tap water at 75 ± 5 degrees F. Upon examination after 30 days of immersion, panels shall be unaffected except for discoloration of the epoxy-mastic coating. There shall be no blistering, softening, or visible rusting of the coating beyond 1/16 inch from the edge of the scribe mark.

   b. **Salt Water:** Panels shall be scribed down to the base metal with an X having at least 2-inch legs and immersed in a 5 percent sodium chloride solution at 75 ± 5 degrees F. Panels shall be unaffected, except for discoloration of the epoxy-mastic coating, upon inspection after 7, 14, and 30 days of immersion. There shall be no blistering, softening, or visible rusting of the coating beyond 1/16 inch from the center of the scribe mark. The sodium chloride solution shall be replenished with fresh solution after each examination.

   c. **Weathering:** Panels shall be tested in accordance with ASTM G23, Type D, at the beginning of the wet cycle. After 1,000 hours of continuous exposure, the coating shall show no rusting, loss of adhesion to the steel test panel, or blistering.

d. **Salt Fog:** Panels shall be scribed with an X having at least 2-inch legs down to base metal. Test panels shall then be tested in accordance with ASTM B117. After 1,000 hours of continuous exposure, the coating shall show no rusting or blistering beyond 1/16 inch from the center of the scribe mark or a loss of bond.

4. **Packaging and Labeling:** Epoxy-mastic coating shall be commercially packaged in two containers labeled "Part A" and "Part B." Each container shall bear a label that clearly shows the manufacturer and brand name of the paint, lot number, and date of manufacture. The label on the vehicle container shall also include complete instructions for use. The container shall be coated, if necessary, to prevent attack by the paint components.

5. **Application Instructions:** The manufacturer's current printed instructions for applying aluminum epoxy-mastic coating shall be submitted to the Department for acceptance prior to application.

6. **Product Certification:** The manufacturer shall certify that the modified aluminum epoxy mastic has been used successfully for at least 2 years in a similar service and environment and that the material was applied in one coat at a dry film thickness of 5 mils. Successful performance shall include adhesion to steel and old coatings of the type found on bridges.

   The manufacturer shall submit a certified test report from an independent testing laboratory showing specific test results conforming to all quantitative and resistance test requirements herein prior to approval and use of an aluminum epoxy-mastic coating. The test report shall also contain the date of testing, lot numbers from which the data were compiled, manufacturer's name, and brand name of the paint. Upon approval by the Department, the product will be placed on the Materials Division Approved Products List, List No. 21, Qualified No. 14 Aluminum Epoxy Mastic Coatings (System F) and further resistance and quantitative tests will not be required of that manufacturer for that brand name of paint unless random samples tested by the Department show nonconformance with any of the requirements herein. However, the manufacturer shall submit new certified test results whenever the manufacturing process or paint formulation is changed.

(c) **Colored epoxy mastic** for use as a finish coat over No. 14 primer (System F) shall be supplied by the manufacturer of the primer and shall conform to the salt fog resistance requirements specified in (b) herein. Upon approval by the Department, the colored epoxy mastic will be placed on List No. 21, Qualified No. 14, Aluminum Epoxy Mastic Coatings List (System F) as an approved colored topcoat.

(d) **Colored urethane topcoats** for use as a finish coat over No. 14 primer (System F) shall be an aliphatic urethane from the Materials Division Approved Products List, List No. 21, Qualified No. 14 Aluminum Epoxy Mastic Coatings (System F) as an approved colored topcoat.

(e) **No. 101, 102, and 103 water reducible paint** (System W) shall be a one component acrylic water borne paint with a VOC of less than 2.8 pounds per gallon as applied.

1. **Composition:**

	No. 101		No. 102		No. 103	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Pigment (% by weight)	20	25	35	40	10	20
Red iron oxide (86% F_e2O_3)	45					
Zinc phosphate	10		5		5	
Phthalocyanine Blue		2				
Calcium carbonate			30			
Titanium dioxide (ASTM D476, Type II)			45			
Magnesium silicate				12		
Tinting compounds[1]						95
Vehicle (% by weight)	75	80	60	65	80	90
HG-54 solids	30		30		30	
Water		55		55		58
Methyl carbitol	5		5		5	
Texanol	2		2		5	
Dibutyl phthalate	2		2			
Paint Characteristics						
Weight per gallon (pound)	9.7		11.0		9.0	
Solids by volume	35		37		30	
Grind	5		5		5	
Viscosity (KU)	90	100	90	100	90	100
Drying time (ASTM D1640)						
Set to touch (hr)		3		3		3
Drying time (hr)		24		24		24
Leneta sag	10		10		10	
pH	8.0	8.5	8.0	8.5	8.0	8.5
Adhesion (ASTM 3359)	3B		3B		3B	
Gloss, pecular at 80 degrees					40	

[1]Tinting compounds shall be prime-hiding pigments.

2. **Mixed Paint:** Mixed paint shall not liver, thicken, curdle, gel, or settle rapidly. After mixing, all coarse particles and skins shall not amount to more than 0.05 percent by weight of the total mixture when passed through a 60-mesh screen.

3. **Storage Life:** The paint shall not show thickening, curdling, gelling, or gassing after being stored for 1 year from date of manufacture when packaged in tightly covered unopened containers at a temperature between 50 degrees and 90 degrees F.

4. **Working Properties:** The paint shall spray easily and show no streaking, running, or sagging when tested in accordance with Federal Test Method Standard 411, Methods 4331 and 4541.

SECTION 232—PIPE AND PIPE ARCHES

232.01—Description

These specifications cover materials used for the conveyance of water, including drainage, storm water, sanitary systems, and waste water.

232.02—Detail Requirements

Concrete, corrugated steel, polyethylene, and polypropylene pipe shall only be supplied from manufacturers currently having an approved Quality Control Plan on file with the Department.

(a) **Concrete Pipe:**

1. **Concrete pipe for culverts and sewers** shall be circular or elliptical in cross-section, either plain concrete or reinforced concrete, and of the modified tongue-and-groove design in sizes up to and including 18 inches in internal diameter and either standard or modified reinforced tongue-and-groove in sizes above 18 inches in internal diameter. Pipe shall conform to the specified AASHTO requirements except that pipe having an internal diameter of 36 inches or less shall be manufactured without lift holes. Pipe larger than 36 inches in internal diameter may be manufactured with lift holes provided the holes are created by molding, forming, coring, or other methods to be cylindrical or conical in shape and are sufficiently smooth to permit plugging with an elastomeric or other approved plug type.

a. **Plain concrete culvert pipe** shall be composed of hydraulic cement, water, and mineral aggregates conforming to b(3) and b(4) herein. Pipe shall conform to the following:

Min. Inside Diameter (in)	Min. Wall Thickness (in)	Groove Depth (in)	Crushing Strength (lb/lin ft)
12	1 3/4	1 3/4	1,800
15	2	1 3/4	2,125
18	2	1 3/4	2,400
21	2 3/4	2	2,700
24	3	2 1/4	3,000

Pipe shall also comply with AASHTO M170 for manufacture, finish, marking, inspection, and rejection.

b. **Reinforced concrete culvert pipe:**

(1) **Circular pipe** shall conform to AASHTO M170, class as specified, or AASHTO M242. Circular pipe that does not have values listed in the AASHTO M170 design tables for diameter, wall thickness, compressive strength, and reinforcement shall be certified in accordance with Section 105.10. Pipe conforming to AASHTO M242 shall also be certified in accordance with Section 105.10.

(2) **Elliptical pipe** shall conform to AASHTO M207, class as specified. Elliptical pipe that does not have values listed in the AASHTO M207 design tables for wall thickness, compressive strength, and reinforcement shall be certified in accordance with Section 105.10.

(3) **Fine aggregate** shall conform to Section 202 for quality except that the void content, grading, and uniformity shall be controlled as necessary to produce the specified level of strength and absorption.

(4) **Coarse aggregate** shall conform to Section 203 for Grade A crushed stone or gravel.

(5) **Positioning of reinforcement** when two layers of wire or bar reinforcement are used shall be such that welded joints are at an angle of approximately 60 degrees to each other.

(6) **Strength tests** shall be performed by the three-edge bearing method in accordance with AASHTO T280 or by control cylinders tested in accordance with ASTM C31 and C39 or by the testing of cores in accordance with ASTM C42. Control cylinders for acceptance testing shall be cured under the same conditions as the concrete the cylinders represent. Hand cast pipe and end sections may be tested in accordance with ASTM C31 and C39. Concrete pipe may be shipped after reaching 85 percent of design strength as determined by control cylinders or cores.

(7) **Absorption tests** shall be performed in accordance with AASHTO T280 on specimens of broken pipe or cores.

2. Concrete pipe for underdrains shall conform to AASHTO M86, Class I, and the perforation requirements of AASHTO M175, Type I, except that spalls shall be not more than 1 1/2 inches in diameter or 3/16 inch in depth and shall not adjoin. When used as underdrainage outlet pipe, pipe shall not be perforated.

   Porous concrete pipe for underdrains shall conform to AASHTO M176, standard strength.

3. **Concrete pipe for water lines, water mains, and sanitary sewers:**

   a. **Concrete pressure pipe** (steel cylinder) shall conform to AWWA C300, AWWA C301, or AWWA C303 for the size, minimum working pressure, protective coating, seal coat, and type of joint as specified.

   b. **Nonreinforced concrete sanitary sewer pipe** shall conform to AASHTO M86 for the class specified.

   c. **Reinforced concrete water pipe** (noncylinder) shall conform to AWWA C302 for size, minimum working pressure, seal coat, protective coating, and type of joint specified.

   d. **Reinforced concrete sanitary sewer pipe** shall conform to AASHTO M170 for the class specified.

(b) **Cast Iron and Ductile Iron Pipe and Fittings:**

1. **Cast iron pipe** shall conform to ASTM A888 for the class specified.

2. **Ductile iron pipe** shall conform to AWWA C151 for size, joint type, class, type of coating and lining as specified, and minimum working pressure if applicable. Flanged joints shall conform to AWWA C115.

3. **Fittings** for cast iron and ductile iron pipe for water lines, water mains, and sanitary sewers shall conform to AWWA C110 (ANSI A21.10) or AWWA C153 (ANSI A21.53) for size, joint type, pressure rating, and type of coating and lining as specified.

4. **Cement mortar linings** shall conform to AWWA C104 (ANSI A21.4).

(c) **Steel Pipe:**

1. **Corrugated steel culvert pipe and pipe arches** shall conform to AASHTO M36 except that helically formed pipe shall be tested in accordance with AASHTO T249 at the rate of one test per week per corrugation machine per work shift. The Contractor shall maintain records of such test for a period of 24 months. Pipe shall be fabricated from materials conforming to AASHTO M218 for galvanized pipe, AASHTO M274 for aluminum coated pipe, AASHTO M246 for polymer coated pipe and AASHTO M289 for aluminum zinc alloy coated pipe. Steel spiral rib pipe shall be of smooth wall spiral rib construction. When connecting bands or flared end sections are required, helically formed pipe shall have rerolled ends with a minimum of two annular corrugations. End sections shall be produced in accordance with AASHTO M36 from materials conforming to the applicable requirements of AASHTO M218 for use with galvanized pipe, AASHTO M274 for use with aluminum-coated or polymer coated pipe, or AASHTO M289 for use with aluminum zinc alloy-coated pipe.

   Pipe sections shall be joined with annular corrugated bands, hugger bands, maxidimple bands, or flat bands conforming to AASHTO M36 and shall be designed to form a leak-resistant joint. Maxidimple bands shall have two rows of circumferential dimples spaced approximately 4 to 6 inches on center. Coupling band widths shall be at least 7 inches for pipe 12 through 30 inches in diameter and 10 1/2 inches for pipe 36 through 120 inches in diameter. Coupling bands shall be not more than 0.109 inch (12 gage) and not less than 0.052 inch (18 gage) in thickness, and the thickness shall be equal to the pipe thickness or up to two numerical thicknesses lighter than the pipe thickness. (Example: For 12-gage pipe, coupling bands may be 12, 14, or 16 gage) Coupling bands shall have the same metallic or polymer coating as the pipe sections on which they are connecting.

2. **Corrugated steel pipe** for underdrains shall conform to AASHTO M36.

3. **Black and galvanized steel pipe:**

   a. **Black steel pipe for bridge deck drains and drainage systems** shall conform to ASTM A53, extra strong (Schedule 80), with a wall thickness of at least 0.337 inch except that the hydrostatic test will not be required.

   b. **Galvanized steel pipe for handrails** shall conform to ASTM A120 or ASTM A53 for standard or extra strong pipe as indicated except that the hydrostatic test will not be required.

   c. **Black and galvanized steel pipe for miscellaneous items** shall conform to ASTM A53 except that the hydrostatic test will be required only when the pipe is used as pressure pipe.

4. **Smooth wall pipe (jacked or casing for general use):**

   a. **Steel encasement pipe** shall conform to ASTM A139 with a minimum wall thickness of 0.500 inch or ASTM A53 Standard Weight Class and shall have beveled

edges suitable for welding or be threaded. The hydrostatic test for such pipe will not be required.

b. **Pipe for jacking** shall be of sufficient strength, diameter, and wall thickness to accomplish the specific task without deflection or damage and shall be approved by the Engineer.

5. **Steel water pipe, flanges, and fittings:**

a. **Steel pipe** shall conform to AWWA C200 for the minimum design working pressure, wall thickness, and type of pipe ends as specified. The protective coating shall conform to AWWA C203 for coal tar protective coating, and the lining shall conform to AWWA C205 for cement mortar lining.

b. **Flanges** shall conform to AWWA C207 as specified for pressure rating and size.

c. **Fittings** shall conform to AWWA C208.

6. **Galvanized steel water pipe and fittings:**

a. **Galvanized steel pipe** shall conform to ASTM A53, Schedule 40 or 80, for the size; method of manufacture; type, plain or threaded; couplings; and class specified.

b. **Fittings** shall be galvanized malleable iron conforming to ASTM A47. Threads shall conform to ANSI B2.1.

7. **Concrete-lined corrugated steel pipe** shall conform to Section 232.02(c)1 and shall be fabricated from material conforming to AASHTO M274 for aluminum coated pipe. The concrete lining shall be at least 1/8 inch in thickness over the inside crest of corrugation. Concrete for the lining shall be composed of cement, sand, and water mixed to produce a dense, homogeneous lining.

The Contractor shall fill the separation between pipe sections with a cement grout after pipe is installed. After finishing, the area shall be sprayed with a liquid membrane-forming compound.

8. **Polymer coated steel pipe** shall conform to Section (c)1 herein. Polymer coating material shall conform to AASHTO M246. Polymer coating shall have a minimum thickness of 0.10 inch and shall be applied to both sides of the pipe material. Polymer coating shall be labeled with the brand name of the material and the manufacture in accordance with AASHTO M246.

9. **Corrugated steel double wall pipe** shall conform to Section (c)1 herein. Corrugated steel double wall pipe shall consist of a standard corrugated steel exterior shell that meets the structural requirements for the pipe and a smooth interior steel liner. The interior liner is to be continuously attached to the exterior shell along the lock seam. The interior liner is to have a minimum thickness of 0.052 inches. Both the exterior shell and the interior liner are to have a polymer coating applied to both sides of the pipe material in accordance with Section (c) 8, herein.

(d) **Structural Plate Pipe, Pipe Arches, and Arches:** Pipe, pipe arches, and arches shall conform to AASHTO M167 for corrugated steel pipe and AASHTO M219 for aluminum alloy pipe.

(e) **Aluminum Alloy Pipe:**

1. **Corrugated aluminum alloy culvert pipe and pipe arches** shall conform to AASHTO M196. Material used to produce end sections for use with corrugated aluminum alloy pipe shall conform to AASHTO M196.

   Aluminum spiral rib pipe used for storm drains shall conform to AASHTO M196 except that it shall be of smooth wall, spiral ribbed construction. Connecting bands for aluminum drainpipe shall conform to the thickness and the corrugations or ribs of the pipe to which they are connecting.

2. **Corrugated aluminum alloy pipe underdrains** shall conform to AASHTO M196, Type III. When used as underdrainage outlet pipe, pipe shall not be perforated.

(f) **Polyvinylchloride (PVC) Pipe:**

1. **PVC water and pressure sewer pipe** shall conform to AWWA C-900, PC-150 for water facilities and ASTM D1785 for pressure sewers, and shall have a pressure rating of at least 150 pounds per square inch.

2. **PVC gravity sewer pipe** shall conform to ASTM D3034, SDR35; ASTM F794, Series 46; or ASTM F949.

3. **PVC ribbed pipe for culverts and storm drains** shall conform to AASHTO M304 or ASTM F949.

4. **PVC underdrains** shall conform to ASTM F758, Type PS 28; or ASTM F949.

(g) **Glass Fiber-Reinforced Epoxy Pipe and Centrifugally Cast Fiberglass Reinforced Polymer Mortar Pipe and Fittings:** Pipe and fittings shall conform to ASTM D2996, ASTM D2997, or AWWA C950 with a continuous rating of at least 150 pounds per square inch at 150 degrees F for pipe, fittings, and adhesive joints.

(h) **ABS Pipe:**

1. **ABS semiround underdrain pipe with top shield** shall be at least 4 5/8 inches in diameter with drain holes 1/4 or 3/8 inch in diameter drilled at least 7/8 inch apart under the roof line. Pipe shall weigh at least 0.80 pound per foot. When used as combination underdrains, pipe shall not be perforated.

2. **ABS sewer pipe and fittings** shall conform to ASTM D2680 for the type of joints specified and shall have a pressure rating of at least 150 pounds per square inch.

(i) **Polyethylene (PE) Pipe:**

1. **PE corrugated underdrain pipe** shall conform to AASHTO M252. Pipe shall be supplied in individual lengths with no lengths shorter than 10 feet. The Department will only allow coil pipe in 4-inch or 6-inch diameters if it is machine installed. If the pipe starts to recoil during installation, the Contractor shall cease operations until a method of anchoring the pipe in the trench is approved. When used as underdrainage outlet pipe, the pipe shall be smooth wall, nonperforated.

2. **PE corrugated culvert pipe** shall conform to AASHTO M294. PE pipe used for storm drains and entrances shall conform to classification Type S. For all other applications, PE pipe shall be Type C or S.

3. **PE pipe and fittings** shall conform to AWWA C-901 for water mains and ASTM D2239, Grade P34, for sanitary sewers and shall have a pressure rating of at least 150 pounds per square inch.

(j) **Copper Water Pipe or Tubing:** Copper water pipe or tubing shall conform to ASTM B88 and shall have the cast or wrought pattern. Fittings for concealed soft drawn pipe may be the flared mechanical type. Unions shall be the ground joint type.

(k) **Polybutylene Pipe and Fittings:** Pipe and fittings shall conform to AWWA C902 for water mains.

(l) **Polypropylene (PP) Pipe:** PP corrugated culvert and storm drain pipe shall conform to AASHTO M330, and shall be double wall pipe (Type S) for nominal diameters of 12 inches through 30 inches, inclusive, and shall be triple wall pipe (Type D) for nominal diameters of 36 inches through 60 inches, inclusive. The Department will not permit the use of polypropylene pipe less than 12 inches or greater than 60 inches in diameter. Fittings and joining systems shall also meet AASHTO M330.

SECTION 233—GALVANIZING

233.01—Description

These specifications cover the use and repair of zinc coatings (galvanizing) on a variety of materials.

233.02—Detail Requirements

Galvanizing of fabricated items shall be performed after fabrication.

Galvanized items shall be stored off the ground in a manner that will allow free drainage of water from galvanized surfaces.

(a) **Galvanizing of iron and steel hardware** shall conform to ASTM A153 for the hot-dip process or ASTM B695, Class 50, for the mechanical process.

(b) **Galvanizing of rolled, pressed, and forged steel shapes, plates, bars, and strips** shall conform to ASTM A123.

233.03—Repair of Galvanized Surfaces

Galvanizing surfaces that have been damaged or have uncoated areas shall be repaired in accordance with ASTM A780 except that repair materials shall not contain lead or cadmium.

SECTION 234—GLASS BEADS FOR REFLECTORIZING TRAFFIC MARKINGS

234.01—Description

This specification covers glass beads applied on the surface or incorporated into traffic-marking materials so as to produce a retroreflective surface.

234.02—Detail Requirements

Beads shall be manufactured from glass of a composition designed to be highly resistant to traffic wear and weather. Glass beads shall conform to AASHTO M247, Type 1-5, except that at least 80 percent of the beads shall be round when tested in accordance with ASTM D 1155, Procedure B.

The Contractor shall provide a written certification that each batch of glass beads used in or on VDOT pavement markings conforms to AASHTO M247 including the total concentration limit of Lead and Arsenic.

SECTION 235—RETROREFLECTORS

235.01—Description

Retroreflectors shall consist of a housing/backing with a retroreflective surface on the front and back, if applicable.

Retroreflectors for delineators and pavement markers, except temporary markers, shall be molded of methyl methacrylate plastic conforming to Federal Specification L-P-380, Type I, Class 3.

Retroreflectors for temporary pavement markers shall have a surface consisting of reflective sheeting or a plastic prismatic element. The housing/backing for temporary pavement markers shall be constructed of methyl methacrylate plastic conforming to Federal Specification L-P-380, Type I, Class 3.

Delineators and pavement markers shall be approved by reviewing performance data from one or both of the following test programs:

(a) AASHTO's National Transportation Product Evaluation Program (AASHTO/NTPEP). Test data values used for approval may be based upon the data generated per the applicable NTPEP Work Plan.

(b) VDOT Test Facility – VDOT may elect to evaluate performance from their own test facility.

235.02—Detail Requirements

(a) **Steel castings for snowplowable pavement markers** shall conform to ASTM A536, hardened to 52-54 RC, and shall weigh approximately 5 1/2 pounds. Keels shall be parallel, approximately 0.70 inch thick by 1.90 inches deep, and shall have notched edges. The forward and

rear noses of the casting shall be shaped to deflect snowplow blades. Castings shall retain their hardness after removal of adhesives and other foreign residues or shall be capable of conforming to the specified hardness with additional heat treating to ensure the castings can be recycled.

(b) **Plastic panels for delineators** shall be at least 0.080 inch thick, have a minimum tensile strength at yield of 5,000 pounds per square inch when tested in accordance with the requirements of ASTM D638. Plastic panels shall also have minimum impact strengths of 2.0 foot-pounds per inch of notch at –20 degrees F and 14.0 foot-pounds per inch of notch at 73 degrees F when tested in accordance with the requirements of ASTM D256, Method A. The panels shall be flexible and able to recoil to within 5 degrees of vertical after impact. Panels shall not deteriorate when exposed to UV rays, petroleum products, ozone, deicing salts, exhaust fumes, or herbicides.

(c) **Aluminum panels for delineators** shall be at least 0.064 inch thick conforming to ASTM B-209, alloy 5052.

(d) **Delineators** shall have the retroreflective surface and the housing/backing fused to form a homogenous unit sealed against dust, water, and vapor. Retroreflectors shall show no change in shape or color when subjected to 4 hours in a circulating air oven at 170 degrees F to 180 degrees F. The adhesion system shall be as recommended by the manufacturer. Refer to VTM 70 for additional Delineator Testing Requirements.

The specific intensity shall be not less than the following values:

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)	
		Clear	Yellow
0°	0.1°	119	71
20°	0.1°	47	28

(e) Raised, recessed, and snowplowable raised pavement markers shall have a retroreflective surface area not less than 1.4 square inches, and the slope of the reflective surfaces shall not be less than 30 degrees or more than 33 degrees when measured from the pavement surface. The reflective surface shall be protected with a bonded glass face or coated with a clear acrylic compound that uses a UV inhibitor. Refer to VTM 71 for additional Pavement Marker Testing Requirements.

The specific intensity shall not be less than the following values when tested in accordance with VTM-71:

Raised and Recessed Pavement Markers

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)		
		White	Yellow	Red
0°	0.2°	3.0	1.8	0.75
20°	0.2°	1.2	0.72	0.25

The crushing strength shall not be less than 4,000 pounds when tested in accordance with VTM-71.

Raised and recessed pavement markers shall be at least 4 inches and not more than 4.75 inches in width and not more than 0.55 inch in height.

Retroreflectors for snowplowable raised pavement markers shall be installed in steel castings conforming to (a) herein and shall have a nominal width of 4 inches excluding the castings.

(f) **Temporary pavement markers** shall have a retroreflective surface not less than 1.0 square inch. The specific intensity shall not be less than the following values:

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)	
		White	Yellow
0°	0.2°	3.0	1.8
20°	0.2°	1.2	0.72

SECTION 236—WOOD PRODUCTS

236.01—Description

These specifications cover the uses and requirements for structural timber and lumber, miscellaneous wood products, and preservative treatments for such wood products where specified.

236.02—Detail Requirements

(a) **Structural timber and lumber** shall conform to AASHTO M168. The species and grade of structural lumber shall be as shown on the plans. The Engineer may approve the substitution of another species of equal or greater strength selected from the "Allowable Unit Stresses for Structural Lumber—Visually Graded" of AASHTO's *Standard Specifications for Highway Bridges* or the supplement to *National Design Specification for Stress-Grade Lumber and Its Fastenings* of the National Forest Products Association.

Except as otherwise specified, the species and grade of structural lumber, timber, and posts for the following applications shall be as follows:

1. **Bridges** shall be at least 1,550 Fb and:

   a. 5 inch by 5 inch and larger: Southern Pine, No. 1 Dense.

   b. 2 inch through 4 inch by 2 inch through 4 inch: Southern Pine, No. 2 Dense.

   c. 2 inch through 4 inch by 5 inch and through 6 inch: Southern Pine, No. 1.

   d. 2 inch through 4 inch by 8 inch only: Southern Pine, No. 1 Dense.

   e. 2 inch through 4 inch by 10 inch only: Southern Pine, Non-Dense Select Structural.

   f. 2 inch through 4 inch by 12 inch only: Southern Pine, Non-Dense Select Structural.

2. **Signs** shall be at least 1,100 Fb with material being dressed on all sides and:

   a. 4 inches and less in the least dimension: Southern Pine, No. 2 Non-Dense.

   b. Over 4 inches in the least dimension: Southern Pine, No. 1.

3. **Guardrail** shall be at least 1,250 Fb Southern Pine, No. 1 Dense.

4. **Fence** shall be Southern Pine, No. 2, for line, corner, and brace units.

5. **Signalization and electrical service** shall conform to ANSI Class 5.1.

   Sawn material, both rough and dressed, shall be certified by the mill as to grade and shall be grade marked in accordance with the grading rules and basic provisions of the American Lumber Standards (PS-20-70) by a lumber grading or inspection bureau or agency approved by the Department. The grade mark shall be applied after dressing if the sawn material is dressed.

(b) **Timber piles** shall conform to ASTM D25. Piles shall be clean peeled and have a butt circumference of at least 31 inches. The Engineer will accept piles for fender systems or other non–load bearing uses under the following criteria provided the piles can be properly driven: A straight line from the center of the butt to the center of the tip may lie partly outside the body of the pile, but the distance between the line and pile shall be not more than 1/2 percent of the length of the pile or 3 inches, whichever is smaller.

Points for timber piles shall be steel or cast iron and of a shape that will allow a secure connection to the pile and withstand driving.

Timber piles shall be branded prior to shipment with the supplier brand, year of treatment, species of timber and preservative treatment, retentions, class, and length. Brand symbols shall conform to AWPA M6.

(c) **Timber preservatives** shall be used according to their suitability for the condition of exposure to which the timber will be subjected and shall not be used interchangeably. Treatments shall conform to the following limitations:

1. Waterborne preservatives shall be used for timber where a clean surface is desirable. The moisture content of wood material shall be not more than 19 percent at the time of treatment.

2. Pentachlorophenol and creosote may be used for timber that is not to be painted. Timbers treated with pentachlorophenol or creosote shall be free of excess preservative on the wood surface.

3. Preservatives shall conform to the requirements of the American Wood-Preservers Association (AWPA).

4. Pressure treatment shall conform to the AWPA "Use Category System" as follows:

   - Lumber and timber for bridge structures including bridge decking, guardrail posts, and offset blocks shall be treated to conform to UC4B.

- Foundation piles shall be treated to conform to UC4C.
- Wood composites shall be treated to conform to UC4A.
- Sign posts, fence posts, and gates shall be treated to conform to UC4A.
- All other sawn products and round posts less than 16 feet in length shall be treated to conform to UC4A.

5. Marine applications where wood structures or products will be placed in or above salt water, brackish water, or tidal water shall be treated to conform to UC5B.

6. Wood used for highway construction, bicycle trails, pedestrian overlooks and maintenance applications for sign posts, fence posts, wood posts, guardrail posts, bridge decking, gates, stair treads, and offset blocks shall be treated with a chromated copper arsenate (CCA) preservative. Wood used for highway construction, bicycle trails, pedestrian overlooks and maintenance applications for piles, timbers, and composites shall be treated with a CCA, pentachlorophenol, or creosote preservative.

7. Wood used for hand-contact surfaces such as handrails, playground equipment, and picnic tables shall be treated with either ammoniacal copper quaternary (ACQ) salt or copper azole (CA) preservative. ACQ and CA wood treatments are highly corrosive to metal. Fasteners or connectors that will be in contact with wood using ACQ or CA wood preservative treatments shall be either 304 or 316 stainless steel or hot-dipped galvanized steel that conforms to ASTM A153 or ASTM A653, Class G185. The Engineer will not permit the use of mechanically galvanized steel hardware or fasteners with ACQ and CA wood treated wood.

SECTION 237—STRUCTURE BEDDING MATERIAL AND BEARING PADS

237.01—Description

These specifications cover material used under bearing devices of structures.

237.02—Detail Requirements

(a) **Elastomeric Bearing Pads:** The elastomer portion of pads shall be new neoprene compound. Pads shall be cast under heat and pressure and may be individually molded or cut from pressure-cast stock. Variations from the dimensions shown on the plans shall be not more than the following: thickness, ±1/16 inch; width, –1/8 to +1/4 inch; length, –1/8 to +1/4 inch. Tolerances, dimensions, finish and appearance, flash, and rubber-to-metal bonding shall conform to A 4-F3-T.063-B2, Grade 2, Method B, in accordance with the RMA Rubber Handbook. Pads shall be furnished in one piece and shall not be laminated unless otherwise specified. Pads shall be furnished in identifiable packages.

Adhesive for use with elastomer pads shall be an epoxy-resin compound, compatible with the elastomer, having sufficient shear strength to prevent slippage between pads and adjacent bearing surfaces.

Laminated pads shall consist of alternate laminations of elastomer and hot-rolled steel sheets molded together as a unit. The bond between the elastomer and metal shall be such that failure shall occur in the elastomer and not between the elastomer and steel when tested for separation.

Material having a nominal durometer hardness of 70 and 50 shall be used for nonlaminated pads and laminated pads, respectively. Test samples shall be prepared from finished pads. Samples of each thickness will be taken from 2 full-size pads from each shipment of 300 pads or less, with 1 additional pad for each additional increment of 300 pads or fraction thereof. Samples shall comply with the following physical requirements when tested in accordance with the ASTM methods designated.

1. **Original physical properties:** Test results for tear resistance, tensile strength, and ultimate elongation shall be not more than 10 percent below the following specified value:

Property	Nominal Hardness 50	Nominal Hardness 70
Min. tear resistance, ASTM D624, Die C (lb/in of thickness)	180	200
Hardness, ASTM D2240 (points)	50 ± 5	70 ± 5
Min. tensile strength, ASTM D412 (average psi of longitudinal and transverse)	2,500	2,500
Min. ultimate elongation (%)	400	300

The compressive deflection tested in accordance with ASTM D575, Method A, shall be as follows:

a. **Laminated pads:** The maximum compressive deflection shall be 7 percent of the total rubber thickness at the total load given in the plans. The maximum shear resistance shall be 50 pounds per square inch of the plan area at 25 percent shear deformation at –20 degrees F. Test pads shall be subjected to a compressive load of 1.5 times the maximum design load given in the plans without visible damage.

b. **Nonlaminated pads:** When loaded within 300 to 800 pounds per square inch, material shall show a compressive deflection within 20 percent of that given in the charts of VTM-23, interpolating for actual measured hardness.

2. **Changes in original physical properties:** When pads are oven aged 70 hours at 212 degrees F in accordance with ASTM D573, changes shall be not more than the following:

Property	Value
Hardness (points change)	0 to +15
Tensile strength (% change)	±15
Ultimate elongation (% change)	-40

3. **Extreme temperature characteristics:** Compression set under constant deflection in accordance with ASTM D395, Method B, 22 hours at 212 degrees F, shall be not more than 35 percent. When tested in accordance with the low temperature brittleness test, ASTM D746, breaks shall not occur above –20 degrees F.

4. **Ozone cracking resistance:** Upon exposure to 100 parts per million of ozone in air by volume at a strain of 20 percent and a temperature of 100 ± 2 degrees F in a test conducted otherwise in accordance with ASTM D1149, cracks shall not develop within 100 hours. Samples shall be wiped with solvent before the test to remove traces of surface impurities.

5. **Oil swell:** The volume change shall be not more than +120 percent when tested in accordance with ASTM D471 with ASTM Oil No. 3, 70 hours at 212 degrees F.

(b) **TFE Bearing Surfaces:**

1. TFE resin shall be virgin material conforming to ASTM D1457. The specific gravity shall be 2.13 to 2.19. The melting point shall be 623 ± 2 degrees F.

2. Filler material shall be milled glass fibers, carbon, or other Department approved inert filler materials.

3. Adhesive material shall be an epoxy resin conforming to FS MMM-A-134, FEB film or Department approved equal.

4. When tested in accordance with ASTM D1457, finished unfilled TFE sheets shall have a tensile strength of at least 2,800 pounds per square inch and an elongation of at least 200 percent.

5. Filled TFE sheets shall contain inert filler material uniformly blended with TFE resin. Finished filled TFE sheets containing glass fiber or carbon shall conform to the following:

	ASTM Method	15% Glass Fibers	25% Carbon
Min. tensile strength	D1457	2,000 psi	1,300 psi
Min. elongation	D1457	150%	75%
Min. specific gravity	D792	2.20	2.10
Melting point	D1457	621 ± -50°F	603 ± -50°F

6. Fabric containing TFE fibers shall be manufactured from oriented multifilament TFE fluorocarbon fibers and other fibers as required by specific designs. When tested in accordance with ASTM D2256, the tensile strength of TFE fibers shall be at least 24,000 pounds per square inch and the elongation shall be at least 75 percent.

7. Where TFE sheets are to be epoxy bonded, one surface of the sheet shall be factory treated by an approved manufacturer using the sodium naphthalene or sodium ammonia process.

8. Stainless steel mating surfaces shall be at least 16 gage in thickness and shall conform to ASTM A240, Type 304. The mating surface shall be a true plane surface with a Brinnel hardness of at least 125 and a surface finish of at least No. 8 mirror finish in accordance with ASTM A480. Stainless steel mating surfaces shall be polished or rolled as necessary to conform to the friction requirements specified herein. The stainless steel shall be attached to the sole plate by means of a seal weld around the entire perimeter of the facing material.

9. The coefficient of friction for the completed bearing assembly shall be not more than the following:

Bearing Pressure

Material	500 psi (3.447 MPa)	2,000 psi (13.790 MPa)	3,500 psi (24.132 MPa)
Unfilled TFE, fabric containing TFE fibers, TFE perforated metal composite	.08	.06	.04
Filled TFE	.12	.10	.08
Interlocked bronze and filled TFE structures	.10	.07	.05

(c) **Sheet Lead and Common Desilverized Bedding Material:** Material shall conform to ASTM B749 and shall be furnished in single sheets of the specified thickness.

(d) **Preformed Fabric Bedding Material:** Material shall be composed of multiple layers of 8-ounce cotton duck impregnated and bound with high-quality natural rubber or its equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plys shall be such as to produce the specified thickness after compression and vulcanizing. Finished pads shall withstand compression loads perpendicular to the plane of the laminations of at least 10,000 pounds per square inch without a detrimental reduction in thickness or extrusion.

SECTION 238—ELECTRICAL AND SIGNAL COMPONENTS

238.01—Description

These specifications cover conduits, conductors, junction boxes, traffic signal components, and necessary fittings to complete a described electrical or traffic signal system.

238.02—Detail Requirements

(a) **Metal Conduit and Fittings:** Conduit shall be galvanized and conform to of UL-6. Fittings for metal conduit shall be galvanized and conform to UL-514B. Conduit for use in underground installations, concrete encasements, or corrosive environments shall also be coated on the outside with an asphalt mastic conforming to AASHTO M243 or shall have a PVC coating of 40 mils or another Department approved coating.

(b) **PVC Conduit and Fittings:** Conduit shall be heavy wall conduit conforming to UL-651. Fittings for PVC conduit shall conform to the requirements of UL-514B. Exposed PVC conduit shall be UL or ETL Testing Laboratories, Inc. listed for use in direct sunlight. Each section of conduit shall be marked with the letters UL or ETL. Solvent cement used for joining conduit or fittings shall conform to ASTM D2564. Protective shields shall be galvanized sheet steel of commercial quality with a coating designation conforming to ASTM A653, coating designation G115, and a thickness of 0.0625 inch.

PVC used in a directional boring operation shall be Schedule 40 with integral male/female couplings, a gasket, locking rings, and grooves designed to secure the conduit sections for installation in the bored area. Joints shall have a pull rating of 7,000 pounds for 3-inch conduit,

8,700 pounds for 4-inch conduit, 11,300 pounds for 5-inch conduit, and 14,000 pounds for 6-inch conduit.

(c) **Fiberglass-reinforced Epoxy Resin Conduit and Fittings:** Conduit shall conform to NEMA TC-14. Conduit used in exposed areas shall be heavy wall and sunlight resistant. Epoxy adhesive used for joining conduit shall conform to NEMA TC-14. Protective shields shall conform to the same requirements as those with PVC conduit.

(d) **PE Conduit:** PE conduit shall conform to NEMA TC-7 for high-density PE duct except that the wall thickness of conduit with a diameter of 1 1/4 inches and less shall conform to UL-651 for heavy-wall PVC conduit. Conduit shall have a carbon black loading of 2.5 ± 0.5 percent by weight in accordance with ASTM D1603. The average diameter of the carbon black shall be no larger than 40 millimicrons in accordance with ASTM D1514. Conduit shall contain at least 1,000 parts per million of hindered phenolic long-term antioxidant in accordance with ASTM D3895.

(e) **Splice Boxes or Pull Boxes (512 cubic inches or less):** The Engineer will only allow boxes conforming to UL-514B in exposed areas. Boxes shall be compatible with the appropriate conduit.

(f) **Electrical and Signal Junction Boxes:**

Boxes, frames, and covers shall be water resistant. Covers shall be secured with stainless steel bolts and fasteners. Covers shall be flush with surface of the junction box and not protrude above the top of the junction box flange.

Junction box bolt attachment holes shall be drilled through to prevent debris from collecting in the threaded bolt holes.

A Materials Division approved independent testing laboratory shall test and certify junction boxes as meeting the requirements herein prior to their use. The Contractor shall furnish the Engineer documentation of such test results.

Testing reports shall provide complete test results for the type of design testing indicated for the respective type of junction box.

Junction Boxes for deliberate traffic in the roadway applications:

- Concrete shall conform to Section 217 and shall be designed to meet the provisions of AASHTO's Standard Specifications for Highway Bridges for HS20 loading. Concrete shall have a design minimum compressive strength of 4000 psi.

- Gray Iron frame and covers shall conform to Section 224.

Junction Boxes for off roadway applications:

- Boxes shall conform to ANSI/SCTE 77 2007 and tier 15 loading. Boxes shall be open bottom.

- Boxes shall be polymer concrete with straight sides or polymer concrete with flared or straight fiberglass sides.

- The Engineer may approve other materials for the sidewalls provided they conform to the requirements of ANSI/SCTE 77 2007 and tier 15 loading.

Junction Boxes frames and covers for bridge structures encasements shall be one of the following types:

1. Steel castings conforming to Section 224, galvanized inside and out.

2. Welded sheet steel having a thickness of at least 3/16 inch or 7 gage, galvanized inside and out.

3. Polymer concrete with fiberglass sides or all polymer concrete.

(g) **Conductor Cables:**

1. **Power conductor cables** shall be copper conforming to ASTM B3 and B8. Conductor cable sizes shall be based on No. 8 AWG minimum. Conductor cables of No. 8 AWG and larger shall be stranded. Conductor insulation shall be UL listed for the use specified on the plans and rated for 600-volt operation.

   a. **Service entrance conductor cables** shall be UL with Type SE insulation.

   b. **Underground service entrance conductor** cables shall be UL with Type USE insulation.

   c. **Direct burial conductor cables** shall be UL with Type USE or UF insulation.

   d. **Conductor cables in conduit** shall be UL with Type THWN insulation except as follows:

      When the conduit size specified on the plans is such that the allowable percentage of conduit fill in Table 1, Chapter 9, of NEC is not exceeded, then UL Type RHW, TW, THW, XHHW, or XLPE insulation may be used.

   Direct burial conductor cables may be spliced to THWN conductor cables only at accessible locations where direct burial conductor cables enter a conduit.

2. **Communication and signal cables:**

   a. **Signal cables from the controller cabinet to signal heads** shall be No. 14 AWG copper with 3, 4, 5, 7, or 12 straight-lay conductors.

      (1) IMSA 19-1 or 20-1 cables shall be used for aerial and duct installations.

      (2) IMSA 19-5 or 20-5 cables shall be used for direct buried installations.

   b. **Interconnect cables between controllers** shall be No. 14, 18, 19, or 22 AWG solid copper.

      (1) No. 14 AWG cables shall conform to IMSA 19-2 or 20-2 for aerial and duct installations; IMSA 19-4 or 20-4 for self-supporting aerial installations; or IMSA19-6 or 20-6 for direct buried installations.

(2) No. 18, 19, or 22 AWG cables shall be solid copper conforming to IMSA 39-2 or 40-2 for aerial and duct installations; IMSA 39-4 or 40-4 for self-supporting aerial installations; or IMSA 39-6 or 40-6 for direct buried installations.

c. **Loop detector cables** shall be No. 12 or 14 AWG stranded copper.

(1) No. 12 AWG cables shall conform to IMSA 51-3 Type XHHW insulations.

(2) No. 14 AWG cables shall conform to IMSA 51-5.

d. **Loop and magnetic detector lead-in cables** shall be stranded copper, twisted pair, No. 14 AWG conforming to IMSA 50-2.

(h) **Electrical Components:**

1. **Safety switches** shall be enclosed in a rain-tight metal box and cover conforming to NEMA 3R, with a lock-on/lock-off external switch handle. Safety switches shall be heavy duty, two-pole minimum with solid neutral and fused compatible with the equipment load. Safety switches shall be rated at 100 amp/240 volts for signal installations.

2. **Circuit breaker boxes** used as a service disconnect for signal equipment shall be a rain-tight metal box and cover conforming to NEMA 3R. The circuit breaker box shall be rated at 100 amp/240 VAC with a solid neutral and shall contain two single-pole, 120-VAC breakers with an ampere rating compatible with the equipment load and shall have provisions for padlocking. The service load shall be wired to only one breaker.

3. **Grounding electrodes (rods)** shall be copper-clad rods conforming to UL-467. Grounding electrodes shall have a diameter of 3/4 inch and a length of 10 feet. Grounding electrodes couplers shall be UL approved and shall be bronze, stainless steel, or copper clad with a solid center providing 100 percent conductivity.

4. **Grounding electrode conductors** shall be no less than No. 6 AWG (bare solid wire) conforming to ASTM B2.

5. **Ground clamps** shall be heavy-duty bronze or brass or galvanized malleable iron conforming to ASTM A220, any grade.

6. **Signal head sections:**

a. **Vehicle traffic signal head sections** shall conform to the ITE Standard for Vehicle Traffic Control Signal Heads dated April 1985 without the optical unit.

Vehicle traffic signal head section modules shall conform to:

(1) ITE Vehicle Traffic Control Signal Heads-Light Emitting Diode Circular Signal Supplement dated June 27, 2005 for signal head sections containing circular signal indications; or

(2) ITE Vehicle Traffic Control Signal Heads-Light Emitting Diode Vehicle Arrow Signal Supplement July 1, 2007 for signal head sections containing arrow signal indications

The Light Emitting Diode (LED) signal module shall use the same mounting hardware used to secure an incandescent lens and gasket assembly and shall only require a screwdriver or standard installation tool to complete the mounting.

b. **Pedestrian signal head sections** shall consist of a housing (with visor and/or screen as specified in the Contract), a door, pedestrian traffic signal module, gaskets, and miscellaneous hardware. The housing, door, gaskets, and miscellaneous hardware shall conform to the following requirements of the ITE Standard for Vehicle Traffic Control Signal Heads dated April 1985:

(1) The top and bottom opening and serration requirements in Section 3.01 – Physical and Mechanical Requirements: General

(2) Section 3.02 – Physical and Mechanical Requirements: Strength Requirements

(3) Section 4.01 – Housing, Door, and Visor: General

(4) Section 4.04 – Housing, Door, and Visor: Materials and Fabrication, except the requirements for lens openings, visor, and backplates.

(5) Section 7.00 – Exterior Finish

Pedestrian traffic signal modules shall conform to the ITE Specifications for Light Emitting Diode Pedestrian Traffic Signal Modules dated August 4, 2010. The displays shall include "Walking Person" and "Upraised Hand" symbol indications in a separate or overlay configuration, as specified in the Contract. Symbol indications shall be filled.

c. **LED vehicle traffic control and pedestrian signal modules** shall be tested in accordance with the applicable ITE Specifications. The Contractor shall provide the LED manufacturer's certificate of ITE compliance for the applicable module(s) furnished and independent laboratory test reports. Independent laboratory tests shall include specific test and test results of each test as specified in the ITE Design Qualification Testing Sections of the ITE Standards for both vehicle control signal and pedestrian modules. Independent test reports shall be submitted at the same time as the catalog cut is submitted for the model and type of LED signal module furnished.

The Independent laboratory used for LED testing shall be on OSHA's current list of Nationally Recognized Test Laboratories (NRTLs). The testing laboratory shall be located within the continental United States or Canada.

LED traffic signal modules shall be warranted by the manufacturer for 5 years from the date of manufacture against manufacturing defects and workmanship. The Contractor shall be responsible for the replacement and installation costs if the module fails due to material and/or workmanship defects during this 5-year period.

7. **Backplates for signal heads:**

a. **Aluminum** shall conform to Section 229.

b. **Virgin ABS plastic** shall contain 60 percent styrene, 20 percent rubber, and 20 percent acrylic, with a thickness of at least 0.125 inch. Plastic shall contain ultraviolet inhibitors and stabilizers and shall be compounded for application in cold weather. Plastic shall have a tensile stress at yield of at least 5,300 pounds per square inch at 73 degrees F and a flexural strength at yield of at least 9,300 pounds per square inch at 73 degrees F. Plastic shall conform to or exceed the requirements of UL-94, Test H.B. for fire retardance. The color of backplates shall be impregnated into the plastic. Backplates shall be vacuum formed; the inside and outside edges shall be formed with at least a 1/2-inch flange turned away from the front surface.

8. **Cable clamps** shall conform to NEMA PH-23 except for dimension which shall be as required to accommodate cable as specified:

   a. Two bolt clamps shall be 4 inches in length, made to accommodate 1/4 inch diameter tether wire.

   b. Three bolt clamps shall be the heavy 6-inch length made to accommodate span wire ranging from 1/4 to 5/8 inch in diameter.

9. **Cable rings and lashing wires** shall be weather resistant and the industry standard.

10. **Connectors and terminals** shall conform to NEC 110. Breakaway connectors shall consist of line and load side sections designed to separate without breaking the conductor. Connectors shall be waterproof with an insulation rating of 600 volts. Current carrying components exposed when the connector is separated shall be in the load section of the connector. Connectors for the hot conductors shall be designed for 13/32 inch by 1 1/2 inch cartridge type fuses. A fuse of a suitable ampere rating (10 amps maximum) shall be provided for lighting fixture devices and conductors.

11. **Angle thimbleyes** shall be Rural Utilities Service (RUS) listed.

12. **Span wire saddle clamps** for span wire connection on a bridle span shall use U-bolts for securing the clamp to the span wire and shall be galvanized malleable iron with a tensile strength of at least 25,000 pounds.

13. **Stainless steel straps** shall be solid, 5/8 inch width minimum, with a tensile strength of at least 100,000 pounds per square inch.

14. **Service entrance heads** shall be galvanized malleable iron.

15. **Tether wire** shall conform to ASTM A475, Common Grade, Class A, seven strand, or Type I, General Purpose, Class I, 6 x 7, iron, galvanized, fiber core, conforming to FS RR-W-00410C. The breaking strength of tether cable shall be not more than 3,000 pounds.

16. **Thimbleye bolts** shall conform to ANSI C135.4 and the following:

   a. The tensile strength shall be at least 18,350 pounds for 3/4-inch bolts.

   b. Dimensions for 3/4-inch bolts shall comply with the following as related to Figures 1 and 2 in ANSI C135.4:

Bolt Diameter	A	D	E
3/4 in	13/16 in	9/32 in	11/32 in

17. **Thimbleye nuts** shall conform to ANSI C135.4.

18. **Washers for use with thimbleye bolts** shall conform to NEMA PH-10.

19. **Electrical Tape:**

    a. **Vinyl tape** shall be for electrical use and shall conform to ASTM D2301, Type 1.

    b. **Rubber tape** shall be for electrical use and shall conform to ASTM D4388.

20. **Photoelectric controls** shall conform to ANSI C136.10 and the following:

    The photoelectric control shall be solid state, fail-on type, single-voltage rated and shall be factory preset and calibrated to turn on at 1.5 footcandles ± 0.5 footcandle. The ratio of the turn-off light level to the turn-on light level shall not exceed 1.65:1. The photoelectric control shall use a cadmium sulfide sensor. The output control relay shall have a time delay of 5 to 15 seconds. The photoelectric control shall have a built-in 160-joule metal oxide varistor for surge/transient protection. The contact shall be mechanical, and contact "chatter" upon opening of the contacts shall not exceed 5 milliseconds. The cover shall be an impact- and ultraviolet-resistant material that complies with the flammability and impact requirements of UL-773.

21. **Miscellaneous signal line hardware and/or attachments** shall be galvanized or stainless steel.

22. **Span wires** shall conform to ASTM A475, High-Strength Grade, Class A.

23. **Splice kits** shall be packaged containing materials from a single supplier and shall consist of a plastic molded body with a compound that provides a water-resistant seal and insulation for the conductor cables for at least 600 volts.

24. **Span wire clamps** for signal head mounting shall use U-bolts for securing the clamp to the span wire and shall be galvanized malleable iron or aluminum with a tensile strength of 6,000 pounds.

25. **Contactors** shall be UL listed, open type. The contactor shall be rated to be compatible with the equipment load and type of load.

26. **Dead-end strain vise clamps** shall be designed for the size of the span wire or tether wire and their tensile strength shall be the same as or exceed the tensile strength of the cable. Clamps shall be fabricated from corrosion-resistant materials or shall be galvanized. Clamps shall have a release slot for holding the jaws back for retensioning and removal of the wire. Clamps shall be internally coated with inhibitor oils to prevent corrosion and to allow for the free movement of the jaws.

27. **Heat-shrink tubing** shall consist of an adhesive-lined, polyolefin flexible material conforming to the following requirements:

Property	Requirement
Shrinkage ratio	2:1
Water absorption	0.3% max.
Electrical rating	≥600 volts

28. **Guy markers** shall be white, unless otherwise specified, and shall be PVC or polyolefin material complete with all necessary manufacturer-approved installation/mounting hardware and shall conform to the following minimum requirements:

Property	Test Method	Unit	Materials	
			PVC	Polyolefin
Mechanical				
Tensile strength	ASTM D638	psi (MPa)	6,500 (45)	4,500 (31)
Tensile modulus	ASTM D638	psi (MPa)	380,000 (2617)	141,000 (971)
Hardness, Shore D	ASTM D2240/D2583	N/A	78	68
Notched impact	ASTM D256	ft-lb/in (J/m)	11.0 (587)	5.0 (267)
Thermal				
Heat distortion temperature at 264 psi (1.8 MPa)	ASTM D648	degrees F degrees C	162 72	N/A N/A
Flammability	UL-94		V-O	N/A
Electrical				
Dielectric constant	ASTM D150	Volts per mil of thickness	3.5	2.3
Dielectric strength	ASTM D149	Volts per mil of thickness	480	500

29. **Stainless steel cables** for traffic signal hanger assemblies and traffic sign hanger assemblies to be installed on mast arms shall be stainless steel, 7x19, Type 304 in accordance with Federal Specification RR-W-410E with a breaking load of 3700 pounds. Ends shall be swaged to withstand a 4200 pounds pull.

SECTION 239—SODIUM CHLORIDE AND CALCIUM CHLORIDE

239.01—Description

These specifications cover chloride used as a stabilizer or to control snow and ice.

239.02—Detail Requirements

(a) **Sodium chloride** shall conform to AASHTO M143, Type I, with the following exceptions:

1. The sodium chloride content shall be at least 97 percent of the dry weight.

2. The moisture content shall be not more than 5 percent.

3. When shipped in bulk, sodium chloride shall contain an anticaking additive.

4. Sodium chloride will be tested in accordance with VTM-28.

   When practicable, the Engineer will take samples at the source from indoor storage or from adequately protected outdoor storage at the rate of approximately one sample per 4,000 tons. Samples will not be taken from uncovered storage.

   The Engineer will take samples at the destination at the time of delivery when inspection at the source is not practicable, or when material is shipped directly from uncovered storage.

   Inspection service will be provided when the frequency of shipments from approved stock at the source, makes it economically justified. The Inspector's stamp on the shipping or delivery report will indicate inspection of the shipments. When inspection service is not provided, the supplier may ship material but shall certify that the sodium chloride came from an approved source. An authorized representative of the supplier shall sign the certification if it is stamped on the shipping or delivery report.

(b) **Calcium chloride** shall conform to AASHTO M144.

SECTION 240—LIME

240.01—Description

These specifications cover lime to be used as a stabilizer or soil conditioner.

240.02—Detail Requirements

(a) **Hydrated lime** shall conform to ASTM C207, Type N, except that the average percentage of calcium oxide shall be at least 93. Single test results shall not be below 90 percent.

(b) **Hydraulic lime** shall conform to ASTM C141.

(c) **Agricultural lime:**

1. **Ground limestone** shall be of such fineness that at least 86 percent will pass a No. 20 mesh screen, at least 47 percent will pass a No. 60 mesh screen, and at least 28 percent will pass a No. 100 mesh screen. Material shall have a calcium carbonate equivalent of at least 85 percent.

2. **Pulverized limestone** shall be of such fineness that at least 90 percent will pass a No. 20 mesh screen, and at least 66 percent will pass a No. 100 mesh screen. Material shall have a calcium carbonate equivalent of at least 85 percent.

(d) **Lime for soil stabilization** shall be quicklime or hydrated lime conforming to AASHT0 M216.

SECTION 241—FLY ASH

241.01—Description

These specifications cover fly ash (burnt coal residue) used as an additive in hydraulic cement concrete or as a soil stabilizer.

241.02—Detail Requirements

(a) **Fly ash used in hydraulic cement concrete** shall conform to ASTM C618, Class F, or Class C.

(b) **Fly ash used in lime stabilization** shall conform to ASTM C593. The Engineer may approve the use of bulk material if requested.

SECTION 242—FENCES

242.01—Description

These specifications cover material requirements for fence components used in the construction of chain link, pedestrian, barbed wire, woven wire, and lawn fences and material specifications for temporary silt fences, geotextile fabric silt barriers, and filter barriers used for erosion and sediment control.

242.02—Detail Requirements

Steel posts and braces for standard fence and chain link fence may be fabricated from pregalvanized material in lieu of galvanization after fabrication provided ends and other areas of exposed metal are satisfactorily treated or repaired using a material conforming to Section 233.

(a) **Chain Link and Pedestrian Fences:** Fabric material shall be new 9-gage core conforming to the following:

1. **Galvanized wire fabric for use in chain link fence** shall be hot-dip galvanized after weaving in accordance with AASHTO M181, Type I, Class D. wire fabric for use in pedestrian fence shall be hot-dip galvanized after weaving in accordance with AASHTO M181, Type I, Class C.

2. **Aluminum alloy wire fabric** shall conform to AASHTO M181, Type III.

3. **Aluminum-coated wire fabric** shall conform to AASHTO M181, Type II.

4. **Coated wire fabric:**

   a. **Vinyl-coated wire fabric** shall conform to AASHTO M181, Type IV, Class A or Class B, except that vinyl coated fabric may be No. 9 gage overall, including the vinyl

coating, provided the core wire has a minimum zinc coat weight of 0.30 ounce per square foot and a minimum breaking strength of 1,290 pounds force.

b. **Other conforming organic polymer-coated wire fabric** shall conform to ASTM F 668 Class 1, Class 2a or 2b.

5. **End, corner, and gate posts** shall be one of the following:

a. welded or seamless steel galvanized pipe conforming to ASTM F1083, Schedule 40

b. roll-formed steel sections conforming to ASTM F1043, Group II with Type A external and internal coating

c. aluminum alloy pipe conforming to ASTM B429, Schedule 40

d. galvanized pipe conforming to ASTM F1043, Group IC, with Type B external coating and Type D internal coating

e. vinyl or other conforming organic polymer-coated pipe conforming ASTM F1043, Group IA, with Type A external and internal coatings

f. vinyl or other conforming organic polymer-coated pipe conforming to ASTM F1043, Group IC, with Type B external coating and Type D internal coating

6. **Line posts** shall be one of the following:

a. round galvanized steel pipe conforming to ASTM F1083, Schedule 40

b. roll-formed C-sections conforming to ASTM F1043, Group II with Type A external and internal coating

c. aluminum alloy pipe conforming to ASTM B429, Schedule 40

d. galvanized pipe conforming to ASTM F1043, Group IC, with Type B external coating and Type D internal coating

e. vinyl or other conforming organic polymer-coated pipe conforming to (a)5.e. or (a)5.f. herein

7. **Braces** shall be one of the following:

a. welded or seamless steel galvanized pipe conforming to ASTM F1083, Schedule 40

b. roll-formed steel sections conforming to ASTM F1043, Group II with Type A external and internal coating

c. aluminum alloy pipe conforming to ASTM B429, Schedule 40

d. galvanized pipe conforming to ASTM F1043, Group IC, with Type B external coating and Type D internal coating

e. vinyl or other conforming organic polymer-coated pipe conforming to (a)5.e. or (a)5.f. herein

8. **Gates** shall be complete with hinges, latches, stops, and other necessary fittings. Gate frames shall be fabricated and coated with the same material as the adjoining fence framework and fabric.

9. **Aluminum alloy post surfaces that will be in contact with concrete and up to 1 inch above concrete** shall be uniformly coated with an aluminum-impregnated caulking compound or a solvent asphalt-fiber-filled and aluminum-pigmented coating conforming to ASTM D2824, Type III. Care shall be taken to prevent voids in the coating and the smearing of visible surfaces of concrete or posts except as otherwise noted herein.

10. **Tension wire** shall conform to one of the following:

    a. aluminum-coated tension wire conforming to AASHTO M181

    b. zinc-coated tension wire conforming to AASHTO M181, Class 1

    c. vinyl-coated tension wire conforming to AASHTO M181, Class A or Class B. The core wire shall be 6 or 7 gage, with a tolerance of ± 0.005 inch. The minimum weight of the zinc coating shall be 0.40 ounce per square foot. The breaking strength of the core wire shall conform to AASHTO M181 for tension wire.

    d. other conforming organic polymer-coated tension wire shall be 6 or 7 gage with a tolerance of ± 0.005 inch conforming to ASTM F1664. The breaking strength of the core wire shall conform to AASHTO M181 for tension wire.

11. **Fittings** shall be fabricated and coated with the same material as the fence framework and fabric.

12. **Temporary High Visibility Fence:** When specified on the plans or other Contract documents, temporary high visibility fence shall be a minimum of 40 inch high, international orange, plastic (high density polyethylene, polypropylene, or polyolefin) web fencing. Fence posts shall be conventional metal "T" or "U" shaped posts, 6 feet in length. The plastic web fencing shall be securely fastened to the posts in a manner approved by the Engineer. Plastic web fencing fabric shall have the following physical qualities:

    The tensile strength shall be at least 100 lbs./ft. in the machine direction and 80 lbs./ft. in the transverse direction when determined using ASTM D638.

(b) **Barbed Wire Fence, Woven Wire Fence, and Lawn Fence:**

1. **Barbed wire** shall conform to one of the following:

    a. ASTM A121, Coating Type Z, Coating Class 3 Design Number 12-4-5-14R

    b. ASTM A121, Coating Type Z, Design Number 15-4-5-16R except that the tensile strength of the line wire shall be at least 475 pounds per strand and the zinc coating shall be at least 0.70 ounce per square foot

c. single-strand oval-shaped wire having a diameter of at least 0.08 inch in its least dimension but not more than 0.135 inch in its greatest dimension and a tensile strength of at least 1150 pounds; wire shall have four barbs of 14-gage wire and a zinc coating of at least 0.30 ounce per square foot

d. vinyl and other polymer-coated barbed wire conforming to the requirements of ASTM F1665, Type I

2. **Woven wire fence fabric** shall conform to AASHTO M279. Standard FE-W1 woven wire fence fabric shall conform to Design No. 1047-6-11, Class 3, or No. 1047-6-12 1/2, Grade 125, Class 3. Standard FE-W2 woven wire fence fabric shall conform to Design No. 1047-12-11, Class 3, or No. 1047-12-12 1/2, Grade 125, Class 3.

3. **Lawn fence** shall be the type shown on the plans, a similar type that will match the existing fence, or a type desired by the landowner and approved by the Engineer.

4. **Wood post and braces:**

a. **Species of wood:** Posts and braces for standard fence shall be Southern pine, Ponderosa pine, Douglas fir, Western hemlock, larch, or white or red cedar as defined in AASHTO M168. Locust may be used for woven wire farm fence and barbed wire fence.

b. **Cutting requirements:** Round or square posts and braces shall be cut from live growing trees.

c. **Seasoning:** Posts and braces shall be sufficiently air seasoned in an approved manner for a suitable length of time under favorable climate conditions or otherwise conditioned as part of the treating process to permit adequate penetration of preservative without damage to the wood.

d. **Peeling:** Posts and braces shall have the inner bark removed to the extent defined by the Southern Pine Inspection Bureau. Knots and projections shall be cut or shaved smooth and flush with the surrounding surface of the unit.

e. **End finish:** Butt ends of posts shall be sawn square.

f. **Dimensions:** Posts shall not vary from the length specified on the plans by more than 1 inch. Thickness dimensions shall be undressed dimensions and shall not vary from the dimensions shown on the plans by more than 1/4 inch.

g. **Straightness:** Wood posts and braces shall be free from bends in more than one place and free from short or reverse bends. The straightness of the post or brace shall be such that a straight line from the center of the tip to the center of the butt shall not depart from the center of the post by more than 2 percent of the length.

h. **Grading for square posts and braces:** Grading shall conform (b)4.a. herein.

i. **Preservative treatment:** Posts and braces, except cedar and locust, shall be treated with a preservative in accordance with Section 236 except that waterborne preservatives shall not be used in the treatment of posts and braces to be erected in marshy

areas. Oil-borne preservatives shall not be used where the posts and braces will come into contact with salt water.

Cutting and trimming of the ends shall be performed prior to treatment.

5. **Metal posts and braces:** Post anchor plates shall have a surface area of at least 16 square inches. Posts shall be in accordance with ASTM A702 and the following:

   a. **Steel posts and braces** shall be galvanized in accordance with Section 233.

   b. **Galvanized pipe** shall conform to (a)5.d. herein.

6. **Gates** similar in type to those that exist may be substituted for gates shown in the Plans or the Standard Drawings if preferred by the landowner and approved by the Engineer.

7. **Brace wire** shall be 9 gage and shall conform to AASHTO M279, No. 9, Grade 60, Class 3.

(c) **Temporary Silt Fences, Geotextile Fabric, and Silt Barriers:**

1. **Geotextile fabric** shall conform to Section 245.

2. **Posts for temporary silt fences** shall be a nominal 2 by 2 inch oak, or steel having a weight of at least 1.25 pounds per linear foot and a length of at least 5 feet.

SECTION 243—EPOXY-RESIN SYSTEMS

243.01—Description

These specifications cover epoxy-resin systems to be used for all applications requiring bonding of various materials or as patching or overlay of concrete slabs.

243.02—Detail Requirements

Epoxy-resin materials shall conform to the applicable requirements of Table II-19 and Table II-21.

(a) **Epoxy Systems:**

1. **Types EP-3B and EP-3T** shall be 100 percent reactive high-build coatings designed as a two-coat (minimum) system for protection of concrete exposed to splash zones and tidal water. Type EP-3B shall be the prime or base coat, and Type EP-3T shall be the finish or topcoat.

2. **Types EP-4, EP-5, and EP-6** shall be moisture-insensitive systems designed for structural bonding, sealing, and grouting of dry, damp, or wet structural material free from standing water. Mortar shall be prepared by mixing 2 parts by volume of loose oven-dried sand to 1 part of premixed Type EP-4 or EP-5 epoxy; however, Type EP-6 shall be

TABLE II-19
Requirements: Component A

Type Property	EP-3B Max.	EP-3T Max.	EP-4 Max.	EP-5 Max.	EP-6 Max.	EP-7 Max.
Epoxide equivalent	245	220	225	270	245	270

prepared by mixing 0.6 parts by volume of loose oven dried sand to 1 part of premixed EP-6 epoxy.

Mortars shall be mixed to a uniform consistency.

Type EP-4 shall be a high-modulus, rigid, general purpose adhesive with a tensile elongation of 1 to 3 percent. Type EP-4, low viscosity, shall be used to seal rigid cracks.

Type EP-5 shall be a low-modulus patching, sealing, and overlay adhesive with an elongation of at least 10 percent. When used as a penetrating sealer and to repair nonrigid cracks, Type EP-5 shall be of a low viscosity.

Type EP-6 shall be a low-modulus, nonsagging, flexible adhesive with an elongation of at least 5 percent. Type EP-6 shall be used for bonding or repairing damp and underwater surfaces where a nonsagging, low-modulus material is required.

3. **Type EP-7** shall be used for epoxy concrete overlays on bridge decks and high friction surface treatments on roads.

(b) **Classes:** Epoxy resin shall be formulated for use at specific temperatures. Three classes of systems are defined according to the range of temperatures for which they are suited. The controlling temperature shall be that of the surface of the hardened concrete to which the bonding system is applied.

Where unusual curing rates are desired, and with the Engineer's approval, a class of bonding agent may be used at a temperature other than that for which it is normally intended. The class and gel temperature shall be as follows:

1. **Class A:** for use with ambient air and surface temperatures less than 40 degrees F

2. **Class B:** for use with ambient air and surface temperatures greater than or equal to 40 degrees F and less than or equal to 60 degrees F

3. **Class C:** for use with ambient air and surface temperatures greater than 60 degrees F

(c) **Mixing Epoxy:** Epoxy resin shall be furnished in two components for combining in accordance with the manufacturer's instructions immediately prior to use. Component A shall conform to Table II-19. Component B shall contain one or more hardening agents that, when mixed with Component A, will cause the system to polymerize and harden to conform to Table II-21. The Department will permit the use of thixotropic agents in accordance with the manufacturer's recommendations to control viscosity. The Contractor shall only use complete units as packaged by the manufacturer if the mixture proportion of Component A to Component B exceeds 2:1.

TABLE II-21
Requirements: Mixed Epoxy Systems

Type	**EP-3B Red**		**EP-3T Gray**		**EP-4 Straw**		**EP-5[1,2] Straw**		**EP-6 Lt. Gray**		**CTE Black**		**EP-7 Brown/Straw**	
Property	Min	Max	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Pot Life/ Gel Time at 75° F	40	65	40	65	35	55	35	55	20	30	20	40	15	45
Tensile Strength (psi) at 75° F, 7 days					3,000		2,000		1,500		400		2,000	
Tensile elongation (%) at 75° F, 7 days					1		5		5		30		30	
Water absorption (Max %)		0.8		0.8		0.8		0.8		0.8		0.8		0.8
2 inch cubes, compressive strength (psi) dry, min														
3 hours													1,000	
24 hours					6,000								5,000	
48 hours, wet, min					7,000		4,000		4,000					
	3,000		3,000		3,000				3,000		2,500			
Ash content (%)	20	30	20	30		0.5		0.5	5	15		5		0.5
Viscosity														
Poises	40	100	40	150	20	40	10	25					7	25
Spindle No.	4		4		3		3		Gel				3	
Speed	10 or 20		10 or 20		20		20						20	
Volatile content (max. %)			6.0		3.0		3.0		3.0		20.0		3.0	

TABLE II-22
Fine Aggregate (Silica Sand)

Grading	Amounts Finer Than Each Laboratory Sieve (Sieve Opening) (% by Weight)						
	No. 4	No. 8	No.16	No. 20	No. 30	No. 40	No. 100
D		Min 100	30-70		Max 5		Max 1
E		Min 100	99 ± 1	95 ± 5		Max 10	
F	Min 100	30-75	Max 5		Max 1		

Contents of the separate packages containing Component A and Component B shall be thoroughly stirred prior to use. The same paddle shall not be used to stir Component A that is used to stir Component B. The Contractor shall dispose of solvents used for cleaning in accordance with applicable policies and procedures of the Virginia Department of Waste Management. Components A and B shall be stored between 65 degrees F and 80 degrees F for at least 2 hours before use. Epoxy components may be heated in hot water or by indirect heat prior to mixing to bring them to the required temperature. Solvents and thinners shall not be used except for cleaning equipment.

Mixing of epoxy components shall be in accordance with the manufacturer's instructions.

When mineral fillers are specified, they shall be inert and nonsettling or readily dispersible. Materials showing a permanent increase in viscosity or the settling of pigments that cannot be readily dispersed with a paddle shall be replaced at the Contractor's expense. At least 95 percent of the filler shall pass the No. 300 sieve.

(d) **Aggregates:** Aggregate for surface application work shall be nonfriable, nonpolishing, clean, and free from surface moisture. The Contractor shall use silica sand having a well-rounded particle shape. Aggregate for epoxy concrete overlay shall be angular grained silica sand or basalt having less than 0.2 percent moisture, and free of dirt, clay, asphalt and other foreign or organic materials. Aggregates that will be exposed to traffic shall have a Mohs scale hardness of at least 7. In surface applications, the aggregate shall be applied on the epoxy surface in excess of the amount necessary to cover the surface, shall be sprinkled or dropped vertically in such a manner that the level of epoxy mixture is not disturbed, and shall be applied within 5 minutes after application of the epoxy. At temperatures below 70 degrees F, a maximum of 10 minutes will be allowed. The grading analysis of the fine aggregate (silica sand) shall conform to the requirements of Table II-22.

Grading D aggregate shall be used in Class I waterproofing and other skid-resistant applications. Grading E aggregate shall be used in epoxy patching mortars and loop detector sealants Grading F aggregate shall be used in epoxy concrete overlay. Aggregates shall be oven dried.

243.03—Handling and Storing Materials

The Contractor or supplier shall furnish the two components of the epoxy-resin system in separate containers that are nonreactive with the materials. The size of the containers shall be such that the recommended proportions of the final mixture can be obtained by combining one container of Component A with one container of Component B. When less than one complete unit is used, each component shall be measured within ±2 percent of the volume required. Batches of less than 6 fluid ounces shall be measured within ±1 percent.

Containers shall be identified as "Component A—Contains Epoxy Resin" and "Component B—Contains Hardener" and shall show the type, class, and mixing directions. Each container shall be marked with the name of the manufacturer; class, batch, or lot number; date of packaging; date of shelf life expiration; pigmentation, if any; and the quantity contained in pounds and gallons.

243.04—Acceptance

Shipments of less than 15 gallons may be accepted upon certification. The Contractor shall submit to the Engineer a certification from the manufacturer that Components A and B conform to these specifications. The certification shall consist of a statement by the manufacturer that Components A and B have been sampled and tested according to the requirements herein. The certification shall be signed by an authorized agent of the manufacturer and contain actual results of tests performed in accordance with the methods specified herein.

The Department will take at least one random test sample of each component from each batch or lot number for shipments of 15 gallons or more. The quantity of Component A required to react with 1 quart of Component B will be a sufficient sample for the tests specified. Components shall be furnished in as few different batches or lots as possible.

Tests for the cited characteristics will be performed in accordance with the following methods:

Characteristics[1]	**Test Method**[1]
Viscosity	VTM-115, Model DV-II Brookfield Viscometer VTM-115 test conditions: Determinations to be made at: Class A, 32°F Class B, 50°F Class C, 77°F
Epoxide equivalent	ASTM D1652
Volatile content	ASTM D1259, Method B, for mixed system ASTM D1259 test conditions: Sample cured 4 days at room temperature and weighed on previously weighed metal foil.
Filler content	AASHTO T-111, on Component A
Ash content	ASTM D482 AASHTO T237
Pot life[2]	AASHTO T237 test conditions: Determinations to be made at: Class A , 32°F Class B, 50°F Class C, 75°F
Tensile strength	ASTM D638
Bond strength	VTM-41
Compressive strength	VTM-41
Water absorption	ASTM D570
Thermal shear	VTM-42

(continued)

[1] Epoxy system for epoxy concrete overlay shall have the same requirements as epoxy system EP-5 except for the following:
[2] Pot life test method shall be ASTM C881 (50 ml sample in paper cup)
Tensile strength test method shall be ASTM D638 type 1
Tensile elongation test method shall be ASTM D638 type 1
Viscosity test method shall be VTM 115 (Model RVF Brookfield, Spindle No. 3 at 20 rpm)
Mini. compressive strength at 3 hrs test method. shall be ASTM C109 (Use plastic inserts)
Mini. compressive strength at 24 hrs. test method shall be ASTM C109
Min. adhesion strength at 24 hrs test method. shall be VTM-92

SECTION 244—ROADSIDE DEVELOPMENT MATERIALS

244.01—Description

These specifications cover the various materials, such as fertilizers, seeds, plants, sod, and mulches used in landscaping as well as materials used for soil retention to help prevent erosion and siltation. All considerations and recommendations pertaining to soil fertility and soil amendments (fertilizer and lime) shall be in reference to the VDOT Nutrient Management Plan for Turf Establishment on Construction Projects or the Department Nutrient Management Plan for Maintenance Activities, as applicable.

244.02—Detail Requirements

(a) **Herbicides:** Herbicides shall be registered with the Virginia Department of Agriculture and Consumer Services in accordance with the Virginia Pesticide Law and shall be supplied in the manufacturer's containers clearly labeled as to the composition, brand, and name and address of the manufacturer.

Herbicides used shall be listed in the current Virginia Cooperative Extension, Pest Management Guide: Horticultural and Forest Crops volume. For information on Right of Way and Non-crop Weeds or Aquatic Weed applications, select the "Low Management Crops and Areas" chapter. For information on pre-emergent weed control in ornamental areas, select the Weed section of the "Nursery Crops" chapter. And for information about growth regulators for turf areas, choose the Growth Regulator section of the "Turf" chapter. Other applications may be made as approved by the Engineer.

(b) **Topsoil:** Topsoil may be naturally occurring or may be manufactured and shall be free of foreign objects such as refuse, woody vegetation, stumps, roots, brush, stone larger than 3/4 inches, and other material deleterious to plant growth. Maximum size of other foreign objects shall be 2 inches. Topsoil shall conform to the following:

Property	Physical Requirement
PH	5.5 to 7.0
USDA Soil Textural Classification	Sandy Loam, Loamy Sand, Sandy Clay Loam, Loam, Silt Loam,
Organic Matter Content	2 to 10 percent
Available Phosphorus (P)	Minimum Fertility Rating of "Medium (M)"

Topsoil shall be of the following classifications:

1. **Class A topsoil:** Class A topsoil shall be stockpiled topsoil that has been salvaged from within the project limits in accordance with Section 303.04(a). It shall be the original layer of the soil profile formed under natural conditions, technically defined as the "A" horizon or as defined by the United States Department of Agriculture–Natural Resources Conservation Service (USDA–NRCS) Soil Survey Division.

2. **Class B topsoil:** Class B topsoil shall be topsoil furnished from sources outside the project limits and shall be the original top layer of a soil profile formed under natural conditions, technically defined as the "A" horizon or as defined by USDA–NRCS Soil Survey Division, or manufactured top soil. The Contractor shall provide to the Engineer a source of materials for topsoil planned for use on the project prior to use.

   Manufactured topsoil shall consist of a mineral component and amendments to meet the specified organic content, PH and other requirements as detailed herein. Organic material used in conjunction with amending or manufacturing of topsoil shall meet all regulatory requirements of the Virginia Department of Environmental Quality or the equivalent state regulatory agency from the state of origin and the United States Environmental Protection Agency Electronic Code of Federal Regulations (e-CFR, current edition) Title 40, Part 503—Standards For The Use Or Disposal Of Sewage Sludge, as applicable.

3. **Testing and documentation:** The Contractor shall submit the following test reports to the Engineer for Class A and Class B topsoil prior to use. Testing shall be completed by a DCR-approved soils testing laboratory.

   a. **Soil analysis** of topsoil, including pH factor, mechanical analysis (composition), salinity (soluble salts), percentage of organic content, and soil classification based thereon.

   b. **Recommendations** on the types and quantities of additives required to establish a satisfactory pH and bring the supply of nutrients to a level satisfactory for establishing and sustaining turf and/or for use as a soil mix for planting, if applicable.

(c) **Seeds:** Kinds and varieties of seeds shall be delivered to the project in separate sacks bearing a green seed label denoting that the seed was inspected and approved by the Virginia Crop Improvement Association. The Engineer will reject any open bags. Seeds shall be mixed on the project or at other approved locations under the observation of the Engineer. Seeds shall comply with applicable state and federal seed laws and the Contract requirements. The Engineer must approve seed selected for use on the project.

Seed shall be subject to inspection by Virginia State Seed Regulatory Inspectors of the Virginia Department of Agriculture and Consumer Services.

Seed tests shall have been completed within the 9-month period prior to the beginning of the scheduled seeding period for the area to be seeded.

Seed shall not be or have been stored in an enclosure where herbicides, kerosene, or other material detrimental to seed germination has been or is stored.

Noxious weed seeds, as defined by the rules and regulations adopted for enforcement of the Virginia Seed Law will not be permitted except as stated herein. The number of restricted

noxious weed seeds shall be not more than the number per ounce or per pound of noxious weed seeds specified in the rules and regulations of the Virginia Seed Law.

The VDOT portion of the green tag from each sack of seed shall be signed by the Contractor and delivered to the Engineer after each sack is completely used.

(d) **Fertilizers:** Fertilizer shall be uniform in composition, free flowing, and suitable for application with approved equipment. The fertilizer shall be delivered to the project in bags or other convenient containers, each fully labeled, and shall conform to all applicable state and federal laws and regulations. Additional nutrients shall be added only when specified in the Contract or in accordance with the provisions of Section 109.05. Fertilizer shall be subject to testing by the Virginia Department of Agriculture and Consumer Services. The Department reserves the right to reject fertilizer materials that do not comply with the requirements of these specifications or to be compensated in an amount as decided by the Engineer for failure of complying with the requirements of the Virginia Fertilizer Law. Other fertilizer products and rates may be substituted with the prior written approval from the Engineer.

The Contractor shall provide the Engineer a copy of the material safety data sheet (MSDS) for each type of fertilizer supplied to the project with each fertilizer delivery. Any fertilizer delivery that is not accompanied by the appropriate MSDS will be rejected.

1. **Fertilizer for seeding, sodding, sprigging, and plugging** shall have a guaranteed nitrogen, phosphorous, and potassium (NPK) analysis as detailed in the plans, with a minimum 30 percent of the nitrogen from a slow release or slowly soluble source. The following types of slow release or slowly soluble nitrogen fertilizers may be used: urea formaldehyde (UF), ureaform, methylene urea, and methylene diurea/dimethylene triurea); isobutylidene diurea (IBDU); sulfur-coated urea (SCU); and polycoated urea (PCU)]. All UF and IBDU products shall indicate the slow release/slowly available nitrogen source on the fertilizer analysis label as water-insoluble nitrogen. PCU and SCU shall have a minimum 3-month release duration for the total product. Slow release or slowly soluble fertilizers may be applied with a hydraulic seeder except for SCU. Fertilizer shall be applied in accordance with Section 603.

2. **Fertilizer for planting plants** shall have a guaranteed 1-2-1 (Nitrogen-Phosphorous-Potasium) ratio and a 15-30-15 analysis with a minimum of 40 to 50 percent of the nitrogen from one of the following slow release or slowly soluble sources, with the remainder of the nitrogen from urea or ammonium nitrate: soluble UF, SCU, and PCU. The UF products shall have a minimum activity index of 40 percent. SCU and PCU products shall have a minimum 3-month release duration for the total product. Slow release or slowly soluble fertilizers shall be applied. Slow release or slowly soluble fertilizers may be applied with a hydraulic seeder except for sulfur-coated urea (SCU). Fertilizer shall be applied in accordance with Section 603.

(e) **Lime, Fast Acting Lime, and Iron Sulfate**

1. **Lime** shall be agricultural grade ground limestone applied to raise the soil PH. Agricultural grade pulverized or pelletized lime products may be substituted at no additional cost to the Department.

The material source shall be registered with and approved by the Virginia Department of Agriculture and Consumer Services in accordance with the Virginia Agricultural Lime Law

and shall conform to Section 240. All lime shall be subject to testing by the Virginia Department of Agriculture and Consumer Services. Other hydrated lime or industrial co-products may be substituted with the Engineer's approval.

2. **Fast Acting Lime**

Fast acting lime is a highly processed grade of agricultural lime that has a higher percentage by weight of material passing the U.S. Standard 100 Sieve. Fast acting lime can be supplied in liquid or dry form. The minimum calcium carbonate equivalent (CCE) for fast acting lime shall be as follows:

Physical Form	Minimum CCE %
Liquid	55%
Dry	85 %

3. **Iron sulfate** shall be an approved agricultural product manufactured and labeled for reducing soil pH. Iron sulfate labeled as a fertilizer may also be used to supply sulfur or iron as a plant nutrient. Iron sulfate shall be supplied as a fine powder or pelletized powder with a minimum purity of 15 percent water soluble iron derived from ferrous sulfate.

(f) **Inoculating Bacteria for Treating Leguminous Seeds:** Bacteria shall be a pure culture of nitrogen-fixing bacteria selected for maximum vitality. Cultures shall be not more than 1 year old and shall be subject to the Engineer's approval.

(g) **Mulches for Seeding or Erosion Control** shall be according to the following based on functional longevity, slope length, and slope gradient as detailed herein.

1. **Dry Straw or Hay -** Dry straw or hay shall be used to facilitate vegetative establishment on slopes of 4:1 or less gradient designed to be functional for up to thirty (30) days. The dry straw or hay shall be free from noxious weeds, reasonably bright in color, and not be musty, moldy, caked, decayed, or dusty. Straw or hay shall be applied by (1) tacking with a Hydraulic Erosion Control Product (HECP), Type 1, at the rate of 1000 pounds per acre and applied as recommended by the manufacturer by (2) punching or disking into the soil or (3) by other Engineer-approved methods.

2. **Hydraulic Erosion Control Products (HECP)**

Hydraulic Erosion Control Products shall be dyed green or contain a green dye in the package that will provide a color to facilitate visual inspection of the uniformly spread slurry. Mulch, including dye and tackifiers, shall not contain germination-inhibiting or growth-inhibiting factors. The mulch shall be manufactured and processed so that it will remain in uniform suspension in water under agitation and will blend with seed, fertilizer, and other additives to form a homogenous slurry. The mulch shall form a blotter-like ground cover on application having moisture absorption and percolation properties. It shall cover and hold grass seed in direct contact with the soil, promoting the germination and growth of grass seedlings.

The manufacturer shall provide certification that all components are pre-packaged by the manufacturer to assure material performance and compliance with the minimum requirements of Table II-22A. Under no circumstances will field mixing of HECP additives or HECP components be allowed. Mulch shall be delivered in packages of uniform weight

bearing the name of the manufacturer, the net weight, and an additional statement of the net dry weight content.

When polyacrylamide is used as part of a hydroseeding mix, only an anionic polymer formulation with free acrylamide monomer residual content of less than 0.05% is allowed. Cationic polyacrylamide shall not be used in any concentration. The Contractor shall ensure polyacrylamide-containing mixtures are not sprayed onto pavement. Polyacrylamide-containing mixtures may include tackifiers, flocculants, or moisture-holding compounds.

In addition to making field performance determinations, the Department may sample and perform such other tests on mulch as it deems warranted to ensure that the mulch conforms to these specifications. Only those materials that have been evaluated by the Department and are deemed acceptable will appear on the Materials Division's Approved Products List. Mulch types shall contain a tackifier or additive as detailed below that upon drying becomes insoluble and non-dispersible to eliminate direct raindrop impact on soil. Typically, all HECP products shall be applied when the soil is dry and rain is not expected within at least 48 hours after application.

HECP types are as follows:

a. **HECP, Type 1** shall be used to facilitate vegetative establishment on slopes of 1V:4H or flatter gradient. Products shall be functional for up to 2 months after application and shall be composed of non-toxic fibers consisting of a minimum of 70% specially prepared wood fiber, paper fiber, or a mixture of shredded wood fiber and paper fiber.

b. **HECP, Type 2** shall be used to facilitate vegetative establishment on slopes of 1V:3H or flatter gradient. Products shall be functional for up to 3 months after application and shall consist of a hydraulically applied matrix composed of a minimum of 70% of non-toxic defibrated organic fibers with, at a minimum, one of the following non-toxic tackifiers or additives:

    - Soil tackifiers,
    - Soil flocculants,
    - Soil polymers,
    - Cross-linked hydro-colloidal polymers, or
    - Cross-linked tackifiers.

    HECP, Type 2 products shall not contain materials composed of paper, cellulose fiber, or any mixture containing paper or cellulose.

c. **HECP, Type 3** shall be used to facilitate vegetative establishment on slopes of 1V:2H or flatter gradient. Products shall be functional for up to 6 months after application and shall consist of a hydraulically applied matrix composed of a minimum of 70% of non-toxic long-strand organic fibers heated to a minimum temperature of 212 degrees Fahrenheit for sterilization purposes with, at a minimum, one or more of the

following non-toxic additives that, upon drying, become insoluble and non-dispersible to eliminate direct raindrop impact on soil:

- Soil tackifiers,
- Soil flocculants,
- Soil polymers,
- Cross-linked hydro-colloidal polymers, or
- Cross-linked tackifiers.

TABLE II-22A
Minimum HECP Performance and Physical Requirements

HECP Property	Test Method[1]	HECP Type 1	HECP Type 2	HECP Type 3	HECP Type 4
Physical	**Requirement**				
Color	Visually Observed	Colored to provide contrast upon application, shall be stable and not stain concrete or painted surfaces.			
Organic Matter	ASTM D2974	90% minimum			
Water Holding Capacity	ASTM D7367	400% minimum	500% minimum	600% minimum	700% minimum
Acute Toxicity	ASTM 7101 EPA 2021.0-1	Non Toxic			
Endurance	**Requirement**				
Functional Longevity	VDOT approved Testing Methods[3]	Up to 2 Months	Up to 3 Months	Up to 6 Months	Up to 12 Months
Performance	**Requirement**				
Maximum Slope Application	Observed	4.0 H:1V	3.0 H:1V	2.0 H:1V	1.0 H:1V
Rainfall Event (R-Factor)	ASTM D6459 [2]	N/A	75 < R	140 < R	175 < R
Cover Factor	ASTM D6459 [2]	C ≤ 0.50	C ≤ 0.10	C ≤ 0.05	C ≤ 0.01
Vegetation Establishment	ASTM D7322 [2]	200% minimum	300% minimum	400% minimum	500% minimum

[1] All products must meet the requirements of this Specification to be listed on the Materials Division's Approved List for HECPs.
[2] ASTM test methods developed for Rolled Erosion Control Products (RECPs) that have been modified to accommodate Hydraulic Erosion Control Products (HECPs).
[3] Functional Longevity performed at a VDOT test facility or test facility approved by VDOT.

HECP, Type 3 products shall not contain materials composed of paper, cellulose fiber, or any mixture containing paper or cellulose.

d. **HECP, Type 4** shall be used to facilitate vegetative establishment on slopes of 1V:1H or flatter gradient. The product shall be functional for up to twelve (12) months after application. HECP, Type 4 shall be applied when the soil is dry, when the site requires immediate erosion protection or when there is a risk of impending adverse weather. HECP Type 4 shall consist of a hydraulically applied matrix composed of a minimum of 70% thermally refined wood fibers, cross-linked hydro-colloidal tackifiers (10% by weight), and crimped man-made fibers.

3. **Compost Blanket** – Compost blankets shall be used to facilitate vegetative establishment on slopes with gradients of 1V:2H or flatter. The compost shall meet the requirements listed in Section 244.02 (j) with the exception of particle size as stated below:

Percentage (%) by Dry Weight Passing Sieve Size

3”	1”	¾ “	¼ “
100	90-100	65-100	0-75

Compost used as a compost blanket shall be uniformly applied to the depth specified in the Contract. Compost may be manually spread, or distributed by the use of a pneumatic blower or slinger type spreader unit. Compost shall be projected directly at the soil surface, thereby preventing water from moving between the soil\compost interface. The Contractor shall apply the compost layer approximately 3 feet beyond the top of the slope or overlap it into or underneath existing vegetation.

(h) **Sod:** Sod shall be cultivated material conforming to the requirements of the State Board of Agriculture for state-approved sod or the state Sod Certification Agency for state-certified sod. Root development shall be such that standard size pads will support their own weight and retain their size and shape when suspended vertically from a firm grasp on the uppermost 10 percent of the area. The top growth of sod shall be mowed so that the height of the grass will be 2 to 3 inches at the time of the stripping operation. Sod may be furnished in any standard pad width and length provided the dimensions do not vary from the average by more than 5 percent. Sod shall be machine stripped at a uniform soil thickness of at least 1 inch. Broken, torn, or irregularly shaped pads will be rejected.

(i) **Trees, Shrubs, Vines, and Other Plants:** The botanical and common name of plants shall be in accordance with the latest edition of the following reference works in order of priority: 1.) Hortus Third, prepared by L.H. Bailey, and 2.) Standardized Plant Names, prepared by the Editorial Committee of the American Joint Committee on Horticultural Nomenclature in effect on the date of the Notice of Advertisement.

1. **Quality and size:** All plants supplied shall be first class representatives of their normal species or varieties unless otherwise specified. Plants shall conform to the requirements of the current American Standard for Nursery Stock (ANSI Z-60.1) by the American Nursery and Landscape Association and these specifications.

All B&B (balled and burlapped) plants shall be nursery grown and dug within 30 days of planting, unless otherwise specifically permitted, and shall have been growing in USDA Plant Hardiness Zones 6 or 7 prior to award date of the Contract.

Shade and flowering trees are to be symmetrically balanced according to their normal habit of growth. Shade trees of standard variety shall have a single leader and shall be branched as indicated on the plans or Standard Drawings. Major branches shall not have V-shaped crotches capable of causing structural weakness. Trunks shall be free of unhealed branch removal wounds greater than a one inch diameter. Evergreens shall be full foliage. Deciduous and evergreen shrubs shall be uniformly branched and have ample, well balanced root systems. All vines, ground covers, ornamental grasses, and herbaceous plants shall have been growing for at least three months in the size of container specified and show full and substantial growth conforming to the industry standard size of the plant indicated.

All container grown plants shall be well-rooted, vigorous and established, with full and well-balanced tops, in the appropriate container size for the height or spread of the plant specified, and shall not be root bound. Material arriving with broken or loose balls, insufficient protection of roots or top, shriveled dry or insufficiently developed roots, or are weak and thin, are damaged or defective or which do not comply with the specifications will be rejected. Plant material which shows evidence of containing any parts (seeds, rhizomes, roots) of Johnson Grass, Bull Thistle, or Canada Thistle will be rejected.

Plants shall be grown in a state-approved, certified nursery. Plants shall comply with state and federal laws governing inspection for plant diseases and insect infestation and shall be free from insect pests, plant diseases, disfiguring knots, stubs, sunscald, bark abrasions, or any other form of damage or objectionable disfigurements. All tree pruning shall conform to the current edition of the National Arborist Association's "Pruning Standards for Shade Trees".

When a minimum and maximum size or range is specified, an average size shall be furnished. Plants shall not be pruned before delivery or cut back from larger sizes to conform to the sizes specified. Sizes furnished shall be those specified at the time of delivery and before the usual pruning at the time of planting. Plants from cold storage will not be accepted. Deciduous plants, except those grown in containers, shall be dormant when planted.

2. **Digging and protection:** Digging shall be in accordance with the current American Standards for Nursery Stock and done in a manner that will avoid damage to or loss of roots. Roots that are cut shall be cleanly cut. Balled and burlapped plants shall be properly dug and protected to preserve the natural earth in contact with the roots. The Engineer will not accept manufactured balled or processed balled stock. Balls shall be firmly wrapped and tied with approved materials. Balled plants will not be accepted if the ball is broken, cracked, or loose. After plants are dug, their roots shall be protected from damage. Roots of bare root plants shall be kept moist at all times. Bare root plants shall be further protected by wrapping in wet straw, moss, burlap, or other approved material.

3. **Plantable pots:** In lieu of using burlap with balled plants, plants may be dug as specified herein and placed in plantable pots. Pots shall be constructed of organic, biodegradable material that will readily decompose in soil and shall not be smaller in any dimension than the size specified for balled and burlapped root systems. At the time of planting, the lip or rim of pots shall be broken away, and drainage holes shall be provided in the plantable pots as directed by the Engineer. Plants with balls that have been grown in pots or plants with loose stems will be rejected.

4. **Container-grown plants:** In addition to the requirements of the *American National Standard for Nursery Stock,* container-grown plants shall conform to the following:

   a. The space between the rim or top of the container and the soil line within the container shall not be more than 1½ inches for the 1-gallon and 2-gallon sizes, and not more than 2½ inches for the 5-gallon size.

   b. Encircling roots shall not have grown in such a manner that they have or will cause girdling of the trunk or stems.

   c. Roots shall have been grown in the soil medium for a minimum of 6 months, extending to the limits of the container on all sides and from top to bottom.

5. **Collected plants:** Collected plants from wild or native stands shall not be used without the written permission of the Engineer unless specified on the plans. Wild or native plants shall be clean, sound stock and free from injury. The quality of the plants shall be similar to that specified for nursery-grown material. Stock shall have sufficient root systems to ensure successful transplanting and rejuvenation. Balls, when specified, shall be tight and well formed.

6. **Clump and Multi-trunk Trees:** Clump form and multi-trunk trees shall be designated by the number of stems (trunks), height and caliper as appropriate to the species. Clump form shall refer to a plant with 3 or more stems (trunks) arising from the top of the root structure as independent stems (trunks). Multi-trunk shall refer to a plant with 3 or more stems arising out of a single base (trunk) within 6 inches of the top of the root structure.

7. **Specimen Quality:** Trees or shrubs designated as "Specimen Quality" shall refer to plants of exceptional quality for the species and size designated, being symmetrical in form and full in canopy and limb structure, usually grown for use as a focal point, but may be designated for use otherwise. Deciduous trees shall have the maximum canopy size for the caliper or height specified as per ANSI Z60.1. Evergreen trees shall have the maximum width to height ratio for the height specified as per ANSI Z60.1.

8. **Street Tree:** Trees designated as "Street Tree" form shall be cultivated for street tree use having a straight, vertical trunk with a single dominant and central leader, nursery pruned for the development of a symmetrical canopy, an upward and outward growing branch pattern with strong branch unions and low aspect ratios of 1 to 3 or greater, shall be uniform in appearance without crossing branches or suckers. A specific height of branching (from the ground to the first branch) may be specified on the Planting Summary Sheet as appropriate for the specific site.

9. **Specimen Street Tree:** Where so designated, trees shall conform to the requirements of both "Specimen" and "Street Tree" as indicated above.

(j) **Compost, General Specifications:** All compost shall meet or exceed all standards for classification as EPA Exceptional Quality (EQ) compost, suitable for unrestricted end use. All material shall be sampled and tested as required by the Seal of Testing Assurance (STA) Program of the United States Composting Council (USCC). Testing of material shall be performed by an STA Certified laboratory.

Compost shall be reasonably free of sticks, stones or refuse materials deleterious to soil structure, or any material toxic or detrimental to plant germination and growth. The composted material shall not possess objectionable odors and shall not resemble the raw material from which it was derived. Prior to delivery, the Contractor shall submit to the Engineer a sample of the material for approval which shall meet or exceed the requirements herein.

1. **Compost** shall conform to the following material requirements:

Compost General Product Parameters		
Parameters [1,6]	**Reported as (units of measure)**	**General Range**
pH[2]	pH units	6.0 - 8.0
Soluble Salt Concentration[2] (electrical conductivity)	mmhos/cm (dS/m)	Maximum 8
Moisture Content	%, wet weight basis	35 – 50
Organic Matter Content	%, dry weight basis	Minimum 40%
Particle Size	Particle size, % passing a selected mesh size, dry weight basis	Composted: ¾ in. (19 mm), 98% passing
Stability[3] Carbon Dioxide Evolution Rate	mg CO2-C per g OM per day	< 5
Maturity[3] (Bioassay) Seed Emergence and Seedling Vigor	%, relative to positive control %, relative to positive control	Minimum 80% Minimum 80%
Physical Contaminants (inerts)	%, dry weight basis	< 1
Chemical Contaminants4	mg/kg (ppm)	Meet or exceed US EPA Class A standard, 40 CFR § 503.13, Tables 1 and 3 levels
Biological Contaminants[5] Select Pathogens Fecal Coliform Bacteria, or Salmonella	MPN per gram per dry weight MPN per 4 grams per dry weight	Meet or exceed US EPA Class A standard, 40 CFR § 503.32(a) levels

[1] Recommended test methodologies are provided in Test Methods for the Examination of Composting and Compost (TMECC), the US Composting Council.

[2] It should be noted that the pH and soluble salt content of the amended soil mix is more relevant to the establishment and growth of a particular plant, than is the pH or soluble salt content of a specific compost (soil conditioner) used to amend the soil. Each specific plant species requires a specific pH range. Each plant also has a salinity tolerance rating, and maximum tolerable quantities are known. Most ornamental plants and turf species can tolerate a soil/media soluble salt level of 2.5 dS/m and 4 dS/m, respectively. Seeds, young seedlings and salt sensitive species often prefer soluble salt levels at half the aforementioned levels. When specifying the establishment of any plant or turf species, it is important to understand their pH and soluble salt requirements, and how they relate to existing soil conditions.

[3] Stability/Maturity rating is an area of compost science that is still evolving, and as such, other various

test methods could be considered. Also, never base compost quality conclusions on the result of a single stability/maturity test.

[4] US EPA Class A standard, 40 CFR § 503.13, Tables 1 and 3 levels = Arsenic 41ppm, Cadmium 39ppm, Copper 1,500ppm, Lead 300ppm, Mercury 17ppm, Molybdenum 75ppm, Nickel 420ppm, Selenium 100ppm, Zinc 2,800ppm.

[5] US EPA Class A standard, 40 CFR § 503.32(a) levels = Salmonella <3 MPN/4grams of total solids or Fecal Coliform <1000 MPN/gram of total solids.

[6] Landscape architects or engineers may modify the allowable compost specification ranges based on specific field conditions and plant requirements.

2. **Submittals:** The Contractor shall submit the following information to the Engineer at least 30 days prior to the date the compost is shipped to the construction site:

   a. A vendor's certificate or affidavit attesting that the material complies with the requirements of this specification, the Virginia Department of Environmental Quality, or a sister state agency from the state of origin.

   b. A 2-gallon sample of the material for visual inspection. In addition, the test report shall indicate that the compost material is free of viable weed seed, plant propagules, and harmful pathogens. Non-organic materials such as concrete, plastic, metal, glass, paper products, chemically treated plywood, plywood, pressboard, and organic pine by-products will not be accepted. Other compost products may be substituted with the prior written approval of the Engineer in concert with the Landscape Architect.

(k) **Miscellaneous Planting Materials**

1. **Twine** for wrapping balled and burlapped shrubs and trees shall be at least two-ply and made of an organic, biodegradable material such as sisal, jute, hemp burlap, or a similar product.

2. **Horticultural Grade Perlite** shall be a fine-to-medium grade, non-organic volcanic mineral identified as Perl-Lome having closed air cells and surface cavities, expanded to form a granular, snow-white material, 5 to 20 times its original volume. Perlite shall have a weight of 5 to 8 pounds per cubic foot. Prior to delivery, the Contractor shall submit to the Engineer for approval, a sample of the perlite and a manufacturer's test report or product certification verifying that the material complies with the following analysis and gradation:

   pH = 6.5 to 7.5
   Nutrient Content = Sterile

Standard Sieve or Micron Size	Perlite Gradation	
	Fine	**Medium**
+16 mesh	10% maximum	60% maximum
+100 mesh	60% minimum	85% minimum

3. **Burlap for wrapping tree balls** shall be made of an organic biodegradable material.

4. **Water** used in watering plants shall be obtained from fresh water sources and shall be free from chemicals and other toxic substances harmful to plants. Brackish water shall not be used. The source of water shall be subject to the approval of the Engineer.

5. **Staking and guying materials** shall be webbed or nylon cloth tree straps or flat, woven polypropylene with 900 lb. minimum break strength. Stakes for anchoring trees and shrubs shall be straight 2 inch by 2 inch rough dressed hardwood in the appropriate length and reasonably free of knots. Trees and shrubs shall be anchored in accordance with Section 1200 of the Department's Road and Bridge Standards unless otherwise indicated on the plans. Other staking, guying, and anchoring methods and materials specifically designed for securing trees and shrubs may be substituted with prior approval in writing from the Engineer or as designated on the plans.

6. **Below-ground tree anchors** shall be below-grade steel stabilizers capable of fixing the root ball in place until the tree has established itself. Prior to ordering material, the Contractor shall furnish the Engineer the manufacturer's product data for the type of anchoring system proposed for use, for review and approval.

7. **Tree protection tubes** shall be constructed from flexible UV-inhibited polyethylene, poly propylene, or similar material designed to speed photosynthesis, promote seedling growth, and reduce planting stress by trapping moisture, thereby raising relative humidity and ambient temperature inside the tube. Tree tubes shall protect the tree seedlings from animals, wind desiccation, small rodents, chemical sprays, and insects. The design of the tree tubes shall not be detrimental to the establishment and growth of the seedling or young tree. Tree tube designs shall be capable of accommodating tree growth for at least 3 years after planting.

8. **Marking Dye.** Marking dyes shall be used to color spray solutions, shall be non-phytotoxic, oil- or water-soluble, and compatible with the pesticide products with which they are applied. Marking dye products and application rates shall be subject to approval by the Engineer.

9. **Mulch for individual planting pits and planting beds** shall be pine bark, double-shredded hardwood bark or other material as indicated in the Planting Summary General Notes. A representative sample shall be submitted to the Engineer for approval prior to delivery to the work site.

(l) **Rolled Erosion Control Products:**

Rolled Erosion Control Products (Standard EC-2) shall conform to Table II-22C and the following requirements. EC-2 products shall be designed for use on geotechnically stable slopes and channels as detailed herein.

1. **EC-2, Type 1** shall be a relative short-term single-net erosion control blanket or open weave textile. EC-2, Type 1 shall be one of the following materials: (1) an erosion control blanket composed of processed degradable natural or polymer fibers mechanically-bound together by a single degradable synthetic or natural fiber netting to form a continuous matrix; or (2) an open weave textile composed of processed degradable natural or polymer yarns or twines woven into a continuous matrix. EC-2, Type 1 shall typically have a 12-month functional longevity from the date of installation, be designed for use on up to 1V:3H slopes and channels, with shear stresses up to 1.50 pounds per square foot.

2. **EC-2, Type 2** shall be a relative short-term double-net erosion control blanket. The blanket shall be composed of processed natural or polymer fibers mechanically bound between two natural fiber or synthetic nettings to form a continuous matrix. EC-2, Type 2 materials shall typically have a 12-month functional longevity from the date of installation, be designed for use on up to 1V:2H slopes and channels, with shear stresses up to 1.75 pounds per square foot.

3. **EC-2, Type 3** shall be an extended term erosion control blanket or open weave textile. EC-2, Type 3 blankets shall be one of the following materials: 1) an erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically-bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix; or 2) an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix. EC-2, Type 3 material shall typically have a 24-month functional longevity from the date of installation, be designed for use on slopes up to 1V:1.5H and channels, with shear stresses up to 2.00 pounds per square foot.

4. **EC-2 Type 4** shall be a long-term erosion control blanket or open weave textile. EC-2, Type 4 blankets shall be one of the following materials: (1) an erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically-bound together

TABLE II-22C
Rolled Erosion Control Products (Std. EC-2)

Property	1	2	3	4	Test Method
Typical functional longevity[(1)] (months)	12	12	24	36	N/A
Minimum tensile strength[(2)] (pounds per foot)	50	75	100	125	ASTM D 4595
Maximum "C" factor[(3)]	0.15 at 1V:3H	0.20 at 1V:2H	0.25 at 1V:1.5 H	0.25 at 1V:1H	ASTM D6459 or other qualified independent test[(6)]
Minimum permissible shear stress[(4)(5)] (pounds per square foot)	1.50	1.75	2.00	2.25	ASTM D6460 or other qualified independent test[(6)]

[(1)] Obtain max "C" factor and allowable shear stress for mulch control nettings with the netting used in conjunction with pre-applied mulch material.
[(1)] Functional longevities are for guidance only. Actual functional longevities may vary based on site and climatic conditions.
[(2)] Minimum average roll values, machine direction.
[(3)] "C" factor calculated as ratio of soil loss from rolled erosion control product protected slope (tested at specified or greater gradient, v:h) to ratio of soil loss from unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC) Test Method #2).
[(4)] Minimum shear stress the rolled erosion control product (unvegetated) can sustain without physical damage or excess erosion (> 1/2-inch soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using ECTC Test Method #3.
[(5)] The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 to 0.05.
[(6)] Other large scale test methods determined acceptable by the Department.

between two slow degrading synthetic or natural fiber nettings to form a continuous matrix; or (2) an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix. EC-2, Type 4 material shall typically have a 36-month functional longevity from the date of installation, be designed for use on up to 1:1 slopes and channels, with shear stresses up to 2.25 pounds per square foot.

Permanent Rolled Erosion Control Products (Standard EC-3) shall be permanent turf reinforcement mats conforming to Table II-22D and the following.

a. **EC-3, Type 1** shall be a non-degradable mat of sufficient thickness, strength and void space for permanent erosion protection and vegetation reinforcement on geotechnically stable slopes with gradients up to 1.5V:1H, channels with design shear stresses up to 6.0 pounds per square foot, and on other areas where design flow conditions exceed the limits of sustainability for mature natural vegetation.

b. **EC-3, Type 2** shall be a non-degradable mat with sufficient thickness, strength and void space for permanent erosion protection and vegetation reinforcement on geotechnically stable slopes with gradients up to 1V:1H, channels with design shear stresses up to 8.0 pounds per square foot, and other areas where design flow conditions exceed the limits of sustainability for mature natural vegetation.

c. **EC-3, Type 3** shall be a non-degradable mat with sufficient thickness, strength and void space for permanent erosion protection and vegetation reinforcement for use on

TABLE II-22D
Permanent[1] Turf Reinforcement Mats (Std. EC-3)

Properties	Requirements per Rolled Erosion Control Type EC-3			Test Method
	1	2	3	
Minimum tensile strength[(2)(3)] (pounds per foot)	125	150	175	ASTM D4595
UV stability (minimum % tensile retention)	80	80	80	ASTM D 4355 (500-hour exposure)
Minimum thickness[(2)] (inches)	1/4	1/4	1/4	ASTM D 6525
Minimum permissible shear stress[(4)] (pounds per square foot)	6.0	8.0	10.0	ASTM D 6460 or other qualified independent test[(5)]

[1] For turf reinforcement mats containing degradable components, obtain all property values on the non-degradable portion of the matting alone.
[2] Minimum average roll values (MARV), machine direction only.
[3] Field conditions with high loading and high survivability requirements may warrant the use of turf reinforcement mats with tensile strengths of 3,000 pounds per foot or greater.
[4] Minimum shear stress the turf reinforcement mat (fully vegetated) can sustain without physical damage or excess erosion (>1/2-inch soil loss) during a 30 minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council Test Method no.3.
[5] Other large-scale test methods determined acceptable to VDOT.

geotechnically stable slopes up to 0.5V:1H, channels with design shear stresses up to 10.0 pounds per square foot, and other areas where design flow conditions exceed the limits of sustainability for mature natural vegetation.

(m) **Fencing for Protection of Landscape or other environmentally significant designated areas** shall be 40 inches in height and conform to Section 242.02(a) 12.

Other fencing materials may be specified for use in accordance with Section 507 as noted on the plans or as approved by the Engineer.

(n) **Biological Growth Stimulants**

Biological growth stimulants shall be composed of non-toxic materials having no germination or growth inhibiting factors and incapable of forming a water-resistant crust that can inhibit plant growth. Biological growth stimulants shall be commercially available for such use, be pre-packaged by the manufacturer, and meet the following requirements:

Property	Test Method	Required Value
Acute Toxicity	ASTM 7101 EPA Method 2021 or EPA Method 2002	Non Toxic
Performance		
Seed Germination	ASTM D7322[1]	200% minimum
Plant Height	ASTM D7322[1]	200% minimum
Plant Mass	ASTM D7322[1]	110% minimum
[1]ASTM D7322 test method developed for Rolled Erosion Control Products (RECPs) that have been modified for comparison to control between 14 and 21 days.		

When applied, biological growth stimulants shall provide an immediate seedbed adjustment to help stimulate seed germination, improve the availability of nutrients to the plants, increase the mass and depth of root development, and generate robust plant growth which is more tolerant of changes in environmental conditions. Biological growth stimulants shall be comprised of one or more of the following:

- Humic acid (humates),
- Humectats,
- Cold water processed seaweed/kelp extract,
- Beneficial microbes,
- Cytokinins,
- Gibberellins,
- Auxins (growth hormones), and
- Endo-mycorrhizae

Animal by-products or municipal waste are not acceptable growth stimulants under this specification. Liquid fertilizers are not acceptable as biological growth stimulants under this specification.

(o) **Sediment Retention Rolls**

A sediment retention roll is a manufactured 3-dimensional device of a specified filler material encapsulated within a flexible containment material utilized in sediment and flow control applications. Sediment retention rolls may be used to reduce runoff flow velocities on sloped surfaces as slope interrupters, as curb inlet protection, and as ditch check dams. Sediment Retention rolls may be one of the following products:

1. **Compost Filter Sock** is a three-dimensional tubular sediment control device that consisting of a knitted material filled with compost. The compost shall be reasonably free (< 1% by dry weight) of man-made foreign matter and meet the product parameters listed in 244.02 (g) 3. Compost used in filter sock products shall be certified through the U.S. Composting Council's (USCC) Seal of Testing Assurance (STA) Program. Compost used for compost filter sock shall meet the following product size specification:

Parameters for	Gradation (units of measure)	Blanket Media to be Vegetated
Compost Filter Sock	% passing a selected mesh size, dry weight basis	• 2" (50 mm), 99% passing • 3/8" (10mm), 30 to 50% passing • Maximum particle length of 2" (50 mm)

The knitted material for compost filter socks shall conform to the following:

Physical Requirements	3 mil HDPE	5 mil HDPE	5 mil HDPE	Multi-Filament Polypropylene (MFPP)	Heavy Duty Multi-Filament Polypropylene (HDMFPP)
Sock Diameters	12" 18"	12" 18" 24" 32"	12" 18" 24" 32"	12" 18" 24" 32"	12" 18" 24" 32"
Mesh Opening	3/8"	3/8"	3/8"	3/8"	1/8"
Tensile Strength	26 psi	26 psi	26 psi	44 psi	202 psi
Ultraviolet Stability, % Original Strength (ASTM G155)	23% at 1000 hr.	23% at 1000 hr.	23% at 1000 hr.	100% at 1000 hr.	100% at 1000 hr.
Minimum Functional Longevity	6 months	9 months	6 months	1 year	2 years

NOTE: All material must be knitted. Extruded material will not be permitted. All material must be photo-degradable.

2. **Sediment Tubes** shall be composed of compacted geotextiles such as certified 100% weed free curled excelsior wood with 80% of the fiber materials being at least 4 inches in length, natural coconut fibers (bristle and mattress form obtained from freshwater cured coconut husk.), certified 100% weed free agricultural straw, certified 100% weed free hardwood mulch, or a mix of these materials or other VDOT-accepted materials enclosed by a flexible netting material. Sediment tubes shall be constructed of a tubular, flexible outer netting consisting of one of the following:

   - Seamless, high-density, polyethylene, polyester, and/or ethyl vinyl acetate, photo-degradable materials treated with ultraviolet stabilizers.
   - Seamless, high-density, polyethylene, non-degradable materials.
   - Seamless, high-density, polypropylene, non-degradable materials.
   - Coir netting or coir fastening twine.

   Straw, curled excelsior wood, or natural coconut products that are rolled up to create a sediment tube without an outer netting will not be allowed. Natural pine needles, leaf mulch, and grass clipping-filled sediment tubes will not be permitted.

SECTION 245—GEOSYNTHETICS AND LOW PERMEABILITY LINERS

245.01—Description

These specifications cover artificial fiber textile products to be used in transportation construction work, and low permeability liners for stormwater management facilities.

245.02—Shipping, Handling, and Storage Requirements

Geosynthetic shall be permanently marked with a clearly legible print showing manufacturing plant or plant Identification Code number, located on the roll edge at least every 16 feet. Rolls shall be labeled at both ends of the outside of the roll outer wrapping and both ends of the inside of the geotextile roll core, and labels shall list the roll number, production date, AASHTO M288 class(es) the product meets, and the product name; if the permanent marking contains this information, the labels may be omitted.

Each geosynthetic roll shall be wrapped or otherwise packaged in a manner that will protect the geosynthetic, including the ends of the roll, from damage due to shipment, water, sunlight, and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.

During storage, geosynthetics rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage; precipitation; extended ultraviolet radiation including sunlight; strong acids or strong bases; flames including welding sparks; temperatures in excess of 160 degrees F; and other environmental conditions that may damage the physical property values of the geosynthetic. Geosynthetics that are not properly protected may be subject to rejection.

245.03—Testing and Documentation

Each geosynthetic material provided to the project shall have a manufacture date within its current NTPEP product 3-year evaluation cycle. The manufacturer and any subsequent private labeler facility shall be listed as compliant by NTPEP within the current calendar year, or immediate past calendar year with an application for audit for the current calendar year.

The Department may sample and test product from a facility or project at any time to verify compliance with specification requirements. Failure may result in the product being rejected or removed from the Approved List.

Property values in these specifications represent minimum average roll values (MARV) in the weakest principal direction unless direction is otherwise specified; permittivity values specified are minimum; AOS and panel vertical strain values are maximum; or mass per unit area, UV degradation, and asphalt retention values are typical.

Product acceptance is determined by comparing the manufacturer test data against these specifications and using independent assurance testing, verification sampling and testing, and facility audits.

(a) **Geotextile Fabric for Use in Silt Fences:** Geotextile shall be a woven fabric and function as a vertical, permeable interceptor designed to remove suspended soil from overland water flow. Fabric shall filter and retain soil particles from sediment-laden water to prevent eroding soil from being transported off the construction site by water runoff.

Physical Property	Test Method	Requirements
Filtering efficiency	ASTM D5141-11 and NTPEP Erosion Control Products Committee Work Plan	Min. 75%
Flow rate	ASTM D5141-11 and NTPEP Erosion Control Products Committee Work Plan	Min. 0.2 gal/ft^2/min

In addition to these requirements, the geotextile shall comply with the requirements of AASHTO M288, Table 7, Temporary Silt Fence Property Requirements, for grab strength and ultraviolet stability.

(b) **Geotextile for Use as Riprap Bedding Material:** Geotextile shall comply with the requirements of AASHTO M288, Table 3-Separation Geotextile Property Requirements, for apparent opening size and ultraviolet stability and Table 1-Geotextile Strength Property Requirements, Class 2, for grab strength and puncture strength.

(c) **Geotextile Fabric for Use in Drainage Systems (Drainage Fabric):** Drainage fabric shall be nonwoven and clog resistant, suitable for subsurface application, and thermally and biologically stable.

Polypropylene material is acceptable in environments with pH values between 3 and 12 inclusive; polyester material between 3 and 9 inclusive.

Physical Property	Test Method	Requirements
Permittivity	ASTM D4491	Min. 0.5 sec^{-1}
Apparent opening size	ASTM D4751	Max. No. 50 sieve

In addition to these requirements, the geotextile shall comply with the requirements of AASHTO M288 Table 1-Geotextile Strength Property Requirements, Class 3, for grab strength.

(d) **Geotextile for Use in Stabilization:** These are geotextiles used in saturated and/or unstable conditions to provide the functions of separation and reinforcement.

1. **Subgrade Stabilization Fabric:**

Physical Property	Test Method	Requirements
Apparent opening size	ASTM D 4751	Max. No. 20 sieve

In addition to this requirement, the geotextile shall comply with the requirements of AASHTO M 288 Table 1-Geotextile Strength Property Requirements, Class 3, for grab strength, tear strength, and puncture strength.

2. **Embankment Stabilization Fabric Up to 6 Feet High:**

Physical Property	Test Method	Requirements
Apparent opening size	ASTM D 4751	Max. No. 20 sieve
Seam strength	ASTM D 4632	90% specified grab strength

In addition to this requirement, the geotextile shall comply with the requirements of AASHTO M288 Table 1-Geotextile Strength Property Requirements, Class 1 for grab strength, tear strength, and puncture strength.

(e) **Prefabricated Geocomposite Pavement Underdrain:** Prefabricated geocomposite pavement underdrain shall consist of a polymeric drainage core encased in a nonwoven filter fabric envelope having sufficient flexibility to withstand bending and handling without damage. Prefabricated geocomposite pavement underdrain shall conform to the following:

1. **Core:** The drainage core shall be made from an inert, polymeric material resistant to commonly encountered chemicals and substances in the pavement environment and shall have a thickness of not less than 3/4 inch. Outer surfaces shall be smooth to prevent excessive wear of bonded filter fabric.

Physical Properties	Test Method	Requirements
Compressive strength panel vertical strain and core area change	ASTM D1621/D2412	Min. 40 psi at 20% deflection after 24 hrs at 0 deg F and at 125 deg F
Panel vertical strain and core area change at 22.7 psi	ASTM D6244	Max. 10% for core area and panel height
Water flow rate (after 100 hr at 10 psi normal confining pressure gradient of no more than 0.1)	ASTM D4716	Min. 15 gal/min/ft width for 12-in specimen length

2. **Filter Fabric:** Geotextile shall be bonded to and tightly stretched over the core. Geotextile shall not sag or block the flow channels, shall have a life equivalent to that of the core material, and shall conform to the requirements of (c) herein.

(f) **Geocomposite Wall Drains:** Prefabricated geocomposite wall drain shall consist of a polymeric drainage core encased in a nonwoven filter fabric envelope having sufficient flexibility to withstand bending and handling without damage. Geocomposite wall drains shall conform to the following:

1. **Core:** The drainage core shall be made from an inert, polymeric material resistant to commonly encountered chemicals and substances in the roadway. Outer surfaces shall be smooth to prevent excessive wear of bonded filter fabric.

Physical Property	Test Method	Requirements
Compressive strength at 20% deflection	ASTM D1621/ D2412	Min. 40 psi after 24 hrs at 0 degree F and at 125 degree F
Water flow rate (after 100 hr at 10 psi normal confining pressure and gradient of no more than 1.0)	ASTM D4716	Min. 15 gal/min/ft width (for 12-in specimen length)

2. **Filter Fabric:** Geotextile shall be bonded to and tightly stretched over both sides of the core. Geotextile shall not sag or block the flow channels, shall have a life equivalent to that of the core material, and shall conform to the requirements of (c) herein, except that grab strength requirement shall meet AASHTO M288 Table 1, Class 2.

(g) **Geomembrane Moisture Barrier:** Geomembrane moisture barrier shall be resistant to biological attack. geomembrane shall be constructed of PVC and shall conform to the requirements of the PVC Geomembrane Institute 1104 material specification for PVC geomembrane (Revision #1 effective April 15, 2008) and shall meet the following additional or more stringent requirements:

Physical Property	Test Method	Requirements
Thickness	ASTM D5199	Min. 30 mils
Tensile (1-in strip)	ASTM D882	Min. 0.80 kip/ft (ultimate)
Tear Strength (Die C)	ASTM D1004	Min. 8 lbf
Seam Seal Strength	ASTM D1004	Min. 0.18kip/ft

(h) **Dewatering Bag:** A nonwoven geotextile sewn together to form a bag that can be used in lieu of a de-watering basin for the purpose of filtering out suspended soil particles. The bag shall be capable of accommodating the water flow from the pump without leaking at the spout and seams.

Physical Property	Test Method	Requirements
Grab strength @ Elongation >50%(CRE/Dry)	ASTM D4632	Min. 250 lb (min)
Seam strength	ASTM D4632	90% Specified grab strength
Puncture	ASTM D4833	Min. 150 lb
Flow rate	ASTM D4491	Min. 0.189 $ft^3/sec/ft^2$(min)
Permittivity	ASTM D4491	Min. 1.2 sec^{-1}
UV resistance	ASTM D4355	Min. 70% at 500 hr
AOS	ASTM D4751	Max. 100 sieve

(i) **Pavement Interlayer:** Paving geosynthetics shall be used as an interlayer between pavement layers. Specific application of these paving interlayers shall be determined by the Engineer.

1. **Paving Fabric:** The geotextile shall conform to the requirements of AASHTO M288 Paving Fabric Property Requirements, Section 10.

2. **Paving Mat:** The paving mat shall meet the requirements of ASTM D7239 Geosynthetic Paving Mat, Type 1.

(j) **Low Permeability Liners for Stormwater Management Facilities:** SWM liner soil shall be classified as CL, CH or MH in accordance with ASTM D2487 and shall have a maximum coefficient of permeability of 1 x 10^{-6} cm/sec in accordance with ASTM D5084, after compaction. The maximum particle size shall be three inches in its largest dimension. Natural soils, which do not meet these specifications, may be blended with bentonite to provide the specified permeability characteristics.

Geosynthetic Clay Liner shall have a maximum coefficient of permeability of 1 x 10^{-8} cm/sec in accordance with ASTM D5887.

This specification is not intended for dam embankment material or clay core cut-off trench material.

SECTION 246—PAVEMENT MARKING

246.01—Description

These specifications cover material for use in various retroreflective pavement-marking applications.

246.02—Detail Requirements

Materials that must be heated for application shall not exude fumes that are toxic or injurious to persons or property when heated to the application temperature.

The marking material (including primers and adhesives) shall not be formulated with any compounds of the heavy metals listed in 40 CFR 261.24, Table 1, except that barium sulfate is allowed. Total heavy metal levels, with the exception of barium sulfate, shall not exceed 20 times the specified regulatory limits.

The marking material (including primers and adhesives) shall meet the Virginia Department of Environmental Quality (VDEQ) regulations (9 VAC 5-45, Articles 5 and 6) for Volatile Organic Compounds (VOC).

Materials shall withstand air and roadway temperature variations from 0 - 140 degrees F without deforming, bleeding, staining, or discoloring and shall maintain their original dimensions and placement without excessive chipping, spalling, cracking, or loss of adhesion. Material shall not deteriorate because of contact with snow and ice control materials or oil and gasoline drippings from vehicles.

Pavement marking materials shall produce a retroreflective line, message, legend or symbol of specified thickness, width or design in accordance with the latest edition of the Manual on Uniform Traffic Control Devices for Streets and Highways and the Contract requirements.

Pavement marking material shall have the pigment, glass beads, and filler well dispersed in the resin and shall be free from skins, dirt, and foreign objects.

Glass Beads shall conform to Section 234.

The amount and type of yellow pigment and inert filler for yellow material shall be at the discretion of the manufacturer provided the material complies with this specification.

All marking materials shall be suitable for use up to 1 year after the date of manufacture when stored in accordance with manufacturer's instructions. Pavement marking and pavement marker materials shall conform to the specific requirements for the individual types as indicated hereinafter:

(a) **Approval of Pavement Markings**

The Department will evaluate and approve pavement markings by reviewing performance test data from one or both of the following testing programs:

- AASHTO's National Transportation Product Evaluation Program (AASHTO/NTPEP) Testing

  Test data values used for approval will be based upon the data generated per the NTPEP, Pavement Marking Material Work Plan. Testing and evaluations shall be performed on a Northern Region test deck unless otherwise approved by the Materials Division.

- VDOT Test Facility – VDOT may evaluate pavement marking performance from data generated at its own test facility. Test data values used for approval will be based upon the data generated by following the testing requirements in VTM-125, Evaluation of Pavement Markings on Road Surfaces.

When pavement markings are installed on the NTPEP test deck or the VDOT facility, the material's thickness, beads/reflective optic types, and formulation shall be documented to ensure the equivalent thickness, beads/reflective optic types and formulation are installed on VDOT roadways following approval.

Approved pavement marking products later found not meeting the batch testing requirements will be removed from the Materials Division's Approved Products List.

Black contrast pavement markings of paint, thermoplastic, epoxy, and polyurea shall be accepted based upon batch testing requirements listed herein (as applicable). Retroreflectivity, color, luminance(Y%), and road testing are not required for the black portion of the pavement markings. Black contrast tape requirements are listed in the applicable section below.

Initial Approval

Pavement marking products will be included on the Materials Division's Approved Products List after the Department determines conformance to the specifications on both asphalt and hydraulic cement concrete roadway surfaces. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO's / NTPEP or other VDOT Test Facilities in accordance with the requirements for the respective pavement marking material types.

(b) **Certifications**

The pavement marking material manufacturer shall certify each batch or lot of material supplied and installed is the same product (thickness, reflective optic package and formulation) that was tested and approved on the AASHTO/NTPEP or VDOT test facility in accordance with the Materials Division, Manual of Instructions for Certification I and II Materials. The certification shall include the NTPEP test number from the Materials Division's Approved Products List. The Contractor shall retain the manufacturer's certifications.

(c) **Warranty Requirements**

Pavement marking products shall carry the warranties as supplied by the manufacturer of the individual marking types (classes) for the specific timeframes per type and class and the material requirements for reflectance, durability, color, and adhesion as referenced herein. Warranties shall be those commercially supplied or those unique to the Commonwealth in the case of certain products, such as Type B, Class VI preformed pavement marking tape as detailed herein. Manufacturers' warranties shall be obtained by the Contractor and assigned to the Department in writing prior to final acceptance. Warranty periods shall begin on the date of receipt at the project as verified by delivery tickets signed by the Engineer.

Type B, Class VI pavement marking tape shall be warrantied for six years against failure resulting from material defects regardless of method of manufacturer's prescribed application or pavement type. The material shall be warranted to retain its Retroreflectivity, Day and Nighttime Color and Luminance (Y%) and durability including adherence to the pavement and shall be free of other obvious defects or failures. All Type B Class VI pavement marking tape that has failed to meet the warranty conditions shall be replaced at no additional cost to the Department. The warranty shall cover all pavement striping materials (regardless of method of installation), labor, equipment, mobilization\demobilization, tools, incidentals required to remove (eradicate) and replace the pavement striping including maintenance of traffic during eradication and reinstallation operations

246.03—Pavement Marking Materials

Pavement marking and pavement marker materials shall conform to the specific requirements for the individual types as indicated hereinafter:

(a) **Paint Pavement Marking Material (Type A)**

Paint material shall be a fast-drying, waterborne, nonleaded, acrylic or modified acrylic resin paint suitable for use on both asphalt and hydraulic cement concrete pavement surfaces and shall be selected from the Materials Division's Approved Products List No. 20.

1. **Initial Approval -** Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

   a. **Maintained Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with ASTM E1710 for 30-meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle when measured in the skipline or centerline areas:

Coefficient of Retroreflected Luminance (RL) (mcd/ft²/fc) Paint

Color	Initial	1 Year In-Service
White	200	100
Yellow	150	100

b. **Day and Nighttime Color and Luminance (Y%):** Measured according to ASTM D6628

c. **Durability:** Paint shall have a durability rating of at least 6 when determined in the wheel path area when tested in accordance with the NTPEP Work Plan.

d. **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

e. **IR Scan from NTPEP,** if available.

2. **Batch Testing**

Paint batch testing shall be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. The test results shall be compared against NTPEP lab test results and the Specifications. Testing shall be performed to determine the following physical requirements and properties:

a. **Solids, (% weight)** according to ASTM D2369: Acceptable range from NTPEP results (+/- 2 %).

b. **Pigment (% weight)** according to ASTM D3723: Acceptable range from NTPEP results (+/- 2 %).

c. **Density (wt/gal.)** according to ASTM D1475: Acceptable range from NTPEP results (+/-0.3 lbs/gal).

d. **Viscosity (KU)** according to ASTM D562: Acceptable range from NTPEP results (+/-5KU).

e. **Contrast Ratio** according to ASTM D2805 (2°,D 65): Paint shall show a dry hiding quality that will give a contrast ratio of at least 0.96 at (15 mil) wet film thickness.

f. **Day Color, Luminance (Y%) - (without Drop-on Beads):**

Color testing results shall conform to the chromaticity coordinate limits that follow. Color determination for paint materials will be made without drop-on beads at least 24 hours after application in accordance with ASTM D6628.

Day Color, Chromaticity Coordinates (Without Drop-on Beads), Paint

	x	y	x	y	x	y	x	y	Y%
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375	80.0 Min
Yellow	0.493	0.473	0.518	0.464	0.486	0.428	0.469	0.452	50.0-60.0

g. **Settling properties:** Settling shall be no less than a rating of 8 when tested in accordance with the NTPEP Work Plan.

h. **Freeze-thaw and heat stability:** Paint shall show no coagulation or change in viscosity greater than +/- 5 KU when tested in accordance with the NTPEP Work Plan.

i. **Water resistance:** Paint shall show no blistering, peeling, wrinkling, softening, or loss of adhesion when tested in accordance with the NTPEP Work Plan.

j. **VOC:** The VOC content shall be no greater than 150 grams/liter when tested in accordance with EPA Method 24.

k. **Flash point:** Paint shall have a flash point of at least 201 degrees F when tested in accordance with ASTM D93, Pensky-Martens Closed Cup.

l. **No-track time:** Paint shall have a 60-second maximum vehicle no-track time when measured in accordance with the NTPEP Work Plan.

m. **IR Scan:** Should match IR scan from NTPEP.

(b) **Thermoplastic Pavement Marking Material (Type B, Class I)**

Thermoplastic material shall be suitable for use on asphalt and hydraulic cement concrete pavement surfaces and shall be selected from the Materials Division's Approved Products List No. 43.

The binder shall be either alkyd or hydrocarbon based. If an alkyd thermoplastic is used, the binder shall consist of synthetic resins, at least one of which is solid at room temperature, and high-boiling plasticizers. At least one-half of the binder composition shall be a maleic-modified glycerol ester of resin and shall be at least 10 percent by weight of the entire material formulation.

Thermoplastic marking materials shall be capable of application at pavement surface temperatures of 50 degrees Fahrenheit and above on all asphalt and hydraulic cement concrete pavement surfaces. Thermoplastic material shall be capable of successfully fusing to itself and previously applied thermoplastic pavement markings.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance, Y%), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

a. **Maintained Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with ASTM E1710 for 30-meter geometry when measured in the skip line or centerline areas.

Coefficient of Retroreflected Luminance (R_L) (mcd/ft^2/fc) Thermoplastic

Color	Initial	1 Year In-Service
White	300	250
Yellow	250	200

b. **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628

c. **Durability:** Thermoplastic shall have a durability rating of at least 8 as determined in the wheel path area when tested in accordance with the NTPEP Work Plan.

d. **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested per ASTM E303, if available.

2. **Batch Testing:**

Thermoplastic batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. The tests results will be compared against the following specifications and requirements:

a. **Pigment and Glass Bead (% Weight)** according to ASTM D4451 — 82.0% Max

b. **Glass Bead Content (% Weight)** according to AASHTO T250 and ASTM D4797 — 25.0% Min

c. **TiO2 (%)** according to ASTM D1394 or equivalent method — 8.0% Min

d. **Binder (%)** according to AASHTO T250/ASTM D4451 — 18.0% Min

e. **Calcium Carbonate and Inert Fillers** — 49.0 % Max

f. **Day Color, Luminance (Y%) (Without Drop-on Beads):** Color testing results shall conform to the chromaticity coordinate limits that follow. Color determination for thermoplastic materials will be made without drop-on beads after cooling in accordance with AASHTO T250 and ASTM D6628.

Day Color, Chromaticity Coordinates (Without Drop-on Beads), Thermoplastic

	x	y	x	y	x	y	x	y	Y%
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375	80.0 Min
Yellow	0.499	0.466	0.545	0.455	0.518	0.432	0.485	0.454	40.0-60.0

g. **Nighttime Yellow Color (with Drop-on Beads):** The initial nighttime color of yellow thermoplastic pavement marking material shall conform to the following CIE chromaticity coordinate requirements when tested in accordance with ASTM D6628 and VTM-111:

Night Time Color, Chromaticity Coordinates (with Drop-on Beads) Thermoplastic

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
Yellow	0.486	0.439	0.520	0.480	0.560	0.440	0.498	0.426

h. **Water absorption:** Materials shall not have more than 0.5 percent retained water by weight when tested in accordance with ASTM D570, Procedure A.

i. **Softening point:** Materials shall have a softening point of at least 194 degrees F as determined in accordance with ASTM E28.

j. **Specific gravity:** The specific gravity of the thermoplastic compound at 77 degrees F shall be from 1.7 to 2.2.

k. **Impact resistance:** The impact resistance shall be at least 10 inch-pounds at 77 degrees F after the material has been heated for 4 hours at 400 degrees F and cast into bars of 1-inch cross-sectional area, 3 inches long, and placed with 1 inch extending above the vise in a cantilever beam, Izod-type tester conforming to ASTM D256 using the 25 inch-pound scale.

l. **No-Track Time:** Material shall set to bear traffic in not more than 2 minutes when the road temperature is 50 degrees F or above.

m. **Intermixed Glass beads:** Glass beads shall conform to Section 234.

n. **Flashpoint:** The material flashpoint shall be no less than 500 degrees F when tested in accordance with ASTM D92.

(c) **Preformed Thermoplastic Pavement Marking Material (Type B, Class II):**

Preformed thermoplastic material shall be suitable for use on asphalt and hydraulic cement concrete pavement surfaces, and shall be selected from the Materials Division's Approved Products List No. 73.

Preformed thermoplastic shall be installed in strict accordance with the manufacturer's installation instructions. Upon cooling to normal pavement temperatures, these materials shall produce an adherent, retroreflective pavement marking capable of resisting deformation by traffic.

Preformed thermoplastic shall be supplied at a minimum of 30% (by weight) of intermixed glass beads.

During application (when molten) all preformed thermoplastic shall be flooded with additional glass beads. Additional retroreflective optics shall also be added to the surface in quantities and types that match what was used for initial approval of these individual products.

Preformed thermoplastic material shall be supplied at 125 mils thickness.

Reversible arrows shall have a minimum of 30% by weight intermixed beads only. During application, surface beads for reversible arrows shall be applied to the thermoplastic material when it is molten.

Preformed thermoplastic may be either of the following types:

- **Type A** where the manufacturer requires preheating of the roadway surface to a specified temperature prior to installation of the preformed thermoplastic material.

- **Type B** where the manufacturer requires preheating of the roadway surface prior to installation of the preformed thermoplastic material to only remove moisture when necessary.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

   a. **Retroreflectivity:** Photometric quantity to be measured is coefficient of retroreflected luminance (R_L) in accordance with ASTM E1710. R_L shall be expressed in milli-candelas per square foot per foot per foot-candle and shall be at least the following values when measured in the skip line area.

Coefficient of Retroreflected Luminance (R_L) (mcd/ft^2/fc) Preformed Thermoplastic

Color	Initial	1 Year In-Service
White	300	250
Yellow	250	200

   b. **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628.

   c. **Thickness:** 120-130 Mils

   d. **Durability Rating:** The marking shall have a durability rating of at least 8 as determined in the wheel path area after 1 year when tested in accordance with NTPEP Work Plan.

   e. **Skid Resistance:** The surface of the installed marking shall provide an initial average skid resistance value of 45 BPN when tested according to of ASTM E303, if available.

   f. **No Track Time:** When installed with glass beads or other reflective media, the markings shall reach a no-track condition in less than 3 minutes.

2. **Batch Testing:**

   Preformed thermoplastic batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. Testing results shall be compared against the following specifications and requirements:

   a. **Day and Nighttime Color and Luminance (Y%):** Refer to initial requirements

   b. **Thickness:** Refer to initial requirements

   c. **Nighttime Yellow Color (with Drop-on Beads):** The initial night time color of yellow preformed thermoplastic pavement marking material shall conform to the following CIE chromaticity coordinate requirements when tested in accordance with ASTM D6628 and VTM-111:

Night Time Color, Chromaticity Coordinates (with Drop-on Beads) Preformed Thermoplastic								
Color	1		2		3		4	
	x	y	x	y	x	y	x	y
Yellow	0.486	0.439	0.520	0.480	0.560	0.440	0.498	0.426

(d) **Epoxy-Resin Pavement Marking Material (Type B, Class III)**

Epoxy-resin is a two-component pavement marking material, suitable for use on both asphalt and hydraulic cement concrete pavement surfaces and shall be selected from the Materials Division's Approved Products List No. 75. The ratio of resin to hardner shall be 2:1 respectively.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

   a. **Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with ASTM E1710 for 30-meter geometry when measured in the skipline or centerline areas.

Coefficient of Retroreflected Luminance (R_L) (mcd/ft^2/fc) Epoxy

Color	Initial	1 Year In-Service
White	300	250
Yellow	250	200

   b. **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628

   c. **Durability:** Epoxy shall have a durability rating of at least 8 as determined in the wheel path area.

   d. **Skid Resistance:** The initial skid resistance shall be at least 45 BPN, if available.

2. **Batch Testing:**

   Epoxy batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. Tests results shall be compared against the following specifications and requirements:

   a. **Pigment (% Weight)** according to ASTM D2371 — 23.0 % Min.

   b. **Epoxy Content** according to ASTM D2371 — White, 82.0% Max; Yellow, 77.0% Max

   c. **Contrast Ratio (Hiding Power)** according to ASTM D2805 (at 15 Mils wet):

Readings will be determined in accordance with ASTM E1349 using CIE 1931 (2 degrees standard observer and CIE standard Illuminant D65). 96 Min.

d. **TiO2 (%),** White conforming to ASTM D476, Type IV according to ASTM D1394 or equivalent 18.0 Min.

e. **Total Amine, Hardener (ASTM D 2074 ERF)** shall be within +/- 50 of the value obtained when tested by NTPEP.

f. **Day Color, Luminance (Y%) (Without Drop-on Beads)**

Color testing results shall conform to the International Commission on Illumination (CIE) chromaticity coordinate limits that follow. Color determination for epoxy materials will be made without drop-on beads at least 24 hours after application in accordance with ASTM D6628.

Day Color, Chromaticity Coordinates (Without Drop-on Beads), Epoxy

	x	y	x	y	x	y	x	y	Y%
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375	80.0 Min
Yellow	0.493	0.473	0.518	0.464	0.486	0.428	0.469	0.452	50.0-60.0

g. Nighttime Yellow Color (with Drop-on Beads): The initial nighttime color of yellow epoxy pavement marking material shall conform to the following CIE chromaticity coordinate requirements when tested in accordance with ASTM D6628 and VTM-111:

Night Time Color, Chromaticity Coordinates (with Drop-on Beads) Epoxy								
Color	1		2		3		4	
	x	y	x	y	x	y	x	y
Yellow	0.486	0.439	0.520	0.480	0.560	0.440	0.498	0.426

h. **Hardness:** Hardness, Shore D determined in accordance with ASTM D2240 shall be 75 to 100.

i. **Tensile strength:** Tensile strength, determined in accordance with ASTM D638, shall be at least 6,000 pounds per square inch after the material has cured for 72 hours at 73 ± 4 degrees F.

j. **Compressive strength:** Compressive strength, determined in accordance with ASTM D695, shall be at least 12,000 pounds per square inch after the material has cured for 72 hours at 73 ± 4 degrees F.

k. **Adhesion to concrete:** Adhesion of markings shall achieve at minimum, a rating of Substrate Failure B when tested in accordance with ASTM D7234 after the material

has cured for 72 hours at 73 ± 4 degrees F. Concrete used for the test shall have a tensile strength of at least 300 pounds per square inch.

l. **No-Pick-Up:** Epoxy marking materials when mixed in proper ratio and applied at a wet film thickness of 15 +/- 1 mils with surface, ambient, and material temperatures being 73.5 +/- 3.0 degrees Fahrenheit, shall reach a no-pick-up time in less than 10 minutes when tested in accordance with ASTM D711.

m. **Weight per epoxy equivalent:** The weight per epoxy equivalent of Part A of the epoxy pavement marking material shall be within ±50 of the target value provided by the manufacturer when tested in accordance with ASTM D1652.

n. **Abrasion resistance:** The wear index shall be no greater than 80 gm/cycle when tested in accordance with ASTM D4060.

(e) **Polyurea Pavement Marking Material (Type B, Class VII):** Polyurea is a two-component pavement marking material suitable for use on both asphalt and hydraulic cement concrete pavement surfaces. Polyurea pavement marking material shall be selected from the Materials Division's Approved Products List No. 74. The components shall be formulated such that the complete cure occurs when they are mixed at the time of application.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

a. **Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with ASTM E1710 for 30-meter geometry. RL shall be measured in the skipline or centerline areas.

Coefficient of Retroreflected Luminance (R_L) (mcd/ft^2/fc) Polyurea

Color	Initial	1 Year In-Service
White	300	250
Yellow	250	200

b. **Color and Luminance (Y%):** According to ASTM D6628

c. **Durability:** Polyurea shall have a durability rating of at least 8 when determined in the wheel path area in accordance with NTPEP guidelines.

d. **Skid Resistance:** The initial skid resistance shall be at least 45 BPN, if available.

2. **Batch Testing:**

Polyurea batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. Tests results shall be compared against the following specifications and requirements:

a. **TiO2 (%)** White, ASTM D476, (Types II, III, IV) according to ASTM D1394 or equivalent White = 18.0 % Min. / Yellow = 10.0% Min.

b. **Hardness:** Hardness, Shore D as determined in accordance with ASTM D2240, shall be 75 to 100.

c. **Adhesion to concrete:** Adhesion, determined in accordance with ACI 503, shall be at 100 percent concrete failure after the material has cured for 72 hours at 73 ± 4 degrees F. Concrete used for the test shall have a tensile strength of at least 300 pounds per square inch and shall be 90 degrees F when the material is applied.

d. **No-Track TIme:** Material shall dry to a "no-track" condition in the time limit stated accordancing to the manufacturer's specification.

e. **Abrasion resistance:** The wear index shall be no greater than 80 when abrasion resistance is tested in accordance with ASTM D4060.

f. **Hiding (Contrast Ratio):** The marking shall show a dry hiding quality that will yield a contrast ratio of at least 0.96 with the Morest Black and White Power Chart, Form 03B (or equivalent), when drawn down at a 15-mil wet film thickness. Readings will be determined in accordance with ASTM E1349 using CIE 1931, 2 degrees standard observer and CIE standard Illuminant D65.

(f) **Permanent, Plastic-Backed, Preformed Tapes (Type B, Class IV and Type B, Class VI)**

Permanent tape shall be a durable, retro-reflective pliant material consisting of a mixture of polymeric materials, pigments, and glass beads (reflective optics) evenly distributed throughout its cross-sectional area and embedded into the surface. Permanent tapes shall be selected from the Materials Division's Approved Products List No. 17. Tape shall be applied in strict accordance with the manufacturer's instructions and the limitations set herein or on the Approved Products List.

Flat Tape (Type B, Class IV) – Flat tape shall be capable of being surface applied to asphalt cement or hydraulic cement concrete pavement following paving operations on new, dense, or open graded asphalt concrete and shall be ready for traffic immediately after application

Patterned Preformed Tape(Type B, Class VI) – Pattered preformed tape shall be capable of being surface applied to asphalt cement or hydraulic cement concrete surfaces following paving operations or inlaid during paving operations on new asphalt concrete, and shall be ready for traffic immediately after application.

Contrast Tape – When specified, Contrast tape shall be a minimum of 3 inches wider than the width specified in the pay item. This additional tape width shall be black and non-reflective with 1 1/2 inches minimum on both sides of the white or yellow product. The black area of the contrast tape shall meet initial requirements of durability, skid resistance, thickness, and adhesion as noted below. Batch testing (sampled per the Manual of Instructions) shall meet the requirements of thickness, width, length, and skid resistance as noted below.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance), durability, and adhesion shall conform to the following requirements after the material has been installed on the test deck for 1 year:

a. Retroreflectivity: The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with ASTM E1710 for 30-meter geometry when measured in the skip line or centerline areas.

Coefficient of Retroreflected Luminance (R_L) (mcd/ft^2/fc) Tape-Type B, Class IV and VI

Color	Initial	1 Year In-Service
White	400	300
Yellow	300	200

b. **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628.

c. **Durability:** Permanent tape shall have a durability rating of at least 8 as determined in the wheel path area when tested in accordance with the NTPEP Work Plan.

d. **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

e. **Thickness (without adhesive):**

Class IV 60 - 120 mils.
Class VI Thinnest portion, 20 Mils Minimum; Thickest portion, 65 Mils Minimum

f. **Adhesion:** No line shall be displaced, torn or missing per NTPEP Pavement Marking Work Plan.

2. **Batch Testing:**

Permanent tape batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. Test results shall be compared against the following specifications and requirements:

a. **Maintained Retroreflectivity** (Refer to initial requirements). Retroreflectivity will be measured in both directions on the roll. The lowest value being recorded.

b. **Color (including Luminance, Y%):** Refer to initial requirements

c. **Thickness:** Refer to initial requirements.

d. **Width:** The width shall be no less than the nominal width and no greater than 1/8" of the nominal width.

e. **Length:** The length shall be no less than the length stated on the manufacturer's packaging.

f. **Skid Resistance:** Refer to initial requirements

(g) **Temporary Pavement Marking Materials:** Construction (temporary) pavement markings shall consist of Type D removable tape; Type E removable black, non-reflective tape; and Type

F temporary pavement marking material. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO's NTPEP or other VDOT Test Facilities.

1. **Removable Tape (Type D, Class II):**

Removable tape shall be a durable, retro-reflective pliant material consisting of a mixture of polymeric materials, pigments and glass beads (reflective optics) evenly distributed throughout its cross-sectional area and embedded into the surface. Temporary removable tape shall be suitable for use on both asphalt and hydraulic cement concrete pavement surfaces and shall be selected from the Materials Division's Approved Products List No. 17.

a. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and adhesive bond rating shall conform to the following requirements after the material has been installed on the test deck for 90 days:

1) **Maintained Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with ASTM E1710 for 30-meter geometry when measured in the skipline or centerline areas.

Coefficient of Retroreflected Luminance (R_L) (mcd/ft^2/fc) Removable Tape-Type D, Class II

Color	Initial	1 Year In-Service
White	250	150
Yellow	200	100

2) **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628.

3) **Adhesive Bond Rating:** The average adhesive bond rating (from transverse and longitudinal lines) shall be 3 or higher according to the NTPEP Work Plan.

4) **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

5) **Thickness:** Per the manufacture's recommendation.

6) **Adhesion:** No line shall be displaced, be torn or missing.

b. **Batch Testing**

Removable tape batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. Test results will be compared against the following specifications and requirements:

1) **Maintained Retroreflectivity:** Refer to initial requirements

2) **Color (including Luminance):** Refer to initial requirements

3) **Thickness:** Refer to initial requirements

4) **Width:** The width shall be no less than the nominal width and no greater than 1/8" of the nominal width.

5) **Length:** The length shall be no less than the length stated on the manufacturer's packaging.

6) **Skid Resistance:** Refer to initial requirements

2. **Wet Reflective, Removable Tape (Type D, Class III):**

Wet reflective, removable tape shall be a durable, retro-reflective pliant material consisting of a mixture of polymeric materials, pigments, and glass beads (reflective optics) evenly distributed throughout its cross-sectional area and embedded into the surface. This tape shall be suitable for use on both asphalt and hydraulic cement concrete surfaces and shall be selected from the Materials Division's Approved Products List No. 17.

a. **Initial Approval** - Maintained retroreflectivity (dry and wet), color (including luminance), and adhesive bond rating shall conform to the following requirements after the material has been installed on the test deck for 90 days:

1) **Maintained Dry Retroreflectivity:** The dry photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with ASTM E1710 for 30-meter geometry when measured in the skip line or centerline areas.

Coefficient of Retroreflected Luminance (R_L) (mcd/ft^2/fc)
Dry Retro Removable Tape-Type D, Class III

Color	Initial	90 Days In-Service
White	250	150
Yellow	200	100

2) **Maintained Wet Retroreflectivity:** The wet photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with VTM-124 (Visual Evaluation or ASTM E2177, Recovery Method) when measured in the skip line or centerline areas.

Coefficient of Retroreflected Luminance (R_L) (mcd/ft^2/fc)
Wet Retro Removable Tape-Type D, Class III

Color	Initial	90 Days In-Service
White	150	100
Yellow	125	75

3) **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628.

4) **Adhesive Bond Rating:** The average adhesive bond rating (from transverse and longitudinal lines) shall be 3 or higher according the NTPEP Work Plan.

5) **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

6) **Thickness:** Per the manufacturer's recommendation.

7) **Adhesion:** No line shall be displaced, torn or missing.

b. **Batch Testing**:

Wet reflective, removable tape batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. Test results shall be compared against the following specifications and requirements:

1) **Retroreflectivity:** Refer to initial requirements

2) **Day and Night Color and Luminance:** Refer to initial requirements

3) **Thickness:** Refer to initial requirements

4) **Width:** The width shall be no less than the nominal width and no greater than 1/8" of the nominal width.

5) **Length:** The length shall be no less than the length stated on the manufacturer's packaging.

6) **Skid Resistance:** Refer to initial requirements.

3. **Removable Black, Non-Reflective Tape (Type E):**

Removable black, non-reflective tape shall be a durable, pliant material consisting of a mixture of polymeric materials, pigments and a friction material evenly distributed throughout its cross-sectional area and embedded into the surface. Removable black, non-reflective tape shall be suitable for use on asphalt concrete pavement surfaces, and shall be selected from the Materials Division's Approved Products List No. 17.

a. **Initial Approval** - Maintained adhesive bond rating shall conform to the following requirements after the material has been installed on the test deck for 90 days:

1) **Adhesive Bond Rating:** The average adhesive bond rating (from transverse and longitudinal lines) shall be 3 or higher according to the NTPEP Work Plan.

2) **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

3) **Thickness:** Per the manufacturer's recommendation.

4) **Adhesion:** No line shall be displaced, be torn or missing.

b. **Batch Testing**

Black removable, non-reflective tape batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. Test results shall be compared against the following specifications:

1) **Skid Resistance:** Refer to initial requirements

2) **Thickness:** Refer to initial requirements

3) **Width:** The width shall be no less than the nominal width and no greater than 1/8" of the nominal width.

4) **Length:** The length shall be no less than the length stated on the manufacturer's packaging.

4. **Temporary Pavement Marking Material (Type F):**

Temporary pavement marking material (waterborne paint) shall be suitable for use on both asphalt and hydraulic cement concrete pavement surfaces, and shall be selected from the Materials Division's Approved Products List No. 48.

a. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 90 days:

1) **Maintained Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with ASTM E1710 for 30-meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle when measured in the wheel path areas:

Coefficient of Retroreflected Luminance (R_L) ($mcd/ft^{-2}/fc^{-1}$) (Type F)

Color	Initial	90 Days In-Service
White	200	100
Yellow	150	100

2) **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628.

3) **Durability:** Material shall have a durability rating of at least 8 when determined in the wheel path area.

4) **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

5) **Thickness:** Not to exceed 15 mils.

b. **Batch Testing**

Temporary pavement marking paint materials batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field

in accordance with the Materials Division's Manual of Instructions. The batch tests and results are the same batch test parameters described in the section above for waterborne paint.

SECTION 247—REFLECTIVE SHEETING

247.01—Description

This specification covers reflective sheeting used on traffic control devices to provide a retroreflective surface or message. The color of the reflective sheeting shall be as specified in the Contract. Reflective sheeting shall be certified in accordance with Section 106.06.

247.02—Detail Requirements

Reflective sheeting shall be selected from the Materials Division's Approved Products List No. 46. Reflective sheeting products are included on the Approved Products List only after the Department determines conformance to the specification requirements listed herein. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO's National Transportation Product Evaluation Program (NTPEP), VDOT's own testing facility, or other Department-approved facilities, except when outdoor testing is not a requirement as noted herein. NTPEP testing includes analysis of new and outdoor weathered sign sheeting. When tested after outdoor weathering, sign sheeting color (Chromaticity and Luminance Factor, Y%) and retroreflectivity must have been maintained within the Specifications limits for the duration of the test period noted. The sheeting and any applied coatings such as inks, overlay films, and other coatings shall be weather resistant according to ASTM D4956 after being tested by AASHTO, NTPEP, VDOT, or other Department approved facilities, except where outdoor testing is not required as noted herein.

Reflective sheeting shall conform to the following for the applications listed:

(a) **Type IX sheeting used for the following applications** shall conform to the retroreflectivity and color requirements of ASTM D4956:

- Permanent signs, except those addressed in Sections 247.02(b)
- Construction signs (used during temporary construction, maintenance, permit, utility, and incident management activities)
- Object markers (including bridge end panel markers)
- Guardrail end terminals
- Permanent impact attenuators (except permanent sand barrels)
- Delineators - Standard ED-2, Standard ED-3, barrier, guardrail, and permanent flexible post
- Vertical panels - (Group 2 channelizing devices) and directional indicator barricades

- Traffic gate arms
- Automatic Flagger Assistance Device (AFAD) gate arms
- The "STOP" side of sign paddles (hand signaling devices)
- The rear panel of truck- and trailer-mounted attenuators
- Permanent barricades

1. **Fluorescent Yellow-Green Type IX reflective sheeting** shall be used on regulatory and warning signs, including supplemental plaques, related to school zones, pedestrians, and/or bicyclists unless otherwise specified on the plans.

2. **Fluorescent Yellow Type IX reflective sheeting** shall be used for the following applications unless otherwise specified on the plans:

   - Rear panel of truck- and trailer-mounted attenuators
   - Yellow sheeting on object markers
   - All W1-series signs (warning signs for changes in horizontal alignment), including all supplemental plaques beneath W1-series signs
   - Delineators (Standard ED-2, ED-3, Barrier, Guardrail, or permanent flexible post)
   - Permanent impact attenuators (except sand barrels)

Retroreflectivity and Color requirements shall be maintained for the values listed in ASTM D4956 after 3 years on the outdoor weathering test rack.

(b) **Type III Reflective sheeting used on permanent recreational and cultural interest area guidance signs, on permanent educational pedestrian signal signs (R10-3 series signs), and on signs to be erected on bikeways physically separated from adjacent roads** shall conform to the retroreflectivity and color requirements of ASTM D4956.

Retroreflectivity and Color requirements shall be maintained after 3 years on the outdoor weathering test rack.

(c) **Reflective sheeting used to delineate the back frame of trailer mounted traffic control devices including but not limited to Portable Changeable Message Signs (PCMSs), Automatic Flagger Assistance Devices (AFADs), arrow boards, Highway Advisory Radios, Speed Trailers, Camera Trailers, portable lights, etc. and traffic control devices equipped with a gate arm** shall conform to the retroreflectivity requirements of 49 CFR 571.108 for a Grade DOT-C2 truck conspicuity marking.

Color shall conform to the requirements of ASTM D4956.

Outdoor weathering testing is not required for sheeting used in these applications.

(d) **White and Fluorescent Orange Type IX reflective sheeting** used on construction signs (used for temporary construction, maintenance, permit, utility and incident management activities), on vertical panels, directional indicator barricades, temporary Type 3 Barricades, barrier panels temporarily installed on concrete traffic barrier service, on the rear panel of truck and trailer-mounted attenuators, on temporary impact attenuators (except temporary sand barrels), and the "SLOW" side of sign paddles (hand signaling device) shall conform to the retroreflectivity and color requirements of ASTM D4956.

The retroreflectivity of the sheeting after 1 year on the outdoor weathering test deck shall be at least 50 percent of the retroreflectivity values specified for new (non-weathered) sheeting.

Color requirements shall be maintained after 1 year on the outdoor weathering test rack.

(e) **Reflective sheeting used on tubular markers, drums, and temporary sand barrels** shall conform to the Supplementary Requirements (S2) of ASTM D4956 and the following:

Minimum Coefficient of Retroreflection R_A
(R_A =Candelas per foot-candle per square foot)
(Prismatic Lens)

Observation Angle (°)	Entrance Angle (°)	White	Fluorescent Orange
0.2	-4	400	175
0.2	+30	200	100
0.2	+40	135	60
0.2	+45	120	40
0.5	-4	150	70
0.5	+30	50	30
0.5	+40	45	25
0.5	+45	40	20

Color shall conform to the requirements of ASTM D4956.

The retroreflectivity of the sheeting after 1 year on the outdoor weathering test deck shall be at least 50 percent of the retroreflectivity values specified for new (non-weathered) sheeting.

Color requirements shall be maintained after 1 year on the outdoor weathering test rack.

(f) **Type III (High Intensity sheeting) White and Yellow reflective sheeting used on permanent sand barrels and cones** shall conform to ASTM D4956 including Supplementary Requirement S2. **Note:** Cones shall also conform to the following supplementary table:

Minimum Coefficient of Retroreflection R_A
(R_A =Candelas per foot-candle per square foot)
(High Intensity) for Cones

Observation Angle (°)	Entrance Angle (°)	White
0.2	+50	60
0.5	+50	35

Color shall conform to the requirements of ASTM D4956.

The retroreflectivity of the sheeting used on permanent barrels after 1 year on the outdoor weathering test deck shall be at least 50 percent of the retroreflectivity values specified for new (non-weathered) sheeting.

Color requirements for reflective sheeting used on permanent barrels shall be maintained after 1 year on the outdoor weathering test rack.

Outdoor weathering testing is not required for reflective sheeting used on cones.

(g) **Reflective sheeting used on Retroreflective Rollup Signs (used for temporary construction, maintenance, permit, utility and incident management activities)** shall conform to the following:

Minimum Coefficient of Retroreflection R_A
(R_A =Candelas per foot-candle per square foot)
(Prismatic Lens)

Observation Angle (°)	Entrance Angle (°)	White	Green	Fluorescent Orange	Fluorescent Pink
0.2	–4	500	60	200	200
0.2	+30	200	24	80	100
0.5	-4	225	-	90	100
0.5	+30	85	27	35	35
1.0	-4	20	10	10	10
1.0	+30	15	-	8	10
1.5	-4	5	-	3	2
1.5	+30	4	-	1.5	2

Color shall conform to the requirements of ASTM D4956.

Outdoor weathering testing is not required for reflective sheeting used on rollup signs.

(h) **Reflective sheeting used on Retroreflective Red Flag (hand signaling devices) and Automatic Flagger Assistance Devices (AFADs)** shall conform to the following:

Minimum Coefficient of Retroreflection R_A

Observation Angle (°)	Entrance Angle (°)	Red Sheeting (R_A)
0.2	-4	50

247.03—Reflective Sheeting Warranty Requirements

Permanent Signs: 10-year warranty with 7 years being 100 percent full replacement covering all material and labor costs associated with fabrication and installation of the sign or device and the final 3 years being 100 percent sheeting replacement cost.

Construction, Work Zone, Rollup, Reboundable Signs: 3-year full replacement covering all material and labor costs associated with fabrication of the sign or device.

The minimum values of retroreflectivity maintained during the warranty period shall be the same as those required for the maintained coefficient of retroreflection values as indicated in ASTM D4956 for Outdoor Weathering Photometric Requirements for All Climates.

Loss of colorfastness is considered to have occurred if the color of the sheeting is not within the color specification limits in ASTM D4956 during the full duration of the warranty period.

Warranty periods shall begin on the date of delivery to the project and shall be documented as follows:

Each permanent traffic control device (except permanent barrier delineators, guardrail delineators, or flexible post delineators) using reflective sheeting shall be marked on the reverse side in a location not to be obscured by sign supports or backing hardware, with labeling showing 1.) Month and year the sign or reflective sheeting application was fabricated, marked via punch-out numerals or as indicated below, 2.) Sheeting manufacturer's name or logo and product designation or number, and 3.) Sign or device manufacturer's name or logo. Labels shall be made of a durable, self-adhesive, permanent weather resistant material and shall be a minimum 4" by 4" in size. Labels may be made from permanent sign material provided the finished label meets all other aspects required for warranty documentation.

Where the information required for the label is not furnished by punched-out numerals, etching, engraving, etc., it shall be supplied by other permanent means, such as sign ink, capable of resisting weathering so as to be legible for the full duration of the warranty period.

Prior to applying the label, the area shall be thoroughly cleaned to ensure proper adhesion and retention.

SECTION 248—STONE MATRIX ASPHALT CONCRETE

248.01—Description

These specifications cover the materials used to produce stone matrix asphalt (SMA) concrete pavement. SMA shall be in accordance with this specification and Section 211. SMA consists of a combination of coarse aggregate, fine aggregate, mineral filler, fiber additives, and liquid asphalt binder mechanically mixed in a plant to produce a stable gap-graded asphalt concrete paving mixture.

248.02—Materials

(a) **Coarse Aggregate:** Coarse aggregate shall conform to the following requirements when tested in accordance with the specified tests:

Requirement	Test	Value
Los Angeles Abrasion	AASHTO T96	40% max.
Flat and Elongated Particles: Measured on No. 4 retained,	VTM-121	
3 to 1		20% max.
5 to 1		5% max.
Magnesium Sulfate Soundness Loss, 5 cycles	AASHTO T104	15% max.
Particles retained on No. 4 sieve shall have at least	ASTM D5821	
1 fractured face		100% min.
2 fractured faces		90% min.
Absorption	AASHTO T85	2% max.

Except for the determination of flat and elongated particles {Section 248.02(a)}, the aggregate properties specified are for each stockpile of coarse aggregate material designated on the job mix form (Form TL-127). The material contained in each stockpile shall meet the minimum or maximum criteria specified.

For flat and elongated particles, these values are based on the mathematical blend of the coarse aggregate material designated on the job mix form (TL-127). During production, these values are based on the SMA material sampled during the acceptance process (QC testing).

SMA must contain two or more coarse aggregate sizes. At least two of the aggregate sizes must comprise a minimum of 10% of the total mix composition each. At least one cold feed bin shall be used for each aggregate size.

The Engineer will not permit the use of slag in the job mix formula.

At the Engineer's discretion, mixes containing Reclaimed Asphalt Pavement (RAP) may be tested by VDOT for aggregate breakdown during lab compaction in accordance with VTM-99. If the percent of the total mix passing the No. 4 sieve increases by more than 10 percent after being compacted to N_{design}, then the RAP component shall be changed or the Engineer will discontinue allowing its use in the mix.

(b) **Fine Aggregate:** Virgin fine aggregates shall consist of a blend of 100 percent crushed aggregate. If RAP is being used as a component in SMA then the portion of the final SMA blend passing the No. 8 sieve shall have a minimum Fine Aggregate Angularity (FAA) value of 45 percent as determined in accordance with AASHTO T304 (Method A). The magnesium sulfate soundness loss in 5 cycles shall not exceed 20 percent. In addition, the liquid limit shall not exceed 25 as determined in accordance with AASHTO T89.

(c) **Asphalt Binder:** Asphalt binders shall be performance graded binder PG 64H-22 or polymer modified binder PG 64E-22 conforming to the mix designation (E) as specified by the Department. The supplier shall certify to the Department that the binder complies with the requirements for all properties of the grade as specified in AASHTO M332 Table 1 for performance-graded asphalt binder. This certification shall be based on testing performed on samples of binder provided to the Contractor for incorporation into the mixture. The Engineer will not allow certification based on testing performed on laboratory-produced binders.

The Contractor shall submit to the Engineer for Department review the source, formulation, and PG grading of the binder at least 15 days prior to the production of the SMA mixture.

The Department will test samples taken from storage at the hot-mix asphalt plant during mixture production at the Engineer's direction to determine the binder PG grade. The Contractor shall be responsible for obtaining the sample of binder when requested by the Engineer. If the Department determines the binder does not comply with the requirements of the specified PG grade, production will be stopped until further testing indicates that the problem has been corrected.

(d) **Mineral Filler:** Mineral filler shall consist of finely divided mineral matter such as rock or limestone dust or other suitable material. The Engineer will not permit the use of hydrated lime and fly ash. The supplier may blend up to two mineral fillers to comply with the mineral filler requirements. Mineral filler shall conform to Section 201 with the following modifications. The mineral filler or mineral filler blend used in surface and intermediate SMA shall have a

minimum of 55 percent passing the No. 200 sieve. At the time of use, it shall be sufficiently dry to flow freely and be essentially free from agglomerations.

(e) **Fiber Additive:** The supplier shall use cellulose fiber in either loose or pelletized form. The minimum dosage rate for cellulose is 0.3 percent by weight of the total mixture. The Department may require the percentage of fiber additive to be increased during production if visual inspection or draindown testing on plant-produced material indicates that draindown in excess of 0.3 percent by weight of the mixture is occurring as determined in accordance with VTM-100. Allowable tolerances of fiber dosage shall be ±10 percent of the required fiber weight.

NOTE: When using pelletized fiber, the dosage rate shall be adjusted to comply with the specified minimum dosage rates for cellulose fiber. Pelletized fiber consists of cellulose fiber and a binder. The specified minimum dosage rates are based on fiber content only. Therefore, the amount of pelletized fiber added shall typically be higher than for loose fiber.

The Engineer will accept fibers based on the manufacturer's certification.

TABLE II-23
Cellulose Fiber Properties

Sieve Analysis		Requirement
Method A: Alpine Sieve[1] Analysis		
Fiber Length:		0.25 inch max.
Passing	No. 100 Sieve	70% (±10%)
Method B: Mesh Screen[2] Analysis		
Fiber Length:		0.25 inch max.
Passing	No. 20 Sieve	85% (±10%)
	No. 40 Sieve	65% (±10%)
	No. 140 Sieve	30% (±10%)
Ash Content[3]		18% (±5%) non-volatile
pH[4]		7.5 (±1.0)
Oil Absorption[5]		5.0 (±1.0) (times fiber weight)
Moisture Content[6]		<5%

[1] *Method A: Alpine Sieve Analysis.* Performed using an Alpine Air Jet Sieve (Type 200 LS). A representative 5-gram sample of fiber is sieved for 14 minutes at a controlled vacuum of 22 inches (±3 inches) of water. The portion remaining on the screen is weighed.

[2] *Method B: Mesh Screen Analysis.* This test is performed using standard Nos. 20, 40, 60, 80, 100, and 140 sieves, nylon brushes, and a shaker. A representative 10-gram sample of fiber is sieved, using a shaker and two nylon brushes on each screen. The amount retained on each sieve is weighed and the percentage passing calculated.

[3] *Ash Content:* A representative 2- to 3-gram sample of fiber is placed in a tared crucible and heated between 1100 and 1200 degrees F for not less than 2 hours. The crucible and ash are cooled in a desiccator and reweighed.

[4] *pH Test:* Five grams of fiber is added to 3.5 ounces of distilled water, stirred, and allowed to set for 30 minutes. The pH is determined with a probe calibrated with a pH 7.0 buffer.

[5] *Oil Absorption Test:* Five grams of fiber is accurately weighed and suspended in an excess of mineral spirits for not less than 5 minutes to ensure total saturation. It is then placed in a screen mesh strainer (with a hole size of approximately 0.5 square millimeter), and shaken on a wrist action shaker for 10 minutes (approximately 1¼-inch motion at 20 shakes/minute). The shaken mass is then transferred without touching to a tared container and weighed. Results are reported as the amount (number or times its own weight) the fibers are able to absorb.

[6] *Moisture Content:* Ten grams of fiber is weighed and placed in a 250 degree F forced air oven for 2 hours. The sample is then reweighed immediately upon removal from the oven.

(f) **Antistripping Additive:** An antistripping additive shall be used in all stone matrix asphalt mixes. It may be hydrated lime or a chemical additive from the Materials Division's Approved Products List No. 7, or a combination of both. The approved chemical additive shall be added at a rate of not less than 0.30 percent by weight of the total asphalt content of the mixture.

The mixture shall produce a tensile strength ratio (TSR) of not less than 0.80 for the design and production tests. The TSR shall be determined in accordance with AASHTO T283, including a freeze-thaw cycle (4-inch specimens compacted with a Marshall Hammer or 3.5 by 6-inch specimens when compacted with a gyratory compactor); except that the 16-hour curing time requirement and the 72 to 96-hour storage period will not be enforced by the Department. Design tests shall use the same materials that are to be used in the production mix and shall be conducted in a laboratory approved by the Department.

When a chemical additive is used, it shall be added to the asphalt cement prior to the introduction of the asphalt cement into the mix. Any chemical additive or particular concentration of chemical additive found to be harmful to the asphalt material or that changes the original asphalt binder performance grade (PG) shall not be used.

(g) **Hydrated lime** shall conform to ASTM C977. Hydrated lime shall be added at a rate of not less than 1 percent by weight of the total dry aggregate.

A separate bin or tank and feeder system shall be provided to store and accurately proportion the dry or slurried lime into the aggregate. The lime and aggregate shall be mixed by pugmill or other Department approved means to achieve a uniform lime coating of the aggregate prior to entering the drier. If lime is added in dry form, the aggregate shall contain at least 3 percent free moisture. The Department will not permit the stockpiling of lime treated aggregate.

The feeder system shall be controlled by a proportioning device, which shall be accurate to within ±10 percent of the specified amount. The proportioning device shall have a convenient and accurate means of calibration. A flow indicator or sensor shall be provided with the proportioning device and interlocked with the plant controls, aggregate feed or weigh system, such that production of the mixture shall be consistently maintained and, if there is a stoppage of the lime feed, interrupted.

The method of introducing and mixing the lime and aggregate shall be subject to approval by the Engineer prior to beginning production.

(h) **RAP:** The Contractor or his supplier may use Reclaimed Asphalt Pavement (RAP) material as a component material of SMA mixtures provided it conforms to the following:

1. SMA surface and intermediate mixtures containing RAP shall use the PG grade of asphalt cement designated by the mix specified on the plans or in the proposal, e.g. an SMA-12.5 (64E-22).

2. The final asphalt mixture shall conform to the type specified.

3. During the production process, RAP material shall not be allowed to contact open flame.

4. The Contractor or his supplier shall handle, haul, and store the RAP material in a manner that will minimize contamination. Further, the material shall be stockpiled and used in such manner that variable asphalt contents and asphalt penetration values will not adversely affect the consistency of the mixture.

248.03—Composition of SMA Mixture

The Contractor or his supplier shall design and test the SMA mixture using a gyratory compactor. The designated mixture shall conform to Table II-24 and Table II-25. One percent hydrated lime will be required as an antistripping additive. An alternative antistripping additive can be used only with the Engineer's permission.

Draindown testing shall be conducted in accordance with VTM-100.

RAP percentages shall conform to Table II-26.

TABLE II-24
SMA Design Range

	Percentage by Weight Passing Square Mesh Sieves (in)							
Type No. (See Note)	**1**	**3/4**	**1/2**	**3/8**	**No. 4**	**No. 8**	**No. 30**	**No. 200**
Surface Mixes								
SMA 12.5		100	83-93	80 max	22-28	16-24	15-20	9-11
SMA 9.5		100	90-100	65-75	25-32	15-25		9-11
Intermediate Mixes								
SMA 19.0	100	85-95	50-60	30-45		16-24	12-16	8-10

Note: The required PG binder will be shown in parentheses as part of the mix type on the plans or in the proposal, e.g., SMA 12.5 (76-22).

TABLE II-25
SMA Mixture Requirements

Mix Type	VTM[1] (%)	VMA Design (Min. %)	VMA Production (Min. %)	VCA Design and Production[2] (%)	AC (Min. %)	Draindown (%)	Design Gyrations	Specimen Height[3]
SMA 9.5	2.0-4.0	18.0	17.0	$<VCA_{DRC}$	6.3	0.3 max	75	115
SMA 12.5	2.0-4.0	18.0	17.0	$<VCA_{DRC}$	6.3	0.3 max	75	115
SMA 19.0	2.0-4.0	17.0	16.0	$<VCA_{DRC}$	5.5	0.3 max	75	115

[1] Asphalt content shall be selected at the midpoint of the VTM range but shall not be less than the minimum specified.
[2] The voids in coarse aggregates (VCA) of the dry rodded condition (DRC) and mix shall be determined in accordance with VTM-99.
[3] Specimen height after compaction shall be between 4.25 and 4.75 inches.
[4] The fines-effective asphalt ratio shall be 1.2-2.0

Note: The SUPERPAVE gyratory compactor (SGC) shall be from the Department's approved list maintained by the Department's Materials Division. Gyratory procedures shall be performed in accordance with VTM-99. Calculations for volumetrics shall be performed in accordance with VTM-57 and VTM-58 using 6-inch specimens.

TABLE II-26
Specified Performance Grade of Asphalt and Use of RAP

Mix Type & PG	Allowable RAP Percentage in Mix
SMA-9.5 (64H-22), SMA-12.5 (64H-22) & SMA-19.0(64H-22)	0.0 to 20.0
SMA-9.5 (64E-22), SMA-12.5 (64E-22) & SMA-19.0 (64E-22)	0.0 to 15.0

248.04—Acceptance

The Engineer will consider a lot to be acceptable for gradation and asphalt content if the mean of the test results obtained is within the tolerance allowed from the job-mix formula. The production tolerances for the control sieves and asphalt content shall be as follows:

Process Tolerance

Tolerance on Each Laboratory Sieve and Asphalt Content: Percent Plus and Minus									
No. Tests	**Top Size**	**3/4”**	**1/2”**	**3/8”**	**No. 4**	**No. 8**	**No. 30**	**No. 200**	**A.C.**
1	0.0	8.0	8.0	8.0	6.0	6.0	6.0	4.0	0.60
2	0.0	5.7	5.7	5.7	4.3	4.3	4.3	2.8	0.43
3	0.0	4.4	4.4	4.4	3.3	3.3	3.3	2.2	0.33
4	0.0	4.0	4.0	4.0	3.0	3.0	3.0	2.0	0.30
5	0.0	3.6	3.6	3.6	2.7	2.7	2.7	1.8	0.27
6	0.0	3.3	3.3	3.3	2.4	2.4	2.4	1.6	0.24
7	0.0	3.0	3.0	3.0	2.3	2.3	2.3	1.5	0.23
8	0.0	2.8	2.8	2.8	2.1	2.1	2.1	1.4	0.21
12	0.0	2.3	2.3	2.3	1.7	1.7	1.7	1.2	0.17

The production tolerance for the specimen height after compaction is 110mm to 120mm.

The Contractor shall check and report the VCA of the mix during production for each gyratory sample. If the VCA of the mix exceeds the VCA of the DRC, the Contractor shall stop production and notify the Engineer. Production shall not resume until the Contractor has taken corrective action and the Engineer has accepted the Contractor’s means of correction.

The Contractor shall check and report the percentage of flat and elongated particles (F&E) in the coarse aggregates of the mix design during production. Two of eight sub-lots from the first lot of material shall be selected for F&E verification when the Contractor samples the SMA material for acceptance (gradation and AC content). F&E testing shall be performed on the coarse aggregate material retained on the #4 sieve, in accordance with VTM-121, after the gradation is performed. If passing results are obtained on each sample in the first lot, then F&E testing shall be performed on a frequency of every second lot of material produced (i.e., Lots 3, 5, 7, etc.) by randomly selecting two sub-lots. If the F&E of the mix exceeds the specified limits, the Contractor shall stop production and notify the Engineer. Production shall not resume until the Contractor has taken corrective action and the Engineer has accepted the Contractor’s means of correction. Once production has resumed, the Contractor shall determine the F&E of the mix for two consecutive lots by randomly selecting two sub-lots per lot. If passing results are obtained for these two lots, then the F&E testing frequency shall return to every second lot of material produced.

If the Department determines that the mixture being produced does not conform to the approved job-mix formula and the volumetric properties in Table II-25 based on the Department or the Contractor’s test results, the Contractor shall immediately make corrections to bring the mixture into conformance with the approved job-mix formula or cease paving with that mixture.

The Engineer will limit subsequent paving operations using either a revised or another job-mix formula, which has not been verified as described herein, to a test run of 300 tons maximum if such material is to be placed in Department project work. The Engineer will not allow any further paving for the Department using that specific mixture until the acceptability of the mixture being produced has received the Engineer’s approval based on the 300-ton constraint.

For SMA surface mixes, permeability test data shall be submitted in accordance with VTM 120 using either single point verification or the regression method for each surface mix having a different gradation.

Samples shall be taken in the first lot, and every other lot thereafter, and the results submitted to the appropriate District Materials Engineer for the Contract.

248.05—SMA Mixing Plant

Plants used for the preparation of the SMA mixture shall conform to the following:

(a) **Handling of Mineral Filler:** Adequate dry storage shall be provided for the mineral filler that will, at a minimum, consist of a waterproof cover that shall completely cover the stockpile at all times. Provisions shall be made for metering of the filler into the mixture uniformly and in the desired quantities. In a batch plant, mineral filler shall be added directly into the weigh hopper. In a drum plant, mineral filler shall be added directly onto the cold feed belt. Equipment shall be capable of accurately and uniformly metering the large amounts of mineral filler up to 25 percent of the total mix.

(b) **Fiber Addition:** Adequate dry storage shall be provided for the fiber additive. Provisions shall be made for accurately and uniformly metering fiber into the mixture at plus or minus 10 percent of the desired quantities.

Introduction of loose or pelletized fiber shall require a separate system that can accurately proportion, by weight, the required quantity of fiber in such a manner as to ensure consistent, uniform blending into the mixture at all rates of production and batch sizes. This supply system shall be interlocked with the other feeding devices of the plant system. Sensing devices shall provide for interruption of mixture production if the introduction of fiber fails.

Batch Plant: Loose fiber or pelletized fiber shall be added through a separate inlet directly into the weigh hopper above the pugmill. The addition of fiber shall be timed to occur during the hot aggregate charging of the hopper. Adequate dry mixing time is required to ensure proper blending of the aggregate and fiber stabilizer. Therefore, dry mixing time shall typically be increased 5 to 15 seconds. Wet mixing time shall typically be increased at least 5 seconds for cellulose fibers to ensure adequate blending with the asphalt cement.

When fiber is used, the fiber supply system shall include low level and no flow indicators, and a printout of the date, time, and net batch weight of fiber.

Drum Mix Plant: When fiber is used, the fibers shall be added in such a manner as not to be entrained into the exhaust gases of the drum plant. The fiber supply system shall include low level and no flow indicators, and a printout of status of feed rate in pounds per minute.

When pelletized fibers are used, they shall be added directly into the drum mixer through the RAP inlet or a specialized fiber inlet. Operation of the drum mixer shall be such as to ensure complete blending of the pelletized fiber into the mix.

(c) **Hot Mixture Storage:** When the Contractor does not immediately haul and place the hot mixture on the project, it, the Contractor shall provide suitable bins for storage of the hot mixture. Such bins shall be either surge bins to balance production capacity with hauling and placing capacity

or storage bins that are heated and insulated and that have a controlled atmosphere around the mixture. The Engineer will impose limitations on the holding times based on laboratory tests of the stored mixture. In no case shall the SMA mixture be kept in storage more than 8 hours.

(d) **Mixing Temperature:** The recommended plant mixing temperatures for PG 64H-22 should be 315 to 340 degrees F and at no time shall the temperature exceed 350 degrees F. For PG 64E-22, the plant mixing temperatures shall be within the limits of the asphalt supplier's recommendations.

SECTION 249—FLOWABLE BACKFILL

249.01—Description

These specifications cover materials, design criteria, and mixing and testing procedures for flowable backfill used in applications where modified liquid or plastic concrete is required for backfilling pipe installations and plugging abandoned pipe lines, culverts, and conduits.

249.02—Materials

(a) **Hydraulic Cement** shall conform to Section 214.

(b) **Fly Ash** shall conform to Section 241.02(a).

(c) **Water** shall conform to Section 216, except that wash water as described in Section 216.02 may comprise the total mix water.

(d) **Aggregates** shall conform to Sections 202 and 203 with a combined gradation as determined by the Contractor.

(e) **Admixtures** shall conform to Section 215.

(f) **Granulated Iron Blast Furnace Slag** shall conform to Section 215.

249.03—Mix Design

The Contractor shall provide the appropriate mix design for the flowable backfill application. Flowable backfill shall have a design compressive strength of 30 to 200 pounds per square inch when used as backfill material in pipe installations or in other uses at locations as designated on the plans.

Flowable backfill shall have a design compressive strength of 30 to 1200 pounds per square inch when used as backfill material for plugging pipes and culverts designated for abandonment as shown on the plans. The design compressive strength requirement shall be at 28 days when tested in accordance with ASTM D 4832. Mix design shall result in a fluid product having no less than an 8-inch slump at the time of placement. The Contractor shall submit a mix design verifying compliance with 28 day compressive strength requirements supported by laboratory test data to the Engineer for review. The Contractor must have the Engineer's acceptance of the Contractor's mix design and test data prior to placement of the flowable backfill.

SECTION 250 - CARBON FIBER MESH

250.01—Description

These specifications cover carbon fiber mesh used along with EP-7 epoxy to seal joints in between box beam bridges and other bridge joints.

250.02—Materials

(a) **Carbon Fiber Mesh Materials** shall conform to the following:

The carbon fiber mesh is comprised of high tensile strength carbon fiber strips 4 inches in width. The mesh is not impregnated, wets out with the epoxy, and cured in place in epoxy resin overlay.

General Information	
Constituent Materials:	6K Carbon Fiber unidirectional tows
Primary Fiber Directions	Closed knit 0° X 90°
Color	Black

Carbon Material Properties	**Requirement**	**Test Method**
Nominal Thickness	0.030 inch	
Nominal Tensile Strength per unit width	400,000 psi	ASTM D3039
Nominal Tensile Modulus	33,000,000 psi	ASTM D3379
Failure Strain	1.3%	ASTM D3379
Grid Spacing	1/4” x 1/4” (inch) (longitudinal x transverse)	

SECTION 251 - GALVANIC ANODES

251.01—Description

These specifications cover galvanic anodes used to minimize corrosion between the interface of existing concrete and concrete repair materials.

251.02—Detail Requirements

Anodes shall come pre-manufactured and be supplied with integral tie wires for connecting to the reinforcing steel. Tie wires shall be in accordance with ASTM A82. Anodes shall contain no corrosive constituents or substances detrimental to reinforcing steel.

The material covering the zinc metal shall be inert to fresh concrete and cover the entire zinc material so that the zinc material is protected from coming into direct contact with the reinforcing steel.

Metallic zinc used in the anodes shall be in compliance with ASTM B418 and shall not contain more than the following impurities:

Copper	0.01 % maximum
Lead	0.003 % maximum
Iron	0.015 % maximum
Cadmium	0.003 % maximum

Individual anodes shall provide a current density output equal to or greater than 0.05 µA/cm2 (0.32 µA/in2) at 10 years, based upon manufacturer's recommended steel surface area for placement. The anodes shall be designed and installed such that the anode has the same embedment depth as the reinforcing steel to which it is attached.

Anodes shall be delivered, stored, handled, and installed according to the manufacturer's instructions.

SECTION 252 - GRAVITY-FILL POLYMER CRACK SEALERS

252.01—Description

These specifications cover polymers used for gravity-filling sealing cracks in hydraulic cement concrete surfaces.

252.02—Materials

Gravity-fill polymer crack sealers shall be a high molecular weight methacrylate, epoxy, or urethane conforming to the following:

Properties of Gravity-filled Polymers

Property @ 75 ± 5 °F	Test Method	Requirement
Gel Time, 50 ml sample	ASTM C881	6 hrs. max.
Tensile Strength	ASTM D638	1,500 psi min.
Sand Penetration, MX-45 sand	VTM 101	80% min.

Division III
ROADWAY CONSTRUCTION

SECTION 301—CLEARING AND GRUBBING

301.01—Description

This work shall consist of clearing, grubbing, and activities to remove and dispose of vegetation, debris, fences and other objects unsuitable for construction located within the construction limits except for vegetation and objects that are designated to be preserved, protected, or removed in accordance with the Contract or other provisions of these Specifications.

301.02—Procedures

If approved by the Engineer, the Contractor may clear and grub to accommodate construction equipment within the right of way up to 5 feet beyond the construction limits at his own expense. The Contractor shall install erosion and siltation control devices prior to beginning clearing or grubbing operations. Such devices shall be functional before upland land-disturbing activities take place.

The surface area of earthen material exposed by grubbing, stripping topsoil, or excavation shall be limited to that necessary to perform the next operation within a given area. The Contractor shall confine the grubbing of root mat and stumps to that area of land on which the Contractor shall perform excavation or other land disturbance activities within 14 days following grubbing operations.

The Contractor shall remove stumps, roots, other perishable material, and nonperishable objects that will be less than 5 feet below the top of earthwork within the area directly beneath the roadway pavement and shoulders. Material and objects that will be 5 feet or more below the top of earthwork within the area directly beneath the roadway pavement and shoulders and all such material and objects beneath slopes of embankments shall be left in place unless removal is necessary for installation of a structure. The top of stumps left in place shall not be more than 6 inches above the surface of existing ground or low water level.

Branches of trees that overhang the roadway, reduce sight distance, or are less than 20 feet above the elevation of the finished grade shall be trimmed using approved tree surgery practices in accordance with Section 601.03(b).

Vegetation, structures, or other items located outside the construction limits shall not be damaged. Trees and shrubs in ungraded areas shall not be cut or trimmed without the approval of the Engineer.

The Contractor shall dispose of combustible cleared and grubbed material in accordance with the following:

(a) **Trees, limbs, and other timber having a diameter of 3 inches and greater** shall be disposed of as saw logs, pulpwood, firewood, or other usable material; however, treated timber shall not be disposed of as firewood. The Contractor shall leave no more than 2 feet of trunk attached to grubbed stumps.

When specified in the Contract or directed by the Engineer that trees or other timber is to be reserved for the property owner, such material shall be cut in the lengths specified and piled where designated, either within the limits of the right of way, or not more than 100 feet from the right-of-way line. When not reserved for the property owner, such material shall become the property of the Contractor.

(b) **Material less than 3 inches in diameter** shall be used to form brush silt barriers when located within 500 feet of the source of such material or used where directed by the Engineer. The Contractor shall place material approximately 5 feet beyond the toe of fill in a strip approximately 10 feet wide to form a continuous barrier on the downhill side of fills. Where selective clearing has been done, material shall be piled, for stability, against trees in the proper location. On the uphill side of fills, brush shall be stacked against fills at approximately 100-foot intervals in piles approximately 5 feet high and 10 feet wide. Any such material not needed to form silt barriers shall be processed into wood chips having a thickness of not more than 3/8 inch and an area of not more than 6 square inches. Wood chips may be stockpiled out of sight of any public highway for use on the project as mulch in accordance with Section 605.

(c) **Stumps and material less than 3 inches in diameter** that are not needed to form silt barriers and that are not processed into wood chips shall be handled in accordance with Section 106 and Section 107.

301.03—Measurement and Payment

Clearing and grubbing will be measured and paid for in accordance with one of the following methods, as specified in the Contract:

(a) **Lump sum basis:** The Engineer will not make any measurement of the area to be cleared and grubbed, but the price bid shall be for all clearing and grubbing in the Contract.

(b) **Acre basis:** The work to be paid for will be the number of acres, computed to the nearest 1/10 of an acre, actually cleared and grubbed. Areas within the limits of any existing roadway or local material pit will not be measured for payment.

(c) **Unit basis:** The Engineer will determine the work to be paid for according to the actual count of trees, stumps, structures, or other obstructions removed as designated in the Contract.

These prices shall include properly and legally disposing of cleared and grubbed material.

When clearing and grubbing is not a pay item, the cost thereof shall be included in the price for other appropriate pay items. The Engineer will not authorize payment for clearing and grubbing borrow pits or other local material pits.

Payment will be made under:

Pay Item	Pay Unit
Clearing and grubbing	Lump sum, acre, or unit

SECTION 302—DRAINAGE STRUCTURES

302.01—Description

This work shall consist of installing pipe culverts, endwalls, box culverts, precast concrete and metal pipe arches, storm drains, drop inlets, manholes, spring boxes, junction boxes, and intake boxes and removing

and replacing existing structures in accordance with these specifications and in conformity with the lines and grades shown on the plans or established by the Engineer.

302.02—Materials

(a) **Pipe** shall conform to Section 232 and shall be furnished in accordance with the diameter, wall thickness, class, and strength or corrugation specified in the Contract for the maximum height of fill to be encountered along the length of the pipe culvert, storm drain, or sewer.

(b) **End sections** shall conform to Section 232 as applicable. End sections used with rigid pipe shall be concrete. End sections used with asphalt-coated or paved pipe shall not be asphalt coated or paved but shall be concrete.

(c) **Pipe fittings,** such as tees, elbows, wyes, and bends shall conform to Section 232 as applicable. Fittings shall be of the same type, class, thickness, gage, and strength as the line of pipe in which they are used.

(d) **Steel grates, steel frames, and structural steel** shall conform to Section 226 and shall be galvanized in accordance with Section 233.

(e) **Concrete blocks** shall conform to Section 222 for masonry blocks used in constructing catch basins and manholes.

(f) **Brick** shall conform to Section 222 for bricks used in constructing catch basins and manholes.

(g) **Hydraulic cement mortar** shall conform to Section 218.

(h) **Cast-in-place concrete** shall conform to Section 217 for Class A3.

(i) **Bedding material** shall conform to Section 205.

(j) **Joint material and gaskets** shall conform to Section 212.

(k) **Gray-iron castings** shall conform to Section 224.

(l) **Reinforcing steel** shall conform to Section 223, Grade 40 or 60.

(m) **Curing materials** shall conform to Section 220.

302.03—Procedures

Excavation and backfill operations shall be performed in accordance with Section 303. Foundation exploration shall be performed in accordance with Section 401 unless otherwise provided herein or elsewhere in the Contract. Concrete construction shall conform to Section 404. Reinforcing steel placement shall conform to Section 406. Bearing pile operations shall be performed in accordance with Section 403. When specified on the plans or directed by the Engineer, the Contractor shall construct a temporary diversion channel to facilitate installation of a pipe or box culvert.

The Contractor shall be responsible for anticipating and locating underground utilities and obstructions in accordance with Section 105.08.

When construction appears to be in close proximity to existing utilities, the trench(es) shall be opened a sufficient distance ahead of the work or test pits shall be excavated to verify the exact locations and inverts of the utility, and determine if changes in line or grade are required for installation of the new work.

The Contractor shall install a lift hole plug furnished by the manufacturer in accordance with Section 232.02(a)1 when lift holes are provided in concrete pipe or precast box culverts. After pipe installation and prior to backfilling, plugs shall be installed from the exterior of the pipe or box culvert and snugly seated.

(a) **Pipe Culverts:** Only one type of pipe shall be used in any one pipeline. When the bid proposal indicates that all types of pipe of one size are combined into one bid item, one bid price shall be submitted for each size of pipe to be used.

When the Engineer permits field cutting of corrugated metal pipe, damaged areas of the protective coating shall be repaired in accordance with Section 233 for galvanized pipe and in accordance with the pipe manufacturer's recommended procedures for such repairs on all other metallic or polymer coatings.

1. **Jack and bore method:** The Contractor shall submit to the Engineer a complete plan and installation schedule for jack and bore pipe installations prior to beginning such work. The submission shall include complete details for dewatering; soil stabilization; jacking and receiving pits; jacks; reaction blocking; boring equipment; sheeting, shoring, and bracing for protecting the roadbed; pavement surface settlement monitoring, installation sequence; materials; and equipment proposed for use. The Engineer will not authorize the Contractor to proceed until the Contractor's plan has been reviewed and accepted.

The jack and bore method shall be applicable for installing concrete pipe 12 through 108 inches in diameter and smooth-wall steel pipe 12 3/4 through 48 inches in diameter.

The Contractor shall select and use pipe having a design strength and wall thickness sufficient to withstand the jacking operation and maximum height of fill to be encountered along the length of the pipe.

Construction shall be performed in such a manner that the pavement surface above the pipe line does not have more than 0.5 inch of settlement when measured with a 10-foot straightedge. The hole shall be bored mechanically with a suitable boring assembly designed to produce a smooth, straight shaft and operated so that the completed shaft will be at the established line and grade. The size of the bored hole shall be of such diameter as to provide ample clearance for bells or other joints required in the installation. The bore holes shall be mechanically produced. The boring shall be accomplished by using either a pilot hole or a dry bore method.

The Contractor shall apply even pressure to all jacks during jacking operations. Provide suitable bracing between jacks and the jacking head so that pressure shall be applied to the pipe uniformly around the ring of the pipe. The jacking head shall be of such weight, construction, and dimensions that it shall not bend or deflect when full pressure is applied at the jack. The jacking head shall be provided with an opening for the removal of excavated material as the jacking operation proceeds. The Contractor shall set the pipe to be jacked on guides that are straight and securely braced together in such manner as to firmly support the section of pipe and to direct it in the proper line and grade as jacking operations proceed.

The Contractor shall ensure installation of the pipeline immediately follows heading or tunneling excavation. Voids occurring behind the pipe during installation shall be filled with hydraulic cement grout conforming to Section 218, placed under pressure, upon completion of the jack and bore operation.

Joint sealant material on concrete pipe shall be placed ahead of the jacking frame. The Contractor shall replace or repair pipe that is damaged during jacking operations at his own expense, when directed by the Engineer shall. Joints of steel pipe shall be butt welded so as to be watertight as installation progresses.

When work is stopped, the heading shall be bulkheaded.

When the Contractor encounters an obstruction during the jacking and boring operation the following procedure shall be followed:

a. The Contractor shall notify the Engineer immediately upon encountering an obstruction that stops the forward progress of the work. The Engineer shall verify that the obstruction has stopped the forward progress of the Contractor's jacking efforts for more than 60 minutes and that the Contractor's efforts to remove or bore through the obstruction have been unsuccessful though deliberately and diligently pursued.

b. The Contractor shall consult with the Engineer and offer appropriate options for advancing the work for consideration. Upon authorization by the Engineer, the Contractor shall proceed with removal of the obstruction by other methods on a force account basis in accordance with Section 109.05. Such alternative methods may include tunneling. If the Engineer determines the Contractor's proposed option for tunneling is necessary, the Contractor shall detail a plan for such an operation including all necessary safety and health precautions for workers as required by local, state, and federal regulations for the work proposed. The Engineer will not authorize the Contractor to proceed until the Contractor's plan has been reviewed and accepted. The Contractor shall notify the Engineer before resuming the work according to the Contractor's authorized plan and afford the Engineer the opportunity to witness all work performed by the Contractor. Payment for obstruction removal shall be from the start of removal operations until the successful removal of the obstruction.

The Contractor shall make a determination, after consultation with the Engineer, as to remaining manner of installation the Contractor will employ after removal of the obstruction.

2. **Open trench method:**

a. **Foundation:** The Contractor shall explore the foundation below the bottom of the excavation to determine the type and condition of the foundation. However, explorations need not be made for routine entrance or crossover pipe 12 through 30 inches in diameter that is to be installed under fills 15 feet or less in height. Foundation exploration shall extend to a depth equal to 1/2 inch per foot of fill height or 8 inches, whichever is greater. The Contractor shall report the findings of the foundation exploration to the Engineer for acceptance prior to placing pipe.

Where the Engineer determines unsuitable foundation material is encountered at the established grade, the Contractor shall remove and replace such material.

Backfill for areas where unsuitable material has been removed shall be placed and compacted in accordance with Section 303.04(g).

b. **Bedding:** Bedding material for culvert foundations, including foundations in soft, yielding, or otherwise unsuitable material, shall be aggregate No. 25 or 26 conforming to Section 205. Where standing or running water is present in the pipe foundation excavation, pipe bedding material shall be aggregate No. 57 for the depth specified on the plans or as directed by the Engineer, capped with 4 inches of aggregate No. 25 or 26. Where such conditions are discovered in the field and the Engineer directs the Contractor to use No. 57 stone, No. 57 stone will be paid for at the existing contract unit price or, if not in the Contract, in accordance with Section 109.05.

Pipe bedding shall be lightly and uniformly compacted and shall be carefully shaped so that the lower section of the pipe exterior is in full contact with the bedding material for at least 10 percent of the overall height of the pipe. Bedding material shall be shaped to accommodate the bell portion of the pipe when bell and spigot pipe is used. The depth of bedding material shall be at least 4 inches, or as specified on the plan or as directed by the Engineer.

c. **Placing pipe:** Pipe shall be placed beginning at the downstream end of the pipeline. The lower segment of pipe shall be in contact with the shaped bedding for its entire length. Bell or groove ends of rigid pipe shall be placed facing upstream.

Paved or partially lined pipe shall be placed so that the longitudinal centerline of the paved segment coincides with the flow line.

The Engineer will inspect the pipe before the Contractor places the backfill. The Contractor shall remove, reinstall or replace pipe found to be out of alignment, unduly settled, or damaged.

d. **Joining pipe:**

(1) **Rigid pipe:** The Contractor's method of joining pipe sections shall be such that ends are fully mated so that inner surfaces are reasonably flush and even to permit sealing of the joint as specified herein.

Joints shall be sealed with any one or combination of the following to form a leak-resistant joint: rubber gasket, preformed neoprene seal, preformed flexible joint sealant from the Materials Division's Approved Products List 14; oakum and mortar; oakum and joint compound; or cold-applied pipe joint sealer.

Rubber ring gaskets shall be installed to form a flexible, leak-resistant seal. Where oakum is used to seal joints, the joint shall be caulked with this material and then sealed with mortar or joint compound.

(2) **Flexible pipe:** Flexible pipe sections shall be aligned and firmly joined by approved coupling bands to form a leak-resistant joint.

e. **Structural plate pipe, pipe arches, and arches:**

Erection shall be in accordance with the manufacturer's assembly diagrams and instruction sheets. Splices in the haunch areas of structural plate pipe arches shall be constructed using the reverse shingle method or the side plates shall be provided without longitudinal seams in the haunch areas. The complete line shall be assembled before backfill is placed. Bolts shall be tightened to a torque of 150 to 250 foot-pounds. If spiraling occurs during installation, the Contractor shall loosen the bolts and adjust the pipe assembly to the correct position before retightening the bolts.

f. **Arch substructures:**

Each side of an arch shall rest in a groove formed into the masonry or on a galvanized angle or channel securely anchored to or embedded in the substructure. Where the span of the arch is more than 15 feet or the skew angle is more than 20 degrees, a metal bearing surface having a width at least equal to the depth of the pipe's corrugation shall be provided.

Metal bearings for arches shall be cold-formed galvanized channel conforming to ASTM A 569 being at least 3/16 inch thick, with the horizontal leg securely anchored to the substructure at points spaced on centers of not more than 24 inches. When the metal bearing is not embedded in a groove in the substructure, one vertical leg shall be punched to allow bolting to the bottom row of plates.

g. **Backfilling:** Class I backfill material shall be crusher run aggregate size No. 25 or 26, aggregate base material size 21A or 21B, flowable fill, conforming to Sections 205, 208 or 249 respectively, or crushed glass conforming to the size requirements for crusher run aggregate size 25 and 26.

Regular backfill material outside the neat lines of the Class I backfill areas shown on the Road and Bridge Standard PB-1 drawings shall be regular excavation conforming to Section 303. Regular and classified backfill shall be placed in uniform layers not more than 6 inches thick, loose measurement, before compaction. Each layer of Class I and regular backfill material shall be thoroughly compacted as specified in Section 303.04(g) with the exception that Class I backfill material shall be placed and compacted at a moisture content of optimum to plus 2 percentage points of optimum. Class I backfill material shall be thoroughly compacted under the haunches of pipe culverts. Each layer of Class I and regular backfill material shall be compacted by rolling, tamping with mechanical rammers, or hand tamping with heavy metal tampers having a face area of at least 25 square inches. If the Contractor uses vibratory rollers in the backfill operations, vibratory motors shall not be activated until at least 3 feet of backfill material has been placed and compacted over the pipe. Backfill and compaction efforts shall be advanced simultaneously on both sides of the pipe. The fill above the top of the regular backfill shall be installed and completed as specified for embankment construction unless the induced trench method of installation is used.

Field density determinations will be performed in accordance with AASHTO T310 and VTM-10 modified to include material sizes used in the laboratory determination of density, with a portable nuclear moisture-density gauge or by other approved methods. When a nuclear gauge is used, density determinations for backfill material will be related to the density of the same material tested in accordance with VTM-1 or VTM-12. When using the nuclear gauge on dense-graded aggregate material used

as backfill, minimum required densities shall be as listed in Table 1 of VTM-10; when using other approved methods of density determination, minimum required densities shall be as referred to in this section.

Concrete pipe with a height of cover greater than that shown for Class V in the Road and Bridge Standard PC-1 drawings shall be special design pipe with Method A bedding and backfill in accordance with Standard PB-1 details.

The Engineer will not permit puddling in backfilling operations. The Contractor shall not place rock more than 2 inches in its greatest dimension within 12 inches of pipe.

3. **Tunneling operations:** The jacked tunneling method shall be applicable for installing concrete pipe 30 through 108 inches in diameter and smooth-wall steel pipe 30 through 48 inches in diameter. The Contractor shall perform tunneling operations in accord with the following requirements where the plans specifically identify tunneling as the means of pipe installation:

The tunnel shall be excavated in such a manner and to such dimensions that shall permit placing of the proper supports necessary to protect the excavation. The Contractor shall take the proper precautions to avoid excavating earth, rock or shattering rock beyond the limits of excavation necessary for the safe and proper installation of the pipe. Damage from excavating and blasting, either to surface or subsurface structures, shall be repaired, or replaced by the Contractor at the Contractor's own expense. The Contractor shall make adequate provisions as required by law or applicable jurisdictional regulations for the safety and health of the workers required by the work being performed.

No pipe shall be placed until the foundation is in a condition satisfactory to the Engineer. Tunnel dimensions shown on the plans are minimum dimensions. Any excess excavation and subsequent backfill, concrete or grout fill shall be at the Contractor's expense. The Contractor shall install the pipe in the tunnel true to line and grade. If required by the plans or for safety, the Contractor shall use suitable steel or timber sheeting, shoring, and bracing to support the sides and roof of the excavation. Supports may be left in place provided they clear the encasement or carrier pipe. The Engineer will not authorize separate payment for supports left in place. Installation of the pipeline shall immediately follow tunneling excavation.

If indicated or specified in the Contract, the Contractor shall grout the entire void between the outside of the pipe and the tunnel walls or the inside face of the tunnel lining according to ASTM C 476 unless the permanent sheeting, bottom, sides, and roof of the tunnel are in a condition satisfactory to the Engineer. The minimum thickness of grout backfill shall be maintained throughout the length of the installation. Grout required for backfill in excess of the excavation tolerances specified herein shall be at the Contractor's expense.

Any pipe damaged during construction operations shall be repaired, if permitted by the Engineer, or removed and replaced by the Contractor at the Contractor's expense.

If corrugated galvanized metal pipe is used, joints may be made by field bolting or by connecting bands, whichever is feasible. When reinforced concrete pipe 24 inches and larger in diameter with tongue-and-groove joints is used for the encasement pipe, the interior joints for the full circumference of the pipe shall be sealed, packed with mortar, and finished smooth and even with the adjacent section of pipe.

(b) **Precast Drainage Structures:** Submittal of designs for precast items included in the Road and Bridge Standards will not be required provided fabrication is in accordance with the Standards. Submittal of designs for precast box culverts produced under the *VDOT Precast Concrete Quality Assurance Program* by a manufacturer on the Materials Division's Approved Products List 34 will not be required provided the Contractor submits a certification that the item shall be fabricated in accordance with the preapproved design drawings.

Requests for approval of a precast design shall include detailed plans and supporting computations that have been signed and sealed by a Professional Engineer having at least 5 years experience in structural design of precast structures or components proposed and licensed to practice engineering in the Commonwealth of Virginia. Unless otherwise specified, concrete exposed to freeze/thaw environments shall conform to Section 217.02 and shall have a minimum design compressive strength at 28 days of at least 4,000 pounds per square inch and an air content of 6 ± 2 percent. Concrete not exposed to freeze/thaw environments shall be exempt from the requirements of Section 217.02(a). The design of the concrete mixture and the method of casting, curing, handling, and erecting precast units shall be subject to review and acceptance by the Engineer. Precast units may be shipped after reaching 85 percent of the minimum design compressive strength as determined by control cylinders. Sampling and testing concrete strength shall be performed using control cylinders in accordance with ASTM C31 and C39 at a rate of one set of cylinders per lot. A set of cylinders is defined as three 4" x 8" cylinders or two 6" x 12" cylinders. A lot is defined as a maximum 250 cubic yards or a single week's production (whichever quantity is less) of precast concrete from each batching operation, being of like material, strength, and manufactured by the same process. Variations of lot definition will be governed by applicable specifications and approved by the Engineer. Control cylinders used for acceptance testing shall be cured under the same conditions as the concrete the cylinders represent. Units shall retain their structural integrity during shipment and shall be subject to inspection by the Engineer at the job site. Approval to use precast units shall not be construed as waiving the size and weight limitations specified in Section 107.21.

1. **Standard precast drainage units** shall conform to the material requirements of AASHTO M199 and the following:

   a. If the grade on the adjacent gutter is less than 1.5 percent, the grade on the invert of the throat section of the inlet shall be at least 1.5 percent. Precast throats having flat inverts will be permitted in sag locations provided the total length of the required throat opening does not exceed 6 feet.

   b. Pipe openings in precast drainage units shall not exceed the outside cross-sectional dimensions of the pipes by more than a total of 8 inches regardless of the placement of the pipes, the angles of intersection, or the shapes of the pipes. Pipe openings shall be formed, neatly drilled, or neatly cut.

   c. The Contractor shall use brick, masonry block, other standard masonry units, or sound local stone in conjunction with mortar to fill the void between the pipe culverts and the precast drainage structures. Stone or masonry units, areas of the pipe openings, and exterior walls of pipe shall be thoroughly wetted and then bonded with mortar by standard masonry practice in such a manner as to provide a contiguous durable masonry connection between the precast drainage structures and the pipe culverts. The remaining exterior and interior voids shall be filled with mortar and smoothly shaped to the contour of the precast structure.

d. When precast units are to be located adjacent to the subbase or base pavement course, the Contractor shall furnish units with chambers having weep holes 3 inches in diameter and hardware cloth. Weep holes shall be located to drain the subbase or base.

e. Precast units located adjacent to cast-in-place concrete items, such as flumes, ditches, and gutters shall be connected to the adjacent unit by means of No. 4 smooth steel dowels spaced on approximately 12-inch centers throughout the contact length and extending at least 4 inches into the precast unit and the cast-in-place item. If holes to receive the dowels are provided in the precast unit, they shall be not more than 5/8 inch in diameter. The Engineer must approve other methods of providing the connection, such as keyed joints prior to fabrication.

f. The chamber section shall be installed in the plumb position. The throat and top sections shall have positive restraints, such as adjacent concrete, pavement, or soil, on all sides to prevent displacement and shall have a positive interlock, such as dowels, with the chamber section. The throat and top sections shall be installed to conform to the normal slope of the finished grade and may be canted up to a maximum grade of 10 percent. The chamber may be built up to a maximum of 12 inches at any point to provide for complete and uniform bearing of the throat and top sections on the chamber flat slab top or other approved top section. The built-up section shall be constructed using whole concrete spacer units where feasible and partial and whole sections of concrete block or brick with high-strength grout and mortar. High-strength grout shall be used to provide the final grade adjustment and uniform bearing. The width of the built-up section shall match the wall thickness of the chamber section. The concrete block and brick shall be thoroughly bonded with mortar and the inside and outside of the built-up section shall be plastered with mortar except that the concrete spacer unit shall not be plastered.

2. **Precast arches** shall conform to the applicable requirements of current AASHTO *LRFD Bridge Design Specifications* and VDOT modifications (current VDOT I&IM-S&B-80) and the following modifications:

a. **Protection against corrosion:** The concrete cover of reinforcement shall be at least 1 1/2 inches.

Reinforcing steel for arches in 0 to 2 foot fills, in corrosive or marine environments, or in other severe exposure conditions shall be corrosion resistant reinforcing steel, Class I. When corrosion resistant reinforcing steel is required, the minimum cover specified shall not be reduced.

Exposed reinforcing bars, inserts, and plates intended for bonding with future extensions shall be protected from corrosion as directed by the Engineer.

Reinforcement shall be designed and detailed in consideration of fabrication and construction tolerances so that the minimum required cover and proper positioning of reinforcement shall be maintained.

b. **Anchorage:** Sufficient anchorage shall be provided at the terminus of lines of precast units. Anchorage may consist of a cast-in-place end section at least 3 feet in length with a headwall or collar around the precast unit(s) provided adequate connection can be made between the collar and units.

c. **Joints:** Joints between units shall be sealed by preformed neoprene seals, rubber gaskets, preformed flexible joint sealants or grout. When preformed flexible joint sealants, preformed seals, or gaskets are used, they shall be of a type listed on the Materials Division's Approved Products List 14.

d. **Pipe openings:** Pipe openings will not be allowed in the precast arch but may be provided through the wingwalls. When required, openings shall conform to (b)1.b. herein.

3. **Precast box culverts** shall conform to the applicable requirements of current AASHTO *LRFD Bridge Design Specifications* and VDOT modifications (current VDOT I & IM-S&B-80) and the following modifications:

a. Precast Box Culverts shall conform to the applicable material requirements of ASTM C1577. The design shall be a Special Design that need not conform to the reinforcing steel and geometry shown in the design tables and the appendix in ASTM C1577.

b. For protection against corrosion, the following minimum concrete cover shall be provided for reinforcement: For boxes with more than 2 feet of fill over the top slab: 1 1/2 inches. For boxes with less than 2 feet of fill over the top slab: top reinforcement of top slab: 2 1/2 inches; bottom reinforcement of top slab: 2 inches; all other reinforcement: 1 1/2 inches.

Reinforcing steel for arches in 0 to 2 foot fills, in corrosive or marine environments, or in other severe exposure conditions shall be corrosion resistant reinforcing steel, Class I. When corrosion resistant reinforcing steel is required, the minimum cover specified shall not be reduced.

c. The type of sealant or gasket used in joints between units shall be from the Materials Division's Approved Products List 14.

Where double or greater lines of precast units are used, a buffer zone of 3 to 6 inches between lines shall be provided. This buffer zone shall be backfilled with porous backfill conforming to Section 204. The porous backfill shall be drained by a 3-inch-diameter weep hole, formed by non-rigid tubing, located at the top of the bottom haunch, centered in the outlet end section and at approximately 50-foot intervals along the length of the box culvert. Weep holes shall be covered with a 3-foot-square section of filter barrier cloth firmly attached to the outside of the box. A 3-foot width of filter barrier cloth shall also be centered over the buffer zone for the entire length of the structure after placement of the porous backfill material. Filter barrier cloth shall conform to Section 245.

Forming weep holes and furnishing and placing of the filter barrier cloth shall be included in the price bid per linear foot for the precast box culvert.

d. At the terminus of precast units, sufficient anchorage shall be provided. This anchorage may consist of a cast-in-place end section at least 3 feet in length with a headwall and curtain wall or a collar cast-in-place around the units provided adequate connection can be made between the collar and the units.

When the ends of precast units are skewed, the end section shall be cast monolithically. The skew may be provided by forming, saw cutting, or other methods approved by the Engineer. Regardless of the method used, the variation in the precast unit from the exact skew shall be not greater than 1 1/2 inches at any point.

e. Pipe openings shall conform to 1.b. herein.

f. Bedding and backfill shall be in accordance with VDOT Road and Bridge Standard PB-1 for box culverts.

(c) **Drop Inlets, Manholes, Junction Boxes, Spring Boxes, Intake Boxes, and Endwalls:** Masonry construction shall not be initiated when the air temperature is below 40 degrees F in the shade.

The foundation shall be explored below the bottom of the excavation to determine the type and condition of the foundation. Foundation exploration shall extend to a depth equal to 1/2 inch per foot of fill height or 8 inches, whichever is greater. The Contractor shall report the findings of the foundation exploration to the Engineer for approval to proceed prior to placing structure.

Where the Engineer determines unsuitable foundation material is encountered at the established grade, such material shall be removed and replaced.

Backfill material for areas where unsuitable material has been removed shall be placed and compacted in accordance with Section 303.04(g).

Bedding material shall be placed in accordance with the Road and Bridge Standards, Standard DSB-1 drawing and shall be aggregate No. 25 or 26 conforming to Section 205 except where standing or running water is present in the foundation excavation. Bedding material shall be aggregate No. 57 for the depth specified on the plans or as directed by the Engineer capped with 4 inches of aggregate No. 25 or 26 when standing or running water is present. Where such conditions are discovered in the field and the Contractor is directed by the Engineer to use No. 57 stone, No. 57 stone will be paid for at the existing contract unit price or, if not in the Contract, in accordance with Section 109.05.

Bedding shall be lightly and uniformly compacted. The depth of bedding material shall be as specified on the Road and Bridge Standards, Standard DSB-1 drawings or in the plans.

Brick and concrete block masonry shall be placed so that each unit will be thoroughly bonded with mortar. Joints shall be full-mortar joints not more than 1/2 inch in width. Where brick masonry is used, headers and stretchers shall be arranged to fully bond the mass. Every seventh course shall be placed entirely with headers. Inside joints shall be neatly pointed, and the outside of such walls shall be plastered with mortar as they are placed.

Iron or steel fittings entering the masonry shall be placed as the work is built up, thoroughly bonded, and accurately spaced and aligned.

Inlet and outlet pipe connections shall conform to the same requirements as the pipe to which they connect and shall be of the same size and kind. Pipe sections shall be flush on the inside of the structure wall and shall project outside sufficiently for proper connection with the next pipe section. Masonry shall fit neatly and tightly around the pipe.

Immediately following finishing operations, hydraulic cement concrete shall be cured and protected in accordance with Section 316.04(j).

Backfilling shall be performed in accordance with Section 303.04(g). Surplus material shall be removed, and the site shall be left in a neat, clean, and orderly condition.

When grade adjustment of existing structures is specified, frames, covers, and gratings shall be removed and the walls shall be reconstructed as required. Cleaned frames shall be reset at the required elevation. Upon completion of the adjustment, each structure shall be cleaned of silt, debris, and foreign matter and shall be kept clear of such accumulation until final acceptance.

(d) **Post Installation Inspection:**

In addition to the visual inspection performed by the Department during the initial installation of storm sewer pipes and pipe culverts, a post installation visual/video camera inspection shall be conducted by the Contractor on all storm sewer pipe and a selected number of pipe culverts in accordance with this specification and VTM 123. Storm sewer pipe is defined as either a component of a storm sewer system as defined in Section 101.02 or any pipe identified on the plans as storm sewer pipe. All other pipe shall be considered pipe culverts. Post installation inspections shall be performed on straight line and radial installations.

A minimum of one pipe culvert installation for each size of each material type used on the project will be randomly selected by the Engineer for inspection; however, in no case will the amount of pipe subject to inspection be less than ten percent of the total contract amount for the size and material type indicated. Where the pipe or culvert's size, orientation, or location permit deflection to be easily visually identified, (as verified with the Engineer) the Contractor may perform visual inspections in lieu of video inspections. If defects as described herein are noted during the inspection, the Engineer may require additional pipe installations of that size and/or material be inspected. The Contractor shall coordinate and schedule all post installation inspections so that these are made in the presence of the Engineer. The post installation inspection shall be performed no sooner than 30 days after completion of the pipe installation and placement of final cover (except for pavement structure). The Contractor shall issue a report detailing all issues or deficiencies noted during the inspection (including a remediation plan for each deficiency noted where applicable) no later than 5 days after completion of the inspection.

The post installation inspection shall be performed prior to paving unless project scheduling dictates that a particular site be paved before the end of the 30 day period. In such cases, a preliminary inspection of the pipe shall be made prior to paving over it, to insure that the pipe has been properly installed and is performing well. Performing such a preliminary inspection prior to paving will not relieve the Contractor from the requirement to perform the post installation inspection after the 30 day period.

The Contractor's inspection report shall identify and address any of the following items observed during the post installation inspection including identifying any proposed remediation measures the Contractor plans to perform where applicable. Remediation measures may consist of repairing or replacing the defective pipe section(s) or a combination of the two where differing conditions exist within the same run of pipe. Where permitted as an option, remediation methods for the various installation defects shall be proposed by the Contractor, reviewed with the Engineer and must have the Engineer's approval prior to implementation of the corrective action. Remediation shall be the sole responsibility of the Contractor. Further, if remediation measures are shown to be necessary, any time associated with such measures

shall be reflected in the impact to the Contractor's progress schedule (may take the form of a time impact analysis, where required by the scheduling requirements) and will not relieve the Contractor of his responsibilities to finish the work required by the contract within the contract time limits or form the basis for any claim of delay where such remediation measures are determined to be a result of the Contractor's fault, omission or negligence.

Upon completion of any corrective remedial measures, the corrected installations are to be re-inspected prior to final acceptance of the project using the test methods identified in VTM 123.

The following criteria shall form the basis for inspections for the respective pipe or culvert types listed:

1. **All pipe and culvert types:**

   Misalignment: Vertical and horizontal alignment of the pipe culvert or storm drain pipe barrel shall be checked by sighting along the crown, invert and sides of the pipe, and by checking for sagging, faulting and invert heaving. Faulting is defined herein as differential settlement between joints of the pipe, creating a non-uniform profile of the pipe. The person assigned by the Contractor to perform the inspection should take into account pipe or culvert laid with a designed camber or grade change in accordance with Contract or site requirements. Horizontal alignment shall be checked for straightness or smooth curvature. Any issues involving incorrect horizontal and/or vertical alignment shall be noted in the inspection report. If any vertical and/or horizontal misalignment problems are visually noted by the Engineer or in the inspection report, a further evaluation will be conducted by the Engineer to determine the impact of the misalignment on the joints and wall of the pipe to ascertain what corrective actions are needed. All corrective actions determined necessary by the Engineer that are a result of the Contractor's negligence, omission or fault shall be the sole responsibility of the Contractor to remedy.

2. **Concrete Pipe\Culverts:**

   a. **Joints:** Leaking joints may be detected during low flows by visual observation of the joints or checking around the ends of pipes or culverts for evidence of piping or seepage.

      Differential movement, cracks, spalling, improper gasket placement, movement, or settlement of pipe\culvert sections, and leakage shall be noted by the Contractor in the report. Joint separation greater than one inch shall be remediated by the Contractor at his expense to the satisfaction of the Engineer. Evidence of soil migration through the joint will be further evaluated by the Engineer to determine the level of corrective action necessary.

   b. **Cracks:** Longitudinal cracks with a width less than one hundredth of an inch (0.01) are considered hairline and minor. They shall be noted in the inspection report; however, no remedial action is necessary.

      Longitudinal cracks having a width equal to or greater than one hundredth of an inch (0.01 but equal to or less than one tenth of an inch (0.1) and determined by the Engineer to be detrimental to the structure shall be sealed by a method proposed by the pipe\culvert manufacturer and approved by the Engineer. Pipes or culverts having

longitudinal cracks with widths greater than one tenth of an inch (0.1) and determined to be beyond the limits of a satisfactory structural repair shall be replaced by the Contractor to the satisfaction of the Engineer.

Pipes or culverts having displacement across the crack greater than 0.1 inch but less than 0.3 inch shall be remediated. Remediation methods shall be in accordance with recommendations of the pipe or culvert manufacturer, be acceptable to and authorized by the Engineer before implementation. Pipes\culverts having displacement across the crack greater than 0.3 inch shall be replaced by the Contractor at the Contractor's expense to the satisfaction of the Engineer.

Transverse cracks will be evaluated using the same criteria as indicated above for longitudinal cracks.

c. **Spalls:** Spalling is defined as a localized pop-out of concrete along the wall of the pipe\culvert (generally caused by corrosion of the steel reinforcement), or at the edges of longitudinal or circumferential cracks. Spalling may be detected by visual examination of the concrete along the edges of the crack. The person conducting the inspection shall check for possible delamination. If delamination is noted or if a hollow sound is produced when the area is tapped with a device such as a hammer, the pipe\culvert shall be remediated. Remediation methods shall be in accordance with recommendations of the pipe\culvert manufacturer, be acceptable to, and authorized by the Engineer before proceeding.

d. **Slabbing:** Any pipe\culvert experiencing slabbing shall be remediated. Slabbing is a structural failure of the pipe\culvert that results from radial or diagonal tension forces in the pipe\culvert. These failures appear as a separation of the concrete from the reinforcing steel near the crown or invert of the pipe\culvert and may span the entire length of a pipe or culvert section (joint to joint). Remediation methods shall be in accordance with recommendations of the pipe or culvert manufacturer, be acceptable to and authorized by the Engineer before proceeding, and shall be the sole responsibility of the Contractor. Where slabbing is of such magnitude that, in the opinion of the Engineer, the integrity or service life of the pipe or culvert is severely compromised, the section(s) of pipe or culvert exhibiting such deficiency shall be replaced by the Contractor at the Contractor's expense, to the satisfaction of the Engineer.

3. **Thermoplastic Pipe\Culvert:**

a. **Cracks:** Cracks or splits in the interior wall of the pipe shall be remediated. Remediation methods shall be in accordance with recommendations of the pipe manufacturer, be acceptable to and authorized by the Engineer before proceeding.

b. **Joints:** Pipes\culverts showing evidence of crushing at the joints shall be remediated. Differential movement, improper joint sealing, movement, or settlement of pipe\culvert sections, and leakage shall be noted in the inspection report. Joint separation of greater than 1 inch shall be remediated. Evidence of soil migration through the joint will be further investigated by the Engineer to determine the level of remedial action required by the Contractor. Remediation methods shall be in accordance with recommendations of the pipe manufacturer, be acceptable to and authorized by the Engineer before proceeding.

c. **Buckling, bulging, and racking:** Flat spots or dents at the crown, sides or flow line of the pipe due to racking shall be noted in the inspection report and will be evaluated by the Engineer. Areas of wall buckling and bulging shall also be noted in the inspection report and evaluated by the Engineer for corrective action if deemed necessary by the Engineer. Corrective action, if necessary, shall be the responsibility of the Contractor.

d. **Deflection:** Any one of several methods may be used to measure deflection of thermoplastic pipe\culvert (laser profiler, mandrel, direct manual measure, etc.) If the initial inspection indicates the pipe\culvert has deflected 7.5 percent or more of its original diameter, and if the original inspection was performed using a video camera, then a mandrel test shall also be performed in accordance with VTM 123. All deflections shall be noted in the inspection report. Deflections of less than 5 percent of the original pipe\culvert's diameter will not require remediation. Deflection of 5 percent up to 7.4 percent will be evaluated by the Engineer. If the pipe\culvert experiences additional defects along with deflection of 5 percent up to 7.4 percent of the original pipe\culvert's diameter, the pipe\culvert shall be remediated. Remediation methods shall be in accordance with recommendations of the pipe\culvert manufacturer, be acceptable to and authorized by the Engineer before proceeding.

If the pipe\culvert is deflected 7.5 percent or greater of the original diameter, the pipe\culvert shall be replaced by the Contractor to the satisfaction of the Engineer.

In lieu of the options noted above for remediation of deflection in thermoplastic pipe\culvert installations, the Contractor may elect to follow the payment schedule below:

Amont of Deflection	Percent of Payment
0.0 % to 5.0%	100% of Unit Bid Price
5.1% to 7.5%	75% of Unit Bid Price
Greater than 7.5%	Remove and Replace at Contractor's Expense

Remediation efforts and payment shall apply to the entire section(s) of the deflected pipe or culvert, joint to joint.

4. **Metal Pipe\Culvert:**

a. **Buckling, bulging, and racking:** Flat spots or dents at the crown, sides or flow line of the pipe due to racking shall be noted by the Contractor's inspector in the inspection report and will be evaluated by the Engineer for possible remediation by the Contractor. Areas of wall buckling and bulging shall also be noted in the inspection report and evaluated by the Engineer for possible remediation by the Contractor. If the Engineer determines corrective actions are necessary, they shall be in accordance with the pipe\culvert manufacturer's recommendations, be acceptable to and authorized by the Engineer prior to implementation.

b. **Joints:** Pipes showing evidence of crushing at the joints shall be remediated. Differential movement, improper joint sealing, movement, or settlement of pipe sections, and leakage shall be noted in the report. Joint separation of greater than 1.0 inch shall be remediated. Evidence of soil migration through the joint will be further investigated by the Engineer to determine the level of remedial action required by the Contractor.

c. **Coating:** Areas of the pipe where the original coating has been scratched, scoured, or peeled shall be noted in the inspection report and evaluated by the Engineer to determine the need for immediate repair. If repairs are required, they shall be performed by Contractor in accordance with the recommendations of the pipe\culvert coating manufacturer.

d. **Deflection:** Any one of several methods may be used to measure deflection of metal pipe\culvert (laser profiler, mandrel, direct manual measure, etc.) If the initial inspection indicates the pipe\culvert has deflected 7.5 percent or more of its original diameter, and if the original inspection was performed using a video camera, then a mandrel test shall also be performed in accordance with VTM 123. All deflections shall be noted in the inspection report. Deflections of less than 5 percent of the original pipe\culvert's diameter will not require remediation. Deflection of 5 percent up to 7.4 percent will be evaluated by the Engineer. If the pipe\culvert has experienced additional defects along with deflection of 5 percent up to 7.4 percent of the original pipe\culvert's diameter, the pipe\culvert shall be remediated. Remediation methods shall be in accordance with recommendations of the pipe\culvert manufacturer and be acceptable to and authorized by the Engineer before proceeding.

If the pipe\culvert is deflected 7.5 percent or greater of the original diameter, the pipe shall be replaced by the Contractor to the satisfaction of the Engineer.

In lieu of the options noted above for remediation of metal pipe\culvert, the Contractor may elect to follow the payment schedule below:

Amont of Deflection	Percent of Payment
0.0 % to 5.0%	100% of Unit Bid Price
5.1% to 7.5%	75% of Unit Bid Price
Greater than 7.5%	Remove and Replace at Contractor's Expense

Remediation efforts and percentage of payment shall apply to the entire section(s) of the deflected pipe or culvert, joint to joint.

302.04—Measurement and Payment

Pipe culverts will be measured in linear feet. The quantity will be determined by counting the number of sections and multiplying by the length of the section used. When a partial section is required, the actual length of the partial section will be measured in place.

Structural plate pipe and pipe arches will be measured in linear feet along the invert line.

Pipe tees and elbows will be measured in linear feet of pipe.

Pipe reducers will be measured in linear feet of pipe for payment at the larger pipe size.

Pipe will be paid for at the contract unit price per linear foot. This price shall include excavating, when not paid for as minor structure excavation; sheeting; shoring; dewatering; disposing of surplus and unsuitable material; removing and disposing of existing drainage structures; and restoring existing surfaces. The upper 4 inches of bedding material and the Class I backfill material within the neat lines shown for each foundation type on the Standard PB-1 drawings shall be included in the price for the related pipe.

When unit prices for extended pipelines are not specified, the unit price for new pipe of the same size shall apply. When not a pay item, the cost of temporary stream relocation to facilitate the installation of the pipe shall be included in the price for the pipe. The cost of fittings, anti-seepage collars, and anchor blocks shall be included in the price for the pipe.

Jacked and bored pipe will be measured in linear feet to the nearest 1/10 of a foot along the centerline of the completed jacked and bored pipe for the size indicated, and will be paid for at the contract unit price per linear foot. This price shall include excavating and backfilling jacking and receiving pits, sheeting, shoring, bracing, jacking equipment, casing pipe, casing chocks, furnishing and installing carrier pipe, grout to install carrier pipe, drainage, safety equipment, and all other items necessary for this operation.

Tunneled pipe will be measured in linear feet to the nearest 1/10 of a foot along the centerline of completed tunnel for the size of lining indicated and will be paid for at the contract unit price per linear foot. This item shall include equipment, materials, handling and disposal of all materials encountered, drainage, pumping and dewatering, tunnel support, lining, furnishing and installing pipe, grouting, ventilation, lighting and wiring, coordination and planning with the railroad or other specified entity, and all other appurtenances necessary to complete the work.

Reinstalled pipe will be measured in linear feet along a line parallel to the flow line and will be paid for at the contract unit price per linear foot of pipe. This price shall include excavation, when not paid for as minor structure excavation involved in removing pipe, hauling, cleaning, relaying, backfilling, necessary cutting for joining to other sections of pipe, furnishing and installing new coupling bands, joint sealer, etc.; disposing of surplus excavation, and replacing any otherwise usable sections damaged or broken because of the negligence of the Contractor. This price shall also include sheeting; shoring; dewatering; and restoring existing surfaces.

End sections and pipe spillouts will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each.

Endwalls and arch substructures will be measured in cubic yards of concrete and pounds of reinforcing steel except that EW-12 endwalls will be measured in units of each, complete-in-place. Endwalls and arch substructures will be paid for at the contract unit price per cubic yard of miscellaneous concrete and per pound of reinforcing steel except that crack control bars shall be included in the price bid for miscellaneous concrete and Standard EW-12 endwalls will be paid for at the contract unit price per each.

Minor structure excavation will be measured and paid for in accordance with Section 303.06.

Cast-in-place box culverts will be measured in cubic yards of concrete and pounds of reinforcing steel and will be paid for at the contract unit price per cubic yard of concrete and per pound of reinforcing steel. These prices shall include excavating, sheeting, shoring, dewatering, waterproofing, disposing of surplus and unsuitable material, restoring existing surfaces, the upper 6 inches of bedding material within the neat lines shown on the Standard PB-1 drawings, and all necessary work to key the bottom slab into an existing rock foundation. When not a pay item the cost of temporary stream relocation to facilitate the installation of the structure shall be included in the price for the concrete and steel.

If the Contractor elects to furnish and install precast box culverts or precast arches instead of cast-in-place box culverts, payment will be made for the original quantities shown on the plans for cast-in-place units. No additional compensation will be made for casting, prestressing, or shipping precast units or performing additional work, such as waterproofing, epoxy coating, or joint sealing, required as a result of the substitution.

Precast box culverts will be measured in linear feet along the centerline of the barrel from face of curtain wall to face of curtain wall and will be paid for at the contract unit price per linear foot, unless they are substituting for cast-in-place box culverts. In the event precast box culverts are substituted for cast-in-place box culverts, payment will be made at the contract unit price per cubic yard of concrete and per pound of reinforcing steel for the cast-in-place box culvert plan quantities. This price shall include designing, casting, reinforcing, excavating, sheeting, shoring, dewatering, installing, waterproofing, sealing joints, anchoring, disposing of surplus and unsuitable material, restoring existing surfaces, the upper 6 inches of bedding material within the neat lines shown on the Standard PB-1 drawings, fittings, and providing buffer zones and porous backfill for multiple lines. When not a pay item the cost of temporary stream relocation to facilitate the installation of the structure shall be included in the price for the box culvert.

Grates and frames will be measured in units of each and will be paid for at the contract unit price per each.

Pipe grate will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include fabricating, furnishing, galvanizing, and installing.

Drop inlets and intake boxes will be measured as complete units, including the frame and grate or cover, and will be paid for at the contract unit price per each. The contract unit price for drop inlets will be adjusted at the rate of 5 percent per foot for increases or decreases in the depth indicated on the plans except that no adjustment will be made for changes amounting to less than 6 inches in the height of a single drop inlet. Where curb or curb and gutter extend along the drop inlet, the contract unit price for drop inlets shall include that part of the curb or gutter within the limits of the structure. Bedding material, except aggregate No. 57, will be included in the price of the structure.

Base sections of pipe tee units used as drop inlets and manholes will be measured in linear feet horizontally and will be paid for at the contract unit price per linear foot of pipe specified. The riser section and additional costs for the tee shall be included in the price for the drop inlet or manhole.

Manholes will be measured in linear feet, vertical measure, from top of foundation slab to top of masonry on which the casting frame is placed. However, when manholes are constructed as tee sections, measurement will be made to the pay limits shown on the plans. Manholes will be paid for at the contract unit price per vertical linear foot exclusive of frame and cover. Bedding material, except aggregate No. 57, shall be included in the unit price per foot for the manhole.

Concrete spring boxes will be measured in cubic yards of concrete, pounds of reinforcing steel, and linear feet of pipe and will be paid for at the contract unit price per cubic yard of concrete, per pound of reinforcing steel, and per linear foot of pipe.

Junction boxes will be measured in cubic yards of concrete and pounds of reinforcing steel, pounds of structural steel, and each complete frame and cover assembly and will be paid for at the contract unit price per cubic yard of concrete and per pound of reinforcing steel, per pound of structural steel, and per each frame and cover assembly. Bedding material, except aggregate No. 57, shall be included in the price of the structure.

Casting frames and covers will be measured in units of one complete frame and cover and will be paid for at the contract unit price per each.

Reconstructed manholes will be measured as a complete unit and will be paid for at the contract unit price per each.

Precast arches will be measured in linear feet along the centerline of the invert from face of headwall to face of headwall. When a pay item, precast arches will be paid for at the contract unit price per linear foot. This price shall include designing, forming, casting, reinforcing, excavating, wingwalls, installing, waterproofing, sealing joints, anchoring and bedding, and providing buffer zones for multiple lines. The cost for cast-in-place work other than that specified on the plans shall be included in the price for precast arches.

Epoxy-coated reinforcing steel, when a pay item, will be measured in pounds of uncoated steel and will be paid for at the contract unit price per pound. The weight will be computed from the theoretical weights of the nominal sizes of steel specified and placed in the structure. Measurement will not be made for epoxy-coating material. This price shall include furnishing steel and epoxy-coating material; applying coating material; fabricating, shipping, and placing epoxy-coated reinforcement in the structure; and necessary repairing of epoxy coatings.

Temporary diversion channel lining will be measured in square yards for the class specified and will be paid for at the contract unit price per square yard. This price shall include installing the channel lining and removal when no longer required.

Temporary diversion channel excavation will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. This price shall include excavation, temporary pipe culverts, removal of pipe culverts when no longer required, backfilling, and site restoration including regrading and seeding.

Excavation, backfill, and disposal of unsuitable or surplus material for drop inlets, intake boxes, manholes both new and reconstructed, spring boxes, junction boxes, and base sections of pipe tee units used as drop inlets and manholes will not be measured for separate payment, and the cost thereof shall be included in the bid price for such items. In the event steps or invert shaping is required, the cost thereof shall also be included in the price for such items.

Storm water management drainage structure will be measured in linear feet, vertical measure, from top of concrete foundation to the top of the concrete cover. The price bid shall include Class A3 concrete; reinforcing steel; trash rack; debris rack; orifice; steps; steel plate; and, when required, polyethylene tubing, pipe hangers, and steel pipe.

Temporary sediment riser pipe will be measured in linear feet for the size specified and will be paid for at the contract unit price per linear foot. The price shall include the riser pipe, steel plate, perforated pipe, debris rack, orifice and Class A1 riprap, and anti-vortex device when required.

Storm water management dam will be measured in cubic yards of concrete and pounds of reinforcing steel and will be paid for at the contract unit price per cubic yard of concrete and per pound of reinforcing steel.

Post installation inspection will be included in the contract unit price per linear foot of pipe. Post-Installation Inspection shall include performing visual and video camera inspection(s), preparing and furnishing documentation to include narratives and video media in accordance with the requirements herein and VTM 123.

The cost of the remedial measures (including removal and replacement of the pipe, if necessary) and the re-inspection of the remediated pipe necessitated as a result of the Contractor's negligence, omission, or fault shall be the contractual and financial responsibility of the Contractor.

Payment will be made under:

Pay Item	Pay Unit
Pipe (Size and type)	Linear foot
Structural plate arch (Size)	Linear foot
Jacked and bored pipe (Size)	Linear foot
Tunneled pipe (Size)	Linear foot
Reinstalled pipe	Linear foot
End section (Standard and size)	Each
Pipe spillout (Standard)	Each
Concrete (Class)	Cubic yard
Reinforcing steel	Pound
Endwall grate and frame (Standard)	Each
Precast box culvert (Size)	Linear foot
Endwall pipe grate (Type)	Linear foot
Drop inlet (Standard and length)	Each
Intake box (Standard)	Each
Structural steel (Type)	Pound
Manhole (Standard)	Linear foot
Frame and cover (Standard)	Each
Reconstructed manhole	Each
Precast arch (Size)	Linear foot
Epoxy-coated reinforcing steel	Pound
Temporary diversion channel lining (Class)	Square yard
Temporary diversion channel excavation	Cubic yard
Endwall, Standard EW-12	Each
Storm water management drainage structure (Type)	Linear foot
Temporary sediment riser pipe (Size)	Linear foot

SECTION 303—EARTHWORK

303.01—Description

This work shall consist of constructing roadway earthwork in accordance with these specifications and in conformity with the specified tolerances for the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer. Earthwork shall include regular, borrow, undercut, and minor structure excavations; constructing embankments; disposing of surplus and unsuitable material; shaping; compaction; sloping; dressing; and installing and maintaining temporary erosion and siltation control work while performing these operations.

303.02—Materials

(a) **Borrow excavation** shall consist of approved material required for the construction of the roadway and shall be obtained from approved sources outside the project limits. Borrow excavation shall conform to AASHTO M57 and the requirements herein.

(b) **Materials for temporary silt fences, geotextile fabric silt barriers, and filter barriers** shall conform to Sections 242.02(c) and 245.03(a).

(c) **Geotextile materials used for embankment stabilization** shall conform to Section 245.03(e).

(d) **Mulches for seeding and erosion control** shall conform to Section 244.02(g) and (k).

(e) **Seed** shall conform to Section 244.02(c).

303.03—Erosion and Siltation Control and Stormwater Pollution Prevention

The Contractor shall control erosion, siltation, and stormwater pollution through the use of the temporary devices and methods specified herein or as is otherwise necessary. The Engineer reserves the right to require other temporary measures not specifically described herein to correct an erosion, siltation or pollution condition.

Erosion, siltation control, and pollution prevention devices and measures shall be maintained in a functional condition at all times. Temporary and permanent erosion and siltation control and pollution prevention measures shall be inspected in accordance with Section 107.16(e). The Contractor shall make a daily review of the location of all erosion, siltation control and pollution prevention measures to ensure that they are properly located for effectiveness. Where deficiencies exist, corrections shall be made immediately as approved or directed by the Engineer.

When erosion and siltation control devices function by using wet storage, sediments shall be removed when the wet storage volume has been reduced by 50 percent. Sediments shall be removed from dewatering basins when the excavated volume has been reduced by 50 percent. Sediments shall be removed from all other erosion and siltation control devices when capacity, height, or depth has been reduced by 50 percent. Removed sediment shall be properly disposed of in accordance with Section 106.04. Sediment deposits remaining in place after the device is no longer required shall be removed or dressed to conform to the existing grade, then prepared and seeded in accordance with Section 603.

Geotextile fabric that has decomposed or has become ineffective and is still needed shall be replaced. Temporary erosion and sediment control devices except brush silt barriers shall be removed within 30 days after final site stabilization or after the temporary devices are no longer needed as determined by the Engineer.

(a) **Earth Berms and Slope Drains:** The top of earthwork shall be shaped to permit runoff of rainwater. Temporary earth berms shall be constructed and compacted along the top edges of embankments to intercept runoff water. Temporary Berms and temporary dikes are to be stabilized immediately following installation. Temporary slope drains shall be provided to intercept runoff and adequately secured to prevent movement. Slope drains may be flexible or rigid but shall be capable of being readily shortened or extended. A portable flume shall be provided at the entrance to temporary slope drains.

(b) **Soil Stabilization:** Soil stabilization shall be initiated on any portion of the project where clearing, grading, excavation or other land disturbing activities have permanently ceased or where land disturbing activities have been temporarily suspended for an anticipated duration of greater than 14 days, or upon completion of grading operations for a specific area. Soil stabilization shall begin as soon as practicable, but not later than the next business day (Monday through Friday excluding State holidays) following the day when land disturbing activities temporarily or permanently ceased. Initiation of stabilization activities include, but is not limited to 1) prepping the soil for vegetative or non-vegetative stabilization, 2) applying mulches or other non-vegetative products to exposed soil, 3) seeding or planting the exposed area

4) starting any of the above activities on a portion of the area to be stabilized but not on the entire area or 5) finalizing arrangements to have the stabilization product fully installed within the time frame for completing stabilization. Temporary or permanent soil stabilization shall be completed within 7 days after initiation. Areas excluded from this requirement include areas within 100 feet of the limits of ordinary high water or a delineated wetland, which shall be continuously prosecuted until completed and stabilized immediately upon completion of the work in each impacted area. Soil stabilization includes: temporary and permanent seeding, riprap, aggregate, sod, mulching, and soil stabilization blankets and matting in conjunction with seeding. The applicable type of soil stabilization shall depend upon the location of areas requiring stabilization, time of year (season), weather conditions, and stage of construction operations.

Cut and fill slopes shall be shaped and topsoiled where specified. Seed and mulch shall be applied in accordance with Section 603 as the work progresses in the following sequence:

1. Slopes whose vertical height is 20 feet or greater shall be seeded in three equal increments of height. Slopes whose vertical height is more than 75 feet shall be seeded in 25-foot increments.

2. Slopes whose vertical height is less than 20 but more than 5 feet shall be seeded in two equal increments.

3. Slopes whose vertical height is 5 feet or less may be seeded in one operation.

   Areas that cannot be seeded because of seasonal or adverse weather conditions shall be mulched to provide some protection against erosion to the soil surface. Mulch shall be applied in accordance with Section 603.03(e) and paid for in accordance with Section 603.04. Organic mulch shall be used and the area then seeded as soon as weather or seasonal conditions permit in accordance with Section 603.03. Organic mulches include: straw or hay, hydraulic erosion control products, and rolled erosion controlled products conforming to Section 244.02(g) and (k).

(c) **Check Dams:** As an initial item of work, required check dams shall be constructed at 25-foot intervals below the outfall end of drainage structures unless otherwise shown on the plans.

Synthetic check dams recorded in the Department's Approved List No. 53 may be substituted for Standard EC-4, Rock Check Dams, Type II, with the approval of the Engineer at no additional cost to the Department. Synthetic check dams shall be installed in accordance with the manufacturer's instructions.

(d) **Baled Straw Silt Barriers:** Baled straw silt barriers may be substituted for temporary filter barriers with the approval of the Engineer in noncritical areas, such as pavement areas and rock locations where filter barriers cannot be installed in accordance with the plans and specifications, and locations where the Engineer determines that streams and water beds will not be affected.

(e) **Temporary Silt Fences, Geotextile Fabric Silt Barriers, and Filter Barriers:**

1. **Temporary silt fences:** Silt fences will be specified by type and shall be erected at locations shown on the plans or as determined by the Engineer. Posts shall be driven no less than 24 inches into the ground uniformly installed with an inclination toward the

potential silt load area of at least 2 degrees but not more than 20 degrees. Geotextile fabric used for silt fences shall be provided and erected at a height of 24 inches above original ground. The bottom of the fabric shall be entrenched in the ground 12 inches (6 inches vertically and 6 inches horizontally) in a minimum 6-inch by 6-inch trench. Silt fence may also be entrenched using a slicing method with a minimum of 8 inches sliced into the ground. A continuous roll of fabric cut to the length of the silt fence is preferred to avoid the use of joints. When joints are unavoidable, fabric shall be spliced together only at a support post, with a minimum 6-inch overlap, and securely sealed by double folding ends together. Attaching fabric to existing trees will not be permitted.

a. **Type A** silt fence usage is limited to a fill height of 20 feet or less. Posts shall not be spaced more than 6 feet apart and shall have a finished height no less than 6 inches above the fabric. Fabric shall be firmly secured to the post. The top shall be installed with a 1-inch tuck or reinforced top end section.

b. **Type B** silt fence is required for fill heights greater than 20 feet. Posts shall not be spaced more than 10 feet apart and shall have a finished height no less than 6 inches above the wire fence. In addition to geotextile fabric, wire fence used for silt fences shall be provided and erected at a height of 30 inches above original ground. Wire fence shall be fastened securely to the post with wire ties and embedded no less than 2 inches in the ground. Fabric shall be firmly secured to the post and wire fence. Attachments to the wire fence shall be made with ties spaced every 24 inches horizontally at both the top and vertical midpoint of the fabric.

Two rows of Type A silt fence erected parallel, three to five feet apart, may be used as an alternative to temporary Type B silt fence unless prohibited elsewhere in the Contract.

2. **Geotextile fabric silt barriers:** Existing fences or brush barriers used along the downhill side of the toe of fills shall have geotextile fabric attached at specified locations as shown on the plans. The bottom of the fabric shall be entrenched in the ground in a minimum 6-inch by 6-inch trench and the top shall be installed with a 1-inch tuck or reinforced top end section. Temporary fabric silt barriers may also be entrenched using a slicing method with a minimum of 8 inches sliced into the ground.

   Brush barriers shall be installed prior to any major earth-disturbing activity and trimmed sufficiently to prevent tearing or puncturing fabric. Fabric shall be fastened securely to the brush barrier or existing fence. A 6-inch overlap of fabric for vertical and horizontal splicing shall be maintained and tightly sealed.

3. **Temporary filter barriers:** Barriers shall consist of geotextile fabric and shall be securely fastened to wood or metal supports that are spaced at not more than 3-foot intervals and driven at least 12 inches into the ground. At least three supports shall be used. The bottom of the fabric shall be entrenched in the existing ground in a minimum 4-inch by 4-inch trench.

   Temporary filter barriers may also be entrenched using a slicing method with a minimum of 6 inches sliced into the ground. The top of the fabric shall be installed with a 1-inch tuck or reinforced top end section. The height of the finished temporary filter barrier shall be a nominal 15 inches.

Temporary filter barriers shall be installed at temporary locations where construction changes the earth contour and drainage runoff as directed or approved by the Engineer.

After removal and disposal of the temporary silt fence, geotextile fabric silt barrier, and temporary filter barrier, the area shall be dressed and stabilized with a permanent vegetative cover or other approved permanent stabilization practice approved by the Engineer.

(f) **Sediment Traps and Sediment Basins:** Once a sediment trap or basin is constructed, the dam and all outfall areas shall be immediately stabilized.

(g) **Erosion Control Mulch:** This work shall consist of furnishing and applying mulch used as slope protection (hydraulic mulch used for seeding or used as a temporary erosion control treatment) on slopes exposed to the elements but not at final grade during the period from December 1 to March 1 for periods of up to 30 days prior to final grading or to areas to receive stabilization or paved surfaces within 6 months in accordance with this provision and as directed by the Engineer. Hydraulic mulch used for slope protection during such periods of seasonal or adverse weather shall be applied without seed.

Mulch shall be applied to exposed slopes requiring mulch or to areas to be stabilized or paved within 48 hours after performance of grading operations in accordance with Section 603.03(f).

(h) **Temporary Diversion Dike:** This work shall consist of constructing temporary diversion dikes at the locations designated on the plans and in accordance with the plan details and the Specifications, stabilizing dikes with seed and mulch, maintaining, removing when no longer required, and restoration of the area.

Temporary diversion dikes shall be installed as a first step in land-disturbing activities and shall be functional prior to upslope land disturbance. The dike shall be constructed to prevent failure in accordance with Section 303.04. Seeding and mulch shall be applied to the dike in accordance with Section 603 immediately following its construction. The dikes should be located to minimize damages by construction operations and traffic.

The Contractor shall inspect the temporary diversion dikes after every storm and make repairs to the dike, flow channel, outlet, or sediment trapping facility, as necessary. Once every two weeks, whether a storm event has occurred or not, the dikes shall be inspected and repairs made if needed. Damages to the dikes caused by construction traffic or other activity must be repaired before the end of the working day when the damage occurred.

(i) **Turbidity Curtain:** This work consists of installation, maintenance, and removal of a turbidity curtain, including all necessary cables, weights, and floats in accordance with this provision and in conformity with the lines, grades and details shown on the plans or established by the Engineer. The curtain shall be provided as a temporary measure to minimize the drift of suspended material during construction of the project.

Type I configuration shall be used in protected areas where there is no current and the area is sheltered from wind and waves or in areas where there may be small to moderate current running (up to 2 knots or 3.5 feet per second) and/or wind and wave action.

Type II configuration shall be used in areas where considerable current (up to 3 knots or 5 feet per second) may be present, where tidal action may be present and/or where the curtain is potentially subject to wind and wave action.

The curtain shall be placed at the locations shown on the plans and in accordance with the approved working drawings. The Contractor shall maintain the turbidity curtain in order to insure the continuous protection of the waterway.

The curtain shall extend the entire depth of the watercourse whenever the watercourse is not subject to tidal action and/or significant wind/wave action.

In tidal and/or wind and wave action situations, the curtain shall never touch the bottom. A minimum 1-foot gap shall be established between the weighted lower end of the skirt and the bottom at the mean low water.

303.04—Procedures

Loose rock 3 inches or larger shall be removed from the surface of cut slopes.

When slides occur, the Contractor shall remove and dispose of material as directed by the Engineer.

Where required, surface ditches shall be placed at the top of cut slopes or at the foot of fill slopes and at such other points not necessarily confined to the right of way or shown on the plans and shall be of such dimensions and grades as directed by the Engineer.

Allaying dust, when specified, shall be performed in accordance with Section 511.

Prior to the beginning of grading operations in an area, necessary clearing and grubbing shall be performed in accordance with Section 301.02.

(a) **Regular Excavation:** Existing foundations and slabs located within the construction limits shall be removed and disposed of in a location approved by the Engineer. In lieu of removal, foundations and slabs located 5 feet or more below the proposed subgrade may be broken into pieces not more than 18 inches in any dimension and reoriented to break the shear plane and allow for drainage.

Cisterns, septic tanks, wells, and other such structures shall be cleared in accordance with Section 516.

Balance points shown on the plans are theoretical and may vary because of actual field conditions.

When the material to be excavated necessitates the use of explosives, Section 107.11 relating to the use of explosives shall apply. To prevent damage to newly constructed concrete, the Contractor shall schedule blasting operations in the proximity of proposed concrete structures so that work will be completed prior to placement of concrete.

Regular excavation shall consist of removing and disposing of material located within the project limits, including widening cuts and shaping slopes necessary for preparing the roadbed; removing root mat; stripping topsoil; cutting ditches, channels, waterways, and entrances; and performing other work incidental thereto. The Engineer may require materials in existing pavement structures to be salvaged for use in traffic maintenance.

Undrained areas shall not be left in the surface of the roadway. Grading operations shall be conducted so that material outside construction limits will not be disturbed.

Where rock or boulders are encountered, the Contractor shall excavate and backfill in accordance with the plans and the Contract.

When the presplitting method of excavation is specified for rock cuts, work shall be performed in a manner to produce a uniform plane of rupture in the rock and so that the resulting backslope face will be unaffected by subsequent blasting and excavation operations within the section. Rock shall be presplit along rock slopes at locations, lines, and inclinations shown on the plans or as determined by field conditions. A test section shall be provided to establish the spacing of drill holes and the proper blasting charge to be used in the presplitting operation. Drill holes shall be spaced not more than 3 feet apart and shall extend to the plan grade or in lifts of not more than 25 feet, whichever is less. If drilled in benches, an offset may accommodate the head of the drill, but no offset shall be more than 12 inches. Presplitting shall extend at least 20 feet ahead of the limits of fragmentation blasting within the section.

Where the project has been designed and slopes have been staked on the assumption that solid rock will be encountered, and the Contractor fails to encounter solid rock at the depth indicated, he shall cease excavation in the area and immediately notify the Engineer. If it is necessary to redesign and restake slopes, any additional excavation necessary will be paid for at the contract unit price per cubic yard.

Topsoil stockpiled for later use in the work shall be stored within the right of way unless the working area is such that the presence of the material would interfere with orderly prosecution of the work. Stockpile areas outside the right of way shall be located by the Contractor at his expense. Topsoil used in the work shall be removed first from stockpiles located on private property. Surplus topsoil remaining on private property after completion of topsoiling operations shall be moved onto the right of way and stockpiled, shaped, and seeded as directed by the Engineer.

Stripping topsoil shall be confined to the area over which grading is to be actively prosecuted within 14 calendar days following the stripping operation. Grading operations shall be confined to the minimum area necessary to accommodate the Contractor's equipment and work force engaged in the earth moving work.

(b) **Borrow Excavation:** The Contractor shall make his own arrangements for obtaining borrow and pay all costs involved in accordance with the provisions of Section 106.03.

If the Contractor places an excess of borrow and thereby causes a waste of regular excavation, the amount of such waste, unless authorized, will be deducted from the volume of borrow as measured at the source or computed by vehicle count as specified in Section 109.01.

When borrow is obtained from sources within the right of way and the excavation is performed simultaneously with regular excavation, borrow excavation will be designated as regular excavation. Material secured by widening cuts beyond slope stakes, when taken from previously excavated slopes, will be designated as borrow excavation. When such a procedure is approved, slopes shall be uniform and no steeper than shown on the plans.

Borrow excavation areas shall be bladed and left in a shape to permit accurate measurements after excavation has been completed.

CBR values stipulated for borrow excavation shall apply to the uppermost three feet of fill below the top of earthwork, as defined in Section 101. Borrow excavation installed below the

top three feet shall consist of suitable fill material, available from regular excavation or borrow excavation, as defined and of a quality consistent with Contract requirements.

(c) **Undercut Excavation:** Undercut excavation shall consist of removing and disposing of unsuitable material located within the construction limits in accordance with Section 303.06(a) 3.

Undercut excavation shall be disposed of in accordance with Section 106.04.

(d) **Minor Structure Excavation:** Minor structure excavation shall consist of removing material necessary to accommodate a structure, such as box or arch culverts, including pipe arches, structural plate arches, structural plate pipe, pipe culverts, and storm drains with a span(s) or opening(s) of 48 inches or greater. Minor structure excavation shall also include dewatering, sheeting, bracing, removing existing structures, and backfilling. Removing existing structures shall also include foundations that might be necessary to clear the site.

(e) **Removing Unsuitable Material:** Where excavation to the finished graded section results in a subgrade or slopes of unsuitable material, such material shall be excavated below the grade shown on the plans or as directed by the Engineer. Areas so excavated shall be backfilled with approved material in accordance with (f) herein.

Excavation for structures shall be carried to foundation materials satisfactory to the Engineer regardless of the elevation shown on the plans. If foundation material is rock, the Contractor shall expose solid rock and prepare it in horizontal beds for receiving the structure. Loose or disintegrated rock and thin strata shall be removed. Excavated material, if suitable, shall be used for backfilling around the structure or constructing embankments.

Material shown on the plans as unsuitable and during construction found to be suitable for use shall first be used in embankments where needed in lieu of borrow. However, the use of this material in lieu of borrow shall not alter the provisions of Section 104.02 regarding underruns.

Material shown on the plans as suitable material but found at time of construction to be unsuitable shall be disposed of as unsuitable material.

Unsuitable material shall be disposed of in accordance with Section 106.04.

(f) **Backfill for Replacing Undercut Excavation:** Backfill shall be composed of regular excavation, borrow, select material, subbase material, or other material as directed by the Engineer. Backfilling operations shall be performed in accordance with (g) herein.

(g) **Backfilling Openings Made for Structures:** Backfill shall be suitable material removed for the structure, although the Engineer may require that backfill material be obtained from a source within the construction limits entirely apart from the structure, or other approved material. The opening to be backfilled shall be dewatered prior to backfilling. Backfill shall not be placed against or over cast-in-place box culverts or other structures until the top concrete slab section(s) has been in place 14 days, exclusive of days on which the average high-low ambient temperature is below 40 degrees F in the shade or until the concrete control cylinder(s) has attained a compressive strength equal to 93 percent of the 28-day minimum design compressive strength.

Backfill shall be compacted in horizontal layers not more than 6 inches in thickness, loose measurement, and as specified in (h) herein. Backfill shall be placed in horizontal layers such

that there will be a horizontal berm of compacted undisturbed material behind the structure for a distance at least equal to the remaining height of the structure or wall to be backfilled. Backfill shall be placed in a manner to deter impoundment of water and facilitate existing drainage. Backfill around piers in areas not included in the roadway prism shall be constructed in uniformly compacted layers; however, density requirements will not be enforced.

Box culverts shall not be opened to construction equipment traffic until concrete has attained 100 percent of the 28-day design minimum compressive strength and has a backfill cover of at least 4.0 feet. The minimum height of backfill cover required to protect pipe culverts from construction equipment shall be in accordance with Standard Drawing PC-1 for the type and size specified.

Where only one side of abutments, wingwalls, piers, or culvert headwalls can be backfilled, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning or excessive pressure against the structure. When both sides of a concrete wall or box structure are to be backfilled, operations shall be conducted so that the backfill is always at approximately the same elevation on both sides of the structure.

Openings subject to flooding shall be backfilled as soon as practicable or as directed by the Engineer.

(h) **Embankments:** Work shall consist of constructing roadway embankments; placing and compacting approved material within roadway areas where unsuitable material has been removed; and placing and compacting approved material in holes, pits, utility trenches, basements, and other depressions within the roadway area.

Embankment shall be constructed with approved material and placed so as to be uniformly compacted throughout. Embankment shall be placed adjacent to structures in the same manner as for backfill as described in (g) herein. Embankment shall not contain muck, frozen material, roots, sod, or other deleterious material. Embankment shall not be placed on frozen ground or areas covered with ice or snow.

Unsuitable material used in widening embankments and flattening embankment slopes shall be placed in uniform layers not more than 18 inches in thickness before compaction. Each layer of material placed shall be compacted to the extent necessary to produce stable and reasonably even slopes.

Wherever rock excavation is available on the project, an 8 to 15-inch layer of such materials shall be dump spread over the lower region of embankments in the immediate vicinity of stream crossings and used to cover ditches, channels, and other drainage ways leading away from cuts and fills. However, drainage ways shall be prepared to receive the rock excavation to the extent necessary to avoid reducing their cross section. If rock excavation is not available on the project, rip-rap, jute mesh or soil retention mats shall be used as the covering material and shall be installed in accordance with Section 606.03(b). Limits of the area to be covered will be as noted on the plans or as directed by the Engineer.

Wherever sufficient right of way exists, surplus materials shall be used to widen embankments and flatten slopes as directed by the Engineer.

Rock excavation may be placed on slopes by uniform end dumping of the material from along the top of the embankment or as directed by the Engineer. Slopes that are covered with rock excavation shall not receive topsoil or seed.

When geotextile drainage fabric is required under rock fills, preparation shall be as specified in Section 245.

The Contractor shall schedule excavation and embankment work in a manner that will minimize the quantity of unsuitable material for which more than one handling is required prior to final placement. Therefore, the provisions for additional payment for each rehandling of material specified in Section 303.06(a) will not apply to placing unsuitable material for widening embankments and flattening embankment slopes.

The surface area directly beneath the pavement and shoulders on which embankments of less than 5 feet in depth are to be constructed shall be denuded of vegetation. These areas shall be scarified and compacted to a depth of 6 inches to the same degree as the material to be placed thereon.

Areas that contain material unsuitable as foundations for embankments shall be undercut and backfilled in accordance with (e) and (f) herein.

Embankments to be placed over saturated areas that will not support the weight of hauling equipment may be constructed by end dumping successive loads in a uniformly distributed layer of a thickness capable of supporting the hauling equipment while subsequent layers are placed. The nose, or leading edge, of the embankment shall be maintained in a wedge shape to facilitate mud displacement in a manner that will prevent its entrapment in the embankment. The front slope of the embankment shall be maintained steeper than 2:1. The use of compacting equipment will not be required on the original course. However, the remainder of the embankment shall be constructed in layers and compacted in accordance with these specifications.

When geotextile for embankment stabilization is required, it shall be placed as shown on the plans. Geotextile shall be spliced by sewing double-stitched seams with stitching spaced 1/4 inch to 1/2 inch apart or as shown on the plans.

Once geotextile for embankment stabilization is placed, the initial lift of material to be placed atop shall be free draining and shall be end dumped onto the geotextile and spread to the thickness as shown on the plans. Free-draining material shall be any material of which 15 percent or less passes the No. 200 sieve. If the geotextile becomes punctured or torn, the Contractor shall repair the area with geotextile lapped at least 3 feet all around the damaged area.

When embankment is to be placed and compacted on an existing unpaved road, the existing surface shall be scarified to such degree as will permit an ample bond between old and new material. Hydraulic cement concrete and asphalt concrete pavement structures within the proposed roadway prism shall be demolished in accordance with Section 508.02(a).

Existing slopes shall be continuously benched where embankments are constructed one-half width at a time; against slopes of existing embankments or hillsides; or across existing embankments, hillsides, and depressions at a skew angle of 30 degrees or more or the existing slopes are steeper than 4:1. For slopes steeper than 4:1 but not steeper than 1-1/2:1, the bench shall be at least 6 feet in width. For slopes steeper than 1-1/2:1 but less than 1/2:1, the bench

shall be at least 4 feet in width. Benching shall consist of a series of horizontal cuts beginning at the intersection with the original ground and continuing at each vertical intersection of the previous cut. Material removed during benching operations shall be placed and compacted as embankment material.

When excavated material consists predominantly of soil, embankment shall be placed in successive uniform layers not more than 8 inches in thickness before compaction over the entire roadbed area. Each layer shall be compacted within a tolerance of ±20 percent of optimum moisture content to a density of at least 95 percent of the theoretical maximum density as defined in Section 101.02.

Material having a moisture content above optimum by more than 30 percent shall not be placed on a previously placed layer for drying unless it is shown that the layer will not become saturated by downward migration of moisture in the material.

Field density determinations will be performed in accordance with AASHTO T310 and VTM-10, modified to include material sizes used in the laboratory determination of density, with a portable nuclear field density testing device or by other approved methods. When a nuclear device is used, density determinations for embankment material will be related to the density of the same material tested in accordance with VTM-1 or VTM-12 and a control strip will not be required.

As the compaction of each layer progresses, continuous leveling and manipulating shall be performed to ensure uniform density. Prior to placement of subsequent layers, construction equipment shall be routed uniformly over the entire surface of each layer or the layer shall be scarified to its full depth in the area where the equipment is routed.

When the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in layers of the thickness prescribed without crushing, pulverizing, or further breaking down the pieces resulting from excavation methods, such material may be placed in the embankment in layers that are not thicker than the approximate average size of the larger rocks. Rock not more than 4 feet in its greatest dimension may be placed in an embankment to within 10 feet of the subgrade. The remainder of the embankment to within 2 feet of the subgrade shall not contain rock more than 2 feet in its greatest dimension. Each layer shall be constructed so that rock voids are filled with rock spalls, rock fines, and earth. Rock shall be placed, manipulated, and compacted in uniform layers; however, density requirements may be waived. Rock, rock spalls, rock fines, and earth shall be distributed throughout each embankment layer and manipulated as specified herein so that the voids are filled. Rock shall not be end dumped over the edges of the layer being constructed but shall be deposited on the layer and moved ahead so as to advance the layer with a mixture of rock, rock spalls, rock fines, and earth. The 2 feet of the embankment immediately below the subgrade shall be composed of material that can be placed in layers of not more than 8 inches before compaction and compacted as specified herein for embankments. Rock more than 3 inches in its greatest dimension shall not be placed within 12 inches of the subgrade in any embankment.

Rock, broken concrete, or other solid materials shall not be placed in embankment areas where piling is to be placed or driven.

The best material shall be reserved for finishing and dressing the surface of embankments. Work necessary to ensure the reservation of such material shall be the responsibility of the Contractor. Section 303.06(a) will not apply to subsequent handling of capping material.

CBR values, stipulated for Embankment, shall apply to the uppermost three feet of fill below the top of earthwork, as defined in Section 101.02. Embankment, installed below the top three feet, shall consist of suitable fill material available from regular excavation; borrow excavation, or embankment as defined, and be of a quality consistent with Contract requirements.

Crushed glass shall be limited within the boundaries of the embankment as follows. Crushed glass shall be a minimum of two feet inside the side slope and contain a minimum of two feet of soil embankment cap. For those areas where crushed glass is to be incorporated into the embankment, glass may constitute up to approximately ninety (90) percent by weight of that portion of the embankment, except where 100 percent crushed glass is used for drainage purposes (including blankets).

Crushed glass shall be blended with soil and/or soil like materials as follows:

1. The embankment shall be constructed by placing alternate four-inch layers of waste glass and soil and mixing and blending by scarification or other approved methods during compaction. The thickness of uncompacted layers of soil/glass shall be a maximum of 8 inches (loose); or

2. Pugmilled in predetermined ratios to a visually consistent blend and placed in lifts of a maximum of 8 inches (loose); or

3. As directed by the Engineer.

Compaction of the soil/glass embankment shall be to the satisfaction of the Engineer and shall be accomplished with a vibratory compactor or other approved methods. Moisture and density requirements for the soil/glass embankments shall be the same as other conventional soil embankment in accordance with Section 303.

Normal compaction procedures and requirements are to be used for compaction of the soil embankment "cap" above the crushed glass/soil blends.

(i) **Settlement Plates and Surcharge:** The Contractor shall expedite construction of embankment to provide the maximum time possible for settlement prior to completing grading operations.

1. **Settlement plates:** The base of settlement plates shall be firmly seated into original ground for the full depth of the steel fins. The base shall be leveled. The Engineer shall be provided time to obtain the elevation of the seated base and the top elevation of the pipe extensions prior to placement of embankment material. Pipe extensions shall not be more than 4 feet in length and shall be vertically installed as the embankment is constructed such that the top of the pipe is not covered. As each extension is added, the Engineer shall be provided time to obtain the top elevation of the existing pipe and the top elevation of the new pipe extension. Pipe extensions shall be properly flagged at all times. Care shall be taken while placing and compacting embankment material around pipe extensions. Settlement plates shall be maintained until no longer required, as determined by the Engineer. Upon completion of the normal embankment plus 2 feet of the specified surcharge, the Contractor shall immediately commence placing the remaining surcharge to the limits shown on the plans or as directed by the Engineer. The remaining surcharge shall be placed in lifts of not more than 1 foot in depth and compacted uniformly with construction hauling and spreading equipment. Each lift shall be completed over the entire surcharge area before the next lift is begun.

If a settlement plate is damaged, the Contractor shall notify the Engineer immediately and promptly repair it under the observation of the Engineer to the nearest undamaged pipe. Excavation, backfill, compaction, and repair of settlement plates shall be at the Contractor's expense. The Engineer shall be provided time to obtain the top elevation of the undamaged connection and the top elevation of each subsequent pipe extension.

Settlement plates shall remain in place until settlement has been completed as indicated by elevation readings taken by the Engineer at approximately 2-week intervals. Evaluation of the readings by the Engineer will be the final and sole governing factor for releasing embankments for grading operations. Upon written release by the Engineer, extensions of settlement plate pipe shall be removed to at least 2 feet below the subgrade, the pipe capped, and the area backfilled and compacted.

2. **Surcharge:** When authorized by the Engineer, surcharge shall be removed to the subgrade and embankment slopes graded to the typical section. Removed surcharge shall be placed in roadway embankments not previously brought to grade or shall be disposed of in accordance with Section 106.04 or as directed by the Engineer.

(j) **Hydraulic Embankment:** Hydraulic embankment shall consist of dredging and pumping materials approved by the Engineer from designated areas, placing the material in embankments, and dressing and completing the embankment. Material shall be nonplastic and of such grading that not more than 7 percent will pass the No. 200 sieve.

Unless otherwise shown on the plans, material for the embankment shall not be obtained from sources closer than 300 feet from the toe of the slope of the embankment. The Engineer may reject materials considered to be unsatisfactory for use in the embankment, and such materials shall be stripped at the Contractor's expense before the embankment is built. Muck and unsuitable material shall be removed to the line, grade, and section shown on the plans. Unsatisfactory material brought to the top of the embankment shall be removed by the Contractor at the Contractor's expense, and satisfactory material shall be substituted.

In placing material in the embankment, the Contractor shall begin at the centerline and deposit material in either or both directions toward the toe of slopes. Discharge shall always be in the direction of and parallel with the centerline. The maximum distance from the bottom of the discharge pipe to the surface on which material is being deposited shall be 5 feet unless otherwise directed by the Engineer. Material shall be deposited in a manner that will maintain a higher elevation at the center of the roadway than on either side. The Contractor will not be permitted to construct retaining levees along the roadway of such dimensions as to cause damage to the foundation of the roadway. The Contractor shall conduct operations so that the completed embankment conforms to the cross section shown on the plans except that the Engineer will permit the Contractor to flatten side slopes. However, if material is deposited on private property, the Contractor shall obtain permission in writing from the affected property owner(s), a copy of which shall be furnished to the Engineer. No payment will be made for material beyond the limits of the net pay section.

The embankment shall be placed so as to achieve a minimum relative density of 80 percent of the theoretical maximum density when tested in accordance with (h) herein. If the method of placing the embankment fails to produce the required density, the Contractor shall use approved methods to obtain the specified density.

The Contractor shall take all necessary precautions to prevent placing material in streams. The Contractor shall be responsible for all damage to or caused by the hydraulic embankment.

The Contractor shall provide sufficient material to maintain the embankment in accordance with the typical cross section as shown on the plans or as directed by the Engineer until final acceptance.

The Contractor's plan for support of suction or discharge pipes shall be submitted to and approved by the Engineer. Traffic shall be protected by the display of warning devices both day and night. If dredging operations damage an existing traveled highway, the Contractor shall cease operations and repair damage to the highway.

(k) **Surplus Material:** Surplus material shall not be wasted or sold by the Contractor unless authorized in writing by the Engineer. When authorization has been given for surplus material to be wasted, it shall be disposed of in accordance with Section 106.04.

Material shown on the plans as surplus material will not be considered for overhaul payment.

1. **Disposal of surplus material within the right of way where the haul distance is 2,000 feet or less:** Surplus material shall be used or disposed of where directed within a haul distance of 2,000 feet of its origin. Usage in this manner will not be considered a change in the character of the work.

2. **Disposal of surplus material within the right of way where the haul distance is more than 2,000 feet:** The Engineer may require the Contractor to use surplus material instead of furnishing borrow, or as otherwise directed, where the haul distance from the origin of the material is more than 2,000 feet. Disposal of surplus material at locations requiring a haul of more than 2,000 feet will be considered a change in the character of work unless otherwise noted on the plans.

   When material is declared surplus during construction and must be transported more than 2,000 feet from its origin, the Department will pay the Contractor $0.03 per station per cubic yard for overhaul. The quantity of surplus excavation will be determined by vehicle measurement in accordance with the provisions of Section 109.01 or from cross-section measurements by the average end area method. The haul distance will be measured along a line parallel with the centerline of the roadway from the center of the excavated area to the center of the placement area. Overhaul will be the product of the quantity of surplus material in cubic yards and the haul distance in excess of 2,000 feet in 100-foot stations.

(l) **No Plan (N) or Minimum Plan (M) Project Earthwork:**

The Contractor shall perform all construction or reconstruction activities in accordance with the applicable requirements of the Specifications with the exception of the following:

1. All disturbed slopes shall be uniformly grooved or rough graded as directed by the Engineer.

2. The roadbed shall be shaped and worked until it is smooth and free from large clods or other material unfit for use in the roadbed. Sharp breaks in the roadbed shall be eliminated and the final grade shall be compacted. The maximum gradient on all connections with intersecting roads, streets and entrances shall not exceed 10 percent, unless otherwise noted on plans or directed by the Engineer. Ditchlines shall be graded to facilitate drainage and to prevent the impoundment of water.

3. Excess material from slides, ditches and channels, slopes or drainage easements, and unsuitable material cut from below grade, which cannot be used to flatten fill slopes within the right of way or easements, shall be disposed of by the Contractor in accordance with Section 106.04.

4. The construction or clean out of ditches or channels extending beyond the roadway right of way, the removal and disposal of slide material, and the removal and disposal of unsuitable material required to be removed from below subgrade will be classified as extra excavation.

303.05—Tolerances

(a) **Finished grade of subgrade** shall conform to Section 305.03(c).

(b) **Slopes** shall be graded in the following manner:

1. **Earth excavation slopes:**

a. **Slopes steeper than 2:1** shall be grooved in accordance with the standard drawings and shall not deviate from the theoretical plane surface by more than 0.5 foot.

b. **Slopes steeper than 3:1 up to and including 2:1** shall be rough graded in a manner to provide horizontal ridges and grooves having no more than 0.5 foot deviation from the theoretical line of the typical cross section as accomplished by the normal operation of heavy grading equipment.

c. **Slopes 3:1 or flatter** shall be uniformly finished and shall not deviate from the theoretical plane surface by more than 0.5 foot.

2. **Earth embankment slopes:**

a. **Slopes steeper than 3:1** shall not deviate from the theoretical plane slope by more than 0.5 foot and shall be rough graded in a manner to provide horizontal ridges and grooves not more than 0.5 foot from the theoretical line of the typical cross section as accomplished by the normal operation of heavy grading equipment.

b. **Slopes 3:1 and flatter** shall be uniformly finished and shall not deviate from the theoretical plane surface by more than 0.5 foot.

3. **Rock slopes** shall not deviate from a plane surface by more than 2.0 feet and shall not deviate from their theoretical location by more than 2.0 feet measured along any line perpendicular to the theoretical slope line.

Finished excavation and embankment slopes shall not deviate from their theoretical location by more than 0.5 foot measured along any line perpendicular to the theoretical slope line.

303.06—Measurement and Payment

(a) **Excavation:** Excavation will be measured in cubic yards and will be paid for at the contract unit price per cubic yard unless otherwise specified.

Excavation requiring more than one handling prior to final placement will be paid for at the contract unit price for regular excavation for each handling approved by the Engineer unless there is a pay item for the second handling, in which case work will be paid for at the contract price for such handling.

Quantities of regular or borrow excavation used to backfill pipe, pipe culverts, and box culverts will not be deducted from quantities due the Contractor for payment.

1. **Regular excavation:** When payment is specified on a cubic yard basis, regular excavation will be measured in its original position by cross-sectioning the excavation area. This measurement will include overbreakage or slides not attributable to the carelessness of the Contractor and authorized excavation of rock, muck, root mat, or other unsuitable material except material included in undercut excavation. Volumes will be computed from cross-section measurements by the average end area method.

   When it is impractical to measure material by the cross-section method, other acceptable methods involving three-dimensional measurements may be used.

   Excavation for benching slopes to accommodate roadway embankments as specified in Section 303.04(h) will not be measured for separate payment. The cost thereof shall be included in the price for the related excavation or embankment item.

   Excavation of existing roadways required to incorporate old roadway into new roadway or remove salvageable materials for use in traffic maintenance, other than those covered in Section 508, will be measured as regular excavation.

   When "presplitting rock cuts" is shown on the plans, the work shall be considered incidental to the cost of excavation and will not be measured for separate payment.

   In cut sections, excavation of topsoil and root mat and material down to a point 1 foot below the elevation of the top of earthwork or to the depth specified on the plans will be measured as regular excavation. When areas of unsuitable material are shown on the plans, excavation down to a point 1 foot below the elevation of such material shown on the plans will be measured as regular excavation.

   In fill sections, excavation of topsoil and root mat and material down to an elevation of 1 foot below the bottom of topsoil and root mat will be measured as regular excavation. When areas of unsuitable material are shown on the plans, excavation down to a point 1 foot below the elevation of such material shown on the plans will be measured as regular excavation.

   If slide material approved for measurement cannot be measured accurately, or if the removal of slide material will require different equipment than that being used in the regular excavation operations, payment therefor may be made on a force account basis when authorized by the Engineer.

   Excavation of surface ditches specified on the plans or otherwise required by the Engineer will be paid for as regular excavation except that when required after the slopes have been completed and the work cannot be performed with mechanical equipment, the excavation will be paid for as undercut excavation.

2. **Borrow excavation:** Borrow excavation will be measured in its original position by cross-sectioning the area excavated. The number of cubic yards will be computed from cross-section measurements by the average end area method. When it is impractical to measure the borrow excavation, vehicular measurement in accordance with Section 109.01 may be used.

   Borrow excavation with a stipulated CBR value shall be measured and paid for at the contract unit price as borrow excavation with the CBR value as specified.

   Borrow excavation without a stipulated CBR value shall be measured and paid for at the contact unit price as borrow excavation.

3. **Undercut excavation:** Measurement will be made by cross-sectioning the undercut area. The number of cubic yards will be computed by the average end area method. When it is impractical to measure material by the cross-section method because of erratic location of isolated deposits, acceptable methods involving three-dimensional measurements may be used.

   When unsuitable material must be removed from an area of the project where undercut is not shown on the plans, unsuitable material removed after reaching the depth specified in (a) 1. herein, or 1 foot below original ground in fill sections where topsoil and root mat are not required to be removed, will be measured as undercut excavation.

   Excavation of rock or unsuitable material below the elevation of the bottom of the lower theoretical slab or culvert thickness or below the excavation limits shown on the plans or standard drawings for normal earth foundations, whichever is the greater depth, of minor structures having a span(s) or opening(s) of less than 48 inches will be measured for payment as undercut excavation. Such excavation for structures having a span(s) or opening(s) of 48 inches or greater will be measured as minor structure excavation in accordance with (a) 4. herein.

   Undercut excavation will be paid for at the contract unit price per cubic yard. This price shall include removal and disposal. When not a pay item, undercut excavation will be paid for at twice the unit price per cubic yard for regular excavation.

4. **Minor structure excavation:** Excavation of material above the elevation of the bottom of the lower theoretical slab or culvert thickness, or above the excavation limits shown on the plans for earth foundations, whichever is the greater depth, for culverts having a maximum span or opening of less than 48 inches will not be measured for payment.

   Excavation of material for culverts having a span(s) or opening(s) of 48 inches or greater and excavation for minor structures not covered elsewhere in these specifications will be measured in cubic yards of minor structure excavation and will be paid for at the contract unit price per cubic yard. The quantity allowed for payment will be the actual volume of material removed as bounded by the bottom of the lower theoretical slab or culvert thickness, or lower excavation limits shown on the plans for earth foundations, whichever is the greater depth; the original ground or regular excavation pay line, whichever is the lower elevation; and vertical planes 18 inches outside the neat lines of the structure (excluding wingwalls and other appurtenances) or bound by vertical planes coincident with the applicable bedding excavation limits shown on the plans. Payment for excavation for wingwalls and other appurtenances to structures will be based on the ratio of the

plan area of the wingwalls or appurtenances to the plan area of the barrel. Once the ratio has been determined, the pay quantity for minor structure excavation will be increased accordingly.

If embankment is placed prior to installation of a minor structure, excavation of the embankment area will not be measured for payment unless the Contract requires placement of the embankment prior to the installation of the minor structure.

The volume of the interiors of culverts, drop inlets, and other existing minor structures that must be removed will not be deducted from the overall quantity of minor structure excavation allowed for payment.

The price of minor structure excavation shall include the cost of backfill above the horizontal planes of the neatlines of the Class I or Class II backfill areas to original ground. Class I and Class II backfill shall be measured and paid for in accordance with Section 302.04.

The price of minor structure excavation shall also include the cost of removing and disposing of existing drainage structures when required.

5. **Earthwork:** When a pay item, earthwork will be paid for at the contract lump sum price, wherein no measurement will be made. This price shall include regular excavation, minor structure excavation, and grading.

(b) **Embankments:**

1. **If embankment is not a pay item,** the cost of embankment construction will be considered incidental to other items of excavation.

2. **If embankment is a pay item and regular excavation is to be paid for on a plan quantity basis,** the quantity of embankment for which payment will be made will not be measured separately but will be computed in accordance with the following:

   a. The regular excavation plan quantity will be adjusted in accordance with (c) Plan Quantities herein.

   b. The quantity of unsuitable material will be measured and subtracted from the adjusted regular excavation quantity determined in 2.a. herein. Quantities of unsuitable material removed from fill areas or below the subgrade in cut areas will be determined by using plan dimensions and may be adjusted for deviations based on actual measurement. Actual dimensions will be used to determine the quantity of any other unsuitable material.

   c. The total quantity shown on the plans will be adjusted for quantities not anticipated on the plans, such as changes in grade or undercut determined to be necessary during construction.

   d. The quantity of suitable material determined in 2.b. herein will be subtracted from the adjusted total fill quantity determined in 2.c. herein. The resultant quantity will be the embankment quantity for which payment will be made.

The Contractor shall be responsible for determining the effect of the shrinkage or swell factor of the material, and no adjustment will be made in pay quantities for this factor.

Hydraulic embankment will be paid for as embankment.

3. **If embankment is a pay item and regular excavation is to be paid for on the basis of measured quantities,** the quantity of embankment will be measured in cubic yards computed by the average end area method from the dimensions of the embankment cross section.

   Cross sections of the area to be covered by the embankment will be taken after the denuding or removal of unsuitable material and before any material is placed thereon. These cross sections shall extend laterally from the centerline to the toes of slopes as indicated on the typical cross section. The elevations as determined by these sections will be considered the original ground line. The pay quantity to be measured will be the volume of material included in the section above the original ground and below the upper limits of the typical cross section.

   When regular excavation is a pay item, the embankment area to be cross-sectioned will exclude that portion of the fill constructed from regular excavation. Material outside the limits of typical cross sections as shown on the plans will not be measured or paid for.

4. **Extra embankment required for subsurface consolidation** will be determined by the use of settlement plates. The total settlement recorded at each settlement plate will be allowed across 75 percent of the lateral width of each section. Volumes will be computed using the average end area method. Embankment quantities will be adjusted as specified herein to include extra embankment for subsurface consolidation.

   Settlement plates will be measured and paid for in units of each, complete-in-place. This price shall include furnishing, installing, maintaining, and removing when no longer required.

   Surcharge placement and removal will be measured in cubic yards as determined by the plan quantity and will be paid for at the contract unit price per cubic yard. This price shall include furnishing, placing, and removing surcharge material and disposing of surplus and unsuitable materials.

5. **If geotextile drainage fabric is a pay item,** measurement and payment will be in accordance with Section 504.

6. **Geotextile for embankment stabilization** will be measured in square yards, complete-in-place. Overlaps and seams will not be measured for separate payment. The accepted quantity of geotextile will be paid for at the contract unit price per square yard. This price shall include furnishing, placing and lapping or seaming of material.

   Embankment with a stipulated CBR value shall be measured and paid for as embankment with the CBR value as specified.

   Embankment without a stipulated CBR value shall be measured and paid for as embankment.

(c) **Plan Quantities:** The quantity of regular excavation for which payment will be made when plan quantities are specified will be that specified in the Contract. However, borrow excavation; excavation for entrances; unsuitable material below the top of earthwork; undercut excavation; slide excavation; rock excavation that changes the slopes or causes undercut; and side, inlet, and outlet ditches not covered by plan cross sections will be measured in their original position by cross sections and computed in cubic yards by the average end area method.

Where there are authorized deviations from the lines, grades, or cross sections, measurements will be made and the volume computed in cubic yards by the average end area method for these deviations. The plan quantity will then be adjusted to include these quantities for payment.

When unauthorized deviations occur, allowances will not be made for overruns. However, if the deviation decreases the quantities specified in the Contract, only the actual yardage excavated will be allowed.

(d) **Backfill:** Furnishing and placing backfill material, including backfill for undercut, will be included in the price for excavation and will not be measured for separate payment unless specific material is a pay item for backfill or unless suitable material is not available within the construction limits. When a specific material is a pay item, the unit of measure of the material will be in accordance with the unit specified in the Contract. When suitable backfill is not available within the construction limits, the material furnished and placed by the Contractor will be paid for in accordance with Section 109.05.

(e) **Erosion Control Items:**

1. **Limiting the scope of construction operations, shaping the top of earthwork, and constructing temporary earth berms and brush silt barriers for temporary erosion and siltation control** will not be measured for payment but shall be included in the price for other appropriate pay items.

2. **Erosion control riprap** will be measured and paid for in accordance with Section 414.04.

3. **Temporary protective covering** will be measured and paid for in accordance with Section 606.04.

4. **Check dams** will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing, excavating, constructing, maintaining, repositioning as many times as may be required during construction and removing the check dams if, or when, no longer required.

   Synthetic check dams may be substituted for Type II Rock Check dams (Standard EC-4) at no additional cost to the Department.

5. **Temporary silt fence type A** will be measured in linear feet from edge of the fabric to edge of fabric, complete-in-place, excluding laps, and will be paid for at the contract unit price per linear foot. Decomposed or ineffective geotextile fabric replaced after 6 months from the installation date will be measured in linear feet of temporary silt fence type A and paid for at 1/2 the contract unit price for temporary silt fence. Decomposed geotextile fabric required to be replaced prior to 6 months after installation will not be measured for payment. This price shall include furnishing, installing and maintaining the silt fence,

including fabric and posts; removing and disposing of these materials, and dressing and stabilizing the area.

6. **Temporary silt fence type B** will be measured in linear feet from edge of the wire fence to edge of wire fence, complete-in-place, excluding laps, and will be paid for at the contract unit price per linear foot. Decomposed or ineffective geotextile fabric replaced after 6 months from the installation date will be measured in linear feet of temporary silt fence type B and paid for at 1/2 the contract unit price for temporary silt fence. Decomposed geotextile fabric required to be replaced prior to 6 months after installation will not be measured for payment. This price shall include furnishing, installing and maintaining the silt fence, including fabric, wire reinforcement and posts; removing and disposing of these materials, and dressing and stabilizing the area.

   When two rows of Type A silt fence are erected instead of a single row of Type B silt fence, measurement payment will be as Type A silt fence for the amount of Type A silt fence actually erected.

7. **Geotextile fabric** attached to brush barriers or existing fence or used for another function specified on the plans will be measured in square yards, complete-in-place, excluding laps, and will be paid for at the contract unit price per square yard. This price shall include trimming the brush barrier; furnishing, installing, maintaining, and removing the fabric; and dressing and stabilizing the area.

   The brush barrier will not be measured for separate payment. The cost thereof shall be included in the price for clearing and grubbing.

8. **Temporary filter barriers** will be measured in linear feet, complete-in-place, excluding laps, and will be paid for at the contract unit price per linear foot. Decomposed or ineffective geotextile fabric replaced after 6 months from the installation date and decomposed or ineffective burlap fabric replaced after 3 months from the installation date will be measured in linear feet of temporary filter barrier and paid for at 1/2 the contract unit price for temporary filter barrier. Decomposed geotextile fabric required to be replaced prior to 6 months and decomposed burlap fabric required to be replaced prior to 3 months after installation will not be measured for payment. When permitted, baled straw silt barrier used in lieu of temporary filter barrier will be paid for in linear feet of temporary filter barrier, complete-in-place. This price shall include furnishing, installing, and maintaining the filter barrier, including filter barrier material and posts; removing and disposing of these materials; and dressing and stabilizing the area. If the Contractor is permitted to use baled straw silt barrier in lieu of temporary filter barrier, payment will be made at the price for temporary filter barrier.

9. **Silt cleanout,** when approved or directed by the Engineer, will be measured as siltation control excavation in cubic yards of vehicular measurement in accordance with Section 109.01 for the full volume of the vehicle.

   Silt removal and sediment cleanout will be paid for at the contract unit price per cubic yard of siltation control excavation. Payment shall be full compensation for removal of silt and sediment approved or directed by the Engineer and for transportation and disposal of the material.

If approved or directed by the Engineer, the installation of additional temporary silt fence and temporary filter barrier in lieu of silt cleanout will be measured in linear feet as specified in (e) 5. and (e) 7. herein.

10. **Seeding materials** will be measured and paid for in accordance with Section 603.

11. **Temporary erosion and siltation measures required to correct conditions created because of the Contractor's negligence, carelessness, or failure to install permanent controls in accordance with the plans and sequence for performance of such work** will not be measured for payment.

12. **Slope drains** will be measured in units of each, per location regardless of size or length and will be paid for at the contract unit price per each. Raising slope drains and addition of pipe lengths will not be measured as a new location. This price shall include furnishing, installing, maintaining, and removing the drain and end section or portable flume.

13. **Sediment traps and basins** will be measured in cubic yards of sediment basin excavation and will be paid for at the contract unit price per cubic yard. This price shall include excavation, maintenance, and backfill or removing to original ground when no longer needed.

14. **Storm water management basin excavation** will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. The price shall include excavation, maintenance, and shaping of basin.

15. **Temporary sediment basin excavation** will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. The price shall include excavation, maintenance and when no longer required the removal of dam, pipe, riser pipe, trash rack, backfill and site restoration. This item will not be paid on sites where the Contractor is using sediment filter bags to remove sediment from run-off water.

16. **Inlet protection:**

    a. **Inlet Protection Type A** will be measured in units of each and will be paid for at the contract unit price per each location shown or specified. The price shall include furnishing and installing temporary filter barrier including posts and top rails, coarse aggregate and, if required, sediment forebay. This price shall also include maintenance and removal until no longer required. Inlet Protection Type A will be paid for only one time during the duration of the project.

    b. **Inlet Protection Type B** will be measured in units of each and will be paid for at the contract unit price per each location shown or specified. The price shall include furnishing and installing hardware mesh cloth, concrete blocks, wooden studs, coarse aggregate, and maintenance and removal until no longer required. Inlet Protection Type B will be paid for only one time during the duration of the project.

    c. **Inlet Protection Type C** will be measured and paid for in accordance with the individual pay items and pay units shown in the Standard Drawing for EC-6, Type C. The individual pay items for Inlet Protection Type C will be paid for only one time during the duration of the project for each location shown or specified.

17. **Dewatering basin** will be measured and paid for at the contract unit price per each. This price shall include furnishing, installing, maintaining, and when no longer required, removing the dewatering basin; backfill; and site restoration.

18. **Erosion control mulch** will be paid for per square yard or acre. This includes all materials and equipment necessary for the application.

19. **Temporary diversion dike** will be measured in linear feet, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall be full compensation for installing the diversion dike, stabilizing with seed and mulch, maintaining, removing when no longer required, and restoration of the area.

20. **Turbidity curtain** will be measured in linear feet from edge of the curtain along the support cable. Turbidity curtain will be paid for at the contract unit price per linear foot for the type specified. This price shall include furnishing, installing, maintaining, and removal of all materials.

(f) **No Plan (N) or Minimum Plan (M) Project Earthwork:**

Measurement and payment for No Plan (N) or Minimum Plan project items of work will be in accordance with the applicable requirements of the Specifications with the exception of the following:

1. **Grading** will be paid for at the contract lump sum price wherein no measurement will be made by the Engineer. This price shall be full compensation for mobilization when not specified as a separate bid item; the cost of clearing and grubbing; all regular excavation; construction of embankments, grading of unpaved shoulders and ditches and channels; allaying of dust when not specified as a separate bid item; removing and disposing of excess or unsuitable material above grade; and for removing and disposing of existing minor structures and roadway surface materials.

2. **Extra excavation,** when specified as a bid item, will be measured in cubic yards in accordance with Section 109.01 and will be paid for at the contract unit price per cubic yard. This price shall include performing the required excavation and disposing of material in accordance with Section 106.04 or as directed by the Engineer. When not specified as a contract bid item, extra excavation will be paid for as specified in the Contract.

Payment will be made under:

Pay Item	Pay Unit
Regular excavation	Cubic yard
Borrow excavation	Cubic yard
Borrow excavation (CBR [value])	Cubic yard
Sediment basin excavation	Cubic yard
Siltation control excavation	Cubic yard
Undercut excavation	Cubic yard
Minor structure excavation (Item)	Cubic yard
Earthwork	Lump sum
Embankment	Cubic yard
Embankment (CBR [value])	Cubic yard
Settlement plate	Each

Pay Item	Pay Unit
Surcharge placement and removal	Cubic yard
Geotextile (Embankment stabilization)	Square yard
Check dam (Type) (Log, rock, or straw)	Each
Temporary silt fence (Type)	Linear foot
Geotextile fabric	Square yard
Temporary filter barrier	Linear foot
Slope drain	Each
Storm water management basin excavation	Cubic yard
Temporary sediment basin excavation	Cubic yard
Inlet protection Type A	Each
Inlet protection Type B	Each
Dewatering basin	Each
Erosion control mulch	Square yard or acre
Temporary diversion dike	Linear foot
Turbidity Curtain (Type)	Linear Foot
Grading	Lump Sum
Extra Excavation	Cubic Yard

SECTION 304—CONSTRUCTING DENSITY CONTROL STRIPS

304.01—Description

This work shall consist of constructing control strips in accordance with these Specifications for the purpose of determining density requirements.

304.02—Materials

Materials shall conform to the requirements for the material to be used in the course. Material used in each control strip shall be furnished from the same source and shall be of the same type as the material used in the test sections whose density requirements are established by the control strip.

304.03—Equipment

Equipment shall be approved by the Engineer prior to use. The type and weight of compaction equipment shall be such that a uniform density is obtained throughout the depth of the layer of material being compacted. Control strips shall be compacted using equipment of the same type and weight to be used on the remainder of the course.

304.04—Procedures

The subgrade or pavement structure course upon which a control strip is constructed shall be approved by the Engineer prior to construction of the control strip.

One control strip shall be constructed at the beginning of work on each roadway and shoulder course and each lift of each course. An additional control strip shall be constructed when a change is made in

the type or source of material or whenever a significant change occurs in the composition of the material from the same source. For subbase and base aggregate materials, the maximum theoretical density from either one-point proctor test (VTM-12) or three point proctor tests (VTM-1) may be used in lieu of constructing a control strip, at the discretion of the Engineer.

The project will be divided into "control strips" and "test sections" by the Engineer for the purpose of defining areas represented by each series of tests. The size of each control strip and test section will be in accordance with VTM-10.

Control strips shall be constructed using the same procedure to be used in the construction of the remainder of the course. Rolling of the control strip shall be continued until no appreciable increase in density is obtained by additional roller coverages.

Upon completion of rolling, the mean density of the control strip will be based on 10 tests taken at randomly selected sites within the control strip area using a nuclear testing device. Compaction of the remainder of the course shall be governed by the density obtained in the control strip.

Each test section will be tested for required thickness. Areas that are deficient by more than the specified allowable tolerance shall be corrected in accordance with the applicable requirements of these specifications.

The Engineer may require an additional control strip after the completion of each 10 test sections.

Each control strip shall remain in place and become a section of the completed roadway.

304.05—Tolerances

If the mean density of a test section (roadway or shoulder) does not conform to the applicable requirements stated herein, the Contractor shall continue his compactive effort or shall rework the entire test section until the required mean density is obtained. If an individual test value does not conform to the requirements stated herein, the Contractor shall continue his compactive effort or shall rework the entire area represented by that test until the required density is obtained.

(a) **Roadway:** The density of each test section will be evaluated based on the results of five tests performed at randomly selected sites within the test section. The mean density obtained for the five tests in each test section shall be at least 98 percent of the mean density obtained in the approved control strip. In addition, each individual test value obtained within a test section shall be at least 95 percent of the mean density obtained in the approved control strip.

(b) **Shoulders:**

1. **Aggregate shoulders:** The density of each test section of select or aggregate material used in the construction of shoulders will be evaluated based on the results of five tests performed at randomly selected sites within the test section. The mean density obtained for the five tests in each test section shall be within 95 ± 2 percent of the mean density obtained in the approved control strip. In addition, each individual test value obtained in a test section shall be within 95 ± 5 percent of the mean density obtained in the approved control strip.

2. **Asphalt shoulders:** The density of each test section of asphalt concrete used in the construction of shoulders will be evaluated based on the results of five tests performed

at randomly selected sites within the test section. The mean density obtained for the five tests in each test section shall be at least 98 percent of the mean density obtained in the approved control strip. In addition, each individual test value obtained within a test section shall be at least 95 percent of the mean density obtained in the approved control strip.

304.06—Measurement and Payment

This item is considered incidental to the cost of furnishing, placing, and compacting the specified course and will not be measured for payment. The cost of constructing density control strips shall be included in the cost of the material for which the control strip is required.

SECTION 305—SUBGRADE AND SHOULDERS

305.01—Description

This work shall consist of constructing the subgrade and shoulders to the cross section and grade shown on the plans and within the specified tolerances indicated on the plans and in these specifications.

305.02—Materials

Materials may consist of material in place, treated material in place, or imported material. Imported material may be borrow material, select material, or other material as shown on the plans or specified in the Contract.

Materials other than regular excavation or borrow material that are shown on the plans or specified in the Contract shall conform to the applicable requirements of these Specifications.

Geotextile materials used for subgrade stabilization shall conform to Section 245.03(d).

305.03—Procedures

(a) **Shaping and Compacting Subgrade:**

1. **Subgrade consisting of material in place:** The subgrade area shall be scarified to a depth of 6 inches for a distance of 2 feet beyond the proposed edges of the pavement on each side. If sandy or other soil is encountered that will not compact readily, clay or other suitable material shall be added or water applied in such quantity and within the allowable moisture content specified herein as will permit compaction of the subgrade. Subgrade material shall be compacted at optimum moisture, within ±20 percent of optimum. The density of the subgrade when compared to the theoretical maximum density as determined in accordance with VTM-1 shall conform to the following:

% Retained on No. 4 Sieve	Min. % Density
0-50	100
51-60	95
61-70	90

Percentages of material shall be reported to the nearest whole number.

The Contractor shall then shape and check the subgrade to ensure a typical cross section and uniform grade prior to placement of any subsequent courses. If the subgrade becomes eroded or distorted prior to placement of material for subsequent courses, the Contractor shall scarify, reshape, and recompact it in accordance with the original requirements.

At the time of placing material for subsequent courses, the Contractor shall compact the subgrade to the required density, free from mud and frost, and to a condition that will permit compaction of subsequent courses without distortion.

The Contractor shall remove material from the unstable area and contaminated aggregate if the approved subgrade becomes unstable after placement of the subbase or base course and becomes mixed with the aggregate therein. The area shall then be backfilled and compacted, and the subsequent course thereon reconstructed.

2. **Subgrade consisting of treated materials in place:** Subgrade shall be treated in accordance with the applicable provisions of Section 306.03 and Section 307.05 except that the tolerance for depth will be waived when lime or cement is being used to bridge or correct extremely weak areas.

   The Contractor will not be required to perform additional mixing and compacting if lime can be satisfactorily manipulated during initial mixing, and the Contractor has satisfactorily bridged the weak area. Additional layers of fill may be placed without delay.

   Field density determinations will be performed in accordance with AASHTO T310 and VTM-10, modified to include material sizes used in the laboratory determination of density; with a portable nuclear field density testing device; or by other approved methods. When a nuclear device is used, the nuclear density determination for treated in-place subgrade material will be related to the density of the same material tested in accordance with VTM-1 or VTM-12 and a control strip will not be required.

3. **Subgrade consisting of imported material:** The area to receive the material shall be graded to a true crown and cross section.

   Material shall be placed and compacted in accordance with the applicable specifications governing the type of material. When select material is used, material shall be placed and compacted in accordance with Section 308.02 except that the provision for mixing will not be required. The Contractor shall compact the top 6 inches of the finished subgrade in accordance with the provisions of 1.herein.

   The provisions of 1. herein that are not specifically amended shall apply. Imported material shall be placed in approximately equal layers not more than 8 inches for commercial material and 6 inches for local material, compacted measure. The Engineer will test material after compaction for thickness and density. If material fails to conform to thickness requirements, the Contractor shall correct the material by scarifying, adding material if necessary, mixing, reshaping and recompacting, or removing and replacing. If the material fails to conform to density requirements, the Engineer will require additional rolling until the required density is obtained provided the material is compacted at optimum moisture, within ±20 percent of optimum. If the moisture content is outside the allowable tolerance, the Engineer will require the layer to be scarified, brought to

optimum moisture within the allowable tolerance, and recompacted to the specified density.

An aggregate spreader will not be required in the placement of select material and other imported materials used as subgrade and shoulder courses.

(b) **Treatment of Unsuitable Subgrade:** When solid rock occurs in cuts or the material is not suitable for subgrade or finishing purposes, the roadbed shall be excavated below the grade shown on the plans in accordance with the Standard Drawings.

When solid rock or other unsuitable material has been removed, excavated areas shall be backfilled in accordance with the Standard drawings.

(c) **Finishing Subgrade:** The Contractor shall provide effective drainage for the subgrade and maintain it in a satisfactory condition until the next course is placed.

When practicable, the subgrade shall be prepared at least 500 feet ahead of placement of any subbase, base, or surface course. Material for subsequent courses shall not be placed until the subgrade has been checked and approved. The finished subgrade elevation shall be within ±0.04 foot of the plan elevation unless otherwise specified. When imported material is used, acceptance of the course will be based on Section 308.04.

(d) **Geotextile (Subgrade Stabilization):** When geotextile for subgrade stabilization is required, it shall be placed as shown on the plans. Geotextile shall be spliced by an overlap of at least 2 feet or by sewing double-stitched seams with stitching spaced 1/4 inch to 1/2 inch apart or as shown on the plans.

(e) **Shoulders:** Aggregate shoulder material shall be placed in accordance with the applicable specifications governing the type of material or construction being used and shall be compacted at optimum moisture, within ±2 percentage points of optimum. Except when aggregate material No. 18 is used, the density of the aggregate shoulder material, when compared to the theoretical maximum density as determined in accordance with VTM-1 or VTM-12, shall conform to the following:

% Retained on No. 4 Sieve	Min. % Density
0-50	100
51-60	95
61-70	90

Percentages of material will be reported to the nearest whole number.

When aggregate material No. 18 is used, the density, when compared to the theoretical maximum density, shall be not less than 90 percent or more than 95 percent.

Aggregate in the guardrail section of fills, 1 foot from the roadway side of the guardrail face to the outside of the shoulder, shall be compacted until a density of at least 90 percent of the theoretical maximum density has been obtained. The asphalt mixture in this area shall be sealed immediately after the hot mixture is spread. Rolling of the asphalt mixture shall continue until roller marks are eliminated and a density of at least 85 percent of the theoretical maximum density has been obtained.

Stabilized and paved shoulders shall be constructed in accordance with the applicable specifications for pavement stabilization. If the aggregate shoulder material becomes overconsolidated prior to final finishing, it shall be scarified for the approximate depth, reshaped, and recompacted to conform to the specified grade and cross section.

Shoulders shall be constructed simultaneously with nonrigid types of base or surface courses other than asphalt concrete or in advance of the base or surface course so as to prevent spreading of base or surface materials. The area of shoulders 12 inches adjacent to the pavement shall be rolled simultaneously with the course being deposited.

Where base or surface courses are being constructed under traffic and are more than 1 inch in depth, shoulder material adjacent thereto shall be placed within 72 hours after placement of the base or surface course.

305.04—Measurement and Payment

When material in place is used for the subgrade and shoulders, no measurement will be made by the Engineer. Treated material in place will be measured in accordance with the method of measurement for the specified stabilizing material. When imported material is specified, it will be measured as follows:

(a) **Select material, Type I,** will be measured in tons.

(b) **Select material, Types II and III,** will be measured in cubic yards in its original position.

(c) **Borrow** will be computed in its original position by cross-sectioning the area excavated. If cross-sectioning the area excavated is not practical, the quantity will be determined from compacted measurements in the road and then converted to pit volume.

When cubic yard measurement is specified and the plans do not show the thickness of material required, the material will be measured in the original position by the cross-section method. Where it is impractical to cross-section the area, measurement will be made in trucks in accordance with Section 109.01.

When the ton unit is specified, the quantity will be determined in accordance with Section 109.01.

The Engineer will deduct moisture in excess of optimum, + 2 percentage points from the net weight of both truck and rail shipments.

Allowance will not be made for unauthorized depths beyond those shown on the plans and the allowable tolerances. When tonnage measurement is used, the Engineer will deduct for material exceeding the allowable tolerance based on 110 pounds per square yard per inch of depth.

When material in place is used for subgrade and shoulders, no separate payment will be made. The cost thereof shall be included in the price for other applicable pay items.

When imported materials are used, the subgrade and shoulders will be paid for at the contract unit price per cubic yard or per ton as specified. Treated material in place will be paid for in accordance with the applicable specification.

Stabilized or paved shoulders shown as a pay item will be measured and paid for in accordance with Section 306.04, Section 307.06, Section 312.05, or Section 315.08, as applicable.

These prices shall include furnishing, hauling, placing, manipulating, and compacting material; clearing and grubbing local pits; material royalties; and access roads.

Geotextile for subgrade stabilization will be measured in square yards, complete-in-place. Overlaps and seams will not be measured for separate payment. The accepted quantity of geotextile will be paid for at the contract unit price per square yard. This price shall include furnishing, placing, lapping, or seaming material.

Payment will be made under:

Pay Item	Pay Unit
Borrow excavation	Cubic yard
Select material (Type and min. CBR)	Cubic yard or ton
Aggregate material (No.)	Cubic yard or ton
Aggregate base material (Type and no.)	Cubic yard or ton
Geotextile (Subgrade stabilization)	Square yard

SECTION 306—LIME STABILIZATION

306.01—Description

This work shall consist of stabilizing roadbed material by constructing one or more courses of the pavement structure using a mixture of soil or approved aggregates, lime or lime and fly ash, and water.

306.02—Materials

(a) **Lime** shall conform to Section 240.

(b) **Fly ash** shall conform to Section 241. Bulk fly ash may be transported dry in bulk trucks and stored in tanks or may be transported in the dampened condition, with a maximum of 15 percent moisture, and stockpiled at the job site. The Contractor shall not use excessively wet or contaminated surface material in mixing operations. The Contractor shall cover stockpiled material with a non-absorptive cover material or periodically moisten the fly ash to prevent moisture loss and it from becoming airborne.

(c) **Water** shall conform to Section 216.

(d) **Aggregates** shall conform to Section 205, Section 207, and Section 208 as applicable, or other requirements as described in the Contract.

306.03—Procedures

The Engineer will not allow lime stabilization when aggregates or the surface on which the course is to be placed is frozen. Manipulation shall not be started until the surface is free from mud or frost and the ambient air temperature is at least 40 degrees F.

(a) **Preparing the Roadbed:** The Contractor shall cut or blade the surface of the roadbed to the approximate line, grade, and cross section shown in the plans. The Engineer will not require compaction of the roadbed for the depth of the material to be treated prior to application of lime. When the course placed directly on the roadbed is to be stabilized, the Contractor shall prepare the surface of the roadbed in accordance with Section 305.

Temporary ramps constructed adjacent to existing pavements, bridges, culverts, and similar items shall be removed to the depth necessary to provide the required thickness of pavement structure.

The Contractor shall cut drains through excavated shoulder material on shoulders to drain the roadbed. Drains shall be cut through windrowed base materials at sufficient intervals to prevent ponding of water. The Contractor shall move windrowed material when necessary to permit the subgrade to dry.

(b) **Preparing Materials:** The Contractor shall scarify the prepared roadbed to the depth and width required for stabilization. The depth of scarification and the blading operation shall be controlled in such a manner that the surface of the roadbed below the scarified material shall remain undisturbed and shall conform to the established cross section. The Contractor shall remove any material retained on the 3-inch sieve prior to the beginning of stabilization work.

(c) **Applying Lime:** The application rate of lime shall be as shown on the plans or as directed by the Engineer. The Contractor may apply lime to the partially pulverized material as a slurry or in a dry form. When quicklime is used in a dry form, it shall be applied at the same rate as hydrated lime.

Where quicklime is slaked on the project to produce a slurry, the Engineer will calculate the measurement as indicated herein for each truckload using the certified lime purity for that load. The Engineer will not measure any lime added or replaced for corrective measures during construction or for repairing damaged areas.

A = Certified weight of quicklime delivered x percent purity x 1.32

B = Certified weight of quicklime delivered x percent inert material

A + B = Total hydrated lime produced (pay quantity)

Lime applied by slurry application shall be mixed with water in approved agitating equipment and applied to the roadbed as a thin water suspension or slurry. The distribution equipment shall provide continuous agitation of the slurry from the mixing site until applied on the roadbed. The proportion of lime shall be such that the "Dry Solids Content" shall be at least 30 percent by weight. The Engineer may authorize a lower percent solid provided a uniform suspension of the slurry can be maintained. A weight and purity certification shall accompany each shipment of quicklime to be used in slurry applications.

Spreading equipment shall uniformly distribute the lime without excessive loss. The Engineer will not permit any equipment except water trucks and equipment used for mixing and spreading to pass over the spread lime until it is mixed. The Contractor shall immediately discontinue any procedure that results in excessive loss or displacement of the lime.

When a stationary mixer is used to mix aggregate material, the lime may be added to the mix by an approved feeder.

When applied in dry form, lime shall be spread uniformly over the top of the scarified material by an approved screw-type spreader box or other approved spreading equipment. The spreading operation shall be shrouded to minimize dust. Dry lime shall not be applied pneumatically, dropped from a dump truck, front end loader or bottom dumped. A motor grader shall not be used to spread the dry lime.

The Contractor shall not apply dry lime when the Engineer believes wind conditions are such that the blowing material will become objectionable to adjacent property owners or create potential hazards to traffic.

(d) **Adding Water:** Sufficient water shall be added by means of pressure water distributors or through the mixing chamber of a rotary mixer to provide moisture content at the time of compaction of not less than the optimum for the mixture, nor more than optimum +20 percent of optimum.

(e) **Mixing:** The Contractor shall mix lime and water throughout the scarified material as thoroughly as practicable using a self-propelled rotary mixer capable of mixing to a compacted depth of at least 12 inches. Disc harrows or motor graders shall not be used for mixing. The Contractor shall then spread the mixture over the roadbed. The surface shall be sealed with a steel wheel or pneumatic tire roller to retard the loss of moisture and then allowed to mellow for 4 to 48 hours. After mellowing, the Contractor shall remix the lime-treated material with a rotary mixer until at least 60 percent of the material, exclusive of aggregates, will pass a No. 4 sieve. The Contractor may add additional water, if necessary, during the remixing operations to ensure proper moisture for compaction.

When a stationary mixer is used, the material may be placed, compacted, and finished immediately after mixing.

When traveling plants are used, additional mixing with blades, tillers, or repeated passes of the plant may be required.

During the interval of time between lime application and initial mixing, lime that has been exposed to the open air for 6 hours or more, or lime that has been lost because of washing or blowing will not be measured for payment.

(f) **Compacting and Finishing:** The Contractor shall place and compact the mixture to at least 95 percent of the maximum density determined in accordance with VTM-1 or VTM-12. The Engineer may require the Contractor to lightly sprinkle the mixture during placement operations to maintain the specified moisture content. Compaction shall be accompanied by sufficient blading to eliminate irregularities.

The surface shall be lightly scarified during finishing operations and bladed to eliminate imprints left by the equipment. Final rolling of the completed surface shall be accomplished with a pneumatic tire roller or steel wheel roller. Final compaction and finishing shall be completed within 12 hours after final mixing.

(g) **Tolerances:** The finished stabilized course shall conform to the specified thickness, subject to the following tolerances: Thickness will be determined in accordance with VTM-38A. Areas that are deficient in thickness by more than 1 inch shall be removed or reworked with an additional amount of lime equal to 50 percent of the original amount. In the case of stabilized base courses, the Contractor may correct sections deficient in depth by applying asphalt concrete

provided such correction is authorized by the Engineer. Areas that are excessive in thickness by more than 2 inches shall be reworked, and an amount of lime equal to 50 percent of the original amount shall be added to the mixture. Any replacement, corrective work and additional lime required to address deficiencies shall be at the Contractor's expense.

(h) **Protecting and Curing:** After finishing of the subgrade, no vehicles except sprinkling equipment shall be permitted on the subgrade for a curing period of 7 days or until the next course is placed, whichever is less. During the curing period, the subgrade shall be lightly sprinkled with water at frequent intervals to prevent the surface from drying out and cracking. The Contractor shall plan and execute the work in such a manner as to place the next course during the curing period. If the Contractor has not placed the next course by the end of the curing period, the Contractor shall apply liquid asphalt and cover material at the rate specified on the plans.

Damage to the stabilized course attributable to other phases of construction by the Contractor shall be repaired at the Contractor's expense. At least one subsequent course shall be constructed on the stabilized course before hauling operations for the other phases of construction are permitted on the treated course. If the material loses the required stability, density, or finish before the next course is placed or the work accepted, it shall be recompacted and refinished at the Contractor's expense.

306.04—Measurement and Payment

Lime stabilization will be measured in tons of lime or fly ash, square yards of manipulation, and cubic yards or tons of aggregate material, complete-in-place, and will be paid for at the contract unit price per ton of lime or ton of fly ash, per square yard of manipulation, and per cubic yard or ton of aggregate material. Weighing shall be performed in accordance with Section 109.01 except that transporting vehicles shall be tared prior to each load.

Manipulation shall include preparing the roadbed, scarifying, pulverizing, drying material, mixing, compacting, finishing, protecting, curing, and maintaining the completed course.

Payment will be made under:

Pay Item	Pay Unit
Lime	Ton
Fly ash	Ton
Manipulation (Depth)	Square yard
Aggregate material (Type)	Cubic yard or ton

SECTION 307—HYDRAULIC CEMENT STABILIZATION

307.01—Description

This work shall consist of stabilizing roadbed material as specified or as directed by the Engineer and constructing one or more courses of the pavement structure using a mixture of soil, or approved aggregates and hydraulic cement, on a prepared surface in accordance with these specifications and in conformity with the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer.

307.02—Materials

(a) **Cement** shall conform to Section 214, Type I, IP, or II. Cement shall be transported, stored, and otherwise protected in accordance with Section 217.03.

(b) **Water** shall conform to Section 216.

(c) **Asphalt** used for curing or priming shall conform to Section 210 as applicable.

(d) **Aggregate** shall conform to Section 205, Section 207, or Section 208 or other Contract requirements as applicable.

(e) **Select borrow** shall consist of approved material having the specified CBR.

307.03—Field Laboratory

When a field laboratory is furnished by the Department, the Contractor shall move the laboratory to various points along the project as necessary.

307.04—Weather Limitations

The Engineer will not permit cement stabilization when aggregate or the surface on which the course is to be placed is frozen. The Contractor shall not start manipulation operations until the air temperature is at least 40 degrees F in the shade and rising. The Contractor shall protect the stabilized material from freezing for 7 days or shall cover the stabilized surface with the next pavement course within 4 hours after the cement stabilization has been finished as specified when material may be exposed to freezing temperatures during the first 24 hours of curing.

307.05—Procedures

If the Contractor elects to use full-width paving equipment in the subsequent placement of asphalt concrete base, the width of the stabilized course upon which the base will be placed may be extended 1 foot beyond the designed typical section on each side.

(a) **Preparing Existing Surface:** When the roadbed is to be stabilized, its surface shall be cut or bladed to the approximate line, grade, and cross section; however, the Engineer will not require compaction of the roadbed for the depth of the material to be treated prior to application of cement. The Contractor shall prepare the surface of the roadbed in accordance with Section 305.03 as applicable when the course placed directly on the roadbed is to be stabilized.

Additional material needed to bring the roadway surface into compliance with the required specifications shall be obtained from within the limits of the right of way, if available. When authorized, the Contractor shall obtain such material from borrow pits as provided for in Section 303.

The surface shall be sufficiently firm to support the construction equipment without displacement and shall be in such condition that the compaction can be obtained as specified herein. Soft, yielding, or wet areas shall be corrected and made stable before construction proceeds.

(b) **Preparing Materials:** The Contractor shall scarify and pulverize the material to be treated prior to application of cement when the roadbed is to be stabilized. Pulverizing shall continue during mixing operations until at least 80 percent of the material, exclusive of coarse aggregate, will pass the No. 4 sieve. The Contractor shall remove any material retained on the 3-inch sieve and other objectionable objects.

Applying and mixing cement with material in place or aggregate material shall be performed in accordance with the following methods except that aggregate subbase, aggregate base course, select material, and select borrow specified on the plans shall be mixed in accordance with 2. herein. If the closest central mixing plant is located more than 30 road miles from the project, the Contractor may elect to mix cement with aggregate subbase, aggregate base, select material, and select borrow in accordance with 1. herein provided an additional 1 percent cement by weight is added to the in-place mixing operation and the cement is mixed to a depth of approximately 1 inch less than the depth of the course being stabilized. No additional compensation will be allowed for the changes described herein.

1. **Mixed-in-place method:** The Contractor shall blend any additional required material with the existing material prior to application of cement.

   The Contractor shall uniformly apply cement on the material to be processed. When bulk cement is used, the equipment shall be capable of handling and spreading the cement in the required amount. The moisture content of the material to be processed shall be sufficiently low to permit a uniform mixture of the aggregate material and cement. The Contractor shall replace spread cement that has been lost without additional compensation before mixing is started.

   Mixing shall be accomplished by means of a self-propelled or self-powered machine equipped with a mechanical rotor or other approved type of mixer that will thoroughly blend the aggregate with the cement. Mixing equipment shall be capable of ensuring positive depth control. The Contractor shall exercise care to prevent cement from being mixed below the depth specified. Water shall be uniformly incorporated into the mixture. The water supply and distributing equipment shall be capable of supplying the amount of water necessary to obtain optimum moisture in the material within 1 hour. If more than one pass of the mixer is required, at least one pass shall be made before water is added. Mixing shall continue after all water has been applied until a uniform mixture has been obtained for the full depth of the course.

   The Contractor shall remix any mixture that has not been compacted and remains undisturbed for more than 30 minutes. If rain adds excessive moisture to the uncompacted material, the entire section shall be reworked. If the Contractor is unable to finish the section within the same day, the section shall be reconstructed and an amount equal to 50 percent of the original amount of cement shall be added to the mixture at the Contractor's expense.

2. **Central plant method:** Material shall be proportioned and mixed with cement and water in an approved central mixing plant. The plant shall be equipped with feeding and metering devices that will introduce materials into the mixer in the specified quantities. Mixing shall continue until a uniform mixture has been obtained.

   Mixed material shall be transported to the roadway in suitable vehicles and spread on a moistened surface in a uniform layer by a self-propelled or other approved spreader. Not

more than 60 minutes shall elapse between the start of mixing and the start of compacting the cement-treated mixture on the prepared subgrade.

a. **Mixing aggregate subbase and base material:** The cement content will be determined by the titration method as described in VTM-40. Sampling and testing for determining cement content will be performed at the plant. However, nothing herein shall be construed as waiving the requirements of Section 106.06 and Section 200.02.

The Engineer's acceptance for cement content will be based on the mean of the results of tests performed on samples taken in a stratified random manner from each lot. The rate of sampling shall be four samples per lot. A lot of material is defined as 2,000 tons, or 4,000 tons for contract items in excess of 50,000 tons. If the project requires less than 2,000 tons; the amount of material necessary to complete the project is less than 2,000 tons, or 4,000 tons when the contract item is in excess of 50,000 tons; a portion of the lot is rejected for deficient cement content; the job-mix formula for the aggregates is modified within a lot; or a portion of the lot is rejected for an excessive liquid limit or plasticity index then that amount or the rejected portion of the lot shall be defined as a lot.

A lot will be considered acceptable for cement content if the mean result of the test(s) is within the following process tolerance(s) of the plan design for the number of tests taken: mean of two tests, –1.1 percent; mean of three tests, –0.9 percent; mean of four tests, –0.8 percent. However, no one sample shall have a cement content more than 1.6 percent below the design cement content.

If an individual test result indicates that the cement content of the material represented by the test is deficient by more than 1.6 percent from the design cement content, the portion of the material represented by the sample will be considered a separate part of the lot and shall be removed from the road.

If the value of the test results falls below the allowable process tolerance, a payment adjustment will be applied to the contract unit price at the rate of 1.0 percent for each 0.1 percent the material is outside the process tolerance. If the total adjustment is 8.0 percent or less and the Contractor does not elect to remove and replace the material, the contract unit price paid for the material will be reduced at the rate specified herein. The adjustment will be applied to the tonnage represented by the samples.

b. **Mixing select borrow:** Cement in the mixture shall not vary more than ±7.0 percent by weight from that specified. Feeders and meters for introducing cement into the mixer shall be of such design that the amount of cement can be accurately determined before cement is introduced into the mixer.

(c) **Compacting and Finishing:** Prior to the beginning of compaction, the mixture shall be brought to a uniformly loose condition for its full depth. For subgrade stabilization, the mixture shall be compacted to a density of at least 100 percent of the maximum density as determined in accordance with VTM-1 or VTM-12. For subbase and base stabilization, the mixture shall be compacted to conform to the density requirements of Section 309.05. At compaction, the cement treated subgrade soil shall have a moisture content of not less than optimum or more than optimum + 20 percent of optimum. The cement treated subbase and

base aggregate shall have a moisture content of not less than optimum or more than optimum plus 2 percentage points.

Compaction equipment shall be subject to the Engineer's approval, and the number of such units shall be sufficient to ensure the specified density and completion of the processed section within 4 hours from the time the water is added to the mixture. Initial compaction of soil mixtures shall be accomplished with a tamping roller.

After the mixture has been compacted, the surface shall be shaped to the required lines, grades, and cross sections.

If the material to be shaped is a type in which surface compaction planes will form, the Contractor shall lightly scarify the surface continuously with a drag harrow or similar equipment during the shaping operation. The surface shall then be rolled with steel wheel or pneumatic tire rollers, or both. The moisture content of the surface material shall be maintained at not less than the specified optimum during finishing operations. Compacting and finishing operations shall be completed within the specified time and carried out in a manner that will produce a smooth, dense surface, free from surface compaction planes, cracks, ridges, or loose material.

(d) **Construction Joints:** Each day's operation shall tie into the completed work of the previous day by the remixing of approximately 2 feet of the completed course prior to the processing of additional sections. An amount equal to 50 percent of the original amount of cement shall be added to such transition sections. When the completed section remains undisturbed for more than 24 hours, a transverse construction joint shall be made by cutting back into the completed work to form an approximate vertical face.

(e) **Tolerances:** The finished stabilized course shall conform to the specified thickness and density, subject to the following tolerances:

1. **Density:** The density of the completed work for each day's operations will be determined at representative locations. Any portion on which the density is more than 5 pounds per cubic foot less than that specified shall be removed and replaced.

2. **Thickness:** Thickness will be determined in accordance with VTM-38A. The Contractor shall remove and replace areas that are deficient in thickness by more than 1 inch or, with the approval of the Engineer; the Contractor shall correct sections on stabilized base courses that are deficient in depth by applying asphalt concrete at his own expense. Mixed-in-place areas that are excessive in thickness by more than 1 inch shall be removed and replaced.

   When the central plant method of mixing is used, acceptance of the course will be based on Section 308.04 except when the depth is deficient by more than 1 inch. In such cases of deficiency, correction shall be as specified herein.

(f) **Protecting and Curing:** The next course may be placed after the cement stabilization has been approved. If the next pavement course is not placed immediately, the cement-treated aggregate course shall be moist cured continually or covered by the application of liquid asphalt to prevent surface drying until the next pavement course is placed. The Contractor shall endeavor to place the next pavement course within 7 days after cement stabilization is finished. If this is not possible and a liquid asphalt cover has not been applied, the Contractor shall either seal

the cement-stabilized layer with approved cover material or continually maintain the surface of the cement-stabilized course with moisture until the next pavement course can be successfully applied. The surface of the cement-treated aggregate course shall be maintained in such a manner that the entire surface of the course remains in a moistened condition. If asphalt cover material is used, it shall be applied at the rate of approximately 0.25 gallon per square yard or as shown on the plans. The Engineer shall direct the exact rate of application necessary to produce full coverage without excessive runoff. If asphalt is used, it shall be applied with an approved pressure distributor as specified in Section 314.04 and the asphalt material shall be immediately covered with the specified cover material.

Prior to placing the next course or applying asphalt cover material, the surface of the cement-stabilized layer shall be lightly moistened. In no case shall the cement-treated aggregate course be allowed to dry out completely or go uncovered through the winter. The stabilized course shall be tightly knit and free from loose and extraneous material.

The Contractor shall maintain the cement-stabilized course, including shoulders and ditches, within the limits of the Contract in a condition satisfactory to the Engineer from the time work first starts until the work is officially accepted. Maintenance shall include immediate repairs of defects that may occur either before or after cement is applied, which work shall be performed by the Contractor and repeated as often as is necessary to keep the course continuously intact. Repairs to the course shall be performed in a manner that will ensure the restoration of a uniform surface and stability of the area repaired.

307.06—Measurement and Payment

Hydraulic cement stabilization will be measured in tons of hydraulic cement, cubic yards or tons of aggregate, and square yards of manipulation in accordance with Section 109.01 and will be paid for at the contract unit price per ton of hydraulic cement, per ton or cubic yard of aggregate, and per square yard of manipulation for the depth specified. This price shall include furnishing and applying water for moisture curing and, when grading is not a pay item, restoring shoulders and ditches.

Hydraulic cement-stabilized aggregate material or aggregate base material will be measured in cubic yards or tons and will be paid for at the contract unit price per ton or cubic yard. This price shall include furnishing and installing cement, aggregate, and moisture for curing and, when grading is not a pay item, restoring shoulders and ditches.

Cement-stabilized select borrow will be measured in cubic yards, pit measure, in accordance with Section 109.01 and will be paid for at the contract unit price per cubic yard. This price shall include furnishing component and curing materials and hauling, placing, and curing the cement-stabilized material.

When bulk cement is used, scales capable of weighing loaded cement transports or lesser loads shall be provided at locations approved by the Engineer. Weighing shall be performed in accordance with Section 109.01 except that transporting vehicles shall be tared prior to each load.

Manipulation, when a pay item and the Contractor elects to centrally mix the materials, will be paid for in accordance with the quantity of manipulation shown on the plans. Manipulation will include only the mixing operation.

Asphalt and cover material for curing will not be measured for separate payment.

Payment will be made under:

Pay Item	Pay Unit
Lime	Ton
Fly ash	Ton
Manipulation (Depth)	Square yard
Aggregate material (Type)	Cubic yard or ton

SECTION 308—SUBBASE COURSE

308.01—Description

This work shall consist of furnishing and placing one or more courses of mineral aggregate on a prepared subgrade in accordance with the required tolerances within these specifications and in conformity with the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer.

308.02—Materials

Material shall conform to Section 208.02(a) except where other types of aggregate material are specified in the Contract, in which case the applicable specifications governing the material shall apply. When the Contractor obtains the material from local sources, the sources shall conform to Section 106.03.

308.03—Procedures

Prior to placement of the subbase course, the subgrade shall be constructed in accordance with Section 304 and Section 305 as applicable.

Subbase material shall be mixed in an approved central mixing plant of the pugmill or other mechanical type in accordance with Section 208.05. The Contractor shall place the mixed material on the subgrade by means of an approved aggregate spreader. The Engineer will not require the use of such spreader when the material is being applied solely for the temporary maintenance of traffic or where the width of the course shown on the plans is transitional and impracticable to place with a spreader box.

The Contractor shall spread and compact the material in two or more layers of approximately equal thickness where the required thickness is more than 6 inches. The compacted thickness of any one layer shall be not more than 6 inches, however the Engineer may approve increasing the compacted depth of a single layer of the subbase course to 10 inches when vibrating or other approved types of special compacting equipment are used.

Each layer of subbase course shall be compacted at optimum moisture, within ±2 percentage points of optimum. The density of each layer of subbase aggregate material, when compared to the theoretical maximum density as determined in accordance with VTM-1, shall conform to the following:

% Material Retained on No. 4 Sieve	Min. % Density
0-50	100
51-60	95
61-70	90

Percentages shall be reported to the nearest whole number.

Not more than one sample in every five shall have a density less than that specified, and the density of such a sample shall be not more than 2 percent below that specified.

The Contractor shall scarify, reshape, and recompact the surface of the subbase if it becomes uneven or distorted and sets up in that condition. If the subbase when compacted and shaped shows a deficiency in thickness or if depressions occur in the surface, the Contractor shall scarify such sections at his own expense before additional material is added.

The Contractor shall perform field density determinations with a portable nuclear field density testing device using the density control strip as specified in Section 304 and VTM-10, or by other approved methods. The Engineer will direct the Contractor as to the method of density determination.

308.04—Tolerances

The Engineer will determine the thickness of the subbase course by the depth measurement of holes dug in the subbase in accordance with VTM-38B.

The Engineer's acceptance of the subbase course for the physical property of depth will be based on the mean result of tests performed on samples taken from each lot of material placed. A lot of material is defined as the quantity being tested for acceptance except that the maximum lot size will be 2 miles of paver application width.

The Engineer will consider a lot acceptable for depth if the mean result of the tests is within the following tolerance of the plan depth for the number of tests taken except that each individual test shall be within ±1.00 inch of the plan depth; mean of two tests, ±0.75 inch; mean of three tests, ±0.60 inch; and mean of four tests, ±0.50 inch.

If an individual depth test exceeds the ±1.00 inch tolerance, the Engineer will exclude that portion of the lot represented by the test from the lot. If the individual test result indicates that the depth of material represented by the test exceeds 1.00 inch, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test. If the individual test result indicates that the depth of the material represented by the test is deficient by more than 1.00 inch, The Contractor will be required to make correction of the subbase course represented by the test as specified herein.

If the mean depth of a lot of material is in excess of the allowable tolerance, the Engineer will not pay the Contractor for that material in excess of the tolerance throughout the length and width represented by the test.

If the mean depth of a lot of material is deficient by more than the allowable tolerance, the Engineer correction will not normally require the Contractor to make correction and the Contractor will be paid for the quantity of material that has been placed in the lot.

For excessive depth subbase courses, when tonnage measurement is used, the Engineer will calculate the rate of deduction from the tonnage of subbase material allowed for payment at a weight of 110 pounds per square yard per inch of depth in excess of the tolerance. Areas that are deficient in depth by more than 1.00 inch and areas that do not provide a smooth uniform surface shall be scarified, material added or removed; reshaped; and recompacted to the specified density so as to conform to the depth tolerance and provide a smooth, uniform surface.

308.05—Measurement and Payment

Subbase course will be measured in cubic yards or tons of aggregate material or aggregate base material as specified and will be paid for at the contract unit price per cubic yard or ton. When the cubic yard unit is specified in the contract, the quantity will be determined by compacted measurements on the road unless otherwise specified. When the ton unit is specified, the quantity will be determined in accordance with Section 109.01.

This price shall include furnishing, hauling, placing, manipulating, and compacting subbase course; clearing and grubbing local pits; material royalties; and access roads.

The Engineer will make a deduction from the net weight of both truck and rail shipments for moisture in excess of optimum + 2 percentage points.

Payment will be made under:

Pay Item	Pay Unit
Aggregate material (No.)	Cubic yard or ton
Aggregate base material (Type and no.)	Cubic yard or ton

SECTION 309—AGGREGATE BASE COURSE

309.01—Description

This work shall consist of furnishing and placing one or more courses of aggregates and additives, if required, on a prepared surface in accordance with these specifications and in conformity with the lines, grades, and typical sections and cross sections shown on the plans or as established by the Engineer.

309.02—Materials

(a) **Aggregate material** shall conform to Section 208.02(b) except where other types of aggregate material are specified in the contract, in which case the applicable specifications governing the specified material shall apply.

(b) **Calcium chloride and sodium chloride** shall conform to Section 239.

309.03—Equipment

The Engineer will approve the equipment used for the construction of aggregate base course prior to performance of such work. Any machine, combination of machines, or equipment that handles the material

without undue segregation and produce the completed base in accordance with these specifications for spreading, moistening, mixing, and compacting will be acceptable to the Engineer.

309.04—Procedures

The Contractor shall prepare the surface or course upon which the base course is to be placed in accordance with the applicable provisions of Section 304 and Section 305.

Base course material shall be mixed in an approved central mixing plant of the pugmill type. The Contractor shall place the mixed material by means of an approved aggregate spreader.

309.05—Density Requirements

The Contractor shall spread and compact the material in two or more layers of approximately equal thickness where the required thickness is more than 6 inches. The compacted thickness of any one layer shall be not more than 6 inches, however the Engineer may approve increasing the compacted depth of a single layer of the base course to 10 inches when vibrating or other approved types of special compacting equipment are used.

The Contractor shall compact each layer at optimum moisture within ±2 percentage points of optimum after mixing and shaping. The density of each layer of base aggregate material, when compared to the theoretical maximum density as determined in accordance with VTM-1, shall conform to the following:

% Material Retained on No. 4 Sieve	Min. % Density
0-50	100
51-60	95
61-70	90

Percentages shall be reported to the nearest whole number.

Not more than one sample in every five shall have a density less than that specified, and the density of such sample shall be not more than 2 percent below that specified. The Contractor shall maintain the surface of each layer during the compaction operations in a manner such that a uniform texture is produced and the aggregates are firmly keyed. The Contractor shall uniformly apply water over the base materials during compaction in the amount necessary to obtain proper density.

Irregularities in the surface shall be corrected by scarifying, remixing, reshaping, and recompacting until a smooth surface is secured. The surface shall thereafter be protected against the loss of fine materials by the addition of moisture, when necessary, and shall be maintained in a satisfactory and smooth condition until accepted by the Engineer.

The base course will be tested in place for depth and density. The Contractor shall perform field density determinations with a portable nuclear field density testing device, using a density control strip as specified in Section 304 and VTM-10 . The Engineer will direct the Contractor as to method of density determination to be used.

The Engineer will base acceptance of the aggregate base course for depth on the requirements of Section 308.

309.06—Measurement and Payment

Aggregate base course will be measured in cubic yards or tons, as specified, and will be paid for at the contract unit price per cubic yard or ton for the aggregate type and number specified. When the cubic yard unit is specified in the contract, the quantity will be determined by compacted measurements on the road unless otherwise specified. When the ton unit is specified, the quantity shall be determined in accordance with Section 109.01. The Engineer will make a deduction from the net weight of both truck and rail shipments for moisture in excess of optimum + 2 percentage points.

Calcium chloride and sodium chloride will be measured in tons and will be paid for at the contract unit price per ton.

This price shall include preparing and shaping the subgrade or subbase and shoulders, adding moisture, removing and replacing unstable subgrade or subbase and constructing the base course thereon, and filling test holes.

Payment will be made under:

Pay Item	Pay Unit
Aggregate base material (Type/no.)	Cubic yard or ton
Aggregate material (No.)	Cubic yard or ton
Calcium chloride	Ton
Sodium chloride	Ton

SECTION 310—TACK COAT

310.01—Description

This work shall consist of preparing and treating an existing asphalt or concrete surface with asphalt in accordance with these specifications and in conformity with the lines shown on the plans or as established by the Engineer.

310.02—Materials

(a) **Tack Coat** asphalt tack coat shall be CRS-1, CRS-2, CRS-1h, or CSS-1h conforming to Section 210. Asphalt emulsion CMS-2 conforming to Section 210 may be used during the winter months. With the exception of CMS-2, asphalt emulsion for tack coat may be diluted with 50 percent water provided that the resulting material produces uniform tack application.

(b) **Non-Tracking Tack Coat** liquefied asphalt shall be selected from the Materials Division's Approved Products List 50.1A. The Contractor shall not dilute non-tracking tack coat materials with water.

310.03—Procedures

The existing surface shall be patched, cleaned, and rendered free from irregularities to the extent necessary to provide a reasonably smooth and uniform surface. The Contractor shall remove and replace

unstable corrugated areas with suitable patching materials. The Contractor shall clean the edges of existing pavements that are to be adjacent to new pavement to permit adhesion of asphalt.

The Contractor shall uniformly apply tack coat or non-tracking tack coat material with a pressure distributor conforming to Section 314.04(b). Hand spray equipment shall not be used except in areas inaccessible by a pressure distributor.

Tack at joints, adjacent to curbs, gutters, or other appurtenances shall be applied with a hand wand or with spray bar at the rate of 0.2 gallon per square yard. At joints, the tack applied by the hand wand or a spray bar shall be 2 feet in width with 4 to 6 inches protruding beyond the joint for the first pass. Tack for the adjacent pass shall completely cover the vertical face of the pavement mat edge so that slight puddling of asphalt occurs at the joint, and extend a minimum of 1 foot into the lane to be paved.

Care shall be taken to prevent splattering adjacent items during the application of tack coat. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, the Contractor shall ensure equipment is parked so that the spray bar or mechanism will not drip asphalt on the surface of the traveled way.

The Contractor shall apply tack coat and non-tracking tack coat in accordance with the weather limitations that apply to the course being placed as well as the manufacturer's recommendations. The Engineer shall approve the quantity, rate of application, temperature, and areas to be treated prior to application.

The tack coat or non-tracking tack coat shall be applied in a manner to offer the least inconvenience to traffic and to permit one-way traffic without pick up or tracking of the asphalt onto adjacent non-treated areas. All traffic, including construction traffic, shall be excluded from tacked sections until the tack has cured.

Tack shall not be required atop asphalt stabilized open-graded material drainage layers.

(a) **Tack Coat**

Equipment for heating and applying asphalt shall conform to Section 314.04(b). The maximum application temperature of liquid asphalt shall conform to Table III-1.

The Contractor shall apply undiluted asphalt at the rate of 0.05 to 0.10 gallons per square yard. Diluted asphalt shall be applied at the rate of 0.10 to 0.15 gallons per square yard.

The Contractor shall not apply the tack coat immediately prior to the course being placed.

(b) **Non-Tracking Tack Coat**

The Contractor shall apply nontracking tack coat between May 1 and October 1. The Contractor may use tack coat as specified herein at other times.

Equipment for heating and applying asphalt shall conform to Section 314.04(b) or the non-tracking tack coat material's manufacturer's recommendations. The maximum application temperature of liquefied asphalt shall conform to the manufacturer's requirements.

The Contractor shall apply tack material at the rate recommended by the manufacturer. This rate is typically between 0.05 to 0.10 gallons per square yard. The asphalt tack shall be applied to the pavement surface in such a manner that it will bond the overlay and the underlying surfaces together.

TABLE III-1
Liquid Asphalt Application Temperature

Grade	Max. Temperature (°F)
RC-70	180
RC-250	220
RC-800	225
RC-3000	290
MC-70	180
MC-250	220
MC-800	255
MC-3000	290
AC-5	300
AC-10	300
AC-20	300
AC-40	300
RS-2	175
SS-1h	180
AE-4	150
CRS-2	175
CSS-1h	180
CMS-2	200
CRS-1h	175
CRS-1	175

Adjacent concrete or asphalt concrete surfaces shall show minimal visible evidence and white or yellow pavement markings shall show no visible evidence of the asphalt tack material tracking at the end of the production shift. Tracking of the tack material on pavement markings will require the Contractor to immediately restore the marking to their original pre-tack condition. The Contractor shall remove Build-up of the tacking material on existing pavement surfaces.

(c) **Referee System**

When a new asphalt course is placed on a milled or non-milled surface, the Contractor shall take steps to ensure an adequate bond is made between the new material and the existing surface. If the Engineer suspects the Contractor is failing to apply good bond promoting procedures or adequately tacking the existing surface per the manufacturer's recommendations, the Engineer may core a minimum of 6 locations to determine the shear and tensile strength at the interface. The Engineer will determine these locations by using a stratified random selection process. The Department will test cores in the Department's laboratory in accordance with the procedures described in report VTRC 09-R21. For the surface to be acceptable, the average results for shear and tensile strength specified herein must be met. The Department will test a minimum of 3 cores for shear strength and at least 3 cores for tensile strength.

1. **Milled surfaces:** The average shear strength must meet or exceed 100 psi with no single core having a shear strength less than 50 psi. The average tensile strength of the remaining cores must meet or exceed 40 psi with no single core having a tensile strength less than 20 psi.

2. **Un-milled surfaces:** The average shear strength must meet or exceed 50 psi with no single core having a shear strength less than 30 psi. The average tensile strength of the remaining cores must meet or exceed 30 psi with no single core having a tensile strength less than 20 psi.

   The Engineer will reduce the payment for the asphalt concrete tonnage placed in the area of dispute by 10 percent if the minimum shear or tensile strength requirements in that area are not met.

310.04—Measurement and Payment

Tack coat, when a pay item, will be measured in gallons and will be paid for at the contract unit price per gallon. When not a pay item the Contractor shall include the cost in the contract unit price for other appropriate items.

Nontracking tack coat, when a pay item, will be measured in gallons and will be paid for at the contract unit price per gallon. When not a pay item the Contractor shall include the cost in the contract unit price of other appropriate items.

Payment will be made under:

Pay Item	Pay Unit
Tack coat	Gallon
Nontracking tack coat	Gallon

SECTION 311—PRIME COAT

311.01—Description

This work shall consist of preparing and treating an existing surface with asphalt, and cover material if required, in accordance with these Specifications and in conformity with the lines shown on the plans or as established by the Engineer.

311.02—Materials

(a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to Section 210 as applicable.

(b) **Cover material** shall conform to Section 202 or Section 203 as applicable. Lightweight aggregate shall conform to Section 206. The Engineer will not permit cover material to be hauled directly from a washing plant for immediate use in the work.

311.03—Procedures

The rates of application of materials shall be determined in accordance with the method described in Education Series No. 12 of the Asphalt Institute entitled *Asphalt Surface Treatments Construction Techniques.*

The weather limitations of Section 314.03 shall apply to asphalt prime coat work. When asphalt is to be used as a cover for cement stabilization or as a primer for asphalt concrete, the weather limitations specified for these particular operations shall apply.

Equipment for heating and applying asphalt and cover material shall conform to Section 314.04. The maximum application temperature of the liquid asphalt shall conform to Table III-1 in Section 310.03.

The Contractor shall shape the surface to be primed to the required grade and section; render it free from ruts, corrugations, segregated material, or other irregularities; and uniformly compact it prior to the application of prime.

Delays in priming may necessitate reprocessing or reshaping to provide a smooth, compacted surface.

The Contractor shall apply asphalt by means of a pressure distributor in a uniform continuous spread. When traffic is being maintained, not more than 1/2 the width of the section shall be treated in one application. The Contractor shall exercise care so that the application of asphalt at junctions of spreads is not in excess of the specified amount. The Contractor shall remove excess asphalt from the surface by means of a squeegee. Skipped areas or deficiencies shall be corrected.

The Contractor shall exercise care during the application of asphalt to prevent spattering adjacent items. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, the Contractor shall ensure equipment is parked so that the spray bar or mechanism will not drip asphalt on the surface of the traveled way.

When the Contractor must maintain traffic through the area of application, the Engineer will permit one-way traffic on the untreated portion of the roadbed. When the asphalt has been absorbed by the treated surface and will not pick up, traffic shall be transferred to the treated portion and the remaining width of the section primed.

The Engineer must approve the quantity, rate of application, temperature, and areas to be treated before application of the prime coat.

The Contractor shall spread cover material at no additional cost to the Department in an amount that will prevent pick up of the asphalt if after application of the prime coat the asphalt fails to penetrate within the time specified and the roadway must be used by traffic.

311.04—Measurement and Payment

Prime coat will be measured in gallons for asphalt and in tons for cover material and will be paid for at the contract unit price per gallon for asphalt and per ton for cover material.

Payment will be made under:

Pay Item	Pay Unit
Prime coat	Gallon
Cover material (Type)	Ton

SECTION 312—SEAL COAT

312.01—Description

This work shall consist of applying asphalt followed by applying cover material in accordance with these Specifications and in conformity with the lines shown on the plans or as established by the Engineer.

312.02—Materials

(a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to Section 210 as applicable.

(b) **Cover material** shall conform to Section 203 as applicable. Lightweight aggregate shall conform to Section 206. The Engineer will not permit the Contractor to haul cover material directly from a washing plant for immediate use in the work.

312.03—Equipment

The Engineer will require the Contractor to use the following equipment or its equivalent:

(a) equipment for heating and applying asphalt conforming to Section 314.04(b)

(b) a rotary power broom

(c) at least one pneumatic tire roller. The Engineer may also require additional rollers that are tandem steel wheel or three-wheel rollers weighing at least 8 tons. The pneumatic tire roller shall be self-propelled, and the gross load adjustable to apply 200 to 350 pounds per inch of rolling width as directed. Tires shall be designed for a tire pressure of at least 90 pounds per square inch. Steel wheel rollers shall be operated at a maximum speed of 3 miles per hour, and pneumatic tire rollers at a maximum speed of 5 miles per hour.

(d) a mechanical roller-type hopper or a self-propelled aggregate spreader of an approved design.

312.04—Procedures

The rates of application of materials shall be determined in accordance with the method described in Education Series No. 12 of the Asphalt Institute entitled *Asphalt Surface Treatments Construction Techniques.*

The weather limitations specified in Section 314.03 shall apply to seal coat work.

The Contractor shall not begin seal coating operations until the surface is thoroughly compacted and cleaned of dust, mud, and foreign matter and the Engineer has approved the section to be sealed.

The Contractor shall apply asphalt by means of a pressure distributor in a uniform continuous spread over the section to be treated and within the temperature range given in Table III-1. A strip of building paper at

least 3 feet in width and having a length equal to that of the spray bar of the distributor plus 1 foot shall be used at the beginning of each spread. If the cutoff of the distributor is not positive, the use of paper may be required at the end of each spread. The Contractor shall remove and dispose of the paper legally after use. The distributor shall be moving forward at the proper application speed at the time the spray bar is opened. The Contractor shall correct skipped areas and deficiencies. Junctions of spreads shall be carefully made to ensure a smooth riding surface.

The length of the spread of asphalt shall be governed by the quantity of cover material in loaded trucks on the project to ensure all asphalt is adequately covered.

The spread of asphalt shall be not more than 6 inches wider than the width covered by the cover material from the spreading device. Asphalt shall not be allowed to chill, set up, dry, or otherwise impair retention of the cover material.

The Contractor shall exercise care during asphalt application to prevent spattering adjacent items. The Contractor shall not clean or discharge the distributor into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, the Contractor shall ensure equipment is parked so that the spray bar or mechanism will not drip asphalt material on the surface of the traveled way.

The Contractor shall apply cover material in full-lane widths up to 12 feet immediately following asphalt application. Laps shall be made only at lane dividers or at the crown of the roadway. Successive laps at lane dividers and the roadway crown shall be staggered from 3 to 6 inches. Spreading of cover material shall be accomplished in a manner so that the tires of the truck or aggregate spreader do not contact the uncovered and newly applied asphalt.

The Contractor shall moisten the cover material with water to eliminate or reduce dust coating of aggregate when directed to do so by the Engineer. Moistening shall be done the day before the use of aggregate.

The Contractor shall cover deficiently covered areas with additional material immediately after cover material is spread. Rolling shall begin immediately behind the spreader and shall consist of at least three complete coverages.

The Contractor shall lightly broom or otherwise maintain the wearing surface after application of cover material until it has cured as directed. Maintenance of the surface shall include distributing cover material over the surface to absorb free asphalt and cover any area deficient in cover aggregate. The Contractor shall perform maintenance activities so as not to displace embedded material. Excess material shall be swept from the surface by means of rotary brooms as required or as directed by the Engineer.

312.05—Measurement and Payment

Seal coat will be measured in gallons and will be paid for at the contract unit price per gallon for liquid asphalt and per ton for cover material.

Liquid asphalt will be measured in gallons.

Cover material will be measured in tons, complete-in-place, and will be paid for at the contract unit price per ton. These prices shall include furnishing and applying materials and maintaining the treatment.

Payment will be made under:

Pay Item	Pay Unit
Liquid asphalt	Gallon
Cover material (Type)	Ton

SECTION 313—ASPHALT-STABILIZED OPEN-GRADED MATERIAL

313.01—Description

This work shall consist of furnishing and placing a course of asphalt-stabilized open-graded material on a prepared subbase or subgrade in accordance with the required tolerances in these specifications and in conformity with the lines and grades shown on the plans or established by the Engineer.

313.02—Materials

Asphalt-stabilized open-graded material shall conform to Section 211 except as noted herein:

(a) **Coarse aggregate** shall be Grade A crushed stone conforming to Section 203 and shall conform to the soundness requirements of surface course stone.

(b) **Fine aggregate** shall conform to Section 202.

(c) **Asphalt cement** shall be PG 64E-22.

(d) **Reclaimed asphalt pavement** shall not be used as component material.

313.03—Proportioning

Stabilized open-graded material shall be designed to have an in-place coefficient of permeability of at least 1,000 feet per day when tested in accordance with VTM-84.

The following design range shall be used for asphalt-stabilized open-graded material:

Sieve	% Passing	
	Min.	**Max.**
1 in	100	100
¾ in	88	100
½ in	70	90
No. 8	0	15
No. 200	0.5	4.5
Asphalt Content 4.3 ± 0.3%		

Hydrated lime shall be used in all mixtures at the rate of at least 0.5 percent by weight of the total dry aggregates. The Contractor may use chemical additives in addition to or in lieu of lime with the Engineer's approval. The Engineer's approval will be based on previous approvals of chemicals used with the same aggregates in asphalt concrete mixes of other types as detailed in Section 211.

The mix temperature shall be between 250 degrees F and 280 degrees F.

The Engineer will not require design test data.

The Contractor shall perform draindown testing in accordance with VTM-100. Draindown shall not exceed 0.3 percent.

313.04—Acceptance

The Engineer will accept the aggregate coating in asphalt-stabilized open-graded material based upon 100 percent surface coverage of the aggregate as verified by visual inspection.

313.05—Placing limitations

The Contractor shall not place stabilized open-graded material when weather or surface conditions are such that the material cannot be properly handled, finished, or compacted.

Asphalt-stabilized open-graded material shall be placed only when the atmospheric temperature is above 40 degrees F and the surface temperature upon which it is to be placed is no less than 35 degrees F.

The surface upon which mixtures are to be placed shall be free of standing water.

The Engineer will not permit water to be used to cool the asphalt-stabilized open-graded course.

The Contractor shall not use vibratory rollers on the asphalt-stabilized open-graded course.

313.06—Procedures

The Contractor shall not place stabilized open-graded material until the Engineer approves the surface upon which it is to be placed. Preparation shall include provision for surface drainage away from the material to prevent contamination from surface water in the event of rainfall.

The Contractor shall prevent contamination of the stabilized open-graded material. Material that has been contaminated shall be removed and replaced promptly by the Contractor at no additional expense to the Department. Likely indications of contamination include, but are not limited to, the surface being clogged by dirt or other foreign material or observable material damaged as in the cases of loss of material stability.

The finished surface of the stabilized open-graded material shall be uniform and shall not vary at any point more than 0.5 inch above or below the grade shown on the plans or established by the Engineer.

The Contractor shall remove and replace stabilized open-graded material with a surface higher than 0.5 inch above the grade shown on the plans or established by the Engineer with material within the proper

tolerance. If permitted by the Engineer, high spots may be removed to within specified tolerance by any method that does not produce contaminating fines or damage the base to remain in place, except that the Engineer will not permit grinding.

The Contractor shall remove and replace stabilized open-graded material with a surface lower than 0.5 inch below the grade shown on the plans or established by the Engineer with stabilized open-graded material that complies with these specifications to the proper tolerance. The Engineer may permit low areas to be filled with the next pavement course in the same operation in which the pavement is placed provided the next pavement course is provided at no additional cost to the Department.

The Contractor shall not use the open-graded course as a haul road or storage area. Construction traffic will not be permitted on the open-graded course except for equipment required to place the next layer. The Engineer will not permit haul vehicles that are overweight or that have not had a legal load determination on the open-graded drainage course for any purpose.

The Contractor shall place asphalt-stabilized open-graded material in one layer by approved equipment conforming to Section 315.03. Compaction shall begin when the internal mat temperature is approximately 150 degrees F to 200 degrees F. The Contractor shall employ a static, steel, two-wheel roller to compact the material in one to three passes in an established pattern that has been approved by the Engineer. An 8- to 10-ton roller is recommended for such use. The mat shall be compacted sufficiently to support the placement of the next layer but not to the point that it is no longer free draining or that the aggregate is crushed.

The Engineer will not permit placement of the next higher pavement layer if any damage to the stabilized open-graded material is visible. Construction of the next layer shall not proceed until directed by the Engineer.

313.07—Measurement and Payment

Asphalt-stabilized open-graded material will be measured in tons and will be paid for at the contract unit price per ton, complete-in-place. This price shall be full compensation for furnishing and placing asphalt material including aggregate, lime, or other anti-stripping admixture.

Payment will be made under:

Pay Item	Pay Unit
Asphalt-stabilized open-graded material	Ton

SECTION 314—PENETRATION SURFACE COURSES

314.01—Description

This work shall consist of constructing a wearing surface of crushed stone, slag, or crushed gravel penetrated with asphalt in accordance with these specifications and in conformity with the lines shown on the plans or as established by the Engineer.

314.02—Materials

(a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to Section 210 as applicable.

(b) **Aggregate** shall be crushed stone, slag, or crushed gravel that conforms to Section 203 as applicable. The Contractor shall not haul aggregate directly from a washing plant to be used in the work.

(c) **Fine aggregate** shall be Grading B sand conforming to Section 202.

314.03—Weather Limitations

The Contractor shall not place penetration courses when surfaces are wet, when the air temperature is below 50 degrees F, or when the surface temperature is below 70 degrees F. The Contractor shall furnish a properly calibrated infrared instrument for the purpose of measuring the surface temperature and shall measure the surface temperature for conformance to the aforementioned temperature range prior to placement.

314.04—Equipment

The Engineer will evaluate the Contractor's equipment for acceptance in placing the materials prior to performance of the work. Equipment that will handle the materials and produce the completed course or courses in accordance with these specifications is acceptable.

(a) **Spreaders:** Spreaders for coarse aggregate shall be self-propelled spreading and leveling machines or spreader boxes equipped with shoes or runners of sufficient width and length to preclude damage or displacement of the subgrade or other courses.

The mechanical spreader for the fine aggregate shall conform to Section 312.03.

(b) **Distributor:** The distributor shall be so designed, equipped, maintained, and operated that asphalt at the specified temperature range may be applied uniformly on variable widths of surface up to 15 feet. The distributor shall be capable of applying the asphalt at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard, with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.02 gallon per square yard. Distributor equipment shall include a tachometer, pressure gages, accurate volume-measuring devices, or a calibrated tank and a thermometer for measuring temperatures of the contents of the tanks. Distributors shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically. The distributor shall be equipped with a positive shutoff control that will prevent lapping at the junction of two applications. When necessary, the distributor shall be equipped with a positive means of deflecting the spray to prevent coating of adjacent structures and appurtenances. A connection for attaching hand spraying devices shall be provided and the Contractor shall use hand-spraying equipment to cover variable-width areas, patches, and other areas where spray bar application is impractical or would result in excessive asphalt material.

(c) **Rollers:** The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density.

314.05—Procedures

Cover material shall be applied in full-lane widths up to 12 feet. The Contractor shall make laps only at lane dividers or at the crown of the roadway. Successive laps at lane dividers and the crown of the roadway shall be staggered from 3 to 6 inches.

The Contractor shall condition the road surface to receive the materials in accordance with Section 312.04.

(a) **Rates of Application:**

	Asphalt (gal/sq yd)	Aggregate (lb/sq yd)
Light Courses		
Coarse aggregate No. 56		60-139
Asphalt for penetration	0.75-1.20	
Choke aggregate		
No. 68, or		20-30
No. 78, or		22-28
No. 8, or		18-25
Grading B sand		10-15
Asphalt for seal	0.15-0.30	
Seal aggregate, No. 78, or		22-28
Seal aggregate, No. 8		18-25
Heavy Courses		
Asphalt for tack coat	0.10-0.20	
Coarse aggregate, No. 56		140-200
Asphalt for penetration	1.30-1.80	
Choke aggregate, No. 68		20-30
Asphalt for seal	0.20-0.35	
Seal aggregate, No. 78 or		22-28
Seal aggregate, No. 8		18-25

(b) **Sequence and Methods:**

1. If deemed necessary by the Engineer or specified in the contract, the Contractor shall apply a tack coat in accordance with Section 310 immediately prior to the application of coarse aggregate.

2. The coarse aggregate shall be uniformly spread on the prepared base or surface at the specified rate of application. This application shall be mixed and shaped by the use of multiple-blade road planers or other equipment deemed acceptable by the Engineer.

   Immediately following mixing and shaping operations, the Contractor shall roll the surface with a 10-ton, three-wheel or tandem steel wheel roller and, for a heavy penetration surface course; the Contractor shall uniformly choke the surface with No. 68 aggregate. The surface will be tested by the Engineer using a 10-foot straightedge. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall be not more than 1/4 inch. The Contractor shall correct any humps or depres-

sions exceeding the specified tolerance. The coarse aggregate on light penetration courses shall be uniformly choked with the fine aggregate.

3. The prepared course shall be penetrated with asphalt at the rate specified and immediately covered with the choke aggregate. The Contractor's rolling operations shall immediately follow the application of covering aggregate and shall continue until the treatment is bonded. Subsequent rolling and applications of cover aggregate, if required, shall be performed on successive days following the application.

4. The Contractor shall apply and roll a seal coat after the penetration course has cured.

314.06—Measurement and Payment

Asphalt will be measured in gallons.

Aggregate and cover material will be measured in tons.

Penetration surface course will be paid for at the contract unit price per gallon for asphalt and per ton for aggregate and cover material specified.

These prices shall include furnishing and applying materials and maintaining the treatment.

Payment will be made under:

Pay Item	Pay Unit
Liquid asphalt	Gallon
Cover material (Type)	Ton
Aggregate (No.)	Ton

SECTION 315—ASPHALT CONCRETE PLACEMENT

315.01—Description

This work shall consist of constructing one or more courses of asphalt concrete on a prepared foundation in accordance with these Specifications and within the specified tolerances for the lines, grades, thicknesses, and cross sections shown on the plans or established by the Engineer. At the Contractor's option, the asphalt concrete mix may be produced using a warm-mix additive or warm-mix process approved by the Department. When used, the temperature placement limitations for Warm Mix Asphalt (WMA) shall apply.

This work shall also consist of constructing asphalt concrete curb and rumble strips in accordance with these Specifications, plan details, and the Standard Drawings.

315.02—Materials

(a) **Asphalt concrete** shall conform to Section 211. The Contractor shall alter the design if SUPERPAVE design densities begin to exceed 98 percent of the theoretical maximum density during construction.

(b) **Asphalt for Tack Coat** shall conform to Section 210 and shall be applied according to Section 310.

(c) **Asphalt for prime coat** shall conform to Section 210 and shall be applied according to Section 311.

(d) **Curb backup material** shall be asphalt concrete conforming to any surface or intermediate mixture listed in Table II-13 and Table II-14.

(e) **Liquid asphalt coating (emulsion) for rumble strips** shall conform to Section 210. The Contractor shall use CSS-1h or CQS-1h asphalt emulsions for centerline rumble strips. The CSS-1h or CQS-1h liquid asphalt may be diluted by up to 30 percent at the emulsion manufacturer's facility.

315.03—Equipment

(a) **Hauling Equipment:** Trucks used for hauling asphalt mixtures shall have structurally sound, tight, clean, smooth metal or other non-absorptive, inert material bodies equipped with a positive locking metal tailgate. Surfaces in contact with asphalt mixtures shall be given a thin coat of aliphatic hydrocarbon invert emulsion release agent (nonpuddling), a lime solution, or other release agent materials on the Materials Division's Approved Products List No. 8. The beds of dump trucks shall be raised to remove excess release agent prior to loading except when a nonpuddling release agent is used. Only a nonpuddling agent shall be used in truck beds that do not dump. Each Contractor truck used for hauling asphalt shall be equipped with a tarpaulin or other type of cover acceptable to the Engineer that shall protect the mixture from moisture and foreign matter and prevent the rapid loss of heat during transportation.

(b) **Asphalt Pavers:** The asphalt paver shall be designed and recommended by the manufacturer for the type of asphalt to be placed and shall be operated in accordance with the manufacturer's recommendations. The Contractor shall readily have and maintain on the project site any written recommendations from the manufacturer of the mix relative to handling and placing of the mixture. In the absence of the manufacturer's recommendations, the recommendations of the National Asphalt Pavement Association shall be followed. The paver shall be capable of producing a smooth uniform texture, dense joints, and a smooth riding surface even when screed extensions are used.

(c) **Rollers:** Rollers shall be steel wheel, static or vibratory, or pneumatic tire rollers and shall be capable of reversing without backlash. The Contractor shall operate rollers at speeds slow enough to avoid displacement of the mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The Engineer will not allow the use of equipment that results in excessive crushing of aggregate or marring of the pavement surface. If the Contractor's equipment mars the surface of the pavement during construction to the extent that imperfections cannot satisfactorily be corrected or produces permanent blemishes, the Engineer will require the Contractor to discontinue the use of that particular equipment and replace that equipment with satisfactory units.

(d) **Rotary Saw:** The Contractor shall supply a gasoline-powered rotary saw with a carbide blade for cutting test samples from the pavement. The Contractor shall provide gasoline, oil, additional carbide blades, and maintenance for the rotary saw. The Contractor shall cool the

pavement prior to sawing the sample. As an alternative, the Contractor may furnish the necessary equipment for coring and testing 4-inch core samples in accordance with VTM-22.

(e) **Material Transfer Vehicle (MTV):** When required in the Contract, the Contractor shall furnish a self-propelled MTV storage unit capable of receiving material from trucks, storing the material, and transferring the material from the unit to a paver hopper insert via a conveyor system. The paver hopper insert and unit shall have a combined minimum storage capacity of 15 tons. The storage unit or paver hopper insert must be able to remix the material in order to produce a uniform, non-segregated mix having a uniform temperature prior to placing the asphalt material on the roadway surface.

315.04—Placement Limitations

The Contractor shall not place asphalt concrete mixtures when weather or surface conditions are such that the material cannot be properly handled, finished, or compacted. The surface upon which asphalt mixtures is to be placed shall be free of standing water, dirt, and mud and the base temperature shall conform to the following:

(a) **Asphalt Concrete Produced with Warm Mix Asphalt Additives or Processes:**

1. **When the base temperature is 40 degrees F and above:** The Engineer will permit laydown at any temperature below the maximum limits given in Section 211.08.

2. **When the mixture temperature is below 200 degrees F:** The Contractor will not be allowed to place the material.

(b) **Asphalt Concrete Produced without Warm Mix Asphalt Additives or Processes:**

1. **When the base temperature is above 80 degrees F:** The Engineer will allow laydown of the mixture at any temperature conforming to the limits specified in Section 211.

2. **When the base temperature is between 40 degrees F and 80 degrees F:** The Contractor shall use the Nomograph, Table III-2, to determine the minimum laydown temperature of the asphalt concrete mixes. At no time shall the base temperature for base (BM) and intermediate (IM) mixes be less than 40 degrees F. At no time shall the laydown temperature for base (BM) and intermediate (IM) mixes be less than 250 degrees F.

   The minimum base and laydown temperatures for surface mixes (SM) shall never be less than the following:

PG Binder/Mix Designation	Percentage of Reclaimed Asphalt Pavement (RAP) Added to Mix	Minimum Base Temperature	Minimum Placement Temperature
PG 64S-22 (A)	<=25%	40°F	250°F
PG 64S-22 (A)	>25%	50°F	270°F
PG 64H-22 (D)	<=30%	50°F	270°F
PG 64E-22 (E)	<=15%	50°F	290°F
PG 64S-22 (S)	<=30%	50°F	290°F

3. **When the laydown temperature is between 301 degrees F and 325 degrees F:** The number of compaction rollers shall be the same number as those required for 300 degrees F.

Intermediate and base courses that are placed at rates of application that exceed the application rates shown in Table III-2 shall conform to the requirements for the maximum application rate shown for 8-minute and 15-minute compaction rolling as per number of rollers used.

If the Contractor is unable to complete the compaction rolling within the applicable 8-minute or 15-minute period, the Engineer will either require the placing of the asphalt mixture to cease until sufficient rollers are used or other corrective action be taken to complete the compaction rolling within the specified time period. The Contractor shall complete compaction rolling prior to the mat cooling down to 175 degrees F. Finish rolling may be performed at a lower mat temperature.

The Contractor shall not place the final asphalt pavement finish course until temporary pavement markings will no longer be required.

315.05—Procedures

(a) **Base Course:** The Contractor shall prepare the subgrade or subbase as specified in Section 305. The Contractor shall grade and compact the course to the required profile upon which the pavement is to be placed, including the area that will support the paving equipment.

(b) **Conditioning Existing Surface:** The surface on which the asphalt concrete is to be placed shall be prepared in accordance with the applicable specifications and shall be graded and compacted to the required profile and cross section.

When specified in the Contract, prior to placement of asphalt concrete, the Contractor shall seal longitudinal and transverse joints and cracks by the application of an approved crack sealing material in accordance with the special provision for "Sealing Cracks in Asphalt Concrete Surfaces or Hydraulic Cement Concrete Pavement."

1. **Priming and Tacking:** The Contractor shall paint contact surfaces of curbing, gutters, manholes, and other structures projecting into or abutting the pavement and cold joints of asphalt with a thick, uniform coating of asphalt prior to placing the asphalt mixture.

The Contractor shall apply a tack or prime coat of asphalt conforming to the applicable requirements of Section 311 or Section 310 and as specified below. Liquid asphalt classified as cutbacks or emulsions shall be applied ahead of the paving operations, and the time interval between applying and placing the paving mixture shall be sufficient to ensure a tacky residue has formed to provide maximum adhesion of the paving mixture to the base. The Contractor shall not place the mixture on tack or prime coats that have been damaged by traffic or contaminated by foreign material. Traffic shall be excluded from such sections.

a. **Priming aggregate base or subbase:** The Engineer will not require priming with asphalt material on aggregate subbase or base material prior to the placement of asphalt base, intermediate or surface layers unless otherwise specified in the Contract.

b. **Tacking:** Tack at joints, adjacent to curbs, gutters, or other appurtenances shall be applied with a hand wand or with spray bar at the rate of 0.2 gallon per square yard. At joints, the tack applied by the hand wand or a spray bar shall be 2 feet in width with 4 to 6 inches protruding beyond the joint for the first pass. Tack for the adjacent pass shall completely cover the vertical face of the pavement mat edge so that slight puddling of asphalt occurs at the joint, and extend a minimum of 1 foot into the lane to be paved. Milled faces that are to remain in place shall be tacked in the same way for the adjacent pass. Use of tack at the vertical faces of longitudinal joints will not be required when paving is performed in echelon.

The tack coat shall be eliminated on asphalt saturated (rich) sections or those that have been repaired by the extensive use of asphalt patching mixtures when directed by the Engineer.

Tack shall not be required atop asphalt stabilized open-graded material drainage layers.

Tack shall be applied between the existing asphalt surface and each asphalt course placed thereafter.

2. **Removing depressions and elevating curves:** Where irregularities in the existing surface will result in a course more than 3 inches in thickness after compaction, the Contractor shall bring the surface to a uniform profile by patching with asphalt concrete and thoroughly tamping or rolling the patched area until it conforms with the surrounding surface. The mixture used shall be the same as that specified for the course to be placed.

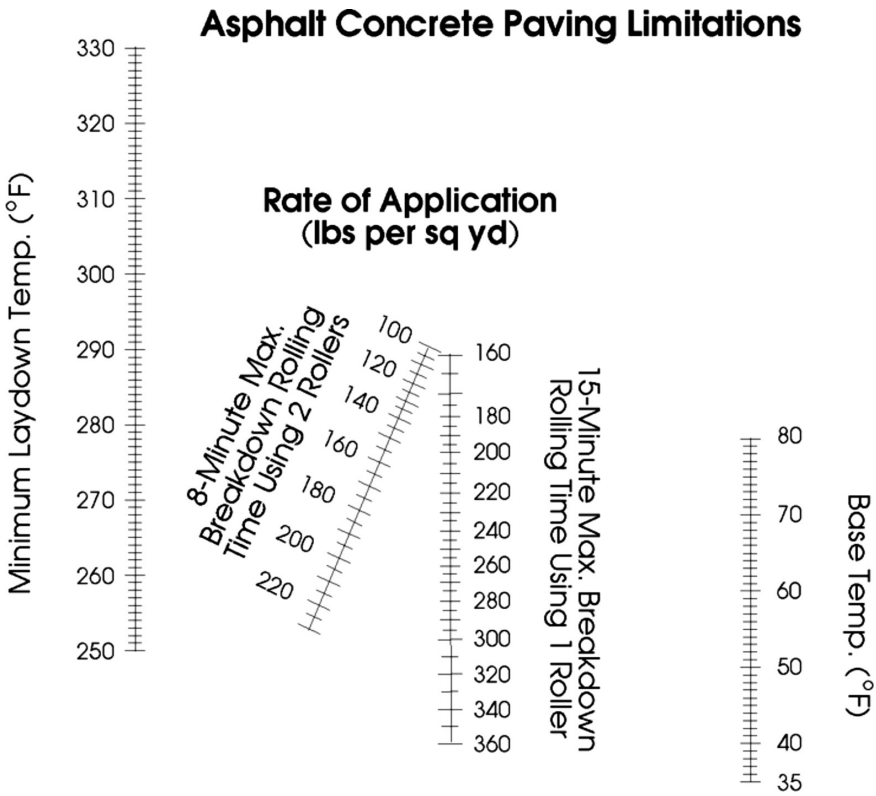
When the Contractor elects to conduct operations to eliminate depressions, elevate curves, and place the surface course simultaneously, the Contractor shall furnish such additional spreading and compacting equipment as required to maintain the proper interval between the operations.

(c) **Placing and Finishing:** The Contractor shall not place asphalt concrete until the Engineer approves the surface upon which it is to be placed.

The Contractor's equipment and placement operations shall properly control the pavement width and horizontal alignment. The Contractor shall use an asphalt paver sized to distribute asphalt concrete over the widest pavement width practicable. Wherever practicable, and when the capacity of sustained production and delivery is such that more than one paver can be successfully and continuously operated, pavers shall be used in echelon to place the wearing course in adjacent lanes. Crossovers, as well as areas containing manholes or other obstacles that prohibit the practical use of mechanical spreading and finishing equipment may be constructed using hand tools. However, the Contractor shall exercise care to obtain the required thickness, jointing, compaction, and surface smoothness in such areas.

The longitudinal joint in one layer shall offset that in the layer immediately below by approximately 6 inches or more. The joint in the wearing surface shall be offset 6 inches to 12 inches from the centerline of the pavement if the roadway comprises two traffic lanes. The joint should be offset approximately 6 inches from the lane lines if the roadway is more than two lanes wide. The Engineer will not require offsetting layers when adjoining lanes are paved in echelon and the rolling of both lanes occurs within 15 minutes after laydown.

TABLE III-2
Cold Weather Paving Limitations



The Contractor shall have a certified Asphalt Field Level II Technician present during all paving operations. Immediately after placement and screeding, the surface and edges of each layer shall be inspected by the Asphalt Field Level II Technician to ensure compliance with the asphalt placement requirements and be straightedged to verify uniformity and smoothness. The Asphalt Field Level II Technician shall make any corrections to the placement operations, if necessary, prior to compaction. The finished pavement shall be uniform and smooth.

The Contractor's Asphalt Field Level II Technician shall be present during all density testing.

Asphalt concrete placement shall be as continuous as possible and shall be scheduled such that the interruption occurring at the completion of each day's work shall not detrimentally affect the partially completed work. Material that cannot be spread and finished in daylight shall not be dispatched from the plant unless the Engineer approves the use of artificial lighting. When paving is performed at night, the Contractor shall provide sufficient light to properly perform and thoroughly inspect every phase of the operation. Such phases include cleaning planed surfaces, applying tack, paving, compacting, and testing. Lighting shall be provided and positioned so as to not create a blinding hazard to the traveling public.

The Contractor shall ensure that the roller does not pass over the end of freshly placed material during the compaction of asphalt concrete except when a transverse construction joint is to be formed. Edges of pavement shall be finished true and uniform.

Asphalt concrete SUPERPAVE pavement courses shall be placed in layers not exceeding four times the nominal maximum size aggregate in the asphalt mixture. The maximum thickness may be reduced if the mixture cannot be adequately placed in a single lift and compacted to the required uniform density and smoothness. The minimum thickness for a pavement course shall be no less than 2.5 times the nominal maximum size aggregate in the asphalt mixture. Nominal maximum size aggregate for each mix shall be defined as one sieve size larger than the first sieve to retain more than 10 percent aggregate as shown in the design range specified in Section 211.03, Table II-13. The Contractor may place base courses in irregularly shaped areas of pavement such as transitions, turn lanes, crossovers, and entrances in a single lift.

The Contractor shall square up overlays in excess of 220 pounds per square yard or lanes with a milled depth greater than 2 inches prior to opening to traffic.

The Contractor shall cut drainage outlets through the shoulder at locations the Engineer designates, excluding curb and gutter sections, on the milled roadway areas that are to be opened to traffic. Plan and prosecute the milling operation to avoid trapping water on the roadway and restore drainage outlets to original grade once paving operations are completed, unless otherwise directed by the Engineer. The cost for cutting and restoring the drainage slots in the roadway shoulder shall be included in the price bid for other items of work.

The Contractor shall plan and prosecute a schedule of operations so that milled roadways shall be overlaid with asphalt concrete as soon as possible. In no instance shall the time lapse exceed 14 days after the milling operations, unless otherwise specified in Section 515 or other provisions in the contract. The Contractor shall keep milled areas of the roadway free of irregularities and obstructions that may create a hazard or annoyance to traffic in accordance with Section 104.

The Contractor shall use a short ski or shoe to match the grade of the newly overlaid adjacent travel lane on primary, interstate, and designated secondary routes. Unless otherwise directed by the Engineer, a 24-foot minimum automatic grade control ski shall be used on asphalt mixtures on divided highways, with the exception of overlays that are less than full width and the first course of asphalt base mixtures over aggregate subbases. Care shall be exercised when working along curb and gutter sections to provide a uniform grade and joint.

The Contractor shall construct the final riding surface to tie into the existing surface by an approved method, which shall include the cutting of a notch into the existing pavement. In addition to notching, the Contractor may use an asphalt mix design containing a fine-graded mix to achieve a smooth transition from the new asphalt concrete overlay to the existing pavement, with the approval of the Engineer. The material shall be of a type to ensure that raveling will not occur. The cost for constructing tie-ins in the asphalt concrete overlay shall be included in the asphalt concrete contract unit price.

Prior to application of tack coat and commencement of paving operations if, in the opinion of the Engineer, the existing pavement surface condition may detrimentally affect or prevent the bond of the new overlay, the Contractor shall clean the existing pavement surface of all accumulated dust, mud, or other debris.

The Contractor shall ensure the surface remains clean until commencement of, and during, paving operations. The cost for cleaning and surface preparation shall be included in the asphalt concrete contract unit price.

The Contractor shall employ a Material Transfer Vehicle (MTV) during the placement of surface mixes (SM) on all Interstate routes. If equipment within the paving train breaks down, paving shall be discontinued once the material on-site has been placed and no more material shall be shipped from the asphalt plant.

When required in the Contract, a MTV shall be used during the placement of designated asphalt mixes on full lane width applications.

(d) **Compacting:** Immediately after the asphalt mixture is placed, struck off, and surface irregularities are corrected, the mixture shall be thoroughly and uniformly compacted by rolling. Rolling shall be a continuous process, insofar as practicable, and all parts of the pavement shall receive uniform compaction.

The asphalt surface shall be rolled when the mixture is in the proper condition. Rolling shall not cause undue displacement, cracking, or shoving of the placed mixture.

The Contractor shall use the number, weight, and type of rollers sufficient to obtain the required compaction while the mixture is in a workable condition. The sequence of rolling operations and the selection of roller types shall provide the specified pavement density.

Rolling shall begin at the sides of the placement and proceed longitudinally parallel with the center of the pavement, each pass overlapping at least 6 inches, gradually progressing to the crown of the pavement. When abutting a previously placed lane, rolling shall begin at the outside unconfined side and proceed toward the previously placed lane. On superelevated curves, rolling shall begin at the low side and proceed to the high side by overlapping longitudinal passes parallel with the centerline.

The Contractor shall correct displacements occurring as a result of reversing the direction of a roller or other causes at once by the use of rakes or lutes and the addition of fresh mixture when required. Care shall be taken in rolling not to displace or distort the line and grade of the edges of the asphalt mixture. Edges of finished asphalt pavement surfaces shall be true curves or tangents. The Contractor shall correct irregularities in such areas.

The Contractor shall keep the wheels/drums of the rollers properly moistened with water, water mixed with a very small quantity of detergent or other Engineer approved material to prevent adhesion of the mixture to the rollers. The Engineer will not allow the use or presence of excess liquid on the rollers

The Contractor shall thoroughly compact the mixture along forms, curbs, headers, walls, and other places not accessible to rollers with hot hand tampers, smoothing irons, or mechanical tampers,. On depressed areas, a trench roller or cleated compression strips may be used under the roller to ensure proper compression.

The Contractor shall protect the surface of the compacted course until the material has cooled sufficiently to support normal traffic without marring.

(e) **Density** shall be determined in accordance with the following:

1. The Contractor shall perform roller pattern and control strip density testing on surface, intermediate, and base courses in accordance with VTM-76. The Contractor shall have a certified Asphalt Field Technician II perform all density testing.

Density shall be determined with a thin-lift nuclear gauge conforming VTM-81 or from the testing of plugs/cores taken from the roadway where the mixture was placed. Density test locations shall be marked and labeled in accordance with VTM-76. When acceptance testing is performed with a nuclear gauge, the Contractor shall have had the gauge calibrated within the previous 12 months by an approved calibration service. In addition, the Contractor shall maintain documentation of such calibration service for the 12-month period from the date of the calibration service. The required density of the compacted course shall not be less than 98.0 percent or more than 102.0 percent of the target control strip density.

Nuclear density roller pattern and control strip density testing shall be performed on asphalt concrete overlays placed directly on surface treatment roadways and when overlays are placed at an application rate less than 125 pounds per square yard, based on 110 pounds per square yard per inch, on any surface. In these situations, the Engineer will not require sawed plugs or core samples and the minimum control strip densities as specified in Table III-3 will not be required. The required density of the compacted course shall not be less than 98.0 percent or more than 102.0 percent of the target control strip.

TABLE III-3
Density Requirements

Mixture Type	Min. Control Strip Density (%)[1]
SM-9.5A, 12.5A	92.5
SM-9.5D, 12.5D	92.2
SM-9.5E, 12.5E	92.2
IM-19.0A, IM-19.0D, IM-19.0E	92.2
BM-25.0A, BM-25.0D	92.2

[1] The control strip density requirement is the percentage of theoretical maximum density of the job-mix formula by SUPERPAVE mix design or as established by the Engineer based on two or more production maximum theoretical density tests.

The Engineer will divide the project into "control strips" and "test sections" for the purpose of defining areas represented by each series of tests.

a. **Control Strip:** Control strips shall be constructed in accordance with these specifications and VTM-76.

The term *control strip density* is defined as the average of 10 determinations selected at stratified random locations within the control strip.

The Contractor shall construct one control strip at the beginning of work on each roadway and shoulder course and on each lift of each course. The Engineer will require the Contractor to construct an additional control strip whenever a change is made in the type or source of materials; whenever a significant change occurs in the composition of the material being placed from the same source; or when there is a failing test strip. During the evaluation of the initial control strip, the Contractor may continue paving operations, however, paving and production shall be discontinued during construction and evaluation of any additional control strips. If two consecutive control strips fail, subsequent paving operations shall not begin or shall cease

until the Contractor recommends correctives actions to the Engineer and the Engineer approves the Contractor proceeding with the corrective action(s). If the Contractor and the Engineer mutually agree that the required density cannot be obtained because of the condition of the existing pavement structure, the target control strip density shall be determined from the roller pattern that achieves the optimum density and this target control strip density shall be used on the remainder of the roadway that exhibits similar pavement conditions.

Either the Engineer or the Contractor may initiate the construction of an additional control strip at any time.

The length of the control strip shall be approximately 300 feet and the width shall not be less than 6 feet. On the first day of construction or beginning of a new course, the control strip shall be started between 500 and 1,000 feet from the beginning of the paving operation. The Contractor shall construct the control strip using the same paving, rolling equipment, procedures, and thickness as shall be used for the remainder of the course being placed.

The Contractor's Asphalt Field Level II Technician shall take one reading at each of 10 stratified random locations. No determination shall be made within 12 inches of the edge of any application width for surface and intermediate mixes or within 18 inches of the edge of any application width for base mixes. The average of these 10 determinations shall be the control strip density recorded to the nearest 0.1 pound per cubic foot. The minimum control strip density shall be determined in accordance with VTM-76.

The control strip shall be considered a lot. If the control strip density conforms to the requirements specified in Table III-3, the Engineer will consider the control strip to be acceptable and the control strip density shall become the target control strip density. If the density does not conform to the requirements specified in Table III-3, the tonnage placed in the control strip and any subsequent paving prior to construction of another control strip will be paid for in accordance with Table III-4 on the basis of the percentage of the Table III-3 value achieved. The Contractor shall take corrective action(s) to comply with the density requirement specified in Table III-3.

TABLE III-4
Payment Schedule for Lot Densities

% of Target Control Strip Density	% of Payment
Greater than 102.0	95
98.0 to 102.0	100
97.0 to less than 98.0	95
96.0 to less than 97.0	90
Less than 96.0	75

b. **Test section (lot):** For the purposes of determining acceptance, the Engineer will consider each day's production as a lot unless the paving length is less than 3,000 linear feet or greater than 7,500 linear feet. When paving is less than 3,000 feet, that day's production will be combined with the previous day's production or added to the next day's production to create a lot as described below.

The standard size of a lot will be 5,000 linear feet (five 1,000 foot sublots) of any pass 6 feet or greater made by the paving train for the thickness of the course. If the Engineer approves, the lot size may be increased to 7,500 linear foot lots with five 1,500 foot sublots when the Contractor's normal daily production exceeds 7,000 feet. Pavers traveling in echelon will be considered as two passes. When a partial lot occurs at the end of a day's production or upon completion of the project, the lot size will be redefined as follows:

- If the partial lot contains one or two sublots, the sublots will be added to the previous lot.

- If the partial lot contains three or four sublots, the partial lot will be redefined to be an entire lot.

The Contractor shall test each lot for density by taking a nuclear density gauge reading from two random test sites selected by the Engineer within each sublot. When saw cores are used to determine acceptance a single test site will be selected by the Engineer. Test sites will not be located within 12 inches of the edge of any application width for surface and intermediate mixes or within 18 inches of the edge of any application width for base mixes.

The Engineer will compare the average of the sublot density measurements to the target nuclear density, or for cores, to the target percent of theoretical maximum density achieved on the control strip to determine the acceptability of the lot. The Engineer will not allow the Contractor to provide additional compaction to raise the average once the average density of the lot has been determined. The Contractor shall immediately notify the Engineer and institute corrective action if two consecutive sublots produce density results less than 98 percent or more than 102 percent of the target control strip density.

Longitudinal joints shall also be tested for density using a nuclear density gauge at each test site in the sublot. For surface and intermediate mixes, the edge of the gauge shall be placed within 4 inches of the joint. For base mixes, the edge of the gauge shall be placed within 6 inches of the joint. The Contractor shall not place the gauge atop the joint. The joint density value shall be recorded. The Contractor shall report to the Engineer and institute corrective action if a single longitudinal joint density reading is less than 95 percent of the target control strip density. The Engineer will not use the values obtained from the joint readings in payment calculation. The Contractor shall furnish the test data developed during the day's paving to the Engineer by the end of that day's operations.

When sawn cores are used for density acceptance, the Contractor shall perform acceptance testing for density for each sublot by obtaining one sawed 4 inch by 4 inch specimen, or one 4-inch-diameter core, at a single random test site selected by the Engineer.

- The sub-lot site shall be marked as described in VTM-76.

- The bulk specific gravity of the cores shall be determined in accordance with VTM-6.

- The density of the cores shall be determined in accordance with VTM-22.

Cores or plugs shall be bulked in the presence of the Engineer. The Department may have the cores or plugs bulked on the project site. The Contractor shall number sublot test sites sequentially per lot, mark these on the pavement, fill them with the paving mixture, and compact them prior to the completion of each day of production.

The tonnage of each lot will be based on the lot's width and length and the mixture application rate as designated in the Contract or as revised by the Engineer. Payment will be made in accordance with Table III-4.

The Engineer may perform lot density verification testing at any time on any project. Lot density verification will be performed by testing plugs. The Contractor shall be responsible for taking plugs for testing. The Engineer will perform verification testing of the plugs.

Surface, Intermediate, and Base mixes:

The Contractor shall take two plugs per Verification, Sampling and Testing (VST) lot at locations selected by the Engineer. If the Engineer determines the density of the plugs does not conform to the requirements for the lot in question or the same payment percentage determined by the Contractor's testing for that lot, then the Contractor may request the referee procedure to be invoked. The Contractor shall take one additional plug from the remaining sublots. Payment for that lot, based on the results of the initial two plugs/cores or referee procedure, will be in accordance with the percentage specified in Table III-4 on the basis of the percentage of the control strip bulk density achieved.

2. **Surface, intermediate, and base courses** not having a sufficient quantity of material to run a roller pattern and control strip shall be compacted to a minimum density of 91.5 percent of the theoretical maximum density as determined in accordance with VTM-22. The Contractor shall be responsible for cutting cores or sawing plugs for testing by the Department. One set of plugs/cores shall be obtained within the first 20 tons of small quantity paving and every 100 tons thereafter for testing by the Department. Core/plug locations shall be randomly selected by the Engineer. If the density is determined to be less than 91.5 percent, the Engineer will make payment in accordance with Table III-5.

TABLE III-5
Payment Schedule for Surface, Intermediate and Base Courses (Not sufficient quantity to perform density roller pattern and control strip)

% TMD	% of Payment
Greater than 91.5	100
90.2-91.4	95
88.3-90.1	90
Less than 88.2	75

Any section in which a mixture (e.g., SM-9.0) is being placed at an application rate of less than 125 pounds per square yard (based on 110 pounds per square yard per inch) that

does not have a sufficient quantity of material for a roller pattern and control strip shall be compacted by rolling a minimum of three passes with a minimum 8-ton roller. The Engineer will not require density testing.

For asphalt patching, the minimum density of 91.5 percent of the maximum theoretical density will be determined in accordance with VTM-22. The Contractor is responsible for cutting cores or sawing plugs. One set of plugs/cores shall be obtained within the first 20 tons of patching material and every 100 tons thereafter for testing by the Contractor or the Department. The Engineer will randomly select core/plug locations. If the density is less than the 91.5 percent, payment will be made on the tonnage within the 20 or 100 ton lot in accordance with Table III-5.

(f) **Joints:** Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. A coat of asphalt shall be applied to contact surfaces of transverse joints just before additional mixture is placed against the previously rolled material.

Joints adjacent to curbs, gutters, or adjoining pavement shall be formed by hand placing sufficient mixture to fill any space left uncovered by the paver. The joint shall then be set up with rakes or lutes to a height sufficient to receive full compression under the rollers.

(g) **Rumble Strips:** This work shall consist of constructing rumble strips by cutting 1/2-inch-deep concave depressions into existing asphalt concrete surfaces as shown on the Standard Drawings and as directed by the Engineer.

Rumble strips shall be installed in accordance with the details of the RS-1 (shoulders) or RS-3 (centerline) Standard Drawings. The maximum allowable center depth is 5/8-inch. Depressions shall have a smooth finish with a maximum 1/16-inch variance between peaks and valleys of the depression.

The Contractor shall demonstrate to the Engineer the ability to achieve the desired cross section and dimensions of the depression and surface area regarding alignment, consistency, and conformity with these specifications and the Standards Drawings prior to beginning production work on mainline shoulders. The test site shall be approximately 25 feet longitudinally at a location mutually agreed upon by the Contractor and Engineer.

The Contractor shall coat the entire rumble strip area with liquid asphalt coating (emulsion) using a pressure distributor following the cutting and cleaning of the depressions of waste material. The approximate application rate shall be 0.1 gallons per square yard for rumble strips installed on the shoulder. The Contractor is not required to seal the rumble strip area of strips installed in a new asphalt concrete surface (new construction or overlay) along the centerline. When the rumble strip is installed along the centerline in an existing asphalt concrete surface (i.e. more than one year since placement), the approximate application rate shall be 0.05 gallons per square yard. The application temperature shall be between 160 degrees F and 180 degrees F. Shoulder rumble strip overspray shall not extend more than 2 inches beyond the width of the cut depressions and shall not come in contact with pavement markings.

Rumble strips shall not be installed on shoulders of bridge decks, in acceleration/deceleration lanes, on surface drainage structures, or in other areas identified by the Engineer.

Waste material resulting from the operation shall be removed from the paved surface and shall not be disposed of where waterways may be at risk of contamination.

(h) **Saw-Cut Asphalt Pavement:** This work shall consist of saw-cutting the existing asphalt pavement to a depth as shown on the plans or as directed by the Engineer.

315.06—Pavement Samples

The Contractor shall cut samples from the compacted pavement for depth and density testing. Samples shall be taken for the full depth of the course at the locations selected by the Engineer. The removed pavement shall be replaced with new mixture and refinished. No additional compensation will be allowed for furnishing test samples and reconstructing areas from which they were taken.

315.07—Pavement Tolerances

(a) **Surface Tolerance:** The Engineer will test the pavement surface by using a 10-foot straightedge. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall not be more than 1/4 inch. The Contractor shall correct humps and depressions exceeding the specified tolerance or the defective work shall be removed and replaced with new material.

(b) **Finished Grade Tolerance:** Finished grade elevations shall be within +/–0.04 foot of the elevations indicated in the plans after placement of the final pavement layer unless otherwise specified, provided the actual cross slope does not vary more than 0.20 percent from the design cross slope indicated in the plans, and the plan depth thickness conforms to the thickness tolerances specified herein.

If the Engineer determines either the finished grade elevations or cross slope exceed the specified tolerances, the Contractor shall submit a corrective action plan to the Engineer for approval.

(c) **Thickness Tolerance:** The thickness of the base course will be determined by the measurement of cores as described in VTM-32.

Acceptance of asphalt concrete base course for depth will be based on the mean result of measurements of samples taken from each lot of material placed. A lot of material is defined as the quantity being tested for acceptance except that the maximum lot size will be 1 mile of 24-foot-width base course.

A lot will be considered acceptable for depth if the mean result of the tests is within the following tolerance of the plan depth for the number of tests taken:

Plan Depth	1 test	2 tests	3 tests	4 tests
≤4”	0.6”	0.5”	0.4”	0.3”
>4.” ≤8”	0.9”	0.7”	0.5”	0.4”
>8”≤12”	1”	0.9”	0.7”	0.5”
>12”	1.2”	1”	0.8”	0.6”

If an individual depth test exceeds the one test tolerance for the specified plan depth, the Engineer will exclude that portion of the lot represented by the test from the lot. If an individual

test result indicates that the depth of material represented by the test is more than the tolerance for one test, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test. If an individual test result indicates that the depth of the material represented by the test is deficient by more than the one test tolerance for the plan depth, the Contractor shall correct the base course represented by the test as specified hereinafter.

If the mean depth, based on two or more tests, of a lot of material is excessive (more than the plan depth specified in the contract), the Engineer will not pay the Contractor for any material in excess of the tolerance throughout the length and width of the lots represented by the tests.

If the mean depth, based on two or more tests, of a lot of material is deficient (less than the plan depth specified in the contract) by more than the allowable tolerance, the Contractor will be paid for the quantity of material that has been placed in the lot. Any required corrective action will be determined by the Engineer.

For excessive depth base courses, the rate of deduction from the tonnage allowed for payment as base course will be calculated at a weight of 115 pounds per square yard per inch of depth in excess of the tolerance. For sections of base course that are deficient in depth by more than the one test tolerance and less than two and half times the one test tolerance, the Contractor shall furnish and place material specified for the subsequent course to bring the base course depth within the tolerance. This material will be measured on the basis of tonnage actually placed, determined from weigh tickets, and will be paid for at the contract unit price for the base course material. Such material shall be placed in a separate course. If the deficiency is more than two and half times the one test tolerance, the Contractor shall furnish and place base course material to bring the base course thickness within the tolerance. Corrections for deficient base course depth shall be made in a manner to provide a finished pavement that is smooth and uniform. Sections requiring significant grade adjustments which have been previously identified and documented by the Engineer as being outside of the control of the Contractor will be exempt from deduction or corrective action.

When the Contract provides for the construction or reconstruction of the entire pavement structure, the surface and intermediate courses shall be placed at the rate of application shown on the plans within an allowable tolerance of ±5 percent of the specified application rate for application rates of 100 pounds per square yard or greater and within 5 pounds per square yard for application rates of less than 100 pounds per square yard. The Engineer will deduct the amount of material exceeding the allowable tolerance from the quantities eligible for payment.

When the Contract provides for the placement of surface or intermediate courses over existing pavement, over pavements constructed between combination curb and gutter, or in the construction or reconstruction of shoulders, such courses shall be placed at the approximate rate of application as shown on the plans. However, the specified rate of application shall be altered where necessary to produce the required riding quality.

315.08—Measurement and Payment

Asphalt concrete base will be measured in tons and will be paid for at the contract unit price per ton. This price shall include preparing and shaping the subgrade or subbase, constructing and finishing shoulders and ditches, and removing and replacing unstable subgrade or subbase.

Asphalt concrete will be measured in tons and will be paid for at the contract unit price per ton. Net weight information shall be furnished with each load of material delivered in accordance with Section 211. Batch weights will not be permitted as a method of measurement unless the Contractor's plant is equipped in accordance with Section 211, in which case the cumulative weight of the batches will be used for payment.

Asphalt used in the mixtures, when a pay item, will be measured in tons in accordance with Section 109.01 except that transporting vehicles shall be tare weighed prior to each load. The weight will be adjusted in accordance with the percentage of asphalt indicated by laboratory extractions.

Tack coat, when not a pay item, shall be included in the price for other appropriate pay items.

Asphalt curb backup material will be measured in tons and will be paid for at the contract unit price per ton. This price shall include placing, tamping, and compacting.

Liquid asphalt cement, when a pay item, will be measured in tons and will be paid for at the contract unit price per ton.

Material Transfer Vehicle (MTV), when required in the Contract, will not be measured for separate payment. The cost for furnishing and operating the MTV shall be included in the contract unit prices of other appropriate items.

Warm Mix Asphalt (WMA) additive or process will not be measured for separate payment, the cost of which, shall be included in the contract unit prices of other appropriate items.

Rumble strips will be measured in linear feet and will be paid for at the contract unit price per linear foot of mainline pavement or shoulder where the rumble strips are actually placed and accepted, excluding the test site. This distance will be measured longitudinally along the center line of pavement (mainline) or edge of pavement (shoulders) with deductions for bridge decks, acceleration/deceleration lanes, surface drainage structures, and other sections where the rumble strips were not installed. This price shall include installing, cleaning up debris and disposing of waste material. The test site will not be measured for payment but shall be included in the unit price for rumble strip.

Liquid asphalt coating (rumble strips) will be measured in square yards and will be paid for at the contract unit price per square yard as described herein. This price shall include cleaning rumble strips prior to application of the coating and furnishing and applying coating as specified herein.

Saw-cut asphalt concrete pavement will be measured in linear feet for the depth specified and will be paid for at the contract unit price per linear foot, which price shall be full compensation for saw-cutting the asphalt pavement to the depth specified, cleaning up debris and disposal of waste material.

These prices for asphalt shall also include heat stabilization additive(s), furnishing samples, and maintaining traffic.

Patching will be paid for at the contract unit price for the various items used unless a reconditioning item is included in the Contract.

Payment will be made under:

Pay Item	Pay Unit
Asphalt concrete base course (Type)	Ton
Asphalt concrete (Type) (Class)	Ton
Asphalt concrete curb backup material	Ton

Pay Item	Pay Unit
Liquid asphalt cement	Ton
Rumble strip (Asphalt)	Linear foot
Liquid asphalt coating (Rumble strips)	Square yard
Saw-cut asphalt concrete (depth)	Linear foot

SECTION 316—HYDRAULIC CEMENT CONCRETE PAVEMENT

316.01—Description

This work shall consist of constructing reinforced, non-reinforced, or continuously reinforced hydraulic cement concrete pavement and approach slabs composed of hydraulic cement concrete, with or without reinforcement as specified, on a prepared subgrade or base course in accordance with these specifications and within the specified tolerances for the lines, grades, thicknesses, and cross sections shown on the plans or as established by the Engineer.

316.02—Materials

(a) **Concrete** shall be central mixed and shall conform to Section 217, Table II-17 for Class A3 paving concrete except that the slump shall not be more than 2 inches for placement by the slipform method. Concrete for placement by the slipform method shall be sufficiently cohesive to prevent detrimental sloughing at the pavement edges as the forms advance. Transit mixed concrete may be furnished for use in constructing approach slabs, ramps, transitions, connections, crossovers, and other miscellaneous pavement. Aggregate used in concrete for pavement and approach slabs that are used as riding surfaces shall be nonpolishing aggregate.

(b) **Reinforcing steel dowels, tie bars, hook bolts, and welded wire fabric** shall conform to Section 223.

(c) **Wide flange beams** used in the anchor slab of continuously reinforced pavement shall conform to ASTM A36.

(d) **Joint sealer and filler** shall conform to Section 212.

(e) **Load transfer devices** shall be fabricated of steel and shall be of an approved type and design.

(f) **Curing materials** shall conform to Section 220.

316.03—Equipment

Equipment and tools necessary for handling materials and performing the work shall be subject to the approval of the Engineer.

The Contractor shall provide the equipment and tools specified herein, or their approved equivalent, and they shall be of such capacity that the rate of placing concrete and finishing pavement will be continuous. If any piece of equipment does not have sufficient capacity to keep pace with the other operations, the

Contractor shall limit the size of the batch or otherwise limit the rate of production to preclude improper placement, poor workmanship, or frequent delays.

(a) **Forms:** Straight side forms shall be made of metal at least 7/32 inch in thickness and shall be furnished in sections at least 10 feet in length. Forms shall have a depth at least equal to the prescribed edge thickness of the concrete, without horizontal joints, and a base width equal to at least the depth of the forms. Flexible or curved forms of proper radius shall be used for curves with a radius of 100 feet or less. The design of flexible or curved forms shall be acceptable to the Engineer. Forms shall be provided with adequate devices for secure anchorage and placement so that when set they will withstand the impact and vibration of consolidating and finishing without visible springing, deformation or settlement. Flange braces shall extend outward on the base at least 2/3 the height of the form. The Engineer will not permit the use of forms that are bent, twisted, or broken or that have battered top surfaces. The Contractor shall not use repaired forms unless the Engineer has inspected and approved them. Built-in forms shall not be used except where the total area of pavement on the project is less than 2,000 square yards. The top face of the form shall not vary from a true plane more than 1/8 inch in 10 feet, and the vertical side shall not vary from a true plane more than 1/4 inch. Forms shall have provisions for locking the ends of abutting form sections together tightly and for secure setting.

(b) **Subgrade Machine:** The machine shall be of an approved mechanical type, capable of preparing the subgrade to within 1/4 inch of the grade shown on the plans or established by the Engineer.

(c) **Subgrade Roller:** The roller shall be of an approved type and capable of obtaining the required density.

(d) **Bulkheads:** Bulkheads for construction joints shall be of sufficient strength to prevent deformation of the joint and shall be constructed to permit dowels or other reinforcement to extend through the joint.

(e) **Work Bridges:** Work bridges shall be provided by the Contractor.

(f) **Mechanical Spreader:** The mechanical spreader shall be a self-powered, self-propelled unit capable of placing the concrete mechanically on the subgrade over the full width and depth of the pavement.

The spreader shall be equipped with a hopper or other type of spreading equipment that will distribute the concrete over the subgrade without segregation. The concrete shall not be placed directly on the subgrade from the hauling equipment except in areas where hand labor must be performed.

(g) **Vibrators:** Vibrators for full-width vibration of concrete pavements shall be internal vibrators with multiple spuds. They may be attached to the spreader or mounted on a separate carriage operating directly behind the spreader. The frequency of vibrators shall be at least 7,000 impulses per minute.

When spud internal vibrators, either hand operated or attached to spreaders, are used adjacent to forms, they shall have a frequency of at least 3,500 impulses per minute.

Vibration shall be controlled by the forward movement of the spreader so that vibration automatically ceases when the forward movement of the spreader is stopped.

(h) **Spraying Equipment:** The Contractor shall provide mechanical spraying equipment mounted on movable bridges when liquid membrane-forming compound is used for curing concrete pavement. The equipment shall be the full atomizing type equipped with a tank agitator and a gage to measure the quantity of material applied. The equipment shall be capable of continuously agitating the membrane during application.

(i) **Concrete Saw:** When sawing joints is elected or specified, the Contractor shall provide sawing equipment with a water-cooled, diamond-edged saw blade or an abrasive wheel having an adequate number of units and power to complete the sawing to the required dimensions.

(j) **Slipform Paver:** The paver shall be designed to consolidate, screed, and float finish the freshly placed concrete in one complete pass of the machine and in a manner so that a minimum of hand finishing shall be necessary to provide a dense and homogeneous pavement. The paver shall be equipped to vibrate the concrete thoroughly for the full width and depth of the strip of pavement being placed.

316.04—Procedures

(a) **Concrete Base Course:** The subgrade or subbase upon which the base course is to be placed shall be prepared in accordance with the applicable provisions of these Specifications for such course.

The construction of a hydraulic cement concrete base course shall conform to these Specifications except for floating and final finishing of the surface. The Contractor shall finish the surface so that there will be no deviation of more than 1/4 inch between any two contact points when tested with a 10-foot straightedge placed parallel with the centerline. Once placed the Contractor shall apply a heavily broomed texture to the surface.

(b) **Preparing Grade:** The Contractor shall prepare the subgrade according to Section 305. The course upon which the concrete pavement will rest, including the area that will support the paving equipment, shall be graded and compacted to the required profile.

The subgrade or subbase course shall be brought to the proper cross section before or after side forms have been securely set to grade. The Contractor shall ensure the finished grade is maintained in a smooth and compacted condition until pavement is placed.

The subgrade or subbase course shall be uniformly moist when concrete is placed, however, the Contractor's method of moistening shall not be such as to form mud or pools of water.

(c) **Placing Reinforcing Steel for Continuously Reinforced Pavement:** The Contractor shall provide a "leave out" joint as detailed on the plans at each location where five or more consecutive days will elapse between placement operations. Longitudinal bars shall be positioned in the finished pavement within ±1/2 inch of the specified vertical position and ±1 inch of the specified horizontal position with a cover of at least 2 inches.

The Contractor may install prebent deformed tie bars, Grade 40 or 60, in the joint between the mainline and ramp pavement to facilitate the use of the slipform paver. Bars shall be prebent with equipment designed especially for fabricating 90-degree bends in 5/8-inch deformed bars without damage to the bars. Side forms of the slipform paver shall be designed in a manner so that the prebent tie bars can be inserted in an appropriate slot and will pass

between the edge of the pavement and the inside face of the trailing forms as the paver advances.

If the Contractor elects to place the reinforced concrete pavement in two layers, he shall ensure the entire width of the bottom layer is vibrated and struck off to such length and depth that the sheet of fabric or bar mat may be placed full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly on the concrete, after which the top layer of concrete shall be placed, struck off, and screeded. Any portion of the bottom layer of concrete that has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor's expense. The reinforcement may be positioned in advance of concrete placement or placed by approved mechanical or vibratory means in fresh concrete after spreading when reinforced concrete is placed in one layer.

Reinforcing steel shall be straight, and its surface condition shall conform to Section 406.03(b).

(d) **Setting Forms:** The Contractor shall compact the foundation under forms to grade so that the forms, when set, will be firmly in contact for their entire length and at the specified grade. The Contractor shall fill any foundation grade that the Engineer finds to be low with granular material in lifts of 1/2 inch or less for a distance of 18 inches on each side of the base of the form and thoroughly compact. The Contractor shall correct any imperfections or variations above grade by tamping or cutting as necessary.

The Contractor shall set forms at least 500 feet in advance of concrete placement, unless, in the opinion of the Engineer, site conditions make this impracticable. After the forms have been set, the grade shall be thoroughly tamped at the inside and outside edges of the base of forms. The Contractor shall ensure forms on any section of pavement are staked into place with a sufficient number of pins of sufficient length to hold the form at the correct line and grade. Form sections shall be tightly locked, free from play or movement. The top of the form, when tested with a 10-foot straightedge, shall not deviate more than 1/8 inch and the longitudinal axis of the vertical face shall not vary more than 1/4 inch from the straightedge. The Engineer will not permit any excessive settlement or springing of forms under the finishing machine. Forms shall be cleaned and oiled prior to concrete placement.

The Contractor shall check and correct the alignment and grade elevation of forms immediately before concrete placement. The Contractor shall reset and recheck any form that has been disturbed or any grade has become unstable.

(e) **Placing Concrete:** The Contractor shall ensure concrete is placed on the grade in a quantity that will provide a uniform and adequate supply for the finishing equipment. Spreading shall be accomplished with a mechanical spreader. Necessary hand spreading shall be performed using square-faced shovels. The Engineer will not allow the use of rakes or hoes nor will workers be allowed to walk in the freshly mixed concrete with boots or shoes coated with soil or foreign substances.

Where concrete is due to be placed from an adjoining previously constructed lane and mechanical equipment shall be operated from the existing lane during the placement, the concrete in that lane shall have attained a modulus of rupture strength of at least 450 pounds per square inch. Test specimens for this purpose shall conform to ASTM C31 and shall be tested in accordance with ASTM C293. The Engineer will not permit equipment that will damage the surface of the existing pavement.

Concrete shall be thoroughly consolidated against forms and joint assemblies by means of full-width vibration. The Contractor shall not allow vibrators to come in contact with a joint assembly, reinforcement, or side forms. The Contractor shall not operate the vibrator for more than 15 seconds in any one location. When fabric or bar mat reinforcement is placed by mechanical equipment that uses vibration or a tamping action, other vibratory equipment may be eliminated except in areas adjacent to side forms.

Concrete shall be placed as close to expansion and contraction joints as is possible without disturbing the joints. Concrete shall be placed over and around dowels in a manner that dowels are fully embedded without displacement.

Concrete for continuously reinforced pavement shall be placed through the openings in the steel in one lift and vibrated with an internal vibrator for the entire width and depth of the placement. The Contractor shall give special attention to the consolidation of the concrete in the immediate vicinity of construction joints and other areas where the performance of vibrators mounted on the paving equipment is questionable.

Following concrete placement, concrete shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement shall conform to the tolerances specified herein for the elevation and grade shown on the plans or as established by the Engineer.

The Contractor shall furnish adequate lighting to ensure proper accomplishing and inspection of the work if the Engineer permits concrete operations to extend after sunset.

(f) **Test Specimens:** The Contractor shall furnish the concrete necessary for casting test beams in accordance with (o) herein. Beams shall be cured by a designated method as specified for the pavement in accordance with ASTM C31.

(g) **Jointed Pavement:** Joints shall be installed in a manner and at such times and temperatures to prevent random or uncontrolled cracking. If random or uncontrolled cracking occurs, the Contractor shall remove and replace sufficient concrete on each side of the cracking to form a slab at least 10 feet long. Transverse construction joints shall be constructed at each end of the slab in accordance with the applicable provisions of 4. herein.

1. **Longitudinal joints:** Deformed tie bars of the specified length, size, spacing, and material shall be placed perpendicular to the longitudinal joints. They shall be placed by approved mechanical equipment and rigidly secured by chairs or other approved supports to prevent displacement or by the insertion of bars with an approved hand tool. When adjacent lanes of pavement are constructed separately, approved two-piece connectors shall be used.

   Longitudinal joints shall be sawed, formed, or created using a strip insert. Longitudinal center joints shall be installed in a manner so that full contact is made at intersections with transverse joints.

   a. **Formed joints:** Formed joints shall consist of a groove extending downward from, and normal to, the surface of the pavement and shall be formed by an approved nonmetallic or removable device that consistently demonstrates its ability to produce in fresh concrete a joint having the dimensions and line indicated on the plans. The groove shall be sealed with a premolded or poured joint material as required.

b. **Strip insert joints:** A longitudinal weakened plane joint may be furnished at traffic lane lines in multilane monolithic concrete pavement in lieu of forming or sawing such joints. Strip insert joints shall be formed by placing a continuous strip of plastic or other approved material. The insert strip shall be of sufficient width to form a weakened plane to the depth shown on the plans. The thickness of the insert material shall be at least 20 mils. Strip insert joints shall not be sawed.

The insert strip shall be inserted with a mechanical device that places the material in a continuous strip. Splices will be permitted provided they are effective in maintaining the continuity of the insert strip. The top edge of the insert strip shall be positioned flush with the finished surface. The insert strip shall not be deformed from a vertical position during installation or in subsequent finishing operations performed on the concrete. The alignment of the finished joint shall be uniformly parallel with the centerline of the pavement and free from local irregularities in alignment that are more than 1/2 inch in 10 feet. The mechanical installation device shall vibrate the concrete during the insertion of the strip in a manner to cause the disturbed concrete to return evenly along the sides of the strip without segregating or developing voids.

If the Contractor is unable to furnish a satisfactory strip insert joint consistently, he shall, upon being notified by the Engineer, discontinue furnishing such joints and furnish other approved formed or sawed joints without additional compensation.

c. **Sawed joints:** Longitudinal sawed joints shall be cut with approved concrete saws. Suitable guidelines or devices shall be used to ensure cutting the longitudinal joint on the true line as shown as soon as the concrete has hardened sufficiently to permit sawing without chipping, spalling, or tearing. Concrete faces of the saw cut shall be protected from drying until the end of the specified curing period. Sawed joints shall be thoroughly cleaned and dried prior to being sealed.

2. **Transverse expansion joints:** Transverse expansion joints shall be formed in accordance with 1.a. herein and shall be sealed using Type D material. Expansion joint filler shall be continuous from form to form, shaped to the subgrade. Preformed joint filler shall be furnished in lengths equal to the pavement width or the width of one lane. Damaged or repaired joint filler shall not be used.

Expansion joint filler shall be held in a position perpendicular to the subgrade. An approved installing bar, or other device, shall be used, if required, to secure preformed joint filler at the proper grade and alignment during placing and finishing of concrete. Finished joints shall not deviate more than 1/4 inch in the horizontal alignment from a straight line. If joint filler is assembled in sections, there shall be no offsets between adjacent units.

3. **Transverse contraction joints:** Transverse contraction joints shall consist of planes of weakness created by cutting grooves in the surface of the pavement and, when shown on the plans, shall include load transfer assemblies.

Edges of concrete adjacent to the joint may be rounded or beveled to a radius or length approved by the Engineer. Any joint having an insufficient opening shall be resawed or ground to the proper size. Where a joint opening is larger than that specified, the Contractor may be required to build up the joint with epoxy mortar or to furnish a larger size seal as determined by the Engineer. The cost of any such additional work or material shall be borne by the Contractor.

4. **Transverse construction joints:**

   a. **Jointed pavement:** Unless specified expansion joints occur at the same points, transverse construction joints shall be constructed at the end of each day's work or when there is an interruption of more than 30 minutes in the concreting operations. A transverse construction joint shall not be constructed within 10 feet of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 10 feet long, the excess concrete back to the last preceding joint shall be removed and disposed of as directed. An approved header board, cut to the required cross section, shall be used to form joints. Deformed dowel bars shall be used in transverse construction joints whose location does not coincide with the specified location of a transverse expansion or contraction joint.

   b. **Continuously reinforced concrete pavement:** Transverse construction joints shall be formed by the use of an approved header board in accordance with 4.a. herein. The header shall consist of two sections; one being placed above and one being placed below the reinforcing mat, and shall be furnished with openings to accommodate the longitudinal steel and additional reinforcement required.

   At any location where a "leave out" is necessary for a detour, at least 100 feet shall be maintained between transverse construction joints.

5. **Load transfer devices:** Plain dowels shall be held in position parallel with the surface and centerline of the slab by a metal device that is left in the pavement.

   The entire free end of each dowel shall be painted with one coat of approved paint. When the paint has dried and immediately before dowels are placed in position, the free end shall be thoroughly coated with an approved lubricant. A metal or plastic dowel cap of approved design to cover 2 inches, ±1/4 inch, of the dowel, with a closed end, and with a suitable stop to hold the end of the sleeve at least 1 inch from the end of the dowel bar shall be furnished for each dowel bar used in expansion joints. Caps or sleeves shall fit the dowel bar tightly, and the closed end shall be mortartight. Dowels, plastic coated in accordance with Federal Specification L-C-530 C or epoxy coated in accordance with ASTM A775, may be used in lieu of painted and lubricated dowel bars.

   In lieu of using dowel assemblies at contraction joints, dowel bars may be placed in the full thickness of pavement by an approved device.

6. **Isolation joints at structures:** Isolation joints shall be formed by placing a strip of 1/2-inch preformed expansion joint filler around each structure that extends into or through the pavement before concrete is placed at that location.

(h) **Final Striking Off, Consolidating, and Finishing:** The sequence of operations shall be as follows: (1) striking off, (2) consolidating, (3) floating, (4) removing laitance, (5) straightedging, and (6) finishing. If the application of moisture to the surface is permitted, it shall be applied as a fog spray by means of approved spray equipment.

1. **Finishing at joints:** Concrete adjacent to joints shall be mechanically vibrated to prevent voids and segregation from occurring against the joint material. Concrete under and around load transfer devices, joint assembly units, and other features designed to extend into the pavement shall also be mechanically vibrated.

a. **Machine finishing:** Concrete shall be spread as soon as placed, struck off, and screeded by an approved finishing machine. Vibration for the full width of the paving slabs shall be provided in accordance Section 316.03(g). The machine shall be operated over each area of pavement as many times and at such intervals as are necessary to result in proper consolidation and develop a surface of uniform texture. Excessive manipulation of a given area shall be avoided.

During the first pass of the finishing machine, a uniform roll of concrete shall be maintained ahead of the front screed for its entire length.

If a uniform and satisfactory density of concrete is not obtained at joints, along forms, at structures, and throughout the pavement, the Contractor will be required to furnish equipment and use methods that will produce pavement conforming to the requirements specified herein.

b. **Hand finishing:** Hand finishing will be permitted only under the following conditions: (1) to finish concrete already deposited on the grade in the event of a break down of mechanical equipment; and (2) to finish narrow widths, approach slabs, or other areas of irregular dimensions where the operation of mechanical equipment is impractical.

Concrete shall be struck off as it is placed and screeded with an approved portable screed. If reinforcement is required, the bottom layer of concrete shall be screeded prior to placement of reinforcement.

Consolidation shall be attained by the use of an approved vibrator or other approved equipment.

Hand finishing shall be kept to the absolute minimum necessary to attain a surface that has a uniform texture, is true to the approximate grade and cross section, and has a closed surface.

2. **Floating:** After concrete has been struck off and consolidated, it shall be further smoothed and made true by means of a float using one of the following methods as specified or permitted:

a. **Mechanical method:** A mechanical float shall be adjusted so that its full length will be in continuous contact with the surface of the pavement.

If necessary, long-handled floats having blades at least 5 feet in length and 6 inches in width may be used to smooth and fill in open-textured areas in the pavement. Long-handled floats shall not be used to float the entire surface of the pavement in lieu of, or supplementing, the prescribed method of floating.

b. **Hand method**: This method will be permitted only in those instances specified in 1.b. herein. Following strike off by an approved screed, concrete shall be smoothed with a darby to level raised spots or fill depressions. Long-handled floats or hand floats of wood or metal, as the area dictates, may be used in lieu of darbies to smooth and level the concrete surface. Excessive bleed water shall be wasted over the side forms after each pass of the float.

3. **Straightedge testing and surface correction:** After floating has been completed and excess water removed, but while concrete is still fresh, the surface of the concrete shall be tested for trueness with a 10-foot straightedge. The Contractor shall furnish and use an accurate 10-foot straightedge swung from handles 3 feet longer than 1/2 the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel with the pavement centerline, and the entire area shall be gone over from one side of the slab to the other as necessary. Advancement along the pavement shall be in successive stages of not more than 1/2 the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, stuck off, consolidated, refinished, and retested. High areas shall be cut down and refinished. Special attention shall be given to ensure that the surface across joints conforms to the requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is free from observable departures from the straightedge and the slab conforms to the required grade and cross section.

4. **Final finish (texture):** Prior to grooving, multi-ply damp fabric shall be dragged over the pavement surface to provide a gritty texture on ridges between grooves. The roadway pavement riding surface shall be textured with (1) uniformly pronounced grooves approximately 1/8 inch in depth and 1/8 inch in width on approximately 3/4-inch centers and transverse to the pavement centerline, or (2) a combination of uniformly pronounced grooves approximately 1/8 inch in depth and 1/8 inch in width on approximately 3/4-inch centers and longitudinal to the pavement centerline and additional grooves 1/8 inch in depth and 1/8 inch in width on grooves 1/8 inch in depth and 1/8 inch in width on approximately 3-inch centers and transverse to the pavement center line.

(i) **Stenciling Station Numbers and Dates:** Before concrete takes its final set and after finishing operations are completed, the Contractor shall stencil station numbers and dates into the pavement in accordance with the standard drawings. The dies for numbering and dating will be furnished by and remain the property of the Department. Dies or numerals lost or damaged by the Contractor shall be replaced at his expense.

(j) **Curing:**

1. **Membrane-forming compounds:** The entire surface of the pavement shall be sprayed uniformly with a white-pigmented membrane-forming compound immediately following the texturing operation.

   The compound shall be applied under constant pressure at the rate of 100 to 150 square feet per gallon by mechanical sprayers mounted on movable bridges. On textured surfaces, the rate shall be as close to 100 square feet as possible. Application shall be such that an even, continuous membrane is produced on the concrete surface. At the time of use, the compound shall be in a thoroughly mixed condition, with the pigment uniformly dispersed throughout the vehicle. During application, the compound shall be continuously and effectively agitated. Hand spraying of odd widths or shapes and concrete surfaces exposed by removing forms and sawing joints will be permitted.

   The membrane shall harden 30 minutes after application. Personnel and equipment shall be kept off the freshly applied material to prevent damage to the seal. If the membrane becomes damaged within the initial 72 hours, damaged portions shall be repaired immediately with additional compound.

Upon removal of side forms, sides of exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface.

If the slipform method of paving is used, edges of pavement shall be cured in the same manner and at the same time as the surface.

2. **PE film:** When PE film is used for curing, it shall be white. However, from November 1 to April 1, clear or opaque PE film will be permitted.

3. **Protection in cold weather:** The Contractor shall prevent the temperature at the surface of the concrete from falling below 40 degrees F during the first 72 hours immediately following concrete placement. Protective material shall be left in place for an additional 48 hours if freezing air temperatures are expected to continue. Such protection shall be furnished in addition to the curing material required elsewhere in these specifications. The Contractor shall be responsible for the quality of the concrete placed during cold weather. Concrete damaged by the action of frost or by freezing shall be removed and replaced at the Contractor's expense.

4. **Curing in hot, low-humidity, or windy weather:** Care shall be taken in hot, dry, or windy weather to protect the concrete from shrinkage cracking by applying the curing medium at the earliest possible time after finishing operations and after the sheen has disappeared from the surface of the pavement.

(k) **Surface Test:** As soon as concrete has hardened sufficiently, the pavement surface will be tested by the Engineer with a 10-foot straightedge. Areas showing high spots of more than 3/16 inch on mainline pavement and approach slabs but not exceeding 1/2 inch in 10 feet shall be marked and, after the concrete has attained the design compressive strength, cut down with an approved cutting tool to an elevation where the area or spot will not show surface deviations in excess of 3/16 inch. Areas showing high spots of more than 3/8 inch on ramps when tested with a 10-foot straightedge shall be marked and, after the concrete has attained the design compressive strength, corrected to within the 3/8-inch tolerance by removing and replacing or by cutting as specified herein. If the slipform method of paving is used, a straightedge tolerance of ±1/4 inch in 10 feet will be permitted for the area within 6 inches of the slipformed edge except for pavement adjacent to connections and ramps. Equipment for cutting shall be designed to cut the surface of the pavement in a longitudinal direction parallel with the centerline and in a uniform planing action. However, the cutting operation shall not produce a polished pavement surface. The equipment shall be adjustable so as to vary the depth of the cut as required. Bush hammering, rubbing with carborundum stone, or hand grinding will not be permitted. Where the departure from the specified cross section exceeds 0.20 percent on mainline pavement, the pavement shall be removed and replaced by and at the expense of the Contractor.

(l) **Removing Forms:** Forms shall not be removed from freshly placed concrete until it has set for at least 12 hours. Forms shall be removed carefully to avoid damage to the pavement. After forms are removed, the sides of the slab shall be cured as specified by one of the methods described herein. Major honeycombed areas will be considered defective work and shall be removed and replaced. Any area of section removed shall be not less than 10 feet in length or less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 10 feet in length shall also be removed and replaced.

(m) **Sealing Joints:** Before pavement is opened to traffic, including the Contractor's equipment, and as soon after completion of the curing period as practicable, joints required to be sealed

shall be filled with joint-sealing material. Just prior to sealing or resealing, each joint shall be thoroughly cleaned by brushing, routing, sawing, grinding, blast cleaning, or any combination thereof to eliminate oil, grease, existing joint material, membrane-forming compound, laitance, protrusions or hardened concrete, dirt, or other foreign material that cannot be removed by means of compressed air to a depth at which the sealer and backup material, if required, are to be installed. Dust and loose material shall be removed from the joint with oil-free and water-free compressed air delivered at a minimum of 120 cubic feet of air per minute and a nozzle pressure of at least 90 pounds per square inch. Existing joint material extending outside the joint shall be removed.

Joint material shall be installed in accordance with the manufacturer's recommendations, however, in the absence of specific recommendations or plan details, the following provisions shall apply.

1. Preformed seals shall be installed by machines that are designed especially for such installation and shall not damage the seal. Types A and D material shall be installed by machine. The seal shall be installed with its vertical axis parallel with the interfaces of the joint.

2. The method of installing preformed seals shall be such that the seal is not stretched more than 5 percent of the length of the joint.

   The method of installation shall be checked for stretching, using transverse joint sealer. The check shall consist of installing sealer in five joints, the full width of the pavement, and removing the sealer immediately after installation and checking the length. If the measured length of any of the five sealers is less than 95 percent of the minimum theoretical length required to seal the joint, the installation method shall be modified so that stretching greater than 5 percent no longer occurs. Once sealing operations have started, 1 joint per every 100 shall be removed and checked for stretch in excess of 5 percent. If a stretched condition is detected, the joint sealers on either side shall be removed until the condition disappears. Affected joints shall be resealed in a satisfactory manner at the Contractor's expense.

3. For rounded or beveled joints, seal or sealant shall be installed in a depth of at least 1/8 but not more than 1/4 inch below the bottom edge of the rounding or bevel. For joints with vertical sides, seals or sealant shall be installed at a depth of 1/4 inch, ±1/16 inch, below the level of the pavement surface.

4. Hot-poured sealer shall be applied to a completely dry joint. The ambient air temperature shall not be below 40 degrees F. The joint shall be filled with hot-poured sealer by means of a sealing device that will not cause air to be entrapped in the joint. Sufficient passes shall be made to achieve the filled joint requirement.

5. Material for hot-poured sealer shall be stirred during heating so that localized overheating does not occur.

6. Sealer shall not be placed directly on the filler but shall be prevented from bonding to the filler by a carefully placed strip of waxed or silicone paper, plastic tape, aluminum foil, or other suitable material placed over the filler before sealer is applied. Masking tape or other means shall be used to avoid spilling sealer onto adjacent concrete surfaces. Excess sealer on such surfaces shall be cleaned off before the material has set without damaging the material in the joint.

7. Silicone sealer shall not be applied when the air temperature is below 40 degrees F. Sealer shall fill the joint and shall be applied inside the joint from the bottom up by means of an application device that will not cause air to be entrapped. Immediately after application, sealer shall be tooled to form a recess below the pavement surface in accordance with the standard drawings. The use of soap, water, or oil as a tooling aid will not be permitted. Primer, if used with silicone sealer, shall be applied to the joint faces prior to installation of backup material. Backup material shall be approximately 25 percent larger than the joint width and shall be installed in the joint such that it is not displaced during the sealing application.

   Sealing material shall be applied in a manner so that it will not be spilled on the exposed surfaces of the concrete. Excess material on the surface of the concrete pavement shall be removed immediately, and the pavement surface cleaned. The use of sand or similar material as a cover for the seal will not be permitted.

(n) **Protecting Pavement:** The Contractor shall protect the pavement and its appurtenances against public traffic and traffic caused by his employees and agents. This shall include furnishing watchpersons and flaggers to direct traffic and erecting and maintaining warning signs, lights, pavement bridges, or crossovers.

In order that the concrete may be properly protected against the effects of rain before it has attained final set, the Contractor shall have covering material available at the work site, such as burlap, cotton mats, curing paper, or plastic sheeting.

If the slipform method of paving is used, the Contractor shall also have material available at all times for protecting the edges of unhardened concrete. Protective materials shall consist of standard metal forms or wood planks having a nominal thickness of at least 2 inches and a nominal width of at least the thickness of the pavement at its edges.

When rain appears imminent, concrete placement operations shall be halted and available personnel shall assist in covering the surface of unhardened concrete.

A layer of coarse burlap shall be applied to the surface of fresh concrete prior to the application of PE film or other protective coverings that tend to “wipe out” or reduce the texture upon contact.

The Engineer will carefully consider any damage to the pavement occurring prior to final acceptance and may allow the Contractor to repair such damage or require the damaged pavement to be replaced.

(o) **Opening to Traffic:** The Contractor shall not open pavement to traffic until specimen beams conforming to (f) herein have attained a modulus of rupture strength of 600 pounds per square inch when tested by the third point loading method in accordance with ASTM C78. The Contractor may use the Maturity Test Method in accordance with ASTM C 1074 to confirm the development of satisfactory strength gain to open the pavement to traffic provided the maturity test results are based upon the same concrete mix design as used in the pavement as approved by the Engineer. In the absence of such tests, The Contractor shall not open the roadway pavement to traffic until 14 days after the concrete is placed. Prior to opening to traffic, the Contractor shall clean the pavement, seal and trim all joints, and install all permanent traffic markings and messages.

(p) **Saw-Cut Hydraulic Cement Concrete Pavement:** This work shall consist of saw-cutting the existing hydraulic cement concrete pavement to a depth shown on the plans and as directed by the Engineer.

316.05—Thickness and Finished Grade Tolerances

The Engineer will determine the thickness of pavement by average caliper measurements of cores taken from the pavement in accordance with VTM-26.

The Engineer will evaluate areas found to be deficient in thickness by more than 1.00 inch, and if in his judgment the deficient areas warrant removal, the Contractor shall remove and replace such areas with concrete of the thickness specified on the plans. The Engineer will calculate the deficient area as the product of the full width of the slab or lane of pavement multiplied by the sum of the distances in each direction from the deficient core along the centerline of the pavement to the first actual cores found not deficient in thickness by more than 1.00 inch.

The Contractor shall fill cored test holes with the same type of concrete as in the pavement.

After placement of the final pavement layer, finished grade elevations shall be within +/– 0.04 foot of the elevations indicated in the plans, unless otherwise specified, provided that the actual cross slope does not vary more than 0.20 percent from the design cross slope indicated in the plans and the pavement thickness conforms to the thickness tolerances specified herein.

If the Engineer determines either the finished grade elevations or cross slope exceeds the tolerances specified, the Contractor shall submit to the Engineer for approval a plan of corrective action.

Finished grades shall be constructed to the proposed cross sections, and cross slopes shall be constructed to the proposed typical section slopes indicated on the plans. The Contractor shall correct or replace areas found to deviate from the indicated cross slopes by 0.20 percent or more at no additional cost to the Department.

316.06—Measurement and Payment

Hydraulic cement concrete pavement will be measured in square yards of concrete pavement and will be paid for at the contract unit price per square yard. This price shall include furnishing and placing materials, including dowels, reinforcement, and joint material, provided that for any pavement found deficient in average thickness, as described in VTM-26, by more than 0.20 inch but not more than 1.00 inch only the reduced price stated herein will be paid. The width of measurement will be the width of the pavement shown on the typical cross section of the plans, additional widening where called for, or as otherwise directed in writing by the Engineer. The length will be measured horizontally along the centerline of each roadway or ramp.

Concrete entrance pavement, concrete launching ramps, and anchor slabs will be measured in square yards of surface area and will be paid for at the contract unit price per square yard.

Bridge approach slabs, when a pay item, will be measured in cubic yards of concrete and pounds of reinforcing steel and will be paid for at the contract unit price per cubic yard of concrete and per pound of reinforcing steel.

Bridge approach expansion joints will be measured in linear feet of transverse measure and will be paid for at the contract unit price per linear foot. This price shall include subslab excavating and furnishing and placing materials.

No additional payment over the contract unit price will be made for any pavement that has an average thickness in excess of that specified on the plans.

Resealing joints, when a pay item, will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include joint preparation, furnishing and placing sealer, and removing and disposing of debris.

Saw-cut hydraulic cement concrete pavement will be measured in feet for the depth specified and will be paid for at the contract unit price per foot. This price shall include saw-cutting the hydraulic cement concrete pavement to the depth specified.

Price adjustments: Where the average thickness of pavement is deficient by more than 0.20 but not more than 1.00 inch, payment will be made at an adjusted price as specified by the following:

Deficiency in Thickness (in)	% of Contract Unit Price Allowed
0.00-0.20	100
0.21-0.30	80
0.31-0.40	72
0.41-0.50	68
0.51-0.75	57
0.76-1.00	50

When the thickness of pavement is deficient by more than 1.00 inch and the Engineer determines that the area of such deficiency should not be removed and replaced, there will be no payment for the area retained.

Payment will be made under:

Pay Item	Pay Unit
Hydraulic cement base course (Depth)	Square yard
Plain hydraulic cement concrete pavement (Depth)	Square yard
Reinforced hydraulic cement concrete pavement (Depth)	Square yard
Continuously reinforced hydraulic cement concrete pavement (Depth)	Square yard
Concrete, Class A4, bridge approach slab	Cubic yard
Reinforcing steel, bridge approach slab	Pound
Bridge approach expansion joint	Linear foot
Concrete entrance pavement (Depth)	Square yard
Concrete launching ramp (Standard)	Square yard
Anchor slabs (Type)	Square yard
Resealing (Type) joints (Material)	Linear foot
Saw-cut hydraulic cement concrete pavement (depth)	Linear foot

SECTION 317— STONE MATRIX ASPHALT CONCRETE PLACEMENT

317.01—Description

This specification covers the furnishing, installation, and acceptance criteria for constructing stone matrix asphalt (SMA) concrete pavement. SMA shall be in accordance with these specifications and Section 315.

317.02—Materials

(a) **Coarse aggregate** shall conform to Section 248.02(a).

(b) **Fine aggregate** shall conform to Section 248.02(b).

(c) **Asphalt binder** shall conform to Section 248.02(c).

(d) **Mineral filler** shall conform to Section 248.02(d).

(e) **Fiber additive** shall conform to Section 248.02(e).

317.03—Composition of SMA Mixture

Composition of Stone Matrix Asphalt shall conform to Section 248.

317.04—Acceptance

Acceptance of Stone Matrix Asphalt shall conform to Section 248.

317.05—SMA Mixing Plant

(a) **Mineral filler handling** shall be in accordance with Section 248.05(a).

(b) **Fiber addition** shall be in accordance with Section 248.05(b).

(c) **Hot-mixture storage** shall conform to Section 248.05(c).

(d) **Mixing temperatures** shall conform to Section 248.05(d).

317.06—Weather Restrictions

SMA mixture shall be placed only when the ambient and surface temperatures are 50 degrees F or above, unless a warm mix additive or process approved by the Department is used to produce the SMA in which case the surface temperature must be 40 degrees F or above.

317.07—Placing and Finishing

For mixtures containing PG 64H-22 asphalt binder, the mixture temperature shall not be less than 300 degrees F in the truck or less than 290 degrees F immediately behind the screed.

For mixtures containing PG 64E-22 asphalt binder, the mixture temperature in the truck and immediately behind the screed shall not be less than the minimum compaction temperature provided by the liquid asphalt supplier.

The minimum mixture or compaction temperature immediately behind the screed when a warm mix asphalt additive or process is used to produce the SMA shall not be less than 200 degrees F.

The Contractor shall be responsible for a continuous paving operation that provides for maintaining constant steady movement of the paver. If excessive stop and go of the paver is occurring, the Engineer will stop production and laydown of the mixture until the Contractor has made satisfactory changes in the production, hauling, and placement operations resulting in a constant steady movement of the paver.

The Contractor shall employ a Material Transfer Vehicle (MTV) during the placement of SMA mixes. The Contractor's paving operation shall have remixing capability in either the MTV or a paver-mounted hopper to produce a uniform nonsegregated mix of uniform temperature. The MTV and paver combination shall have a minimum storage capacity of 15 tons. If equipment breaks down in the paving train, the Contractor shall notify the plant not to ship any more material and discontinue paving shall be discontinued once the material on-site has been placed.

317.08—Compaction

Immediately after the mixture has been spread and struck off, it shall be thoroughly and uniformly compacted by rolling. Rolling shall be accomplished with steel wheel roller(s) with a minimum weight of 10 tons. A minimum of three rollers shall be available at all times for compaction and/or finish rolling.

The Contractor shall approach the use of vibratory rollers on SMA with caution to minimize coarse aggregate fracture/breakage in the aggregate skeleton of SMA mixes. If the Contractor elects to use a vibratory roller, the mat shall receive not more than three vibratory passes. The Contractor shall use the roller only on the highest frequency and lowest amplitude setting.

It shall be the Contractor's responsibility to adjust the rolling procedures to provide the specified pavement density. Rollers shall move at a uniform speed. Rolling shall be continued until all roller marks are eliminated and the minimum density has been obtained. The Contractor shall monitor density during the compaction process by use of nuclear density gages to ensure that the minimum required compaction is being obtained. During the trial section, the Department will randomly select 3 plug or core locations to determine the in-place density according to VTM-22.

The Contractor shall keep the wheels of the rollers properly moistened with water that has been mixed with very small quantities of detergent or other approved additives to prevent adhesion of the mixture to the rollers.

For the purposes of evaluating and determining acceptance, each day's production shall be considered a lot unless the paving length is less than 3,000 linear feet or greater than 7,500 linear feet. When paving is less than 3,000 feet, that day's production amount shall be combined with the previous day's production or added to the next day's production to create a lot as described below.

The standard size of a lot shall be 5,000 linear feet, with 1,000 foot sublots, of any pass 6 feet or greater for the specified thickness of the course. The Engineer may approve an increase in the lot size to 7,500 linear foot lots with 1,500 foot sublots when the normal daily production is in excess of 7,000 feet. Pavers traveling in echelon will be considered as two passes. When a partial lot occurs at the end of a day's production or upon completion of the project, the lot size shall be redefined as follows:

- If the partial lot contains one or two sublots, the sublots will be added to the previous lot.
- If the partial lot contains three or four sublots, the partial lot will be redefined to be an entire lot.

The Contractor shall perform acceptance testing for density for each sublot by obtaining one sawed 4 inch by 4 inch specimen, or one 4-inch-diameter cores, at a single random test site specified by the

Engineer. Test sites shall not be located within 12 inches of the edge of any application width for surface and intermediate mixes.

- The sub-lot site shall be marked as described in VTM-76.
- The bulk specific gravity of the cores shall be determined in accordance with VTM-6.
- The density of the cores shall be determined in accordance with VTM-22.

The Contractor shall bulk the cores or plugs in the presence of the Engineer. The cores or plugs may be bulked on the project site. Sublot test sites shall be numbered sequentially per lot, marked on the pavement, filled with the paving mixture, and compacted prior to completion of each day's production. The payment for lot density will be in accordance with the following schedule:

Payment Schedule

% Density Achieved	% of Payment
More than 98.0	97
94.0 to 98.0	100
92.0 to 93.9	85
90.0 to 91.9	65
Less than 90.0	Remove and replace

317.09—Trial Section

The Engineer will require the Contractor to construct a trial section(s) for evaluation at least 1 week, but not more than 30 days, prior to the start of roadway construction at the start of production of a SMA mix not placed the previous year on a state roadway. The trial section shall be a maximum of 300 tons, shall be constructed at a site designated in the contract or proposed by the Contractor and approved by the Engineer. The Department will use the trial section to evaluate the mixing plant process control, mixture draindown characteristics, placement procedures, SMA surface appearance, and compaction patterns and to calibrate the nuclear density device. Additionally, the Department will calculate the percentage of flat and elongated particles in the SMA material produced for the trial section according to VTM-121 and compare the results to the maximum limits specified in the Coarse Aggregate Table in Section 248.02(a). The Engineer will require a passing flat and elongated sample for acceptance of the trial section.

During the trial section(s), the Engineer will randomly select 3 plugs or cores locations to determine the in-place density according to VTM-22. Payment for density will be in accordance with the Payment Schedule listed in Sec. 317.08.

The Contractor shall remove and replace failing trial sections based on the following criteria. The Engineer will deem a trial section to have failed if the Voids In Total Mix (VTM) is less than 1.0 percent or exceeds 5.0 percent; if the Voids In Coarse Aggregate (VCA) of the mix exceeds the VCA of the dry rodded condition; if the field density is less than 90.0 percent of the maximum theoretical density; or if excessive flushing/bleeding occurs in the wheel paths. Payment for the trial section shall be as described in the previous paragraph. The Contractor shall be responsible for the cost for removing the failed trial section. Payment for replacement of the trial section shall be in accordance with the previous paragraph.

317.10—Prepaving Conference

The Department will hold a prepaving conference with at least two weeks prior to the start of production if the Contractor has never produced or placed Stone Matrix Asphalt.

317.11—Measurement and Payment

Stone matrix asphalt will be measured in tons and will be paid for at the contract unit price per ton for the mix type specified. This price shall include all materials, additives, and equipment as described herein.

The initial trial section will be paid for at the contract unit price for the mix type specified. Up to one additional trial section of the mix type specified will be paid for at the contract unit price. If additional trial sections are needed, the Department and the Contractor shall negotiate the price based upon a reduced percentage of the contract unit price. The Department will pay for no more than four trial sections. The Contractor shall be fully responsible for any additional test sections required to produce and install an acceptable mixture at the Contractor's expense.

Payment will be made under:

Pay Item	Pay Unit
Stone matrix asphalt, (Type) (Class)	Ton

Division IV
BRIDGES AND STRUCTURES

SECTION 401—STRUCTURE EXCAVATION

401.01—Description

This work shall consist of excavating and backfilling or disposing of material necessary for constructing substructures and superstructures of new bridges and altering existing bridges in accordance with these specifications and in conformity with the lines and grades shown on the plans or as established by the Engineer.

401.02—Materials

(a) **Earthen or other backfill** shall conform to Section 303, be free of large or frozen lumps, wood, or rocks more than 3 inches in their greatest dimension, or other extraneous material unsuitable for construction, and shall be approved by the Engineer. Porous backfill shall conform to Section 204.02(c) or as specified herein.

(b) **Pipe underdrains** shall conform to Section 232.02.

(c) **Select backfill material** shall be No. 21A or 21B stone conforming to Section 208 or Select Material Type I, Min. CBR 30 conforming to Section 207.

(d) **Porous backfill** shall consist of crusher run aggregate No. 25 or 26 conforming to Section 205.

(e) **Geocomposite Wall Drains** shall conform to Section 245.

401.03—Procedures

Excavated material shall generally be used for backfilling and constructing embankments over and around the structure. The Contractor shall dispose of surplus or unsuitable material in a place and manner such that it will not affect or re-enter streams or otherwise impair the hydraulic efficiency or appearance of the structure or any part of the roadway.

Where practicable, the Contractor shall construct substructures in open excavation and, where necessary, the excavation shall be sheeted, shored, braced, or protected by other means. If footings can be placed in the dry without the use of sheeting or cofferdams, forms may be omitted with the approval of the Engineer and the entire excavation filled with concrete to the required elevation of the top of the footing. The Engineer will not make adjustments for payment or excavation when forms are eliminated. Measurement and payment for structure excavation and concrete will be on a plan quantity basis.

Unless tremie placement of concrete is specified, foundations for footings shall be kept free from standing or surface water until concrete and backfill operations have been completed. However, if the foundation is rock or the footing is supported on piles, other than for shelf abutments, dewatering need be performed only during concrete and backfill operations.

(a) **Preserving the Channel:** Excavation shall not be performed outside caissons, cribs, cofferdams, or sheet piles. The natural streambed adjacent to the structure shall not be disturbed. The Contractor shall remove any material or obstructions deposited in the stream area because of the Contractor's operations.

The Contractor shall submit a plan to the Engineer that shall include the specific locations of temporary structures or other obstructions that will constrict the stream flow and a description of construction activities that will contribute to constricting the stream flow prior to beginning work. The plan shall also include the dimensions and number of temporary structures and constrictions that are to be placed in the stream at any one time, and a dimensional elevation view of the stream and proposed temporary structures and constrictions.

(b) **Depths of Foundations:** Elevations denoting the bottom of footings shown on the plans shall be considered approximate only. Foundations shall not be considered satisfactory until approved by the Engineer.

The Contractor shall explore foundations by rod soundings or drillings to determine, to the Engineer's satisfaction, the adequacy for the foundations to support the structure. The Engineer will allow the Contractor to only make variations from plan depths to the foundations of open column abutments and solid or column piers by adjusting stem lengths if explorations indicate that satisfactory foundations can be obtained. The Contractor shall consider footing depths shown on the plans as minimum depths. Plan depths of concrete for footings may be increased not more than 24 inches at points of local irregularity over solid rock foundations.

The Contractor shall only make variations from plan depths to foundations of solid or deep curtain-wall abutments by adjusting the depths of footings. The Contractor shall consider plan depths to be minimum depths, not to be exceeded by more than 3 feet.

The Engineer shall be consulted for instructions for further action or redesign if explorations reveal that foundations or subfoundations are inadequate for the structure, or are not within the limits of permissible variation from the bottom of footing elevations as stated herein.

(c) **Preparing Foundations for Footings:** The Contractor shall prepare hard foundation material so that it is free from loose material; clean; and cut to a firm surface that is either level, stepped, or serrated as directed by the Engineer. Seams shall be cleaned out and filled with concrete as directed by the Engineer.

When concrete is to rest on an excavated surface other than rock, the bottom of the excavation shall not be disturbed. The Contractor shall not perform the final removal of foundation material to grade until just prior to concrete placement.

When the elevation of the bottom of a footing is above the level of the original ground, the Contractor shall not place the footing until the approach embankment has been placed and compacted to the elevation of the top of the footing and excavation has then been performed through the embankment to the elevation of the bottom of the footing. When a footing is to be placed over material subject to movement because of pressure from overlying or adjacent fill, the footing or piles for the footing shall not be placed until after the fill has been placed and compacted. Excavation for shelf abutment footings shall be limited to a perimeter extending not more than 18 inches outside the neat lines at the bottom of the footing.

If the Engineer determines the material on which a foundation is to be placed using piles is unsatisfactory, the Contractor shall undercut the originally proposed excavation a depth of 6 to 12 inches as directed by the Engineer and backfill that area with crusher run aggregate, select borrow, or other material approved by the Engineer.

(d) **Holes for Drilled-In Caissons:** Foundation bearing areas shall be cut to an approximately level surface except that they may be stepped or serrated on hard rock. If material is encountered that is not sufficiently cohesive to maintain the proper diameter of the hole, casing shall be used.

(e) **Cofferdams:** Cofferdams for foundation construction shall be as watertight as practicable and carried to a depth that will allow them to function properly without displacement. The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and inspection of their exteriors and permit pumping from outside the forms. Cofferdams that are tilted or moved laterally during sinking shall be realigned to provide the required clearance.

If conditions are encountered that make it impracticable to dewater the foundation, the Engineer may require the Contractor to construct a concrete foundation seal of the dimensions necessary to ensure that the balance of the concrete can be placed in the dry. The Contractor shall provide anchorage, such as dowels or keys, to transfer the entire weight of the cofferdam into the foundation seal when weighted cofferdams are employed and the weight is used to overcome the hydrostatic pressure acting against the bottom of the foundation seal. Cofferdams that are to remain in place shall be ported at the low water level.

The Contractor shall construct cofferdams in a manner to prevent damage to fresh concrete from a sudden rising of the stream and prevent damage to the foundation by erosion. Timber or bracing left in cofferdams shall not extend into the substructure concrete.

The Contractor shall remove cofferdams, including sheeting and bracing, in a manner that will not disturb or damage the finished concrete after completion of the substructure.

(f) **Pumping:** The Contractor shall execute pumping from the interior of a foundation enclosure in a manner as to preclude the possibility of water moving through any fresh concrete. The Engineer will not permit pumping during concrete placement or for at least 24 hours thereafter unless it is performed from a suitable sump separated from the concrete work.

(g) **Protecting Existing Structures or Utilities:** When foundations are located such that excavation may endanger or interfere with an existing structure or utility, the location of bracing and method of protection shall be subject to approval by the owner of the structure or utility.

(h) **Inspection:** The Contractor shall notify the Engineer and request his inspection and approval after each excavation has been completed. The Contractor will not be permitted to place concrete until the Engineer has approved the depth of the excavation and the character of the foundation material.

(i) **Backfilling:** Excavated spaces that are not occupied by wingwalls, abutments, piers, or other permanent work not specifically addressed herein shall be backfilled with soil to the surface of the surrounding ground.

The Contractor shall use select backfill material behind all abutments. The Department will include a detail indicating the limits (zone) of the select backfill in the plans on the abutment detail sheet(s). The Contractor shall compact the material in accordance with Sections 305 and 303 respectively. The top surface of the backfill material shall be neatly graded.

The earthen fill around the perimeter of the select material zone in abutments, wingwalls, and retaining walls shall be placed in horizontal layers not more than 6 inches in loose

thickness and then compacted at ±20 percent of optimum moisture to a density of at least 95 percent as compared to the theoretical maximum density as defined in Section 101.02. The Contractor shall perform tests to verify compliance with density requirements in accordance with VTM-12. The Contractor shall place and compact the backfill in front of units in horizontal layers to the same elevation as the layers behind units until the final elevation in front is reached as the work progresses. Backfill in front of units shall be placed and compacted in horizontal layers to the same elevation as the layers behind units until the final elevation in front is reached. Backfill shall be placed in a manner to prevent wedging action against the concrete. The Contractor shall modify slopes bounding excavation for abutments, wingwalls, or retaining walls to lock in adjacent backfill material by stepping or serrating the existing soils. The Engineer will not permit jetting of the fill behind abutments, wingwalls, or retaining walls.

Fills and backfills around piers not included in the roadway prism shall be constructed in uniformly compacted layers and placed alternately to maintain a uniform elevation on both sides of the structure. However, the Engineer will not require the Contractor to achieve the density requirement for acceptable compaction.

The Contractor shall make provisions for the draining of backfill material. Geocomposite wall drains shall be used to drain the select backfill material in all abutments. Porous backfill shall be used in to drain backfill material in retaining structures unless otherwise stated on the plans. If the Contractor requests the Engineer's approval to substitute geocomposite wall drain in lieu of porous backfill in a retaining structure, and the Engineer approves such a request, the geocomposite wall drain shall be provided at no additional cost.

Geocomposite wall drains shall be installed in accordance with the manufacturer's recommendations. The Contractor shall provide a minimum three (3) inch joint overlap of geotextile fabric at the top, bottom, ends, and at adjoining panels. The geocomposite wall drain shall be connected to an outlet drain pipe or weep hole at least 6 inches in diameter. The outlet drain shall be completely wrapped by the bottom fabric flap of the geocomposite wall drain. The Contractor shall provide a detailed sketch of the proposed outlet drain pipe connection as well as connections to any special drainage systems associated with the structure for the Engineer's approval prior to installation.

Porous backfill for draining backfill material behind retaining structures shall consist of crusher run aggregate, conforming to Section 205 unless stated otherwise on the plans. The Contractor shall place porous backfill at the back of weep holes to extend 18 inches behind the entrance to the hole, 18 inches above the elevation of the bottom of the hole, and 18 inches laterally on each side of the centerline of the hole. If crushed glass is used as porous backfill, No. 78 and/or No. 8 aggregate and an 18-inch by 18- inch swatch of drainage fabric conforming to Section 245.03(c) shall be used to cover the #4 mesh at each weep hole opening exposed directly to crushed glass, or as otherwise approved by the Engineer.

The Contractor will not be permitted to place backfill against abutments or wingwalls until concrete has been in place at least 14 days, exclusive of days on which the average high-low air temperature is below 40 degrees F in the shade or until test cylinders have attained a compressive strength equal to 93 percent of the required 28-day design minimum compressive strength. The exception to this requirement is in cases where completion of grading in the area in front of an abutment is desired. In those circumstances, backfill and/or fill may be placed against abutments or wingwalls to a point no higher than the elevation necessary to complete grading in front of the abutment, provided:

1. The concrete has been in place at least 7 days, exclusive of days on which the average high-low air temperature is below 40 degrees F in the shade, or

2. Test cylinders have attained a design minimum compressive strength greater than or equal to 900 psi and the concrete has been in place a minimum of 2 days, exclusive of days on which the average high-low air temperature is below 40 degrees F in the shade. The Contractor shall take additional cylinders at the time of concrete placement and use a calibrated machine or an independent lab to test the cylinders and verify the design minimum compressive strength requirement has been met prior to backfilling.

Backfill shall be placed as soon as practicable following attainment of the required design minimum compressive strength but not later than 30 days after concrete placement. Excavation openings shall be maintained as dry as practicable at the time of backfilling. The Contractor shall place backfill in a manner to deter impoundment of water and facilitate existing drainage.

(j) **Filled Spandrel Arches:** Fill for spandrel arches within 1 1/2 times the height of the arch shall be placed in a manner to load the ring uniformly and symmetrically. Fill material shall be homogeneous soil and shall be placed in horizontal layers not more than 6 inches in loose thickness, compacted in accordance with Section 303.04(h), and brought up simultaneously from both haunches. The Engineer will not allow the placing of wedge-shaped sections of fill material against spandrels, wings, or abutments.

(k) **Approach Embankment:** Approach embankment shall be constructed in accordance with Section 303.04(h).

401.04—Measurement and Payment

Structure excavation will be measured in cubic yards of material removed from within the limits of vertical planes 18 inches outside the neat lines of footings or within vertical planes 18 inches outside of neat work that does not have footings directly beneath it, such as in cases of curtain walls or cantilevered wingwalls. Structure excavation will be measured from the surface of the original ground or approach roadway down to the bottom of the foundation shown on the plans or such foundation as the Engineer may approve, down to 18 inches below the bottom of the neat work not directly over footings, or to the top of existing concrete where excavation is to permit placing new concrete over existing concrete.

When specified on the plans, structure excavation will include material removed outside the limits specified for the substructure and to a depth of 18 inches below the lowest beam or bottom of the slab of the superstructure or to such depth as shown on the plans. The width of such excavation will be limited to 18 inches outside the exterior beams or edges of the slab or as shown on the plans.

Excavation above the bottom of a proposed channel change or roadway template or an overpass road will not be included as structure excavation.

Structure excavation will be paid for at the contract unit price per cubic yard. This price shall include clearing and grubbing, sheeting, shoring, bracing, placing and compacting backfill, dewatering, furnishing and placing aggregate for weep holes, disposing of unsuitable or surplus material, and clearing the channel of obstructions caused by construction operations.

Excavation for drilled-in caissons will be measured in linear feet of drilled hole from the existing ground to the bottom of the finished hole as measured along the centerline of the hole and will be paid

for at the contract unit price per linear foot. This price shall include drilling, underreaming, furnishing and installing casing, and preparing the hole.

Furnishing and placing backfill will be included in the price for structure excavation and will not be measured for separate payment unless specific material is required by the Engineer and no suitable material is available within the construction limits. When specific material is required for backfill by the Engineer, measurement and payment will be in accordance with Section 104.03.

Porous backfill, when a pay item, will be measured in cubic yards of material within the limits shown on the plans or as otherwise directed by the Engineer and will be paid for at the contract unit price per cubic yard.

Pipe underdrains, when a pay item, will be measured in linear feet and will be paid for at the contract unit price per linear foot for the size specified.

Unsuitable materials removed below the plan foundation will be measured and paid for as structure excavation.

Foundation seals required by the Engineer and that are properly placed for structural adequacy as a part of the planned footing will be accepted as part of the permanent footing. Measurement and payment will be in accordance with Section 404.08. Foundation seals that are not required by the Engineer shall be included in the price for structure excavation.

Clearing and grubbing within the area defined by lines connecting the extremities of the substructure units, regardless of whether excavation is involved, shall be included in the price for structure excavation unless otherwise specified in the Contract.

Cofferdams will be measured in units of each per foundation and will be paid for at the contract unit price per each. This price shall include furnishing, erecting, maintaining, and removing when no longer necessary.

Select backfill (Abutment zone) will be measured in tons and paid for at the contract unit price per ton. This price shall include furnishing, excavating, placing, compacting, and grading select backfill material.

Geocomposite Wall Drain will be measured in square yards and will be paid for at the contract unit price per square yard. This price shall include furnishing and placing the wall drain. Overlaps will not be measured for payment.

Payment will be made under:

Pay Item	Pay Unit
Structure excavation	Cubic yard
Drilled holes	Linear foot
Porous backfill	Cubic yard
Pipe underdrain (Size)	Linear foot
Cofferdams	Each
Select Backfill (Abutment Zone)	Ton
Geocomposite Wall Drain	Square Yard

SECTION 402—SHEET PILES

402.01—Description

This work shall consist of furnishing and installing the type of sheet piles shown on the plans or specified by the Engineer to be removed, or to be left in place as part of the finished structure.

402.02—Materials

(a) **Timber sheet piles** shall conform to Section 236 and may be of any species of wood that can be driven satisfactorily. Piles shall be free from worm holes, loose knots, wind shakes, decayed or unsound portions, or other defects that might impair their strength or tightness.

(b) **Concrete and reinforcing steel for concrete sheet piles** shall conform to Sections 217 and 223, respectively.

(c) **Steel sheet piles** shall conform to Section 228.

402.03—Procedures

(a) **Timber Sheet Piles:** the Contractor shall furnish piles that are sawed with square corners and provided with tongues and grooves of ample proportions, either cut from the solid material or made with three planks securely fastened together. Piles shall be drift sharpened at the lower ends to wedge the adjacent piles tightly together.

The top of piles shall be cut off to a straight line. Piles shall be braced with waling strips that are lapped and joined at splices and corners. Wales shall be in one length between corners and bolted near the top of the piles.

(b) **Concrete Sheet Piles:** Concrete sheet piles shall be manufactured in accordance with Section 403, 404, or 405, as applicable. The Contractor shall install concrete sheet piles in accordance with Section 403.

(c) **Steel Sheet Piles:** When assembled in place, pile sections shall be practically watertight at the joints. Painting of steel sheet piles shall be performed in accordance with Section 403. Piles shall be provided with tongues and grooves of ample proportions for securely fastening together. Wales and structural supports shall be provided as necessary to ensure structural integrity.

(d) **Temporary Sheet Piling:** When shown on the plans or directed by the Engineer, temporary sheet piling will be measured in square feet. The Engineer will measure the horizontal dimensions continuously along the outer face of the sheet piling. The bottom limit will be the bottom of the excavation shown on the plans or authorized by the Engineer. The top limit will be the original ground line or, in areas adjacent to traffic, 3 feet above the original ground line, or as otherwise shown on the plans.

402.04—Measurement and Payment

Sheet piles will be measured in square feet of piles remaining in place and will be paid for at the contract unit price per square foot. The Engineer will measure the horizontal dimensions continuously along the outer face of the piling. For steel sheet piles, the horizontal dimension used shall be not more than the sum of the laying widths or driving dimensions of the individual piles.

Payment for temporary sheet piling will be made at the contract unit price per square foot, which price shall be full compensation for furnishing, driving, and removing the piling.

Sheet piles used for the convenience of the Contractor due to his method and means of performing the work will not be measured for separate payment but will be considered incidental to the work.

Payment will be made under:

Pay Item	Pay Unit
Sheet piles (Type)	Square foot
Temporary sheet piling	Square foot

SECTION 403—BEARING PILES

403.01—Description

This work shall consist of furnishing, driving, cutting off and when required, load-testing piles of the type and dimensions specified on the plans.

403.02—Materials

(a) **Timber piles** shall conform to Section 236.02(b).

(b) **Steel piles** shall conform to Section 228.

(c) **Steel shells for cast-in-place piles** shall conform to Section 228.

(d) **Concrete** shall conform to Section 217. Concrete exposed to tidal water shall contain slag or silica fume.

(e) **Reinforcing steel,** Grade 40 or 60, for use in precast or cast-in-place piles, shall conform to Section 223.

403.03—Pile Types

(a) **Timber Piles:**

1. **Storing and handling:** The Contractor and\or supplier shall exercise diligent care to avoid breaking the surface of treated piles. Cant hooks, dogs, or pike poles shall not be

used to handle piles. Cuts or breaks in the surface of treated piles shall be given three brush coats of the preservative used to treat the pile. Preservative shall be poured into bolt holes so as to coat all surfaces of the hole.

2. **Cutoffs:** The tops of piles shall be cut off at the elevation shown on the plans or as directed by the Engineer. Piles that support timber caps or grillage shall be cut off to conform to the plane of the bottom of the superimposed structure. In general, the length of pile above the elevation of the cutoff shall be sufficient to permit removing material damaged by driving. Piles driven to or near the cutoff elevation shall be trimmed or otherwise rendered free of splintered or damaged material.

(b) **Precast Concrete Piles:** Precast concrete piles with conventional reinforcement shall be furnished in accordance with these specifications. Prestressed concrete piles shall be furnished in accordance with Section 405. Piles shall be manufactured to conform to Section 404. Class A3 concrete shall be used.

1. **Casting:** Forms shall conform to Section 404 and shall be accessible for vibrating, tamping, and consolidating concrete. Care shall be taken to place concrete to produce a satisfactory bond with the reinforcement and avoid segregation of components, honeycombs, or other defects.

   Concrete shall be continuously placed in each pile form and consolidated by vibrating. Forms shall be overfilled, the surplus concrete screeded off, and the top surface finished to a uniform, even texture similar to that produced by forms.

2. **Curing:** As soon as piles have set sufficiently, side forms shall be removed and the piles moist cured for at least 7 days. The Contractor shall not drive piles until the concrete has reached the minimum 28-day design compressive strength specified in Section 217. Concrete piles for use in brackish or tidal water or alkali soils shall be moist cured for at least 30 days before use.

3. **Finishing:** As soon as forms are removed, piles shall be pointed with mortar that conforms to Section 218. Trestle piles exposed to view shall be finished above the ground line with a Class I finish in accordance with Section 404.07(a). Foundation piles, that portion of trestle piles that will be below the ground surface, and piles for use in tidal water or alkali soils shall not be finished except by pointing as specified herein. Piles to be used in tidal water shall be protected in accordance with Section 404.03(i).

4. **Storing and handling:** The Contractor and/or supplier shall store, transport, and handle piles in a manner to prevent bending stresses, cracking, spalling, or other damage. The method of handling shall not induce stresses in the reinforcement of more than 12,000 pounds per square inch or a concrete stress of more than 0.4 f'c, where f'c is equal to the compressive strength of a control test cylinder at the time of handling. Concrete stress shall be not more than 1,200 pounds per square inch.

   Piles shall be supported or picked up only at pickup points shown on the plans or at a greater number of properly spaced pickup points as may be necessary to comply with stress requirements.

5. **Splicing:** The Engineer will not permit splicing unless he deems it necessary. When splicing is permitted, the Contractor shall perform splicing only as specified herein. Splicing shall

be performed only with the piles in their normal driving position. The final locations of splices shall be below the ground line.

Splices shall be made by providing dowels cast into the upper section of the pile. Dowels shall have a total area of at least 1 1/2 percent of the gross cross-sectional area of the pile and shall extend at least 30 bar diameters on each side of the splice. The Contractor shall use at least four dowels. Dowels shall be bonded into holes drilled or formed into the lower section of the pile. Holes shall be serrated to provide a mechanical bond. At least one dowel hole shall be provided with a bleeder vent near the bottom.

Ends of both sections shall be prepared to ensure that the concrete adjacent to the splice is sound material free from material that would interfere with the action of the bonding agent.

The bonding agent shall be a plasticized cement or other Department approved compound that can be placed or otherwise forced into the spaces around dowels and between ends of pile sections. The bonding agent shall have a design compressive strength at least equal to that of the concrete and an adhesive strength equal to the shear and tensile strength of the concrete. The agent shall be able to withstand impact and driving stresses and shall have the same resistance as concrete to damaging water and soil conditions. These properties shall be obtained within a time limit consistent with the driving requirements. If compounds require heating, the manufacturer's instructions shall be closely followed. The temperature of the concrete and the ambient temperature shall be not less than 50 degrees F at the time the splice is made.

The Contractor shall hold pile sections in such a manner that there will be a space of approximately 1/2 inch between the pile ends to permit free flow of the bonding agent. The Contractor shall place a splice form extending approximately 18 inches on each side of the splice around the ends of the pile sections. The form shall have at least four ports for pouring the bonding agent and to allow the escape of air. The bonding agent shall be poured simultaneously through two opposing ports. The Contractor may resume driving operations after sufficient time has elapsed to permit the bonding agent to develop its required properties.

6. **Build-ups:** When necessary, the Contractor shall make build-ups as follows: The Contractor shall cut away concrete at the end of the pile leaving the reinforcing steel or strand exposed for a length of 40 diameters after driving is completed. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel, and the Contractor shall then place the concrete taking care to prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile. Just prior to concrete placement, the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement or other suitable bonding material. Forms shall remain in place at least 7 days and then carefully removed. The exposed surface of the pile shall be finished as specified for precast concrete piles.

(c) **Cast-in-Place Concrete Piles:**

1. **Construction:** The Contractor shall cast piles in previously driven metal shells that shall remain permanently in place. The diameter shown on the plans shall be the nominal diameter of the uppermost section of the shell. Shells shall be classified into the following types:

a. **For driving without mandrels:** Type A, fluted, uniform taper; Type B, straight pipe.

b. **For driving with mandrels:** Type C, corrugated, step taper: when conditions require its use, the lower section may consist of pipe conforming to the requirements for Type B, Type D, corrugated, straight, or uniform taper.

The shell, including the tip, shall be of a design and thickness that are adequate to hold the original shape and prevent distortion of the shell resulting from driving it and any adjacent shell.

The Contractor shall determine whether self-supporting or mandrel-driven shells shall be used and the necessary shell thickness.

The Contractor shall increase the shell thickness or furnish prestressed concrete piles as shown on the plans at his own expense if the steel shells collapse. Concrete for casting piles shall be Class A3.

2. **Reinforcement:** Reinforcement shall consist of a cage of No. 6 longitudinal bars tied with a 0.24-inch or greater spiral bar having a 6-inch pitch. If the thickness of the shell wall is less than 0.12 inch, the Contractor shall use six longitudinal bars. If the thickness of the shell wall is 0.12 inch or greater, the Contractor shall use four longitudinal bars. The depth to which the reinforcement is extended below the top of the shell at the cutoff elevation shall be at least 1/3 the length of the shell, 10 feet below the elevation of material providing firm lateral support, or in any case, 10 feet, except for shells less than 15 feet in length. The reinforcement shall not extend closer than 5 feet to the tip. If the thickness of the shell is 0.188 inch or more, the length of longitudinal reinforcement required herein may be reduced to 5 feet below the top of the shell provided any splices occurring within the length are made sufficient to develop the full strength of the pile shell. In all cases, the longitudinal reinforcement shall extend 15 inches above the top of the shell and shall be provided with standard hooks.

3. **Inspection of metal shells:** The Contractor shall have a light suitable for the inspection of each shell throughout its entire length available. The Contractor shall remove improperly driven, broken, or otherwise defective shells and replace these with suitable sound shells at the Contractor's expense. The Engineer will not accept any shell whose diameter at any section is altered by more than 25 percent.

4. **Placing concrete:** The Contractor shall not place concrete until all driving within a radius of 15 feet is completed unless this is not practicable, in which case the Contractor shall discontinue driving until the concrete in the last cast pile has been in place at least 7 days.

Concrete shall be placed continuously and consolidated by vibrating. Accumulations of water in shells shall be removed before concrete is placed.

(d) **Steel Piles or Steel Pile Shells:**

1. **Cutoffs:** The Engineer will allow the use of cutoffs as extensions to driven or undriven piles, or as complete piles in themselves, provided the length of each cutoff is equal to or greater than the length of the extension or full-length pile required.

2. **Welding:** Splices, points, or point reinforcement shall be welded in accordance with Section 407.04(a) except that welder certification will be required only for the particular welds performed as required for H-pile splices, built-up point reinforcement, and shell splices that require the full strength of the shell to be developed.

3. **Splicing:** The Engineer will permit one splice per pile at locations requiring pile lengths of 40 feet or less. For lengths over 40 feet up to and including 80 feet, two splices will be permitted. For lengths exceeding 80 feet, one splice per 40 feet will be permitted. The Engineer will not allow splices in sections less than 10 feet in length except as a final (top) section of the pile.

   Splices on steel H-piles shall be made by means of butt joints with full penetration welds. Piles spliced in a vertical position shall receive a single-bevel groove weld. Piles spliced in a horizontal position shall receive a single vee or V-groove weld. Abutting ends of piles to be spliced shall be properly prepared for welding, including removing damaged material and squaring the two ends. The Contractor shall securely clamp the two sections of pile in proper position and alignment prior to welding.

   The Engineer must approve the welded or mechanical connection splice. Each splice between abutting pile shell sections shall be welded or adequately connected by mechanical means approved by the Engineer to give a complete seal and the resulting welded splice shall be of adequate strength to withstand handling, driving, and design stresses. If the diameters of abutting shell sections to be spliced are not the same, the shells shall be telescoped at least 6 inches at splices. When splices are required to develop the full strength of the shell, the top of the outside shell at the splice shall be scalloped to provide sufficient fillet welds. Sections of shell less than 5 feet in length shall not be spliced to another shell except as a build-up after driving is completed. The Contractor shall not perform more than one splice within any 15-foot length of completed pile.

4. **Protection by painting:** When steel piles or steel pile shells extend above the ground or water surface, they shall be protected by one coat of No. 14 primer and one coat of epoxy mastic as specified in Sections 231.03(b) and 231.03(c). The coating thickness shall be as specified in Section 411, Table IV-6. Protection shall extend from an elevation 2 feet below the lowest ground or water surface up to a level 2 inches into the concrete in which their tops are to be embedded.

5. **Variations in length:** Where steel H-piles are driven in limestone areas or where extreme variations in length are likely to be encountered, the Contractor shall use the following procedure: Wherever a pile has been driven to a depth requiring a length exceeding that originally anticipated by 30 percent or 15 feet (whichever is greater), a length determined in accordance with Section 403.04 or a length as indicated by the borings or piles already driven, the Contractor shall not drive the pile any further until all other piles in the pier, abutment, or retaining wall have been driven or until a sufficient number of piles has been driven to indicate clearly the trend of lengths. The Engineer will then determine the method to be used to drive the remaining pile .

403.04—Determination of Pile Lengths

For cast-in-place piles, the Contractor shall determine the type, thickness, and driving criteria of the steel pile shell. Lengths shall be determined by performing driving tests.

A driving test shall be performed by driving a pile of the same type and size as that required or proposed for the specific structure at each location shown on the plans or that the Engineer approves.

Driving test piles that are not to be load tested or dynamically analyzed shall be driven their full length or until practical or absolute refusal is reached.

403.05—Initial Preparation

(a) **Suitability of Foundation:** If there is any indication that piles cannot be driven in accordance with these specifications or if the foundation material appears to be capable of supporting footings without piles, the Contractor shall explore foundation in accordance with Section 401.03(b) and submit the results of the exploration to the Engineer for review to determine whether piles will be omitted and the substructure adjusted to give adequate bearing on a firm foundation.

(b) **Preparation for Driving:**

The Contractor shall not drive piles for supporting abutments on very soft or swampy original ground or on newly placed fill until the approach embankment, including any fill in front of the abutment, has been completed to the elevation of the top of the earthwork and compacted as specified in Section 303.

The Contractor shall not drive piles in proximity to uncured concrete.

For steel and timber piling, the pile heads shall be cut and maintained square with the longitudinal axis of the pile. Precast concrete pile heads shall be flat, smooth, and perpendicular to the longitudinal axis of the pile to prevent eccentric impacts from the helmet. Prestressing strands shall be cut off below the surface of the end of the pile. For concrete or timber piles, the pile head shall be chamfered on all sides.

The Contractor shall protect timber piles that are not enclosed in concrete as specified in Section 418.03(d). Collars, bands, or other devices to protect timber piles against splitting and brooming shall be provided when specified by the Engineer.

Tips for timber piles shall be sharpened. When specified, timber piles shall be provided with steel or cast iron points conforming to Section 236.02(b). When points are used, the tips of the piles shall be carefully shaped to secure an even and uniform bearing on the points.

Pile shoes and points shall be used when specified by the Engineer or in the Contract to protect all types of piles when hard driving or obstructions are expected.

Steel pile shoes and points shall be fabricated from cast steel conforming to ASTM A148/A148M (Grade 90-60). End plates used on closed-end pipe piles shall be made of ASTM A36/A36M steel or better. Points shall be welded as recommended by the manufacturer, but the length of the weld shall be not less than twice the width of the flange.

Steel piles and steel pile shells shall be painted as specified in Section 403.03(d) 4.

403.06—Driving Piles

The Engineer will verify the capability of the hammer to drive piles properly from records of the test piles. If the required penetration is not obtained in the driving test by the use of a hammer complying

with the requirements, the Contractor shall provide a heavier hammer or use other approved means at his own expense. The method of driving shall not produce deformed piles. Where determined necessary by the Engineer in order to obtain the required tip elevation, nominal pile resistance or minimum penetration, driving shall be supplemented by jetting or preboring. After driving is completed, voids existing as a result of preboring, soil consolidation, or movement shall be filled with dry sand and consolidated to provide adequate lateral pile support. The Contractor shall remove and replace any damaged piles at the Contractor's expense.

(a) **Pile Driving Equipment:** All pile driving equipment, including the pile driving hammer, hammer cushion, helmet, pile cushion, and other appurtenances to be furnished by the Contractor shall be approved in advance by the Engineer before any driving can take place. Pursuant to obtaining this approval, the Contractor shall submit a PILE AND DRIVING EQUIPMENT DATA form to the Engineer at least three weeks before pile driving is to begin. The description shall contain sufficient detail so that the proposed driving system can be evaluated by wave equation analysis.

If the nominal resistance is to be determined by static load test, dynamic test, quick static load test, or wave equation analysis, the Contractor shall submit to the Engineer results of a wave equation analysis to show that the piles are drivable.

If the nominal resistance is to be determined by dynamic formula, a wave equation analysis is not required. The blow count required by the dynamic formula shall not exceed 10 blows per inch.

The following hammer efficiencies shall be used in a wave equation analysis of vertical piles unless better information is available.

Hammer Type	Efficiency (in Percent)
Drop	25 to 40
Single-acting air/steam	67
Double-acting air/steam	50
Diesel	80
Hydraulic or diesel with built-in energy measurement	95

Hammer efficiencies shall be adjusted for battered driving.

In addition to the other requirements of these specifications, the criterion that the Contractor and the Engineer will use to evaluate the driving equipment shall consist of both the required number of hammer blows per inch at the required nominal resistance, and the pile driving stresses over the entire driving process. The required number of hammer blows indicated by the wave equation analysis at the required nominal resistance shall be between 2 and 10 blows per inch for the driving equipment to be deemed acceptable.

In addition, for the driving equipment to be deemed acceptable, the pile stresses, which are determined by the wave equation analysis for the entire driving operation, shall not exceed the values below:

1. **Prestressed concrete piles:**

   a. **Compression:** $0.85\ f'_c - f_{pe}$

b. **Tension:**

Normal Environments: $3\sqrt{f'_c} + f_{pe}$

Severe Corrosive Environments: f_{pe}

Where:

f'_c = the 28- day compressive of concrete given in terms of pounds per square inch (psi)

f_{pe} = unit prestress (after losses)

If during the driving of a precast concrete pile a reduction in blow count indicates that the point of the pile has passed from a harder material into a softer material that offers little or no resistance to penetration, the energy per blow shall be reduced to an amount specified by the Engineer. When firm-bearing material is reached, the energy per blow shall be returned to normal.

2. **Steel piles:**

a. **Compression:** $0.9\ F_y$

b. **Tension:** $0.9\ F_y$

Where:

F_y = Yield Stress of steel given in terms of pounds per square inch (psi)

3. **Timber piles:**

For timber piles the compressive driving stress shall not exceed $\Phi_{da}F_{co}$, where F_{co} is the base resistance of wood in compression parallel to the grain as specified in Article 8.4.1.3, and Φ_{da} is the resistance factor for stresses incurred during pile driving specified in Article 8.5.2.2 of the current *AASHTO LRFD Bridge Design Specifications,* and Φ_{da} is equal to 1.15.

The Contractor shall use the approved system during pile driving operations. Any change in the driving system shall be considered only after the Contractor has submitted revised pile driving equipment data and wave equation analysis. The Contractor shall be notified of the acceptance or rejection of the driving system changes within five working days of the Engineer's receipt of the requested change. The time required for submission, review, and approval of a revised driving system will not constitute the basis of a contract time extension for the Contractor.

Approval of pile driving equipment shall not relieve the Contractor of the responsibility to drive piles, free of damage, to the bearing and tip elevation shown on the plans, specified in the Contract, or mandated by the Engineer. In addition, approval of pile driving equipment relative to driving stress damage shall not relieve the Contractor of responsibility for piles damaged because of misalignment of the leads, failure of capblock or cushion material, failure of splices, malfunctioning of the pile hammer, other equipment, or other improper construction methods.

(b) **Hammers**

1. **General:** Piles shall be driven with an impact or vibratory hammer conforming to these Specifications. Pile driving hammers shall be of the size needed to develop the energy required to drive the piles at a blow count that does not exceed 10 blows per inch at the required nominal resistance.

2. **Drop Hammers:** Drop hammers shall not be used for concrete piles or for piles whose required nominal resistance exceeds 60 tons.

   Where drop hammers are permitted, the ram shall have a weight not less than 1.0 ton and the height of drop shall not exceed 12 feet. In no case shall the ram weight of drop hammers be less than the combined weight of helmet and pile. All drop hammers shall be equipped with hammer guides and a helmet to ensure concentric impact.

3. **Air Hammers:** If a dynamic formula is used to establish the required blow count, the weight of the striking parts of air hammers used shall not be less than one-third the weight of pile and drive cap. In no case shall the striking part have a weight less than 1.4 tons. If a wave equation analysis is used to establish the required blow count and driving stresses, this limitation on ram weight will not apply.

   The plant and equipment furnished for air-hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. The hose connecting the compressor with the hammer shall be at least the minimum size recommended by the manufacturer.

   Hammer performance shall be evaluated at the end of driving by measuring blows per minute and comparing these blows with the manufacturer's recommendations.

4. **Diesel Hammers:** If open-end (single-acting) diesel hammers are not equipped with a device to measure impact velocity at all times during pile driving operations, the stroke shall be obtained by measuring the speed of operation either manually or with a device that makes the measurement automatically. Closed-end (double-acting) diesel hammers shall be equipped with a bounce chamber pressure gauge in good working order, mounted near ground level so as to be easily read by the Engineer. The Contractor shall provide a correlation chart of bounce chamber pressure and potential energy.

5. **Hydraulic Hammers:** Hydraulic hammers shall allow the ram stroke to be continuously variable and controlled to adapt to the driving conditions. The stroke may be visually estimated; however hammers with a built-in monitoring system which determines the ram velocity just before impact are preferred. The monitoring system shall be in good working order and the results shall be easily and immediately available to the Engineer. When pressure measuring equipment is required to determine hammer energy, the pressure gage shall be calibrated at the beginning of the project.

6. **Vibratory Hammers:** Vibratory or other pile driving methods may be used only when specified in the Contract or in writing by the Engineer. Except when pile lengths have been evaluated from static load test piles, the nominal resistance of piles driven with vibratory hammers shall be verified by additional driving of the first pile driven in each group of 10 piles with an impact hammer of suitable energy to measure the nominal resistance before driving the remaining piles in the group. In case of variable soils, additional

piles shall be verified by an impact hammer as directed by the Engineer. All piles that rely primarily on point bearing capacity shall be redriven with an impact hammer.

The Contractor shall not use vibratory hammers to drive concrete piles.

7. **Additional Equipment or Methods:** If the required penetration is not obtained by the use of a hammer complying with the minimum requirements above, the Contractor may be required to provide a hammer of greater energy or, when permitted by the Engineer, resort to supplemental methods such as jetting or preboring.

(c) **Driving Appurtenances**

1. **Hammer Cushion:** All impact pile driving equipment except drop hammers shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile. Hammers designed such that a hammer cushion is not required to prevent damage to the hammer or pile shall be excluded from this requirement.

   Where applicable, hammer cushions shall be made of durable, manufactured materials that will retain uniform properties during driving. Wood, wire rope, or asbestos hammer cushions shall not be used. A striker plate shall be placed on the hammer cushion to ensure uniform compression of the cushion material. The hammer cushion shall be replaced by the Contractor before driving is permitted to continue whenever there is a reduction of hammer cushion thickness exceeding 25 percent of the original thickness or, for air hammers, when the reduction in thickness exceeds the manufacturer's recommendations.

2. **Helmet:** Piles driven with impact hammers shall be fitted with a helmet to distribute the hammer blow uniformly and concentrically to the pile head. The surface of the helmet in contact with the pile shall be plane and smooth and shall be aligned parallel with the hammer base and the pile top. It shall be guided by the leads and not be free-swinging. The helmet shall fit the pile head in such a manner as to maintain concentric alignment of hammer and pile.

   For special types of piles, appropriate driving heads, mandrels, or other devices shall be provided so that the piles may be driven concentrically without damage.

   For timber piles, the least inside helmet or hammer base horizontal dimension shall not exceed the pile head diameter by more than 2.0 inches. If the timber pile diameter slightly exceeds the least helmet or hammer base dimension, the pile head shall be trimmed to fit the helmet.

3. **Pile Cushion:** A pile cushion shall protect the heads of concrete piles. The cushion thickness placed on the pile head before driving shall be selected by wave equation analysis so that the limiting driving stresses are not exceeded. If the required driving blow count is determined by a dynamic formula, the cushion shall have a thickness of at least 4.0 inches.

   The Contractor shall provide a new pile cushion if, during driving, the cushion is compressed more than 50 percent of its original thickness or begins to smoke. The·pile cushion dimensions shall be such as to distribute the blow of the hammer uniformly over the entire cross-section of the pile.

Pile cushions shall be protected from the weather and kept dry before use. Pile cushion shall not be soaked in any liquid unless approved by the Engineer. The use of manufactured pile cushion materials in lieu of a wood pile cushion shall be evaluated on a case-by-case basis.

A used pile cushion in good condition shall be used for restrike tests.

4. **Leads:** Pile driving leads that align the pile and the hammer in proper positions throughout the driving operation shall be used. Leads shall be constructed in a manner that affords freedom of movement of the hammer while maintaining alignment of the hammer and the pile to ensure concentric impact for each blow.

   The leads shall be designed to permit proper alignment of battered piles when applicable.

   Leads may be either fixed or swinging type. Swinging leads, when used, shall be fitted with a pile gate or other restraint at the bottom of the leads to insure bottom alignment will be maintained. The leads shall be adequately embedded in the ground or the pile constrained in a structural frame such as a template to maintain proper alignment.

5. **Followers:** Followers shall be used only when approved in writing by the Engineer or when specified in the Contract.

   When followers are used, one (1) pile from every group of 10 shall be a long pile driven without a follower and shall be used as a test pile to determine the average nominal resistance of the group.

   For concrete piles, a pile cushion shall be used at the pile top, and the suitability of the follower shall be checked by wave equation analysis to verify the blow count, driving stresses, and nominal resistance.

   For steel or timber piles, if a wave equation analysis is not performed, the follower shall have an impedance between 50 percent and 200 percent of the pile impedance.

   The follower and pile shall be maintained in proper alignment during driving. The follower shall be of such material and dimensions to permit the piles to be driven to the blow count determined to be necessary.

6. **Jetting:** Jetting will be permitted only if specified in the Contract or approved in writing by the Engineer.

   The Contractor shall determine the number of jets and the volume and pressure of water at the jet nozzles necessary to freely erode the material adjacent to the pile.

   The Contractor shall control and dispose of all jet water in a manner satisfactory to the Engineer, or as specified in the Contract. If jetting is specified or approved by the Engineer and is performed according to the project specifications or as directed or approved by the Engineer, the Contractor will not be held responsible for any damage to the site caused by jetting operations. If jetting is used for the Contractor's convenience, the Contractor shall be responsible for all damages to the site caused by jetting operations.

   Unless otherwise indicated by the Engineer or the Contract, jet pipes shall be removed before or when the pile tip is 5 feet above the minimum or final tip elevation, and the pile

shall then be driven without jetting to the final tip elevation or to the required nominal resistance with an impact hammer. If the required nominal resistance is not reached at the final tip elevation, the pile may be allowed to set up and then the required nominal resistance will be determined by restriking the pile.

7. **Preboring:** Preboring shall be performed when indicated on the plans and performed in accordance with plan requirements. In soil, the diameter of each prebored hole shall be approximately 75 percent of the pile diagonal but not more than 100 percent of the pile diagonal, unless otherwise approved by the Engineer. When boring through rock, the diameter of each prebored hole shall be not less than 6" greater than the pile diagonal. If there are both rock and soil strata at the boring location, then the limits on the diameter of the prebore shall be the same as for preboring in rock.

(d) **Additional Requirements**

1. **Installation Sequence:** Unless approved otherwise by the Engineer, the order of installing piles in pile groups shall be either starting from the center of the group and proceeding outward in both directions or starting at the outside row and proceeding progressively across the group.

2. **Penetration:** In general, the penetration for any pile shall be at least 10 feet. In soft material, the penetration shall be at least 20 feet. Where piles are driven through fills, they shall penetrate at least 5 feet into undisturbed original ground under the fill. Friction piles, other than steel H-piles, in fills shall be driven through prebored holes extending to the elevation of the original ground.

3. **Heaved Piles:** If pile heave is observed, level readings referenced to a fixed datum shall be taken by the Engineer on all piles immediately after installation and periodically thereafter as adjacent piles are driven to determine the pile heave range.

   During the driving process for adjacent piles, piles shall be redriven if they heaved more than 0.5 inch.

   The Contractor shall be paid for all work performed in conjunction with redriving piles because of pile heave provided the initial driving was done in accordance with the specified installation sequence.

4. **Repair of Subgrade:** Material forced up between piles shall be removed to correct the foundation elevation before concrete for the foundation is placed.

(e) **Accuracy of Driving:**

Piles shall be driven to within the tolerances specified in Table IV-1 for positions at cutoff elevations.

Piles shall not be driven with a variation of more than 1/4 inch per foot from the vertical or batter specified.

Steel and concrete piles shall not be subjected to force in order to place them in correct alignment or a horizontal position. The position of a timber pile that lies within the tolerance allowed for the driven position as specified in Table IV-1 under pile type No. 4, Condition

TABLE IV-1
Pile Tolerance Criteria

Pile Type	Condition	Tolerance for Position of Single Pile (in)	Center of Gravity for Pile Group[1]	
			Direction	Tolerance
1. Steel and Concrete	Column supports for bent caps and integral abutments	±3	About long axis of footing	3% of distance between extremes[2] or 1 1/2 in, whichever is greater
2. Steel and Concrete	(a) Footing supports for box culverts	±6		
	(b) Footing supports for column piers	±6	About both major axes	3% of distance between extremes[2] or 1 1/2 in, whichever is greater
	c) Footing supports for abutments, retaining walls, and piers other than column piers	±6	About long axis of footing	3% of distance between extremes[2] or 1 1/2 in, whichever is greater
3. Timber	Footing supports for box culverts	±9		
4. Timber	(a) Footing supports for column driven through material that will permit correction of position without damage to pile	±9	About both major axes	4 1/2% of distance between extremes[2] or 2 1/4 in, whichever is greater
	(b) Footing supports for abutments, retaining walls, and piers other than column piers driven through material that will permit correction of position without damage to pile	±9	About long axis of footing	4 1/2% of distance between extremes[2] or 2 1/4 in, whichever is greater
5. Timber	(a) Footing supports for column piers driven through material that will not permit correction of position	±6	About both major axes	4 1/2% of distance between extremes[2] or 2 1/4 in, whichever is greater
	(b) Footing supports for abutments, retaining walls, and piers other than column piers driven through material that will not permit correction of position	±6	About long axis of footing	4 1/2% of distance between extremes[2] or 2 1/4 in, whichever is greater
6. Timber	Fender systems and other uses requiring non-load bearing piles	As required for proper attachment of wales, bracing, etc., or tying of groups for dolphins		

[1]Piles under a separate footing of individually constructed units shall be considered a separate group. The tolerances expressed as a percentage of "distance between extremes" will be allowed only about the axis for which it is computed.

[2]If the group consists of a single row of piles, the distance shall be measured from the centerline of the row to the centerline of the footing.

(a) or (b), shall be corrected to the tolerance given for pile type No. 5, Condition (a) or (b), respectively, by the application of horizontal force wherever conditions will permit such corrective work without damage to the pile.

If the distances between the actual and theoretical pile centers or centers of gravity are more than the specified tolerances, the piles will be considered unacceptable unless the Contractor submits a satisfactory working plan showing the corrective work proposed. Such work shall not proceed until the plan has been approved by the Engineer. The piles in question will be considered as acceptable if corrective actions result in piles within the specified tolerances.

The clear distance between the heads of piles and edge of footings shall be at least 6 inches. Additional concrete and reinforcement required to maintain the required minimum clear distance shall be placed only with the prior approval of the Engineer and shall be furnished at the Contractor's expense.

Timber piles driven below the cutoff elevation specified on the plans or by the Engineer, or otherwise driven outside the limits for the driven position specified herein shall be withdrawn, and a replacement pile driven in the correct position at the Contractor's expense. Other types of piles driven to below the required elevation may be spliced or built up as otherwise provided for in these specifications.

403.07—Determination of Nominal Pile Resistance

Required nominal resistance of piles and method of field validation (loading test, dynamic pile testing, refined wave equation analysis or dynamic formula) will be as shown on the plans or as designated by the Engineer.

(a) **Loading Tests:** When required, nominal pile resistance of piles shall be determined in accordance with 72-hour or quick load tests as specified herein.

When required in the Contract, the loading test shall commence no sooner than 5 days after the pile to be tested has been driven. Telltales consisting of steel rods 1/2 inch in diameter shall be lubricated and inserted in plastic pipe 3/4 inch in inside diameter. Individual sections of telltales shall be joint coupled flush so that each rod is of uniform diameter throughout its length.

Where necessary, the unsupported length of the test pile shall be braced to prevent buckling without influencing the test results.

The clear distance from the reaction frame to the test pile shall be at least 5 times the maximum diameter of the test pile or as approved by the Engineer.

Loading shall be applied through a hydraulic jack with spherical bearings jacked against a platform load. The loading apparatus shall have a capacity of at least that required for the test. If more than one jack is used, the jacks shall have the same piston diameter, be connected to a common manifold and pressure gage, and be operated by a single hydraulic pump.

The method of determining test loads shall be by using a pressure gage or load cell. The pressure gage, hydraulic ram, and hydraulic pump shall be calibrated as a unit to an accuracy of at least 5 percent of the applied load. If a multiple jacking system is used, each jack shall be

fitted with a pressure gage in addition to the master gage. Load-measuring devices shall have been calibrated not more than 3 months prior to the loading test and shall be recalibrated when directed by the Engineer.

Loads shall be applied uniformly with no impact. The load cell or pressure gage shall be continuously monitored, and the jacking pressure adjusted to maintain a constant load.

The load shall be applied to a steel test plate of appropriate thickness for the loads involved and of a size not less than the size of the pile butt and not less than the area covered by the base(s) of the hydraulic jack rams. The plate shall be set in high-strength, quick-setting grout to ensure a uniform bearing. Provision shall be made for the telltale rod to extend through the test plate.

Movement of the pile butt and telltale relative to the pile butt shall be measured with dial gages to an accuracy of 0.001 inch. Dial gages shall have a travel of at least 2 inches, and gage blocks shall be provided to record measurements as required. The pile butt shall be measured by dial gages attached to an independently supported frame. Movement shall be measured by a secondary system consisting of a scale, mirror, and piano wire. The scale and mirror shall be attached parallel with the longitudinal axis of the pile. The wire shall be properly tensioned and supported so that it passes within 1 inch of the face of the scale. The scale shall have gradations of 1/100 of an inch.

Supports for dial gage frames and wires shall be more than 7 feet clear of the pile and as far from anchor piles or reaction supports as is practicable. Supports and frames shall be checked by a surveyor's level.

Gages and measuring devices shall be protected from the weather, including direct sunlight. Adequate ventilation shall be provided to prevent fogging or frosting of the gages.

The Contractor shall provide the Engineer reasonable access to and from the site of the test pile. The Contractor shall assist the Engineer in recording load, settlement, and rebound measurements throughout the test and shall furnish complete information on the driving equipment used and the pile driving record.

Other piles of the same type and size that are not load tested shall be driven to the nominal pile resistance of at least that required for the satisfactory load-tested pile(s).

1. **The 72-hour loading test** shall be taken to the nominal pile resistance applied in increments of 12.5 percent of the nominal pile resistance. Each load increment shall be maintained until the rate of settlement is not greater than 0.01 inch per hour or until 2 hours have elapsed, whichever occurs first. The test load shall be applied fully and continuously for at least 72 hours and shall produce no measurable settlement during the last 24 hours. After the required holding time, the test load shall be removed in decrements of 25 percent of the nominal pile resistance with at least 1 hour between decrements.

   Permanent settlement of the pile after completion of the specified loading test shall be not more than 1/4 inch. If the permanent settlement is more than 1/4 inch, the Contractor shall redrive and test load the same pile or drive and test load additional piles until the loading test is satisfactory.

2. **The quick load test** shall be taken to 150 percent of the nominal pile resistance applied in increments of 5 percent of the nominal pile resistance with a constant time interval be-

tween increments of 5 minutes. Load increments shall be added until continuous jacking is required to maintain the test load or until the specified capacity of the loading apparatus is reached, whichever occurs first. After a 10-minute interval, the full test load shall be removed in four approximately equal decrements with 5 minutes between decrements.

The Contractor shall record readings of time, load, and settlement for the pile and telltale immediately before and after applying each load increment. When the maximum load has been applied, the Contractor shall record when jacking is stopped. Readings shall be repeated after 5 minutes and again at 10 minutes after jacking has stopped. Readings of time, load, and rebound shall also be recorded after each decrement during load removal and repeated 5 minutes and 10 minutes after the load has been removed.

The nominal pile resistance of a pile tested under an axial compressive load is that load which produces a settlement of the pile head equal to the following:

$$S_f = S + (0.15 + 0.008D)$$

Where:

S_f = settlement at failure in inches;
D = pile diameter or width in inches;
S = elastic deformation of pile length in inches = P_tL/AE;
P_t = load on pile in pounds;
L = length of pile in inches;
A = area of pile in square inches; and
E = the modulus of elasticity of the pile in psi [57,000 $(f'_c)^{0.5}$ for concrete; $29X10^6$ for steel].

If the nominal pile resistance determined by the quick load test is less than that required for design, the Contractor shall redrive and test load the same pile or drive and test load additional piles until the loading test is satisfactory.

(b) **Dynamic Pile Testing**

1. **Description:** This work shall consist of dynamic testing of piles by the use of electronic monitoring equipment, reprocessing the data and furnishing the Engineer a written report of the results.

2. **Equipment:** Unless specified in the plans, testing may be done with either attached or embedded gages. All equipment necessary for the dynamic monitoring, including but not limited to the gages and cables, shall be furnished by the Dynamic Testing Consultant. Embedded Data Collector (EDC) gauges shall be embedded in the concrete piles during casting at the casting yards and supplied to Contractor at the project site. A detailed drawing that clearly illustrates the manner in which the EDC equipment will be incorporated into the piles shall be provided to the Engineer for approval. All the equipment shall conform to ASTM-4945-08, Standard Test Method for High Strain Dynamic Testing of Piles.

3. **Personnel:** The Contractor shall employ a Dynamic Testing Consultant to install or supervise the installation of the necessary equipment, to perform the dynamic monitoring and to prepare the Dynamic Testing Report.

The dynamic monitoring operator shall have a minimum of two years experience, at least one of which shall have been in data acquisition from high strain dynamic pile testing and successful performance on at least two projects in similar geotechnical conditions as those covered by the contract, or who has a Certificate of Testing: Basic Level or better on the Foundation QA Examination for Providers of Pile Dynamic Analyzer (PDA) Testing Services. When the EDC will be used to monitor piles and/or test piles, EDC monitoring shall be performed by an Operator who has successfully completed the SmartPile EDC training course and has been certified.

The Dynamic Pile Testing Report shall be prepared by a Registered Professional Engineer with a minimum of five years experience, at least two of which shall have been in data interpretation from high strain dynamic pile testing and successful completion of at least five projects in similar geotechnical conditions as those covered by the contract, or who has a Certificate of Interpretation: Advanced Level or better on the Foundation QA Examination for Providers of PDA Testing Services. When EDC is utilized, the Registered Professional Engineer who prepares the test report shall have successful completed the SmartPile EDC training course level 1 or higher, including signal matching if applicable.

4. **Testing:** Dynamic testing shall be conducted in the presence of the Engineer and during the entire time piles are initially driven or redriven and during pile restrike testing.

The Contractor shall notify the Engineer of the date and time for dynamic testing at least 48 hours prior to testing. Such notice shall be given during the normal work hours of the Department. If additional dynamic testing is ordered by the Engineer, the Contractor shall schedule the tests in cooperation with the availability of the Engineer.

Where possible, splices to the pile(s) shall be made prior to the start of driving so that dynamic testing can be performed without interruption.

The Contractor shall fasten a pair of transducers and a pair of accelerometers in place prior to testing or the Contractor shall have the gauges internally mounted during the casting of the pile, at the top and tip, or at the top only, by properly trained and certified installers at the discretion of the Engineer. Piles shall be driven until the soil resistance measured is 80 percent of the Nominal Pile Resistance shown on the plans and the required minimum tip elevation and penetration have been obtained or as directed by the plans, approved wave equation analysis or as approved by the Engineer. Any pile not developing the specified end of initial drive Mobilized Pile Resistance shall be left at least one foot above cutoff grade to allow for restrike testing. Unless EDC is used, the Contractor shall remove the transducers and accelerometers after the dynamic testing is completed.

Pile restrike testing shall be conducted no sooner than 120 hours after the pile, or any pile within a 25 foot radius, has been driven. Restrike testing shall include dynamic testing of the pile when it is redriven. The pile shall be redriven with the same pile hammer used for initial driving. The restrike driving sequence shall be performed with a warmed up hammer and shall consist of striking the pile for 20 blows or until the pile penetrates an additional 3 inches, whichever occurs first. If the soil resistance measured on restrike is less than the Nominal Pile Resistance shown on the plans, the Engineer may direct the Contractor to drive all or a portion of the remaining test pile length and repeat the restrike testing. The Engineer will notify the Contractor if there is the necessity to perform a second restrike test within 3 days of the receipt of the results from a signal-matching analysis that estimates static soil resistance and simulates static load test results from the initial restrike.

All signals resulting from initial testing and any restrike testing shall be recorded and made available upon the request of the Engineer.

5. **Reports:** If requested by the Engineer, the following information shall be provided within 24 hours after completion of the testing: for each blow from the Dynamic Driving Records provide the Depth, Maximum Transferred Energy, Blows per Minute (including strokes, fuel settings, bounce chamber pressures, etc. as applicable), Maximum Tensile Stress, Maximum Compressive Stress and Pile Resistance.

   The Contractor shall furnish the Engineer a Dynamic Pile Testing Report with the production pile order list.

   The Dynamic Pile Testing Report shall include the following information for each pile tested:

   Project identification and location, Location of test, Date of test, Description of the subsurface soil condition including log of nearest boring, Description of the test pile, Description of pile installation equipment, the lead type and any special installation equipment, description of dynamic testing equipment, including model and software version(s) utilized in obtaining, evaluating and reporting dynamic data, a copy of the Pile Driving Record, pile installation details and comments, discussion of the hammer performance, discussion of pile integrity. For at least every fifth blow from the Dynamic Driving Records: the depth, maximum transferred energy, blows per minute (including strokes, fuel settings, bounce chamber pressures, etc. as applicable), maximum tensile and compressive stress and pile resistance, a graphical presentation of the following: pile penetration versus maximum transferred energy, maximum compressive stress, maximum tension stress and mobilized pile resistance, the results from a signal-matching program that estimates static soil resistance and simulates static load test results for both the end of initial drive conditions and the beginning of restrike conditions including Mobilized Pile Resistance for the shaft and toe with the associated parameters used in the estimation. The skin friction distribution along the pile shall also be presented. EDC signal matching shall be validated using EDC tip gauges measured results.

   When Dynamic Pile Testing is followed by a pile load test include a summary of soil resistance from both Load and Dynamic Testing, including an evaluation of the correlation between the two approaches and discussion of any discrepancies, if applicable. Plot of applied load versus average butt settlement, with determination of the nominal resistance required by the specifications, shall be provided.

   A summary tabulation shall be provided of the following information for both Initial Drive and Restrike: Pile Location and Designation, Date Driven, Pile Tip Elevation, Visual Blow Count Rate, Transferred Energy, Hammer Efficiency, Maximum Driving Stresses, Dynamic Testing Mobilized Pile Resistance, Signal-Matched Mobilized Pile Resistance for Shaft, Toe and Combined.

   Recommendations for production pile driving criteria shall be based on the results of the testing program. Driving criteria shall include: blow count to obtain the required Mobilized Pile Resistance for both initial drive and the restrike of a production pile that does not meet initial criteria (include: stroke(s), fuel setting(s), bounce chamber pressure(s), etc. as applicable), criteria for controlling driving stresses in the pile (including maximum allowable hammer strokes, recommendations for preboring or jetting that might

be required, cushion material, thickness and replacement, etc. as applicable) and criteria for terminating driving in the event of high blow count before reaching the approved tip elevation. Pile driving criteria shall be approved by the Engineer

(c) **Wave Equation Analysis**

Prior to driving test piles, the Contractor shall furnish the Engineer the following information pertaining to the proposed pile driving equipment:

1. Completed Pile and Driving Equipment Data Form for each proposed pile hammer and pile type combination.

2. At each driving test location, where different subsurface conditions exist, the Contractor shall furnish a Wave Equation Analysis of pile driving performed by a Professional Engineer experienced in such work, demonstrating that the piles can be driven with reasonable effort to the required penetration, length and capacity without damage. This analysis shall include the following:

   Copies of computer input and output sheets and graphs showing soil resistance versus blow count as well as maximum tensile and compressive stresses versus blow count. Analyses shall be run at the estimated tip elevation as well as other higher elevations to define maximum stress levels in the pile during driving or a drivability analysis can be performed.

Soil setup (pile freeze effect) may be considered when establishing initial driving criteria. If soil setup is considered, two wave equation analyses, one modeling initial drivability and the second modeling the beginning of restrike conditions, must be performed. However, hammers requiring the consideration of soil setup for approval may require restrikes of the driving test piles, at the Contractors expense, for verification purposes.

After the driving test piles have been installed, if initial parameters selected are judged to be inappropriate, the Contractor may be required to submit a refined wave equation analysis along with the pile order list. The refined analysis shall include any modifications or changes deemed appropriate.

The Engineer will determine driving resistance criteria and/or minimum tip elevations to be used for production piles from the above information.

(d) **Dynamic Formula**

A dynamic formula should not be used if the required nominal resistance is more than 600 kips.
When a dynamic formula is specified to establish the driving criterion, the FHWA Gates Formula specified here in should be used. The nominal pile resistance as measured during driving using this method shall be taken as follows:

$$R_{ndr} = 1.75(E_d)0.5 \log_{10} (10N_b) -100$$

where:

R_{ndr} = nominal pile resistance measured during pile driving (kips)

E_d = developed hammer energy. This is the kinetic energy in the ram at impact for a given blow. If ram velocity is not measured, it may be assumed equal to the potential energy of the ram at the height of the stroke, taken as the ram weight times the actual stroke (ft-Ibs)

N_b = number of hammer blows for 1.0 in. of pile permanent set (blows/in.)

If a dynamic formula other than those provided herein is used, it shall be calibrated based on measured static load test results to obtain an appropriate resistance factor, consistent with *Article CI0.5.5.2 of the AASHTO LRFD Bridge Design Specifications.*

This formula is applicable only when (1) the hammer has a free fall, (2) the head of the pile is not broomed or crushed, (3) the penetration is reasonably quick and uniform, or (4) a follower is not used.

If the Engineer determines that energy losses attributable to pile rebound exceed the nominal values assumed in this formula, the nominal pile resistance shall be reevaluated by wave equation analysis that rationally considers energy losses in the cap, pile, and soil.

403.08—Driving Criteria:

(a) **Bearing:** Bearing resistance values for concrete and steel piles shall be determined by the loading tests specified in 403.07(a). In the absence of loading tests, nominal pile resistance may be determined using a dynamic pile test during pile driving specified in 403.07(b) or results of wave equation analysis in 403.07(c). In the absence of loading tests, wave equation analysis, or a dynamic test, the nominal pile resistance may be approximated by using the pile formula specified in 403.07(d). The character of the soil penetrated; conditions of driving; followers; size, length, and weight of the piles; and computed load per pile shall be given due consideration in determining the nominal pile resistance.

Bearing piles shall be driven until the blow count determined to produce the required nominal pile resistance has been continuously maintained for 2 feet or to practical refusal, whichever occurs first.

(b) **Practical Refusal:** Practical refusal is defined as twice the blow count required to produce nominal pile resistance. In the case of driving to a very dense or hard stratum, the driving criterion should be based on blows per inch criterion and should address limiting the blows following an abrupt refusal to prevent damage. In no case shall driving continue for more than 3 inches at practical refusal driving conditions.

Based on the results of the wave equation, dynamic analysis and/or the driving test, the Engineer may elect to adjust the criteria for practical refusal but in no case shall practical refusal be greater than 20 blows per inch.

(c) A pile shall not be driven above the blow count where wave equation analysis or dynamic testing results indicates that maximum stress levels will be exceeded.

(d) When dynamic testing is not required, the Engineer may direct that a pile be restruck with the same hammer and cushion system used for the initial driving. Pile restrike shall be at least 24 hours after initial driving. A cold hammer shall not be used for the restrike. The hammer shall be warmed up prior to restrike by striking at least 20 blows on a pile that is at least 25 feet from the pile to be restruck. The maximum amount of penetration required during restrike shall be 6 inches or the maximum total number of hammer blows shall be 50, whichever occurs first.

(e) At the Contractor's option, piles reaching the driving resistance required for nominal pile resistance with heads above the cutoff grade may be driven to the cutoff grade provided driving is less than practical refusal and no damage to the piles occur.

Upon completion of pile driving operations for structures on the project, pile cutoffs left in storage, including precast concrete and timber cutoffs, shall become the property of the Contractor and shall be disposed of off the project.

403.09—Order List

The Contractor shall submit to the Engineer an itemized list for precast concrete and timber piles for approval prior to placing the order with the supplier. The list shall include the lengths required for each pile location and the corresponding full or partial lengths of piles to be ordered.

The Contractor shall complete driving tests, dynamic pile tests, loading tests, and refined wave equation analyses for a substructure element prior to submission of an order list for the substructure element.

403.10—Measurement and Payment

Piles will be measured in linear feet from the tip (excluding any added pile point) to the head of the pile remaining in place in the completed structure and will be paid for at the contract unit price per linear foot. This price shall include furnishing piles; driving piles; splices; obtaining safe bearing capacity, tip elevation, or minimum penetration; jetting; performing wave equation analysis; disposing of piling cutoffs; concrete and reinforcing steel required for steel shell piles, including reinforcing steel that extends into the structure footing; painting; and waterproofing.

Precast concrete and timber cutoffs will be measured in linear feet of pile excluding that portion of the precast concrete pile the Contractor elects to furnish to facilitate driving. Only precast concrete and timber cutoffs will be paid for. Payment will be limited to the invoice price plus 15 percent, not to exceed the contract unit price per linear foot of pile.

Pile points for timber and steel H-piles will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include furnishing and attaching to the pile.

Driving tests shown on the plans or required by the Engineer will be measured in linear feet and will be paid for at the contract unit price per linear foot. Piles used in driving tests will be measured from the tip (excluding any added pile point) to the head of the pile. When a pile used in a driving test is incorporated in the completed structure at the required location, no separate measurement of the pile will be made for payment. This price shall include performing the test; furnishing, removing, and disposing of piles; and restoring the pile hole when the pile is not incorporated in the structure.

Driving tests not specified on the plans or required by the Engineer but performed to determine lengths or other required properties will not be measured as driving tests. However, when piles used for the tests are incorporated in the completed structure, they will be measured and paid for the same as other piles of the same type.

Dynamic pile testing will be measured and paid for at the contract unit price per each, which price shall be full compensation for providing all services of the testing consultant and dynamic monitoring operator as specified herein including providing, installing, monitoring and removing the dynamic testing equip-

ment except for EDC, for providing the data and preparing the written documentation specified. This price shall also include all work and equipment necessary to drive the pile during restrike testing, and any additional driving required should the required soil resistance not be obtained. A second restrike test, if required, will be paid for at 2/3 of the contract unit price of the Dynamic Pile Test.

Loading tests will be measured in units of each and will be paid for at the contract unit price per each. This price shall include performing the loading test. If a loading test is terminated by the Engineer because of insufficient bearing capacity, the test will be measured for payment. If a loading test is terminated because of malfunction of the Contractor's equipment or other reasons that are the fault of the Contractor, the test will not be measured for payment.

The length of pile driven to the cutoff grade after obtaining required bearing will be measured in linear feet and will be paid for as cutoff.

Pile restrike will be measured in linear feet of pile from the tip, excluding any added pile point, to the head of the pile remaining in the structure. Payment will be made at the contract unit price for the driving test for the same size and type pile less the invoice price per foot for the pile. This price shall include the equipment and driving effort required for the restrike.

Jetting not shown on the plans but specified by the Engineer in accordance with Section 403.06(d) will be measured in linear feet and will be paid for per linear foot at 30 percent of the contract unit price per linear foot for the particular size and type of pile for which the jetting was ordered. This price shall include jetting, disposing of surplus material and erosion, siltation, and water quality and damage protection controls required as a result of the jetting operations.

Preboring fills in accordance with Section 403.06(e) will not be measured for separate payment. The cost thereof shall be included in the price for pile.

Preboring not shown on the plans but specified by the Engineer in accordance with Section 403.06(d) will be measured in linear feet for the particular size and type of pile for which the preboring was ordered in accordance with Section 104.03 and Section 109.05. This price shall include performing preboring operations including disposing of surplus material and erosion and siltation controls when required as a result of the preboring operations.

Preboring not shown on the plans and not specified by the Engineer will not be measured for payment.

Preboring shown on the plans will be measured in linear feet for the particular size and type of pile for which preboring was specified and will be paid for at the contract unit price per foot. This price shall include performing preboring operations including disposing of surplus material, and erosion and siltation controls when required as a result of the preboring operations.

Payment will be made under:

Pay Item	Pay Unit
Pile (Type and size)	Linear foot
Pile point for (Size and type) pile	Each
Driving test for (Size and type) pile	Linear foot
Dynamic Pile Test	Each
Loading test for (Size and type) pile	Each
Preboring (Size and type) pile	Linear foot

SECTION 404—HYDRAULIC CEMENT CONCRETE OPERATIONS

404.01—Description

This work shall consist of furnishing and placing hydraulic cement concrete in accordance with these specifications and in conformity with the dimensions, lines, and grades shown on the plans or as established by the Engineer.

404.02—Materials

(a) **Concrete** shall conform to Section 217. Aggregate used in concrete for bridge decks shall be nonpolishing. All concrete shall be tested for permeability in accordance with Section 217. When specified on the plans, low shrinkage concrete used in bridge decks and parapets, curbs, rails, medians, and other concrete appurtenances cast above the deck surface shall conform to Section 217 for Class A4 Concrete Modified to Minimize Cracking with Shrinkage Reducing Admixture.

(b) **Curing materials** shall conform to Section 220.

(c) **Concrete admixtures** shall conform to Section 215. Concrete admixture use shall conform to Sections 215 and 217.

(d) **Corrugated metal bridge deck forms** shall be galvanized steel conforming to ASTM A653, Grade SS40, SS50, or SS80, and shall be coating designation G165. Supports, closures, and other fabricated parts shall conform to ASTM A653, Grade SS33, SS40, SS50, or SS80, and shall be coating designation G165.

(e) **Anchor bolts** shall conform to Section 226.

(f) **Reinforcing steel** shall conform to Section 223.

(g) **Waterstops** shall conform to Section 212.

404.03—Procedures

(a) **Forms:** On concrete or steel beam bridges, the Contractor shall have the option of using corrugated metal bridge deck forms or wood forms to form that portion of bridge decks between beams unless otherwise specified on the plans. However, corrugated metal forms shall not be used to form overhangs or portions of slabs where a longitudinal joint occurs between beams or girders.

The Contractor shall submit calculations and layout details of the overhang supports and formwork, including fabrication and erection details, to the Engineer for review in accordance with Section 105.10. Overhang formwork details shall be signed and sealed by a Professional Engineer, holding a valid license to practice engineering in the Commonwealth of Virginia.

Devices for supporting forms of any type shall not be welded to steel beams or girders unless specified on the plans.

Formwork shall be mortartight and of sufficient rigidity to prevent distortion attributable to the pressure of the concrete and other loads incidental to construction operations.

Forms for exposed surfaces shall have a form liner of an Engineer approved type and shall be mortartight. Forms for exposed surfaces below the bottom of slabs of bridges, including substructures, and on endwalls and wingwalls of culverts down to an elevation of 1 foot below low water or 2 feet below the final ground line above water shall be faced with metal, plyboard, or other approved smooth-faced material constructed to provide a minimum of joints and prevent leakage. Concrete shall present a uniform and smooth surface without requiring touch-up or surface finishing upon removal of forms. Uneven joint protrusions of more than 1/8 inch shall be removed. Forms shall be filleted 3/4 inch at sharp corners and given a bevel or draft in the case of projections, such as girders and copings, to ensure easy removal.

Metal ties or anchorages within the form shall be constructed to permit their removal to a depth of at least 1 inch from the face without damage to the concrete. If ordinary wire ties are permitted, wires shall be cut back at least 1/4 inch from the face of the concrete with chisels or nippers upon removal of forms. Fittings for metal ties shall be of such design that cavities left upon their removal will be the smallest size possible. Cavities shall be filled with cement mortar, and the surface left sound, smooth, even, and uniform in color.

Forms shall be set and maintained true to line. When forms appear to be unsatisfactory, either before or during concrete placement, the Engineer may order the work stopped until defects have been corrected.

The shape, strength, rigidity, watertightness, and surface smoothness of reused forms shall be maintained at all times. Warped or bulged lumber shall be resized before being reused.

For narrow walls and columns where the bottom of the form is inaccessible, the lower form boards shall be left loose so that they may be removed for cleaning immediately before concrete placement.

Forms shall be treated with an approved oil or form-coating material or thoroughly wetted with water immediately before concrete placement. For rails or other units with exposed faces, forms shall be treated with an approved oil or form-coating material to prevent adherence of concrete. Material that will potentially adhere to or discolor concrete shall not be used.

Forms shall be maintained at a temperature that will not adversely affect curing of concrete.

Formed voids in concrete shall be of accurate dimensions and locations so that the thickness of surrounding concrete shall not be reduced from plan dimensions.
Methods of positioning void forms and placing surrounding concrete shall be subject to the approval of the Engineer prior to their use.

Bridge deck slabs shall be constructed in a manner so that the thickness of the finished slab shall be not less than the thickness shown on the plans or more than the thickness plus 1/2 inch.

1. **Corrugated metal bridge deck forms:** If the Contractor elects to use corrugated metal bridge deck forms, the Contractor shall submit details of the forms, including fabrication and erection details, to the Engineer for approval in accordance with Section 105.10. Forms shall be designed and erected in accordance with the following:

a. **Design:** The thickness of forms shall be at least 20 gage (0.037 inch). The unit working stress in the sheet metal and supporting units shall be not more than 0.725 of the specified minimum yield strength of the material furnished. In no case shall it be more than 36,000 pounds per square inch. The maximum stress under a design load equal to the weight of the forms and plastic concrete plus a construction live load of 50 pounds per square foot shall be not more than the unit working stress for the material furnished. Deflection of forms under the weight of the form, plastic concrete, and reinforcement shall be not more than 1/180 of the span of the forms or 1/2 inch, whichever is less. In no case shall the loading be less than 120 pounds per square foot total.

When the actual dead load attributable to the use of metal bridge deck forms is more than the design allowance for construction tolerances and methods shown on the plans, the Contractor shall strengthen the beams or girders to the extent necessary to maintain the design live load rating of the bridge and shall submit supporting information and calculations to the Engineer for review.

b. **Erection:** The Contractor shall install forms in accordance with reviewed fabrication and erection plans. Field cutting of forms, supports, and closures at expansion joints, diaphragms, and abutments in skewed areas or in any area where girders or beams are not parallel shall be performed with saws or shears. The outstanding leg of the support angle, channel, or other device shall be not more than 3 inches.

Form sheets shall not rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of one inch at each end. Form supports shall be placed in direct contact with the stringer or floor beam flange by hangers or clips. Attachment of the forms to the form supports shall be made by permissible welds, screws, clips or other approved means. Fasteners along the ends and edges of form sheets shall be spaced at intervals not to exceed 18 inches.

Welding and welds shall conform to Section 407.04 except that 1/8-inch fillet welds will be permitted.

Permanently exposed form metal whose galvanized coating has been damaged shall be repaired in accordance with Section 233.

Corrugated metal forms shall be positioned such that the specified cover for the reinforcing steel and minimum design slab thickness are maintained above crests of the corrugation.

Transverse construction joints shall be located at the bottom of a flute, and 1/4-inch weep holes shall be field drilled at not more than 12 inches on center along the line of the joint.

Closures at edges of forms parallel to beams or girders shall be made by crimping corrugations. Closures at skewed ends may be of the serrated or channel type.

The design span of the sheet shall be the clear span of the form plus 2 inches measured parallel to form flutes.

The permissible form camber shall be based on the actual dead load condition. Camber shall not be used to compensate for deflection in excess of the foregoing limits.

Physical design properties shall be computed in accordance with AISI specifications for the design of cold-formed steel structural units.

c. **Inspection:** After concrete has been in place for at least 2 days, the Contractor shall sound at least 50 percent of the area of at least 25 percent of the individual form panels using a moderate blow administered with a carpenter's hammer. The Engineer will randomly select individual form panels to be sounded. Areas of questionable soundness shall be exposed by removing forms. The amount of sounding and form removal required will be adjusted as the work progresses according to conditions detected by the investigation. When procedures, materials, or equipment used during placement of concrete warrant additional inspection of the underside as determined by the Engineer, the Contractor shall remove at least one form panel at each location selected by the Engineer. If the initial inspection reveals inferior workmanship or unsatisfactory material as determined by the Engineer, additional panels shall be removed to ascertain the extent of the deficiency. The Contractor will not be required to replace metal forms at locations where sections of forms are removed for inspection purposes. However, adjacent metal forms and supports shall be repaired to the extent necessary to render their attachment secure.

The Contractor shall provide facilities required for the safe and convenient conduct of the Engineer's inspection.

(b) **Falsework and Centering:** The Contractor shall have a Professional Engineer (holding a valid license to practice engineering in the Commonwealth of Virginia) inspect the completed falsework assembly supporting a bridge superstructure prior to placing loads. The Professional Engineer shall provide a certification, based upon visual inspection of the completed falsework assembly, that the falsework assembly conforms to the approved working drawings. However, such certification shall not require an exhaustive inspection or testing or make the Professional Engineer liable for any deficiencies in workmanship or materials employed by the Contractor or for such conditions that cannot be ascertained from a visual inspection.

Falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. The Contractor may be required to employ screw jacks or hardwood wedges to take up settlement in the formwork either before or during concrete placement. A design weight of 150 pounds per cubic foot shall be assumed for fresh concrete.
Falsework that cannot be founded on a satisfactory footing shall be supported on piles that are spaced, driven, and removed in a manner approved by the Engineer.

Falsework shall be set in a manner so that after its removal the finished structure will have the finished grade specified or indicated on the plans. Correction for dead-load deflection of cast-in-place concrete beams and slab spans shall be provided for by applying an upward parabolic camber having an ordinate at midspan of 1/8 inch per 10 feet of span length.

Falsework-supporting elements shall remain in place until concrete in the element has attained at least the minimum 28-day design compressive strength.

Arch centering shall be constructed according to centering plans approved by the Engineer. Provision shall be made by means of suitable wedges, sand boxes, or other devices for gradual lowering of centers and rendering the arch self-supporting. When directed by the Engineer, centering shall be placed on approved jacks to take up and correct settlement that may occur after concrete placement has begun.

(c) **Placement and Consolidation:** Individual placements of more than 25 yards of concrete shall be at the following rate:

Quantity (cu yds)	Min. Placement Rate
26-80	25%/hr
Over 80	20 cu yds./hr.

If corrugated metal bridge deck forms are used in lieu of removable forms, concrete placement shall proceed in the direction opposite that of form placement.

Concrete shall be placed as soon as practicable after forms are prepared and excavation is completed. Water shall be removed from excavations before concrete is placed. Flowing water within the excavation shall be diverted outside concrete areas to a sump.

Before concrete is placed, sawdust, chips, dirt, other debris and temporary struts and braces shall be removed from the space to be occupied by concrete. Removable forms shall be thoroughly wetted, oiled, or treated with an approved form-coating material. The depth and character of foundations and the placing of reinforcing steel shall have been approved by the Engineer.

Concrete shall be placed in forms immediately after mixing. Concrete that does not reach its final position in forms within the time specified in Section 217 shall not be used. The method of placement shall be such as to avoid the possibility of segregating ingredients and displacing reinforcement or void forms.

The use of long chutes for conveying concrete from the mixing plant to forms will be allowed only with the written permission of the Engineer. If chutes are allowed and the quality of concrete as it reaches the forms or the methods of placing it therein are not satisfactory, the Contractor shall, upon direction from the Engineer, discontinue the use of chutes and re-equip his operation for placing concrete in a satisfactory manner.

Where steep slopes are required, chutes shall be equipped with baffle boards. When pipes are used, they shall be kept full of concrete and have their lower ends buried in fresh concrete where necessary to prevent an excessive flow rate. Chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thorough flushing with water after each run. Water used for flushing shall be discharged clear of concrete in place and filtered prior to entry into state waters. Open troughs and chutes shall be metal or lined with metal and shall extend as nearly as possible to the point of deposit. When discharge must be intermittent, a hopper or other device for regulating discharge shall be provided.

Dropping concrete a distance of more than 5 feet or depositing a large quantity at any point and running or working it along forms will not be permitted. However, the 5-foot limitation will not apply to dropping concrete into forms for walls of box culverts, catch basins, drop inlets, or endwalls unless there is evidence of segregation.

Concrete placement shall be regulated so that pressures caused by the presence of fresh concrete shall be not more than those used in the design of forms.

Embedded materials shown on the plans shall be installed during each stage of concrete operations and suitably supported and maintained in the correct position. Reinforcement shall be placed in accordance with Section 406.03(d).

Care shall be taken to fill each part of a form by placing concrete as near its final position as possible, working coarse aggregates back from forms, and moving concrete under and around reinforcing bars without displacing them. After concrete has taken its initial set, care shall be taken to avoid jarring forms or placing strain on the ends of projecting reinforcement.

Concrete shall be thoroughly consolidated during and immediately following placement. Consolidation shall be accomplished by mechanical vibration subject to the following provisions:

1. Vibration shall be internal to the concrete but not applied directly to reinforcement or formwork.

2. Vibrators shall be of a type and design approved by the Engineer.

3. The intensity of vibration shall visibly affect a mass of concrete over a radius of at least 18 inches.

4. The Contractor shall provide a sufficient number of vibrators to consolidate each batch immediately after it is placed in forms.

5. Vibrators shall be manipulated to work concrete thoroughly around reinforcement and embedded fixtures and into corners and angles of forms. Vibration shall be applied at the point of deposit and in the area of the freshly placed concrete. Vibrators shall not be pulled through concrete and shall be inserted and withdrawn slowly and maintained nearly vertical at all times. Vibration shall be of sufficient duration and intensity to consolidate concrete thoroughly but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.

6. Vibration shall not be applied directly or indirectly to sections or layers of concrete that have hardened to the degree that it ceases to be plastic under vibration. Vibration shall not be used to make concrete flow in forms, and vibrators shall not be used to transport concrete in forms.

7. Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations inaccessible to vibrators.

8. These specifications shall apply to filler concrete for steel grid floors except that vibration shall be applied to the steel.

9. These specifications shall apply to precast piling, concrete cribbing, and other precast units except that the manufacturer's methods of vibration may be used if approved by the Engineer.

When vibrating is not practicable, concrete shall be consolidated and its faces well spaded by continuous working with a suitable tool in a manner acceptable to the Engineer.

Concrete shall be placed in continuous horizontal layers not more than 12 inches in thickness; however, slabs shall be placed in a single layer. When it is necessary in an emergency to place less than a complete horizontal layer in one operation, the layer shall terminate in a vertical bulkhead. In any given layer, separate batches shall follow each other so closely that each one shall be placed and consolidated before the preceding one has taken initial set. Each layer of concrete shall be left rough to secure efficient bonding with the layer above. A succeeding layer placed before the underlying layer has become set shall be consolidated in a manner to prohibit the tendency to produce a construction joint between layers.

Layers placed at the end of one day's work or prior to temporarily discontinuing operations shall be cleaned of laitance and other objectionable material as soon as the surface has become sufficiently firm to retain its form. The top surface of concrete adjacent to forms shall be smoothed with a trowel.

Horizontal layers located to produce a construction joint at a location wherein a feather edge might be produced in the succeeding layer shall be formed by inset formwork so that the succeeding layer will end in a body of concrete having a thickness of at least 6 inches.

The work on any section or layer shall not be stopped or temporarily discontinued within 18 inches below the top of any face unless the details of the work provide for a coping having a thickness of not more than 18 inches, in which case the construction joint may be made at the underside of the coping at the option of the Engineer.

Care shall be taken when placing concrete to avoid coating reinforcing steel, structural steel, forms, and other items that extend into areas to be involved in a subsequent placement. If coating of steel does occur, no attempt shall be made to remove the mortar until after the concrete steel bond of the earlier placement has developed sufficiently to withstand a cleaning operation. Any coating of mortar on deformed bars that cannot be removed by hand brushing with a wire bristle brush or a light chipping action will not have to be removed.

The method and manner of placing concrete shall be regulated so as to place construction joints across regions of low shearing stress and in locations that will be hidden from view to the greatest extent possible.

Placing and consolidating concrete shall be conducted to form a compact, dense, impervious mass of uniform texture that will show smooth faces on exposed surfaces. Any section of concrete found to be defective shall be removed or repaired as directed by the Engineer.

If concrete operations are permitted to extend after sunset, the work area shall be brightly lighted so that all operations are plainly visible.

1. **Culverts:** Sidewalls of box culverts shall be carefully bonded to the base slab in accordance with (h) herein. Each wing shall be constructed as a monolith if possible. Construction joints, where unavoidable, shall be horizontal.

2. **Girders, slabs, and columns:** Concrete shall be placed by beginning at the center of the span and working toward the ends. Concrete in girders shall be placed uniformly for the full length of the girder and brought up evenly in horizontal layers.

The concrete floor and girders for each span of concrete through girder spans and concrete in T-beams, slab spans, and deck girders shall be placed monolithically.

If the finished top surface of a concrete unit being placed is not level, care in the method of vibration, the use of low-slump concrete, or other means shall be taken to prevent downgrade movement of newly placed concrete. Special attention shall be given to sloping slabs.

Concrete in columns shall be placed in one continuous operation. If cap forms are supported by falsework independent of columns or column forms or are otherwise designed so that no load is placed on columns, concrete may be placed in caps after the concrete in columns has set for at least 12 hours.

Concrete shall not be placed in the superstructure until column forms have been stripped sufficiently to determine the character of the concrete in the columns.

(d) **Pneumatic Placement:** Pneumatic concrete placement will be permitted only when authorized by the Engineer and the method is approved by the Engineer. When permitted, placement shall be in accordance with Section 412.

(e) **Pumping:** Placing concrete by pumping will be permitted provided concrete is pumped through a conduit system that is not aluminum. Equipment shall be arranged such that vibrations that might damage freshly placed concrete will not occur. Equipment shall be thoroughly cleaned prior to use. The operation of the pump shall be such that a continuous stream of concrete without air pockets is delivered. If concrete remaining in the pipeline is to be used, it shall be ejected in such a manner that there will be no contamination of concrete or separation of ingredients.

(f) **Depositing Concrete Under Water:** Concrete shall not be deposited in water except with the approval of the Engineer.

Concrete placed in water shall be Class T3. Concrete shall be carefully placed in a compact mass in its final position by means of a tremie or another approved method and shall not be disturbed after being deposited except as specifically provided herein. Still water shall be maintained at the point of placement.

A tremie shall consist of a tube having a diameter of at least 10 inches, constructed in sections having flanged couplings fitted with gaskets. The discharge end shall be closed at the start of work and entirely sealed at all times. The tremie tube shall be kept full to the bottom of the hopper. When a batch of concrete is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the placed concrete. Concrete seal shall be placed continuously from start to finish. Concrete shall be placed at a rate of at least one vertical foot per hour over the entire area of the seal course. The surface of concrete shall be maintained in a horizontal plane within a tolerance of 6 inches at all times during placement. The tremie shall be supported so that its discharge end is freely movable over the entire work area, or multiple tremies shall be used. Vibration shall be used only when deemed necessary by the Engineer. Supports for tremies shall permit rapid lowering of discharge ends when necessary to retard or stop the flow of concrete. The method of placing the seal shall be subject to the approval of the Engineer prior to concrete placement.

Removal of water from cofferdams or other structures may proceed when the concrete seal has attained final set. Laitance or other unsatisfactory material shall be removed from the exposed surface by scraping and chipping with pneumatic or hand tools to an extent that will expose the aggregate for good bond with the footing to be cast upon it but not to an extent that will damage the concrete.

(g) **Construction Joints:** Construction joints that are not detailed on the plans shall be placed as directed or approved by the Engineer. The Contractor shall use shear keys or inclined reinforcement where necessary to transmit shear or bond the two sections together. Joints shall be constructed so that feather edging does not occur.

For construction joints in deck slabs, a 2 by 1 1/2-inch shear key shall be provided between mats of reinforcing steel.

Construction joints against which earth fill is placed shall be protected by a heavy coat of asphalt conforming to Section 213 applied for a distance of 3 inches on each side of the joint and continuous throughout its length.

In construction joints exposed to view, a waterstop conforming to Section 212 shall be inserted. The waterstop shall be placed at least 3 inches from the face of the concrete and shall extend at least 2 inches into each section of concrete.

Longitudinal or transverse construction joints may be used to facilitate placing concrete in continuous slab spans. Longitudinal joints shall be spaced so that each concrete placement will be at least 10 feet in width. Transverse joints shall be placed at the centerlines of piers provided they are located infrequently, permitting simultaneous longitudinal screeding of as many spans as possible. Concrete shall be placed in one continuous operation between construction joints. The volume of concrete in any one placement shall be not less than the volume of concrete in one end span.

(h) **Bonding Construction Joints:** In preparation for joining fresh concrete to set concrete, the Contractor shall roughen the surface of the work already in place. Shavings, sawdust, and other loose and foreign material shall be removed. The surface shall be washed and scrubbed with wire brooms when necessary to remove substances that will interfere with bonding. Concrete of the preceding placement shall be thoroughly wetted prior to placement of the next unit of fresh concrete.

Prior to placing adjoining concrete, the vertical face shall be cleaned and in a saturated surface moist condition. For bridge deck applications, after the concrete in the second placement has set, a V groove shall be formed along the top of the joint by abrasive blast cleaning to a depth of at least 3/8 inch and sealed with epoxy, Type EP-5, low viscosity, conforming to Section 243.

Suitable keys shall be formed at the top of the upper layer of each day's work and at other levels where work is interrupted to bond successive courses. Keys shall be formed by inserting and subsequently removing beveled wood strips, which shall be saturated with water to induce swelling prior to insertion in fresh concrete. At the discretion of the Engineer, rough stone or steel dowels may be used in lieu of keys. Dowels shall extend an equal distance on each side of the construction joint. Prior to the inserting or driving of dowels into predrilled or preformed holes, holes shall be filled with hydraulic cement grout in the proportion of 1 part cement to 2 parts sand. The size and spacing of keys and dowels shall be determined by the Engineer.

(i) **Concrete Exposed to Tidal Water:** Concrete structures other than box culverts subject to the action of tidal water shall not have construction joints located within a zone 5 feet above to 5 feet below the elevation of the mean tide.

Concrete within 5 feet of the mean tide shall be cured in forms for 48 hours and allowed to dry for 5 days after forms are stripped. After drying, one coat of primer and four coats of asphalt, conforming to Section 213, shall be applied during a period of 48 hours. Each coat shall be allowed to set before the succeeding one is applied. In lieu of primer and asphalt, the coating may consist of one coat of epoxy, Type EP-3B, followed by one coat of epoxy, Type EP-3T, and shall have a total finished thickness of at least 20 mils.

For precast concrete, protective coatings shall be applied in the same manner, but the seal coat shall be allowed to dry 4 days, or as long as necessary to harden, before handling.

Requirements for protective coating shall also apply to inside surfaces of box culverts that are subject to the ebb and flood of tidal water.

Concrete exposed to the action of ice, drift, or other forces producing shock and abrasion shall be protected by encasing that portion of the exposed surface with a special sheathing or protective armor. Provision shall be made in the size of the original cofferdam for sufficient clearance to permit access to the concrete surface for the installation and effective anchorage of the sheathing.

(j) **Removing Formwork and Forming for and Placing Superimposed Elements:** In the determination for removing formwork and constructing superimposed elements, consideration shall be given to the location and character of the structure, the weather, other conditions influencing the setting of the concrete, and materials used in the mixture. Formwork shall include forms, braces, ties, guy wires, and other instruments of stabilization.

1. **Formwork** may be removed as follows:

   a. **Side forms or elements not immediately subjected to loading** (for example: footings and walls or columns with height to width ratios less than 10:1 [h/w < 10:1]): 48 hours or 30 percent concrete strength (f'_c). For the purposes herein, width will be considered the narrowest portion of the element measured horizontally across its surface.

   b. **All other elements** (for example: soffits of pile caps, bent caps and pier caps): 60 percent concrete strength (f'_c).

2. **Forming for superimposed elements** may be as follows:

   a. **Elements not immediately subjected to loading** (for example: footings and walls or columns with height to width ratios less than 10:1 [h/w <10:1]): 48 hours or 30 percent concrete strength (f'_c). For the purposes herein, width will be considered the narrowest portion of the element measured horizontally across its surface.

   b. **All other elements:** 60 percent concrete strength (f'_c).

3. **Placing concrete in forms for superimposed elements** shall not be done until concrete has attained 60 percent concrete strength (f'_c) except for footings, where concrete may be placed when the footing has attained 40 percent concrete strength (f'_c).

The Contractor may submit calculations to show that lower strength requirements may be used but may not proceed to use these requirements before receiving written permission to do so from the Engineer.

Concrete strength (f'_c) is the design minimum laboratory compressive strength at 28 days as specified in Table II-17 for the class of concrete designated. If the time for removing formwork and forming for or placing concrete in superimposed elements is determined by control cylinder strengths, the Contractor will be permitted to perform these operations when the control cylinder strengths reach the values previously specified. Control cylinders shall be cured under conditions that are not more favorable than the most unfavorable conditions for the portion of the concrete the cylinders represent. The Contractor shall furnish molds, labor, and materials; make sufficient test specimens; and transport specimens to the testing facility. Single-use wax paper, paper, plastic, or light-gage metal molds conforming to ASTM C470 may be used for making control cylinders. Control cylinders shall be molded under the observation of the Engineer. Tests for compressive strengths shall be performed by or under the supervision of the Engineer.

The concrete strengths and time periods noted herein for removing formwork or forming for or placing concrete in superimposed elements shall not apply to the use of equipment or other live loads on the structure. Stockpiling materials or using unauthorized equipment on the structure will not be permitted until conformance to Section 404.03(m) has been attained.

Methods of form removal that will overstress the concrete shall not be used. Formwork and its supports shall not be removed without the approval of the Engineer. The Contractor shall ensure that proper curing as required by the Specifications is provided immediately after form removal.

Falsework shall conform to Section 404.03(b).

(k) **Curing Concrete:** The method of curing concrete shall be subject to the approval of the Engineer prior to mixing or placing concrete. When the atmospheric temperature is above 40 degrees F in the shade, concrete surfaces that are not protected by formwork and surfaces from which forms have been removed shall be cured using approved materials applied before the sheen disappears from fresh concrete or immediately upon removal of formwork. Concrete shall be cured for 7 days, regardless of the strength obtained with control cylinders. During this 7-day curing period, a curing agent or medium shall be used.

PE film used for curing shall be white except that opaque or transparent PE film may be used between November 1 and April 1.

When liquid membrane seal is used for curing grooved horizontal surfaces, the application rate shall be 100 to 150 square feet per gallon. The application rate for all other surfaces shall be 150 to 200 square feet per gallon. Application shall be such that an even, white, continuous membrane is produced on the concrete surface.

If the atmospheric temperature falls below 40 degrees F in the shade, water curing shall be discontinued except when it is accomplished by flooding as specified herein. Curing shall be immediately resumed using insulated blankets or other approved methods that will retain or supply moisture and maintain the temperature at the outermost surfaces of the concrete mass

above 50 degrees F for at least 72 hours immediately following concrete placement and above 40 degrees F for at least 48 additional hours.

If the Contractor begins masonry concrete operations when the atmospheric temperature is below 40 degrees F in the shade, the method of cure and protection shall retain or supply moisture and maintain the temperature at the outermost surfaces of the concrete mass above 50 degrees F for at least 72 hours immediately following concrete placement and above 40 degrees F for at least 48 additional hours.

When concrete is cured by flooding with water and the temperature is below 40 degrees F in the shade, a depth of at least 6 inches shall be maintained above the surface of the mass until concrete has attained the minimum required design compressive strength as determined by a test cylinder cured in the same water.

1. **Bridge Deck Curing:** Bridge deck concrete shall be moist cured with white PE sheeting with or without the use of wet burlap. The concrete shall be maintained in a moist condition by fogging after screeding and until covered with the sheeting. The concrete surface shall stay wet under the sheeting until the end of the moist-curing period. The moist-curing period shall be for at least 7 days and until 70 percent concrete strength (f ’c) is achieved. The initial temperature of the outermost surfaces of the concrete mass shall be above 50 degrees F for at least 72 hours and above 40 degrees F until the completion of the moist-curing period. When the burlap and sheeting are removed, white pigmented curing compound shall be applied at the rate of 100 to 150 square feet per gallon while the surface of the concrete deck is damp and free of standing water. Bridge deck overlay concrete shall be cured in accordance with Section 425.

(l) **Protecting Concrete:** Protection of concrete shall begin immediately following concrete placement in the formwork and shall continue without interruption throughout the curing period.

1. **Weather:** The Contractor shall schedule the placement of structural concrete so that the date and hour decided upon reflect consideration of weather conditions.

   Concrete shall be protected from rain.

   Concrete shall not be placed against surfaces whose temperature is below 40 degrees F. Concrete shall be protected from freezing by approved coverings and, when necessary, heating the surrounding air in such a manner that the concrete will not dry.

   Protection shall be provided to prevent rapid drying of concrete as a result of low humidity, high wind, higher concrete temperatures than atmospheric temperatures, or combinations thereof. The Contractor shall perform evaporation rate testing for bridge deck placements and concrete overlays. Immediately after screeding and until the application of plastic sheeting and/or wet burlap, no surface of the freshly mixed concrete shall be allowed to dry. Fogging with pressure sprayers acceptable to the Engineer and sufficient to maintain a moist surface will be required. The protective measures taken shall be sufficient to maintain an evaporation rate at or below 0.10 pound per square foot per hour for normal concrete bridge deck placements or 0.05 pound per square foot per hour for concrete overlays over the exposed surface of the concrete. Other preventative measures described in ACI 308 can be used in addition to fogging. Evaporation retardant films may be applied in a fine mist immediately after screeding to ensure that the surface remains wet until covered. If such materials are used, there shall be no

disturbance of the concrete surface after placement of the retardant film and such film shall not be intermixed with the surface mortar. If plastic shrinkage cracking occurs due to the Contractor's negligence or failure to comply with specification requirements, the Engineer may direct the Contractor to make repairs by epoxy injections, concrete removal and replacement, or other methods approved by the Engineer at no additional cost to the Department.

2. **Construction activities:** Care shall be taken to avoid damage to concrete from vibration created by blasting and pile driving operations, movement of equipment in the vicinity of the structure, or disturbance of formwork or protruding reinforcement.

   Concrete shall be protected from the heat of an open fire. A watchperson shall be provided at the structure throughout any period in which open-flame heaters are operated in the vicinity of the concrete.

   After concrete in finished surfaces has begun to set, it shall not be walked on or otherwise disturbed for at least 24 hours except as provided for in (j) herein.

3. **Silicone treatment:** When unpainted weathering steel is used in a structure and no other concrete waterproofing surface finish is specified, the Contractor shall apply a 5 percent solids, solvent-based, clear, water-repellent silicone treatment in two coats to the surface of the concrete substructure on exposed concrete surfaces below and including the bridge seats, within the limits of vertical planes parallel to and 2 feet outside the extreme edges of exterior beams or girders. The first coat shall be applied at the rate of 60 to 70 square feet of surface area per gallon of treatment solution, and the second coat at the rate of 90 to 110 square feet per gallon. If the treatment is applied by spraying, the nozzle shall not be held further than 24 inches from the surface being treated. The treatment shall be applied after cleaning of exposed substructure concrete surfaces and before any structural steel is erected.

(m) **Opening to Traffic:** Structures shall not be opened to traffic, including construction traffic, or used for storing materials before the concrete has attained the 28-day minimum design compressive strength as specified in Table II-17. Cylinders used for control purposes shall be cured under conditions that are not more favorable than the most unfavorable conditions for the portions of concrete the cylinders represent. When traffic is to be permitted on a partially completed slab span, falsework shall remain in place in accordance with the strength requirements specified herein. Other structures supported on falsework from the ground shall not be opened to traffic until falsework is removed.

404.04—Bridge Deck Construction

Fogging or misting devices attached to the screed shall not be permitted. Water shall not be applied to the concrete surface at any time during the finishing. Fogging or misting to increase the relative humidity is recommended.

When the longitudinal screed is used, the overall length shall be such as to screed independently supported spans up to and including 80 feet. The length of the screed shall be not less than the full length of the span for spans less than 80 feet. When using the longitudinal screed on independently supported spans exceeding 80 feet in length with a screed length less than the full length of the span, the center half of the span shall be completed first. Bulkheads or other substantial supports for the screed shall be placed over

abutments and piers and at the terminal point of placements within the span. The surface of a previously placed section shall not be used as a bearing area for the screed track until control cylinders have attained a strength of at least 50 percent of f'c as specified in Table II-17.

When a transverse screed is used, the screed shall be of sufficient size to finish the full width of the deck between curbs or parapets unless a longitudinal joint in the deck is specified, in which case the portion on either side of the joint shall be placed and finished separately. Wheels of the screed shall bear on temporary rails supported on and directly above the main structural units or on form supports. With continuous spans, form supports shall be fully supported by the principal structural units supporting the deck. Rails shall be sufficiently rigid and strong to permit the screed to finish the surface of the deck within specified requirements. If rails are placed within the roadway area, they shall be elevated a sufficient distance above the deck to permit simultaneous finishing by hand of any portion not finished by the screed. Rail supports extending above the roadway surface shall be fabricated and installed in a manner to permit their removal to at least 2 inches below the top surface of the deck slab. Where rail supports are placed in that portion of the deck under curbs or parapets, supports shall be placed so that they will be at least 2 inches from the face of the curb, parapet walls, or outside edge of the slab.

Prior to placing the concrete, the Contractor shall move the screed over the deck surface with blocks attached to the bottom of the screed to identify any areas where the minimum concrete cover is not likely to be obtained. The Contractor shall make adjustments in the screed placement to insure the minimum concrete cover will be obtained when the concrete is placed.

An approved positive means of permitting access to the surface of the bridge shall be provided for operations requiring access to the deck surface after passing of the screed. The means of access shall not make contact with the deck surface.

Concrete for the entire span or section to be placed shall remain workable until the entire operation of placing, screeding, patching, rescreeding, finishing, and testing is completed. Excess water or soupy material collected by a screeding operation shall be immediately removed from the deck and properly disposed of.

If the areas of bridge decks not accessible by screed require alternate methods of finishing, the Contractor shall take care not to over finish the surface. The Contractor may float the surface to achieve the required grades, but shall not make excessive use of trowels.

The concrete in the deck of a continuous beam or girder span shall be placed in accordance with the Engineer approved placement schedule. Any deviation from the approved placement schedule must be approved in writing by the Engineer after consultation with the District Structure and Bridge Engineer. After the initial placement has been made in any one group of continuous spans, no further placement shall be made until previously placed concrete in the deck of that group has been in place for at least 3 days or until the cylinder strength is at least 0.4 f'_c.

The deck surface shall be tested with a 10-foot straightedge and rescreeded as many times as is necessary to ensure a smooth riding surface. The straightedge shall be held in successive positions at the edges and quarter points and on the centerline, parallel thereto and in contact with the surface. Advancement along the deck shall be in successive stages of not more than the length of the straightedge. The surface shall also be checked transversely at the ends, quarter points, and center of the span. Areas showing high spots or depressions of more than 1/8 inch in 10 feet in the longitudinal direction and 1/4 inch in 10 feet in the transverse direction shall be struck off or filled with freshly mixed concrete. The surface across joints shall conform to the requirements for smoothness as described herein.

(a) **Cover Depth Survey**

The Contractor shall perform a Cover Depth Survey for all concrete decks to determine the acceptability of the as-constructed concrete cover. The Cover Depth Survey shall be divided into lots. The acceptability of as-constructed concrete cover on the top of bridge decks shall be determined on a lot-by-lot basis.

The Contractor shall divide and mark bridge decks into lots of approximately equal size but no greater than 1,500 square feet in area. Lots shall extend from curb to curb for decks less than 60 feet wide and shall extend to the centerline of the deck for decks equal to or greater than 60 feet wide. At least 10 cover depth measurements shall be taken per lot. The locations for cover depth measurements shall be temporarily marked and mapped so that their locations may be tracked and verified on subsequent dates after initial measurements have been taken. Locations for measurements shall be laid out in an equally distributed rectilinear pattern and shall be spaced no more than 20 feet apart transversely and 15 feet apart longitudinally.

The equipment and procedures for conducting the Cover Depth Survey shall be submitted to the Engineer for review and approval. Equipment must be capable of measuring cover depth to an accuracy of 1/8 inch. Procedures shall include a sketch of the lot dimensions, the division lines between lots and the number and locations of measurements proposed per lot.

For each cover depth measurement, the depth of cover will be determined to the outermost reinforcing steel mat. Measurements shall be recorded to the nearest 1/8 inch. Cover depths shall be measured by individuals trained in the use of the equipment and shall be conducted and verified in the presence of the Engineer.

The Contractor shall calculate the mean of the cover depth measurements for each lot to two decimal places. The depth of cover will be deemed acceptable for any lot if the average depth of cover is within 1/2 inch of the clear cover required by the plans or specifications and at least 90 percent of the cover measurements within the lot are within .80 inch of the required cover. These requirements shall apply to average cover depths that are greater than or less than the established limits, so that lots with either excessive or inadequate average cover depths not meeting the limits above shall be deemed unacceptable.

The Contractor shall submit the results of the Cover Depth Survey to the Engineer. The temporary marks for the cover depth measurements shall remain visible for at least 3 days after receipt of the Cover Depth Survey but shall be removed in a manner acceptable to the Engineer prior to the bridge being opened to vehicular traffic.

If any lot on a concrete bridge deck does not meet the minimum cover depth requirements herein the Contractor shall install an epoxy concrete overlay on the insufficient portion of the lot in accordance with Section 431 at no additional cost to the Department. Repair area shall include the insufficient lot or portion thereof and shall extend from curb to nearest curb.

(b) **Bridge Deck Crack Repair**

Concrete bridge decks that exhibit any shrinkage cracks equal to or greater than 0.01 inch in width within 30 days of the date of concrete placement shall be repaired by the Contractor. The Contractor shall repair cracks using Type A, Type B or Type D crack repair methods in

accordance with Section 412. The cracks shall be filled at the Contractor's expense prior to project acceptance.

Cracks not identified as requiring repair within 30 days shall be repaired as directed by the Engineer or by one of the following methods as described in Section 412.03 (b) 5:

- Crack Repair Type A - V grooving
- Crack Repair Type B - Epoxy injection
- Crack Repair Type D - Sealing Linear Cracks In Concrete Decks And Overlays Using Epoxy And Carbon Fiber Mesh

The cost of repairing cracks not identified as requiring repair within 30 days from completion of casting the segment under consideration shall be paid for at the contract unit price for Crack Repair, Type( ) in accordance with Section 412.04.

Bridge decks shall not be recessed, cut, or otherwise permanently altered to facilitate the installation of pavement marking devices. Snow-plowable raised pavement markers or any marking requiring physical modification to the surface of the bridge deck shall not be installed on existing or new concrete bridge decks. When pavement markers are required on concrete bridge decks, the Contractor shall install raised pavement markers conforming to Section 704, which shall be bonded to the surface of the deck using an adhesive in accordance with the manufacturer's recommendations.

404.05—Expansion and Fixed Joints

(a) **Open Joints:** Open joints shall be constructed by inserting and subsequently removing casting templates composed of wood strips, metal plates, or other approved material. Insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete.

Edges of concrete adjacent to joints shall be finished to a radius of approximately 1/8 inch or as shown on the plans.

(b) **Filled Joints:** Materials for filled joints shall conform to the plans or other Contract requirements.

Edges of concrete adjacent to joints shall be finished to a radius of approximately 1/4 inch or as shown on the plans.

When expanded rubber, PVC, or PE filler is used, it shall be attached to the first-placed side of the joint with an approved adhesive and the concrete on the other side shall then be placed against the filler. Care shall be taken not to displace or compress the filler.

Other types of premolded fillers shall be similarly placed but need not be attached by an adhesive.

Finished cast joints shall be free from cracked and spalled areas. The faces of joints shall be free from foreign matter, curing compounds, oil, grease, and dirt. Joint faces shall be sandblasted and the joint blown out with oil-free and water-free compressed air just prior to application of primer or sealer.

(c) **Steel Joints:** Plates, angles, or other structural shapes shall be fabricated to conform to the section of the concrete floor. Fabrication and painting of steel joints shall conform to Section 407 and Section 411. Care shall be taken to ensure that the surface in the finished plane is true and free from warping. Positive methods shall be employed in placing expansion joints to keep them in the correct position during concrete placement so that the opening at the expansion joint shall be that designated on the plans at normal temperature. Care shall be taken to avoid impairing the clearance in any manner. Normal temperature shall be considered as 60 degrees F, and correction to this temperature shall be computed using a coefficient of expansion of 0.0000065 per foot per degree F.

(d) **Waterstops:** Metal waterstops shall be spliced, welded, or soldered to form continuous, water-tight joints.

Nonmetal waterstops shall be furnished full length for each straight portion of the joint without field splices. Manufacturer's shop splices shall be fully vulcanized.

Field splices for neoprene waterstops shall be vulcanized; mechanical using stainless steel parts; or made with a splicing union of the same stock as the waterstop. Finished splices shall have a full-size tensile strength of 100 pounds per inch of width.

Field splices for PVC waterstops shall be made by heat sealing adjacent surfaces in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make splices. The heat shall be sufficient to melt but not char the material.

When being installed, waterstops shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distorting the web or flange.

If waterstops are out of position or shape after concrete is placed, the surrounding concrete shall be removed to the proper dimensions, the waterstop reset if possible, and the concrete replaced, all at the Contractor's expense. If the waterstop is damaged to the extent it cannot be reset, it shall be replaced at the Contractor's expense.

404.06—Bridge Seat Bearing Areas

Bridge seat bearing areas shall be finished plane and level and shall not deviate more than 1/16 inch from plane or more than 1/32 inch per foot from level or from the slope specified on the plans. These limits of tolerance do not necessarily represent fully acceptable construction but are the limits at which construction may become unacceptable. In general, workmanship on bearing areas shall be at a level of quality that will be well within the tolerance limits. Bearing area roughness for elastomeric pads shall conform to Section 408.03(g).

Bearing areas shall be cleaned and tested for planeness and levelness prior to placement of bearing pads or preparation for bearing plates. Preparation of bearing areas for placing bearing plates and setting anchor bolts shall be in accordance with Section 408.03(g) and (h).

404.07—Finishing Concrete Surfaces

Following replacement or satisfactory repair of defective concrete, surface defects produced by form ties, honeycombing, spalls, or broken corners or edges shall be cleaned, wetted, filled with a mortar conforming

to Section 218, and troweled or struck off flush with the surrounding surface. If the surface cannot be repaired immediately following removal of forms or before the concrete surface has become dry, the surface shall be kept wet for 1 to 3 hours, as directed by the Engineer, prior to application of mortar. Repaired areas shall be cured in accordance with Section 404.03(k).

The formed face of the following concrete items shall be given a Class 1 finish: (1) bridge items: wheel guards, the inside and outside faces of parapet walls, and concrete posts and rails; and (2) other items: curbs, raised medians, steps, and retaining walls that lie within 30 feet of the edge of the pavement.

(a) **Class 1, Ordinary Surface Finish:** Following removal of forms, fins and irregular projections shall be removed from exposed surfaces and surfaces to be waterproofed.

Immediately following removal of forms, surfaces that contain cavities having a diameter or depth greater than 1/4 inch shall be cleaned, wetted, filled with a mortar conforming to Section 218, and rubbed with burlap. If the surface cannot be finished immediately following removal of forms or before the concrete surface has become dry, the surface shall be kept wet for 1 to 3 hours, as directed by the Engineer, prior to application of mortar. The finished surface shall be cured in accordance with Section 404.03(k).

Construction and expansion joints in the completed work shall be left free from mortar and concrete. Joint filler shall be left exposed for its full length.

(b) **Class 2, Rubbed Finish:** Rubbing of concrete shall be started immediately after forms are removed. Immediately before this work, concrete shall be kept wet for at least 3 hours. Sufficient time shall elapse before wetting to allow mortar used in the pointing of rod holes and defects to set thoroughly. Surfaces to be finished shall be rubbed with a medium-coarse carborundum stone with a small amount of mortar on its face. Mortar shall be composed of cement and fine aggregate mixed in the proportions used in the concrete being finished. Rubbing shall be continued until form marks, projections, and irregularities are removed; voids are filled; and a uniform surface is obtained. Paste shall be left in place.

The final finish shall be obtained by rubbing with a fine carborundum stone and water. Rubbing shall be continued until the entire surface has a smooth texture and uniform color.

After final rubbing is completed and the surface has dried, the surface shall be rubbed with burlap and left free from unsound patches, paste, powder, and objectionable marks.

(c) **Class 3, Tooled Finish:** This finish shall be produced by the use of a bush hammer, pick, crandall, or other approved tool. Tooling shall not be done until concrete has set for at least 14 days or longer as may be necessary to prevent aggregate particles from being picked out of the surface. The finished surface shall show a grouping of broken aggregate particles in a matrix of mortar, with each aggregate particle in slight relief.

(d) **Class 4, Sandblasted Finish:** The thoroughly cured concrete surface shall be sandblasted to produce an even, fine-grained surface in which mortar has been cut away, leaving the aggregate exposed.

(e) **Class 5, Wire Brushed or Scrubbed Finish:** This finish shall be produced by scrubbing the surface of the plastic concrete with stiff wire or fiber brushes using a solution of muriatic acid in the proportion of 1 part acid to 4 parts water. As soon as forms are removed, and while

concrete is comparatively plastic, the surface shall be scrubbed thoroughly and evenly until the cement film or surface is removed and aggregate particles are exposed, leaving an even, pebbled texture presenting an appearance grading from that of fine granite to coarse conglomerate, depending on the size and grading of the aggregate used. As soon as scrubbing has progressed sufficiently to produce the texture desired, the entire surface shall be thoroughly washed with water to which sufficient ammonia has been added to neutralize and remove all traces of acid.

(f) **Class 6, Bridge Deck Finish:** Methods, procedures, and equipment shall conform to Section 404.03, shall not result in segregating ingredients of the concrete; and shall ensure a smooth riding surface.

Hydraulic cement concrete bridge deck surfaces shall be textured with uniformly pronounced grooves sawed transversely to the centerline. After final screeding of the deck, a multi-ply damp fabric shall be dragged over the deck surface to provide a gritty texture. The deck concrete shall not be grooved until it has reached an age of 14 days or 85 percent of the 28-day minimum design compressive strength. Grooves shall be sawed approximately 3/16 ± 1/16 inch in depth and 1/8 inch in width (nominal) on 3/4-inch (nominal) centers. Grooves shall terminate 12 ± 1 inches from the parapet wall or curb line. Grooves shall not be sawed closer than 2 or further than 3 inches from the edge of any joint. When the width of the cutting head on the grooving machine is such that grooves cannot be practically sawed to within the required tolerance for a skewed transverse joint, grooving shall not be closer than 2 inches or more than 36 inches from the edge of the joint. On curved decks, each pass of the grooving machine shall begin on the side of the deck having the smaller radius and the nominal spacing of grooves at the starting point shall be 3/4 inch on center.

Bridge decks should be grooved prior to opening to traffic. However, the Contractor will be permitted to delay grooving up to 6 months. The Contractor shall provide the Engineer with a plan for traffic control when working under traffic.

If a single pass of the grooving machine cannot be made across the width of the bridge, the mating ends of subsequent passes shall not overlap previous grooves or leave more than 1 inch of surface ungrooved.

After concrete has set and prior to placement of other slabs, the deck surface will be tested by the Engineer. Areas showing high spots or depressions of more than the specified tolerances will be marked as failing to conform to smoothness requirements. Levels may also be run over the surface to determine if there is any deviation from grade and cross section. Decks that do not conform to thickness and surface smoothness requirements will not be accepted until deficiencies have been corrected as directed by the Engineer. Sections that cannot be satisfactorily corrected shall be removed and replaced at the Contractor's expense.

Bridge decks that are to receive an asphalt concrete overlay of 1 inch or more in thickness shall be finished to a tolerance of 1/4 inch in 10 feet in both longitudinal and transverse directions except at expansion joints, where the finished tolerance shall be 1/8 inch in 10 feet.

(g) **Class 7, Sidewalk Finish:** After concrete has been placed, it shall be consolidated and the surface struck off with a strike board and floated with wooden or cork floats. Light metal marking rollers may be used if desired after the initial set. An edging tool shall be used on edges and

at joints. The surface shall not vary more than 1/4 inch under a 10-foot straightedge and shall have a granular texture that will not be slick when wet.

404.08—Measurement and Payment

Concrete will be measured in cubic yards within the neat lines of the structure as shown on the plans and will be paid for at the contract unit price per cubic yard for the Class designated. Deductions will not be made for chamfers 1 inch or less in width or for grooves less than 1 inch in depth. The volume of reinforcing steel or any other material or internal voids within the concrete will be deducted.

The volume of bridge deck slab concrete allowed for payment will be computed using the actual thickness of the slab, not to exceed the plan thickness plus 1/2 inch, for the area between faces of sidewalks, curb lines, railings, or parapets. The area beneath sidewalks, curbs, railings, or parapets will be based on the plan thickness.

Unless designated as separate pay items, this price shall include waterstops, waterproofing, damp-proofing, anchor bolts, drain assemblies, silicone treatment, protective coating for concrete exposed to tidal waters, and trial batches.

If corrugated metal bridge deck forms are used in lieu of removable forms, the price for concrete shall include furnishing and placing metal forms, additional concrete required to fill corrugations, work necessary to facilitate inspection of the underside of the deck, repairing deficiencies, and strengthening beams or girders to maintain the design live-load rating of the bridge.

Bridge-deck grooving will be measured in square yards of deck surface area from the faces of parapets, sidewalks, or curb lines and will be paid for at the contract unit price per square yard. No deduction will be made for drainage items and joints.

Cover Depth Survey will be measured in square yards and will be paid for at the contract unit price per square yard. This price shall include furnishing all personnel and equipment required to perform, document, and deliver the survey to the Engineer.

Payment will be made under:

Pay Item	Pay Unit
Concrete (Class) item	Cubic yard
Bridge-deck grooving	Square yard
Cover Depth Survey	Square yard

SECTION 405—PRESTRESSED CONCRETE

405.01—Description

These specifications cover the use of prestressed or post-tensioned hydraulic cement concrete when called for on the plans.

405.02—Materials

(a) **Concrete** shall conform to Section 217, Class A5, with the following exceptions:

Each project, and bridge unit within a project (if multiple bridges are part of the same project) shall have an approved mix design that accounts for the closest bar spacing in that girder or other element supplied. The maximum top size of aggregate shall not exceed one-fifth of the narrowest dimension of the concrete formwork, three-quarters of the narrowest clear spacing between reinforcing steel bars or bundles of bars and/or strands, or three-quarters of the minimum clear cover over the steel reinforcement. The concrete mix proportions shall be submitted to the Engineer for review prior to production. No. 57, 7, 68, or 78 aggregate may be used for coarse aggregate subject to the limitations for the top size of coarse aggregate above.

(b) **Concrete admixtures** shall conform to Section 215.

(c) **Epoxy-resin compounds** shall conform to Section 243.

(d) **Steel reinforcement and prestressed tendons** shall conform to Section 223.

(e) **Structural steel** shall conform to Section 226.

(f) **Bedding materials and bearing pads** shall conform to Section 237 and Section 408.

(g) **Waterproofing** shall conform to Section 416.

(h) **Hydraulic cement mortar and grout** shall conform to Section 218.

(i) **Fully or partially embedded steel attachments to the prestressed concrete members** shall be galvanized in accordance with Section 233.

405.03—Plant Review

Plants that manufacture precast, prestressed concrete elements shall have PCI certification for all product groups and categories fabricated for use on Department work at that location. PCI inspection reports shall be on file at the plant and available for review by the Engineer. Plants that have not previously produced products for the Department will be inspected by the Department prior to commencement of production.

The Contractor shall provide and furnish a Type III field office in accordance with Section 514 for use in the Engineer's inspection of material and workmanship within the shop. In addition to the requirements specified therein, the Contractor shall provide telephone service by a direct access line, a telephone, and maintenance thereof. Costs for installation of the direct access line, the telephone, maintenance, and local service shall be borne by the Contractor. The cost for long-distance will be borne by the Department. The Engineer shall be allowed free access to the necessary parts of the work for inspection purposes. One inspection of corrective action taken on defective material or defective fabrication will be performed by the Department without cost to the Contractor. The cost of further additional inspections shall be borne by the Contractor.

The Contractor shall request a plant inspection by the Engineer at least 21 days prior to the start of production. As a part of the plant inspection, a meeting will be held with the producer, Contractor,

Engineer, and Inspectors to discuss plant facilities, materials, production methods, review and acceptance of drawings, and production schedules.

In order to qualify new plants for the manufacture of prestressed units other than piles, the Engineer may require the Contractor to test a unit that is representative of each design type and size of unit to be manufactured. The acceptance test shall be as follows: Not more than one line of units shall be cast prior to the satisfactory completion of the acceptance test. A representative unit shall be tested in accordance with VTM-20 in the presence of the Engineer prior to plant approval.

The Engineer will randomly select the unit to be tested. The Engineer must approve jigs and load-testing equipment. The Contractor shall be responsible for the cost of testing and the units selected for testing.

405.04—Concrete Controls

The Contractor is required to perform Quality Control during production. Qualified personnel including certified Concrete Technicians and testing equipment shall be supplied by the Contractor.

The quality of the concrete shall be monitored by testing fresh concrete properties and testing cylinders in compression. Fresh concrete shall be tested in accordance with Section 217.

The Contractor shall prepare two clusters of cylinders for each bed used in production each day concrete is placed. Each cluster shall include a sufficient number of cylinders to demonstrate the product meets the requirements of the Contract, but not less than 12 cylinders per cluster. Failure to have an adequate number of cylinders in each cluster to meet this requirement shall be cause for rejection. Each of the two clusters shall be placed at quarter points of the bed and cured with the product under the same conditions.

Prestressed concrete shall meet the compressive strength specified at release, f 'ci, prior to detensioning, stripping the forms, and handling the product, and the specified 28-day minimum design compressive strength, f 'c, prior to shipment. In the event that there is no specified compressive strength at release in the Contract, the product shall have a compressive strength of 80 percent of f 'c. When using 6 x 12 cylinders, two cylinders from each cluster shall be tested to determine compressive strength, and three cylinders from each cluster shall be used when using 4 x 8 cylinders. The reported compressive strength shall be the average of the strength measured of the two or three cylinders tested as specified above in accordance with ASTM C39. The test results shall be recorded in a bound log book along with the date of casting and the age of the cylinder at testing and made available to the Department inspector. Detensioning or handling an element prior to obtaining the release compressive strength will be cause for rejection.

Concrete batches from which cylinders are made shall be tested for slump in accordance with ASTM C143, and for air content in accordance with ASTM C231.

The Contractor shall maintain records of tensioning operations, curing temperatures, and concrete testing in a form suitable for permanent filing. Records shall be available to the Department and maintained for 10 years.

405.05—Procedures

(a) **Forms:** Forms and centering shall be made and maintained true to the shapes and dimensions shown on the approved drawings.

Forms shall be of metal or other material that will give comparable results. Forms shall be designed and aligned so that they will not restrict the longitudinal movement of the casting when the prestressing force is transferred.

Drilled holes in bulkheads and templates shall be sized to provide for unrestricted movement of strands during tensioning.

Bulkheads may be constructed of adequately reinforced plywood. Wooden bulkheads that are warped or damaged shall not be used.

Form ties shall not be used without the approval of the Engineer.

Joints between panel forms shall be well aligned and tight; and adequate precautions shall be taken to prevent leakage of mortar. Corners or intersections of surfaces exposed in the completed structure shall be chamfered or rounded, with a width or radius of 3/4 inch. Corners of square piles shall be chamfered from 3/4 inch to 1 1/2 inches or rounded to a 2-inch radius. A smaller chamfer not less than 3/4 inch may be used if approved by the Engineer.

Void forms shall be anchored during concrete placement and secured by means other than being tied to strands.

The material used to form internal voids for voided slab and box sections shall be expanded polystyrene having a maximum water absorption (by volume) rate of 10%.

The use of waxed-coated cardboard tubes shall not be permitted.

Precast prestressed concrete box beams and flat slabs shall have one drain provided in each end of each void. The drain shall be located so that the void will drain after the unit has been installed in the structure. The device for forming the drain shall be of such material and design that the drain will not rust, stain, or otherwise disfigure the concrete and shall allow free drainage from the void.

(b) **Placing Strands and Wires and Applying and Transferring Pretension:** The Contractor may be required to submit for the Engineer's approval the detailed computations of gage pressures and elongations proposed.

All steel reinforcement shall conform to Section 406. Wires shall conform to the requirements herein for strands.

The Contractor shall not substitute stress-relieved strands for low-relaxation strands.

Strands with kinks, bends, nicks, broken wires, scales, rust, or other defects shall not be used. The failure of one wire in a seven-wire pretensioned strand or one wire in a parallel-wire post-tensioned cable may be accepted provided the wire is not more than 2 percent of the total number of wires. Slight rusting will not be cause for rejection provided it is not sufficient to cause visible pits. Strands shall be satisfactorily cleaned before concrete operations begin.

Strands shall be placed in proper position and first tensioned individually by a force of at least 5 but not more than 25 percent of the final stressing force. This force shall not vary by more than 5 percent in any group of strands.

The final stressing of strands shall be performed by applying tension to each strand individually or to all strands as a group. The strand or strand group shall be tensioned to the total pretensioning force as indicated on the plans, with a maximum applied stress of 70 percent of the ultimate strength for stress-relieved strands and 75 percent of the ultimate strength for low-relaxation strands.

During stressing, allowance shall be made for the amount of strand anchorage slipping. The proper allowance shall be determined during trial plant operations and satisfactorily checked periodically during actual stressing operations. Strand anchorage devices of each type and source shall be checked as specified herein.

During stressing, allowance shall be made in the amount of strand elongation for the loss or gain in tension resulting from the change in temperature in the strand between the time of stressing and time of the initial set of concrete. The magnitude and method of application of this allowance shall be in accordance with the *PCI Manual for Quality Control* (MNL-116).

A manufacturer's corresponding recommended value for the average modulus of elasticity will be used for each order of strand supplied. Consideration shall be given to the stress-strain data of tests performed on the samples.

Strands shall not be spliced within units.

Pretensioned strands shall be secured by suitable anchorage devices capable of developing at least 90 percent of the ultimate strength of the strand.

When deflected strands are tensioned in their deflected position, they shall be supported by lubricated rollers with solid bushings or other low-friction rollers at hold-up and hold-down points. Provisions shall be made for a cover of at least 1/8 inch of concrete or epoxy mortar on metal parts of the hold-down devices remaining in beams.

The final position of strands and reinforcing steel shall be accurately maintained as shown on the plans.

The tensioning system shall be equipped with a pressure gage indicating the jack pressure to an accuracy of within 2 percent of the pressure corresponding to the full prestress tension in the strand. Gages shall be recalibrated at least once every 6 months, at any time the gaging system appears to be giving erratic or erroneous results, or if the gage indication and elongation measurements indicate materially different stresses. Gages, jacks, and pumps shall be calibrated as a system in the same manner in which they are used in tensioning operations. Calibration shall be performed by an approved testing laboratory or approved calibration service, and a certified calibration curve shall accompany each tensioning system. Load, as measured by gage pressure, shall not vary from that measured by elongation by more than 5 percent. Elongation measurements shall be taken as checks on the final pressure gage reading. Elongation shall be measured to a precision of 1/4 inch. The Contractor shall record elongation and pressure readings during stressing. Calibration documentation shall be provide to the Department representative upon request.

Tension in the strands shall not be transferred to the concrete in the unit until the concrete has attained a compressive strength of f 'ci, in accordance with Section 405.04. Strands shall be transferred gradually, simultaneously, and equally to the concrete when multiple-strand detensioning is used.

When the single-strand release method is used, strands shall be released by heating near the end of each unit in accordance with the Contractor's sequence and schedule. Individual jack release or burning may be used for strands at the dead or live end of the bed. Strands to be released in each step of the sequence shall be burned apart between beams before the next step is begun. No more than two strands shall be included in each step of the pattern.

Strands shall not be burned quickly but shall be heated with a low-oxygen flame played along the strand at least 5 inches until the metal gradually loses its strength and failure of the first wire in each strand occurs after the torch has been applied for at least 5 seconds.

The schedule for single-strand detensioning of units having deflected strands shall incorporate the following:

1. Straight strands located in the upper flange of the unit shall be released first.

2. Tension in the deflected strands at the ends of bed and uplift points shall be released in sequence.

3. Hold-down devices for deflected strands shall be disengaged, and hold-down bolts shall be removed from units.

4. The remaining straight strands of the pattern to be detensioned individually shall be released in sequence.

   If it is desired to release hold-down devices prior to releasing tension in deflected strands, this may be permitted (1) if the weight of the prestressed unit is more than twice the total of the forces required to hold strands in the low position, or (2) if weights or other approved vertical restraints are applied directly over the hold-down points to counteract uplifting forces, at least until the release of deflected strands has proceeded to such a point that the residual uplifting forces are less than 1/2 the weight of the unit.

   Failure to follow these procedures may result in rejection of the units.

(c) **Placing Concrete:** The procedure and equipment for handling, placing, and consolidating concrete shall be such that a uniformly dense and high-grade of concrete is obtained in all parts of the unit under all working and weather conditions.

When placing concrete in continuous horizontal layers in forms for precast I-beams, succeeding layers shall follow the preceding layer before any initial set takes place. Concrete in bottom slabs of precast prestressed box beams shall be placed before void forms are positioned. Concrete may be placed in forms for piling and precast slab units in one continuous horizontal layer.

The use of external vibration shall be at the option of the Contractor; however, improper placing and vibrating may be cause for rejection.

Concrete shall not be placed in forms when the temperature of the forms or embedded items is below 40 degrees F.

(d) **Removing Forms:** Forms for units being moist cured may be removed when concrete reaches the specified compressive strength at release of f 'ci.

After forms are removed, the Engineer will inspect units to determine their acceptability. Patching of any surface irregularities, especially those resulting from honeycombing, shall be performed only after inspection and authorization.

After form removal, the Contractor shall mark each precast unit with a unique identifying number specific to the project.

(e) **Finishing:** Holes and voids in the surface of concrete resulting from bolts, ties, or large air pockets shall be wetted and filled with mortar having the same proportion of fine aggregate and cement as in the concrete, after which exposed mortar surfaces shall be finished smooth and even with a wood float.

If finishing work is necessary, the exterior face of exterior beams shall be finished free from blemishes and then rubbed with burlap. Holes or voids having a depth or diameter greater than 1/2 inch on the interior face of exterior beams, on both faces of interior beams, or on piles shall be filled and finished.

Surfaces to be repaired and finished shall be kept wet for at least 1 hour before hydraulic cement mortar is applied. Immediately following patching work, repaired areas shall be wet cured for at least 48 hours. The wet cure may be accomplished by the use of steam, wet burlap, or continuous spray wetting, or liquid membrane-forming compound may be used on non-composite surfaces. Epoxy may be used and shall be applied and cured in accordance with the manufacturer's recommendations.

Piles subject to tidal waters shall be finished in accordance with Section 404.03(i).

Units that are to be made composite with subsequently placed concrete shall be finished by striking off the top of forms. As soon as the condition of the concrete permits and before it has fully hardened, dirt, laitance, and loose aggregate shall be removed from the surface by means of a wire brush, which shall leave the coarse aggregate slightly exposed or otherwise roughened to an amplitude of 1/4 inch. If concrete has been allowed to harden so that it is impossible to remove laitance and roughen the top surface of units by brushing, the surface shall be cleaned and prepared for bonding by chipping.

Ends of strands shall be allowed to cool to normal temperature after cutting and then shall be covered with at least 1/8 inch of epoxy mortar or other material approved by the Engineer. After mortar is allowed to cure, the entire end of the unit shall be covered with epoxy, Type EP-3T.

Care shall be taken in cutting or burning ends of strands to prevent damaging the concrete surface.

(f) **Protecting and Curing:** Prestressed concrete shall be cured by being kept moist at temperatures that will promote hydration. Proper curing by any method requires that moisture is retained for complete hydration and the formation of surface cracks attributable to rapid loss of water is prevented while the concrete is plastic. Prior to concrete placement, procedures for retaining moisture shall be approved by the Engineer. Moist curing shall continue until such time as the compressive strength of the concrete reaches the strength for detensioning. Moist curing shall commence as soon as possible following the completion of surface finishing.

The Contractor shall have the option of using steam curing in lieu of moist curing in accordance with the following:

1. The design concrete mixture shall be proven adaptable for steam curing using the same cure as proposed for the routine manufacture of prestressed concrete units.

2. The Contractor shall be responsible for the quality of concrete placed in any weather or atmospheric condition. At the time of placement, concrete shall have a temperature of 40

degrees F to 90 degrees F when concrete is moist cured. If accelerated steam curing is used, the temperature of the concrete at placement shall be 40 degrees F to 100 degrees F. Mixing limitations shall be in accordance with Section 217.09.

3. An initial set of a nominal 500 pounds per square inch, determined by the penetration resistance test, shall be obtained prior to the introduction of steam. The penetration resistance test shall be performed in accordance with ASTM C403. Forms shall be covered after surface finishing of the concrete, including the delay period before introduction of steam.

4. The temperature rise in the curing enclosure shall be uniform, with a rate rise of not more than 80 degrees F per hour. Concrete shall be cured at a steam temperature of not more than 180 degrees F, with the steam temperature uniform throughout the curing enclosure and with a variation of not more than 20 degrees F. Approved recording thermometers shall be placed so that temperatures can be recorded at a minimum of two uniformly spaced locations in each curing enclosure.

5. Steam curing shall be maintained until such time as the compressive strength of the concrete attains that specified on the plans for detensioning.

6. Steam curing shall be performed under a suitable enclosure to retain the live steam at 95 percent relative humidity and minimize heat losses. Enclosures shall allow free circulation of steam. Steam jets shall be positioned so that they will not discharge directly on concrete, forms, or test cylinders.

7. Concrete test cylinders shall be subject to the same curing conditions as the units.

8. Immediately after steam curing is terminated, forms shall be loosened and the stress load on the stressing strands shall be released while the concrete is still hot.

(g) **Waterproofing:** Units so designated on the plans shall be waterproofed in accordance with Section 416.

(h) **Handling, Storing, and Erecting:** Units shall be adequately separated in storage immediately following removal from beds to make inspection of finished surfaces possible and to facilitate repair of surface blemishes.

Care shall be taken in handling and storing units to avoid damage to concrete. Concrete must have attained the minimum 28-day design compressive strength before structural units are shipped to the project site.

Piles shall not be driven until at least 7 days after the date concrete is cast and has attained the minimum design compressive strength.

Lifting and support points for all units shall be as shown on the plans. If plans do not indicate lifting and support points, the Contractor shall lift and support units at locations not less than 6 inches or more than the depth of the unit from the end of the unit. The Contractor shall be responsible for the design and safety of the lifting device used. Piles shall be supported at lift points as shown on the contract drawings.

Requests by the Contractor to use lifting or support points other than those indicated must be accompanied by computations showing that stresses are within the allowable range using 50 percent of the dead load as an impact factor.

Units that have been damaged in handling shall be repaired to the satisfaction of the Engineer. Units that have been damaged to such an extent that they are not repairable shall be replaced at the Contractor's expense.

Shear keys required between adjacent units, recesses at ends of transverse ties, holes for anchor bars, and other recesses shown on the plans shall be filled with mortar conforming to Section 218. Mortar shall be applied in one continuous operation for each span.

Where waterproofing material is to be applied to tops of units in the field, longitudinal joints shall be sufficiently smoothed to prevent damage to the material.

Struts and diaphragms between spread units may be cast separately or monolithically with the deck slab. If the Contractor casts struts and diaphragms separately from the slab, the age or compressive strength of the concrete in the struts or diaphragms shall conform to the requirements for I-beams in Section 404.03(j) before deck slab concrete is placed. If the Contractor casts struts and diaphragms monolithically with the slab, each prestressed concrete beam shall be placed and restrained in such a manner that the beam will not be canted during construction of the struts, diaphragms, and slab. The Contractor's method for maintaining acceptable vertical alignment of beams shall be subject to the approval of the Engineer.

Bearing surfaces of units shall be parallel to the bottom surface of the unit or as specified on the plans. Attached bearing assemblies shall be fabricated so that their bottom bearing surfaces shall lie in truly horizontal planes in their erected position. Metal bearing plates or bottoms of precast beams that are to bear on elastomeric pads shall be coated with epoxy, Type EP-2, EP-4, or EP-5, and then surfaced with a No. 36 to No. 46 silicon carbide or aluminum oxide grit.

Ends of beams, at ends of spans, and diaphragms shall be vertical.

Continuity diaphragms for prestressed beams shall not be cast until at least 90 days after the strands in the beams have been detensioned.

Units shall be stored on dunnage placed at the support points shown on the plans and at least 4 inches above the ground. If supports points are not provided on the plans, the Contractor may locate the dunnage at the lifting and support points. If units are stacked, they shall be so arranged that the weight of upper members does not introduce shear or bending effects onto members below. The Contractor shall make all members accessible for inspection by the Engineer upon request.

Once beams, girders, or slabs have been placed on temporary supports for storage, camber measurements shall be taken at midspan, at release and at 2 week intervals thereafter up to 120 days after detensioning. These measurements shall be recorded in the morning to reduce the effects of solar radiation for each member and shall include the date, time, weather conditions, and measurements taken.

Camber shall be measured at midspan and recorded in a bound log book and made available to the inspector.

Piles or other elements supported at more than two points shall have their camber measured at the midpoint of each supported span. Camber measurements that fall outside the tolerances below shall be reported in writing to the Engineer and will be cause for rejection if not corrected to the satisfaction of the Engineer. Each measurement shall include the date of casting,

the date of the measurement, the time of day, the temperature and other weather conditions (as directed by the Engineer) along with the measurement. The contractor shall submit a camber management plan to the engineer indicating the method for controlling camber. The Engineer will review the plan, and once found to be acceptable, the Contractor shall implement the plan if any of the thresholds below are exceeded:

- 130 percent of the computed camber
- 75 percent of the allowable limit between adjacent beams, girders or slabs
- 3/4 inch difference between the high and low units in the same span (for slabs or box beams)

All field welding, such as field welding of sole plates or other metallic components, shall be performed in accordance with Section 407. Coatings shall be repaired in accordance with Sections 233 and 411 as applicable. Payment for field welding, inspection, and coating shall be included in the price bid for other items.

405.06—Tolerances

The limits of tolerance do not necessarily represent fully acceptable construction; they are the limits at which construction may become unacceptable. In general, workmanship shall be at a level of quality that will be well within the tolerance limits.

(a) **Precast Prestressed Concrete I-Beams and T-Beams:**

Characteristic	Values
Depth (overall)	±1/4 inch
Width (flanges and fillets)	±1/4 inch
Width (web)	±1/4 inch
Length of beam	±1/8 inch/10 ft or 1/2 inch, whichever is greater
Exposed beam ends (deviation from square or designated skew)	Horizontal ±1/4 inch, vetical ±1/8 inch/ft of beam height
Side inserts (spacing between centers of inserts and from centers of inserts to ends of beams)	±1/2 inch
Bearing plate (spacing from centers of bearing plates to ends of beams)	±1/2 inch
Stirrup bars (projection above top of beam)	±3/4 inch
Stirrup bars (longitudinal spacing)	±1 inch
Horizontal alignment (deviation from straight line parallel to centerline of beam)	Max. 1/8 inch/10 ft
Camber differential between adjacent beams of same type and strand pattern	1/8 inch/10 ft or max. 1/2 inch (at time of erection)
Camber differential from computed camber	±50% (at time of erection)
Center of gravity of strand group	±1/4 inch
Center of gravity of depressed strand group at end of beam	±1/4 inch
Position of hold-down points for depressed strands	±6 inches
Position of handling devices	±6 inches

(b) **Precast Prestressed Concrete Box Beams and Flat Slabs:**

Characteristic	Values
Depth (top slab)	+1/2 to –1/4 inch
Depth (bottom slab)	0 to +1/2 inch
Depth (overall)	±1/4 inch
Width of web or thickness of sidewalls	±3/8 inch
Width (overall)	+1/8 to –1/4 inch
Length	±1/8 inch/10 ft or 1/2 inch, whichever is greater
Void position (longitudinal)	±1/2 inch adjacent to tie holes ±1 inch adjacent to end block
Square ends (deviation from square)	±1/4 inch
Skew ends (deviation from designated skew)	
Skew angle equal to or less than 30°	±1/4 inch
Skew angle greater than 30°	±1/2 inch
Horizontal alignment (deviation from straight line parallel to centerline of unit)	Max. 1/8 inch/10 ft
Gap between adjacent units	Max. 1/2 inch
Tie rod tubes (spacing between centers of tubes and from centers of tubes to ends of units)	±1/4 inch
Tie rod tubes (spacing from centers of tubes to bottom of beam)	±1/4 inch
Camber differential between adjacent units	Max. 1/4 inch (at time of erection)
Camber differential between high and low units in same span	Max. 3/4 inch (at time of erection)
Camber differential from computed camber on plans	±50 percent (at time of erection)
Side inserts (spacing between centers of inserts and from centers of inserts to ends of beams)	±1/2 inch
Stirrup bars (projection above top of beam)	±3/4 inch
Stirrup bars (longitudinal spacing)	±1 inch
Center of gravity of strand group	±1/4 inch
Center of gravity of depressed strand group at end of beam	±1/4 inch
Position of hold-down points for depressed strands	±6 inches
Position of handling devices	±6 inches

(c) **Prestressed Concrete Piling:**

Characteristic	Values
Width or diameter	–1/4 to +3/8 inch
Head out of square	1/16 inch/12 inch of width
Length of pile	±1 1/2 inch
Horizontal alignment (deviation from straight line parallel to centerline of pile)	Max. 3/16 inch/20 ft of length Max. 1/8 inch in 10-ft chord Max. 1/16 inch in 1 ft
Void location	±1/4 inch
Stirrup bars or spiral position	±1 inch
Center of gravity of strand group	±1/4 inch
Position of handling devices	±6 inch

405.07—Measurement and Payment

Prestressed concrete piles will be paid for in accordance with Section 403.08.

Prestressed concrete structural units that are to be incorporated in the completed structure will be measured in units of each for the unit specified and will be paid for at the contract unit price per each.

These prices shall include manufacturing, fabricating, and furnishing units, mortar seals on ends of units; structural and reinforcing steel for connecting units to struts and diaphragms; reinforcing, structural, and prestressing steel embedded in units, including dowels in place and bearing pads or bearing devices; post-tensioning fittings, strands, and rods, grouting, joint fillers and sealers, waterproofing applied to structural units at the prestressing plant; testing and documentation, hauling, handling, storage, and treatment.

Payment will be made under:

Pay Item	Pay Unit
Prestressed concrete (Shape, beam, description of cross section, and length)	Each
Prestressed concrete slab (Width, depth, and length)	Each

SECTION 406—REINFORCING STEEL

406.01—Description

This work shall consist of furnishing; coating, if required, and placing reinforcing steel or wire mesh used in concrete operations, except prestressed strands and wires, in accordance with these specifications and in conformity to the lines and details shown on the plans.

406.02—Materials

(a) **Steel used for reinforcement** shall conform to Section 223. Except for spiral bars, bars more than 1/4 inch in diameter shall be deformed bars.

(b) **Welded wire fabric** shall conform to Section 223.

(c) **Bar mat reinforcement** shall conform to Section 223.

(d) **Corrosion resistant steel used for reinforcement** shall conform to Section 223.

406.03—Procedures

(a) **Order Lists and Bending Diagrams:** Copies of order lists and bending diagrams shall be furnished to the Engineer when required or requested.

(b) **Protecting Material:** Reinforcing steel shall be stored on platforms, skids, or other supports that will keep the steel above ground, well drained, and protected against deformation.

When placed in the work, steel reinforcement shall be free from dirt, paint, oil, or other foreign substances. Steel reinforcement with rust or mill scale will be permitted provided samples wire brushed by hand conform to the requirements for weight and height of deformation.

(c) F**abrication:** Bent bar reinforcement shall be cold bent to the shape shown on the plans. Fabrication shall be in accordance with the *Manual of Standard Practice for Detailing Reinforced Concrete Structures* (ACI 315).

Spiral bars shall be fabricated to have the proper diameter when placed in position at the pitch shown on the plans. Each end of a spiral bar shall have 1 1/2 finishing turns in a plane perpendicular to the axis of the spiral.

(d) **Placing and Fastening:** Steel reinforcement shall be firmly held during the placing and setting of concrete. Bars, except those to be placed in vertical mats, shall be tied at every intersection where the spacing is more than 12 inches in any direction. Bars in vertical mats and in other mats where the spacing is 12 inches or less in each direction shall be tied at every intersection or at alternate intersections provided such alternate ties will securely and accurately maintain the position of steel reinforcement during the placing and setting of concrete. Placing reinforcing steel in concrete after concrete has been freshly placed is not permitted.

Tie wires used with corrosion resistant reinforcing steel shall be solid stainless or plastic coated.

The minimum clear distance from the face of the concrete to any reinforcing bar shall be maintained as specified herein. In superstructures, the cover shall be at least 2 1/2 inches except as follows:

1. **Bottom of slab:** 1 1/4 inches.

2. **Stirrups and ties in T-beams:** 1 1/2 inches.

3. **Rails, rail posts, curbs, and parapets:** 1 inch.

In substructures, the cover shall be at least 3 inches except as follows:

1. **Abutment neat work and pier caps:** 2 1/2 inches.

2. **Spirals and ties:** 2 inches.

In corrosive or marine environments or under other severe exposure conditions, the minimum cover shall be increased 1 inch. Bars that must be positioned by maintaining clearances from more than one face shall be centered so that clearances indicated by the plan dimension of bars are equalized.

Bars shall be placed so that the concrete cover as indicated on the plans will be maintained within a tolerance of 0 to +1/2 inch in the finally cast concrete.

Where anchor bolts interfere with reinforcing steel, the steel position shall be adjusted without cutting to permit placing anchors in their proper locations.

Reinforcement in bridge deck slabs and slab spans shall be supported by either stainless steel or plastic coated steel bar supports. Bar supports shall be spaced as recommended by CRSI but not more than 4 feet apart transversely or longitudinally. Precast concrete supports, galvanized bar supports, plastic/composite bar supports, or epoxy coated bar supports will not be permitted. The lower mat of steel reinforcement shall be supported by a bolster block or individual chair bar supports and the upper mat can be supported by either individual high chair bar supports or continuous bar supports placed between the upper and lower mats. When the upper mat is supported by continuous bar supports placed between the upper and lower mats, all the bar supports shall be spaced as recommended by CRSI but not more than 3 feet apart transversely or longitudinally. Bar supports shall be firmly stabilized so as not to displace under construction activities. Reinforcing bar supports (standees) may be used for the top mat of steel of simple slab spans provided they hold the reinforcing steel to the requirements specified herein and are firmly tied to the lower mat to prevent slippage. The use of standees will not be permitted for the top mat of steel on any continuous slab spans.

Metal bar supports shall be fabricated from one of the following: (1) stainless steel wire conforming to ASTM A493, or (2) cold-drawn wire protected by plastic coating conforming to CRSI standards, or other protective coating as approved by the Engineer.

In reinforced concrete sections other than bridge slabs, the specified clear distance from the face of concrete to any reinforcing bar and the specified spacing between bars shall be maintained by means of approved types of stays, ties, hangers, or other supports. The use of pieces of gravel, stone, brick, concrete, metal pipe, or wooden blocks will not be permitted as supports or spacers for reinforcing steel. The use of precast concrete block supports will be permitted provided blocks are furnished in correct thicknesses and are shaped or tied to prevent slippage from beneath reinforcing bars. The clear distance between bars shall be at least 1 1/2 times the specified maximum size of coarse aggregate but not less than 1 1/2 inches. Before concrete is placed, the Engineer will inspect reinforcing steel and determine approval for proper position and the adequacy of the method for maintaining position.

(e) **Splicing and Lapping:** Reinforcement shall be furnished in full lengths as indicated on the plans. Except where shown on the plans, splicing bars will not be permitted without the written approval of the Engineer. Splices shall be as far apart as possible.

In lapped splices, bars shall be placed in contact and wired together. Lap lengths shall be as indicated on the plans. When reinforcing bars cannot be fabricated with the lengths shown on the plans, the bars may be lapped at no additional cost to the Department. Lap lengths shall be in accordance with the AASHTO LRFD Bridge Design Specifications.

Mechanical butt splicing will be permitted at locations shown on the plans. The mechanical connection shall develop in tension or compression, as required, 125 percent of the specified yield strength of the bar. The total slip of the bar within the splice sleeve of the connector after loading in tension to 30.0 ksi and relaxing to 3.0 ksi shall not exceed the following measured displacements between the gage points clear of the splice sleeve:

For bar sizes up to No. 14:	0.01 inch
For No. 18 bars:	0.03 inch

For corrosion resistant reinforcing bars, mechanical butt splicers shall be of the same material as the bars being spliced except for stainless clad bars for which the splicers shall be stainless steel.

Reinforcing steel shall be welded only if specified on the plans. Welding shall be in accordance with Section 407.04(a). Reinforcing steel conforming to ASTM A615, Grade 60 shall not be welded. Corrosion resistant reinforcing steels shall not be welded.

Lap lengths for welded wire fabric or bar mat reinforcement shall be in accordance with the current AASHTO LRFD Bridge Design Specifications.

406.04—Measurement and Payment

Reinforcing steel will be measured in pounds of steel placed in the structure as shown on the plans. The weight of welded wire fabric will be computed from the theoretical weight per square yard placed, including allowance for laps not to exceed 8 percent of the net area. Reinforcing steel or welded wire fabric will be paid for at the contract unit price per pound. These prices shall include furnishing, fabricating, and placing reinforcement in the structure. In structures of reinforced concrete where there are no structural steel contract items, expansion joints, plates, rockers, bolts, and similar minor metal parts will be paid for at the contract unit price for reinforcement.

Corrosion resistant reinforcing steel, when a pay item, will be measured in pounds and will be paid for at the contract unit price per pound of the designated class of steel indicated and placed in the structure in the location(s) shown on the plans. This price shall include fabricating, shipping, furnishing and placement.

No payment will be made for fastening or support devices that may be used by the Contractor for keeping reinforcing bars in their correct position. When the substitution of larger bars than those specified is allowed, payment will be made for only the amount of metal that would have been required if the specified size of bar had been used. When full-length bars are shown on the plans and the Contractor obtains approval to use short bars for his convenience, the weight paid will be based on the full-length dimensions with no allowance made for splices.

Payment will be made under:

Pay Item	Pay Unit
Reinforcing steel	Pound
Welded wire fabric	Pound
Corrosion resistant reinforcing steel, (Class)	Pound

SECTION 407—STEEL AND OTHER METAL STRUCTURES

407.01—Description

This work shall consist of furnishing, fabricating, and erecting steel or other metal materials in accordance with these specifications and in conformity with the lines, grades, and dimensions shown on the plans or as established by the Engineer.

407.02—Materials

Steel shall conform to Section 226. Other metals shall conform to their respective sections of the Specifications.

407.03—Working Drawings

The Contractor shall submit to the Engineer working drawings of all structural steel, bearing assemblies, and anchorage devices to be used in the work on the contract for the Engineer's review and acceptance. Details shown on the working drawings shall conform to these specifications and the Structural Steel Design Section of the current *AASHTO LRFD Bridge Design Specifications.* In addition, primary stress units shall be detailed and identified by an individual piece mark. The Engineer's review of working drawings shall not relieve the Contractor of responsibility for errors on the drawings or deviations from the plans made by the Contractor unless such changes are preapproved in writing by the Engineer. Shop work shall not be performed until after the working drawings have been reviewed and accepted.

The Contractor may, in writing, authorize the fabricator to act for the Contractor in matters relating to the working drawings in accordance with Section 105.10. If authority is granted by the Contractor to the fabricator, a copy of such authorization shall be provided to the Engineer.

Working drawings shall specifically identify the composition and grade of metal or alloy of each piece other than steel conforming to ASTM A709, Grade 36. Pieces fabricated of different grades of steel shall not be given the same piece mark, even if they have identical dimensions and details.

407.04—Fabrication Procedures

Workmanship, finish, and fabrication tolerances shall conform to AISC standards and AWS welding codes except where the standards are in conflict with these specifications. Where AISC standards and AWS welding codes allow alternate methods of fabrication, the method used by the fabricator shall be that which produces the higher quality of workmanship and finish. Structural steel shall be fabricated in a shop certified by AISC under the *Certification Program for Structural Steel Fabricators.* Fabricators producing fracture-critical members, intermediate bridges, or advanced bridges shall be required to meet the supplemental requirements as appropriate.

All structural steel fabrication not specifically covered under the *Certification Program for Structural Steel Fabricators* shall be fabricated in a shop certified by AISC under the *Certification Program—Standard for Bridge and Highway Metal Component Manufacturers.*

All complex coating systems, defined as coatings which require special care in surface preparation, coating, component preparation, application control, curing, and in-process inspection, applied to structural steel shall be applied by a firm certified by AISC under the *Certification Standard for Shop Application of Complex Protective Coating Systems.*

Fabrication and welding of structural steel bridge units shall conform to these specifications and *AASHTO/AWS Bridge Welding Code D1.5.* Structural components designated in the Contract as fracture-critical shall conform to the provisions of the *AASHTO/AWS Bridge Welding Code D1.5, Section 12, Fracture Control Plan (FCP) for Non-redundant Members.*

Fabrication and welding of other structural and miscellaneous steel shall conform to these specifications and *AWS Structural Welding Code D1.1 or AASHTO/AWS Bridge Welding Code D1.5,* as appropriate.

The Contractor shall give the Engineer at least 21 days advance notice of the beginning of contract work in the fabrication shop so that the Engineer can arrange for an inspection of the fabrication shop by a Department representative. Work shall not be performed in the shop on contract work before the Engineer has been notified.

The Contractor shall furnish a complete mill analysis showing chemical and physical results from each heat of steel for all units prior to fabrication. Each piece of steel shall be properly identified as follows:

Before cutting, pieces of steel other than steel conforming to ASTM A709, Grade 36, that are to be cut to smaller-sized pieces shall be legibly marked with the ASTM A6 specification identification color code or the material specification designation. The identification color code of the latest system adopted under ASTM A6 shall be used to identify material.

If requested by the Engineer, the Contractor shall furnish an affidavit from the fabricator certifying that the fabricator has marked and maintained the identification of steel in accordance with these specifications throughout the fabrication operation.

(a) **Welds:** Only welding or tack welding noted on the plans shall be performed on structural steel, reinforcing steel, or aluminum units.

Partial penetration welding shall not be allowed without the written permission of the Engineer.

Preheat shall be applied in accordance with the applicable AWS code for the thickness and grade of material, but in no case shall be less than 70 degrees F.

Structural units shall not be used as a worktable. Welding on other work shall be completed before parts are installed on units and shall conform to the following:

1. Groove welds in flange plates, cover plates, and longitudinal stiffeners shall be ground flush. Groove welds in legs of rigid frames, webs of exterior girders, and beams shall be ground flush on the exposed side. Cope holes shall not be filled. The perimeter of cope holes shall be ground smooth. Temporary erection bolt holes shall be filled with high-strength bolts and tightened in accordance with the specifications herein.

2. The Engineer will only allow electroslag and electrogas welding processes if he has pre-approved these in writing.

3. Welds that do not conform to the specifications as determined by visual inspection or nondestructive testing shall be repaired, or if not repairable, removed and replaced by the Contractor by methods permitted in the specifications or the Engineer will reject the entire piece. The Engineer will re-inspect repaired or replaced welds in accordance with the applicable nondestructive testing method.

4. The Contractor shall submit or shall have the fabricator submit to the Engineer a copy of the certificate of qualifications for each welder, welding operator, or tacker employed in the work. The Contractor shall also submit to the Engineer a certificate stating that the welder, welding operator, or tacker has not exceeded any period of 3 months since the date of qualification without performing satisfactory welding in the required process. The qualification certification shall state the name of the welder, operator, or tacker; name and title of the person who conducted the examination; type of specimens; position of welds;

results of tests; and date of the examination. The qualification certification shall be made by a Department approved agency.

Welds for reinforcing steel, including tack welds, shall conform to AWS D1.4.

Welding of aluminum shall conform to AWS D1.2.

Welds for tubular structures shall conform to AWS D1.1 for cyclically loaded tubular structures.

(b) **Straightening and Curving Rolled Beams and Plate Girders:**

1. **Straightening material:** Rolled material shall be straightened before being laid off or worked. When straightening is required, the fabricator shall use methods that will not damage the metal. If straightening is performed by heating, heating shall be performed in accordance with 2. herein.

   The Engineer will reject sharp kinks or bends in the material.

2. **Curving rolled beams and plate girders:** The Contractor shall have the fabricator submit a detailed procedure for the method of heat curving beams or girders.

   Heat shall be applied so as to bring the steel to the temperature required for heat curving as rapidly as possible but not to more than 1200 degrees F, except in the case of steel conforming to ASTM A709 HPS 70W, which shall be no more than 1150 degrees F. The Engineer will reject the unit when any portion of a unit is heated to a temperature in excess of 1200 degrees F, or any ASTM A709 HPS 70W when steel is heated in excess of 1150 degrees F.

   a. **Sequence of operations:** Units shall be cambered before heat curving and shall be heat curved in the fabrication shop before painting.

      Longitudinal stiffeners shall be heat curved or cut separately and then welded to the curved units. When cover plates are to be attached to the rolled beams, they may be attached before heat curving if the total thickness of one flange and cover plate is less than 2 1/2 inches and the radius of curvature is more than 1,000 feet. For other rolled beams with cover plates, beams shall be heat curved before cover plates are attached. Cover plates may be either heat curved or cut separately and then welded to the curved beam.

   b. **Camber compensation:** To compensate for the loss of camber of heat-curved units in service having a radius of 800 feet or less, additional camber shall be provided in the units. The amount of additional camber at the midlength of the unit shall be C_h for units having a radius less than 500 feet and 1/2 C_h for units having a radius from 500 feet to 800 feet. C_h shall be computed as follows:

      $$C_h = \frac{0.02L^2F_y}{EY_o}$$

      where:

      L = the length, in inches, of the unit specified to be cambered
      F_y = the specified minimum yield point of the flange in kips per square inch

E = the modulus of elasticity in kips per square inch
Y_o = the distance from the neutral axis to the extreme outer fiber in inches (maximum distance for nonsymmetrical sections).

The additional camber, C'_h, at any other point in the unit shall be computed as follows:

$$C'h = \frac{C' \text{ x } C_h}{C}$$

where:

C = the camber specified at midlength in the design plans
C' = the camber specified at any other point in the design plans.

The additional camber provided shall be shown on the working drawings.

c. **Type of heating:** Where heat curving is permitted by the plans, plate girders and rolled beams may be curved by either continuous or V-type heating. Heat curving shall not be performed until camber conforms to the requirements of the specifications and plans.

(1) **Continuous method:** A strip along the edge of the top and bottom flange shall be heated simultaneously. The strip shall be of sufficient width and temperature to obtain the required uniform curvature.

(2) **V-type method:** The top and bottom flanges shall be heated in truncated triangular or wedge-shaped areas having their base along the flange edge and spaced at regular intervals along each flange. Spacing and temperature shall be as required to obtain the required uniform curvature. Heating shall progress simultaneously along the outside surface of the top and bottom flange. When the flange thickness is 1 1/4 inches or greater, heat shall be applied simultaneously to the inside flange surface (surface that intersects with the web) and outside flange surface.

d. **Position for heating:** The unit may be heat curved with the web in the vertical or horizontal position. When curved in the vertical position, the unit shall be braced or supported so that the tendency of the unit to deflect laterally during the heat-curving process will not cause the unit to overturn.

When curved in the horizontal position, the unit shall be properly supported to obtain a uniform curvature. The bending stress in the flanges attributable to the dead weight of the girder shall not exceed the allowable design stress. When the unit is positioned horizontally for heating, safety catch blocks shall be maintained at the midlength of the unit within 2 inches of the flanges at all times during the heating process.

The Engineer will reject any method of handling, supporting, or loading that may cause or causes the unit to distort permanently (yield without the application of heat).

e. **Artificial cooling:** The Engineer will not permit quenching to cool the steel. Cooling with dry compressed air will be permitted after the steel has naturally cooled to 600 degrees F.

f. **Measurement of curvature:** Prior to final acceptance of horizontal curvature, welding and heating operations shall have been satisfactorily completed and the unit cooled to a uniform temperature.

(c) **Camber:** Rolled beams and plate girders shall be cambered in the amount indicated on the plans. Camber shall approximate a parabolic curve. Camber for rolled beams shall be obtained by heat-cambering methods. For plate girders, the web shall be cut to the prescribed camber with a suitable allowance for shrinkage attributable to cutting, welding, and heat curving.

Tolerance for the specified camber of welded beams or girders before erection shall not exceed the greater of (A) or (B) where:

$$(A)+1/4 \text{ inch} \times \frac{\text{Feet of test length}}{10} \qquad \text{(Not to exceed 3/4 inch)}$$

$$(B)+1/8 \text{ inch} \times \frac{\text{Feet from nearest end}}{10}$$

Tolerance for the specified camber of rolled beams as measured at midlength shall be:

$$+1/8 \text{ inch} \times \frac{\text{Feet of test length}}{10}$$

Camber shall be measured with the beam or girder laying on its side on a flat horizontal surface.

(d) **Bolt Holes:** Bolt holes shall be punched, drilled, or reamed as specified herein. Holes shall not be flame cut or electrode cut.

Finished holes shall be 1/16 inch larger than the nominal bolt size. Oversized holes will be permitted only with the permission of the Engineer or in accordance with Section 407.06(b). Finished holes shall be within 1/16 inch of the plan gage and match-mating holes, with no offset greater than 1/16 inch. The Engineer will reject holes varying more than 1/16 inch from the plan gage.

Burrs shall be removed from holes.

1. **Punched holes:** The diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch.

   Holes shall not be punched in structural carbon steel with a specified yield point of 36 ksi or less, thicker than 3/4 inch, or in high-strength structural steel with a specified yield point above 36 ksi, thicker than 5/8 inch. When these thicknesses are exceeded, holes shall be subdrilled and then reamed or drilled full size.

   Holes may be punched full size (1/16 inch larger than bolts) in secondary units or members and their connecting plates or angles. Holes shall be clean cut, without torn or ragged edges. The Contractor will not be permitted to punch full sized holes in structural members identified in Section 407.04(k)1 or in the Plans, Special Provisions, or elsewhere in the Contract as main (primary) members or units.

   Subpunched holes that are to be reamed shall be 3/16 inch smaller in diameter than the nominal bolt size. The location offset between subpunched holes assembled for reaming shall be not more than 1/8 inch.

2. **Reamed and drilled holes:** Holes shall be subdrilled and reamed to 1/16 inch larger than bolts. If numerically controlled drilling equipment is used, the Contractor may be required by means of check assemblies to demonstrate that this procedure can consistently produces holes that conform to the dimensions shown on the plans. Connections shall conform to this section. Shop assembly for numerically controlled drilled connections shall conform to AASHTO's *Standard Specifications for Highway Bridges.*

(e) **Cut Edges of Plates and Shapes:** Cut edges shall have their corners rounded to a radius of 1/16 inch.

Sheared edges of plates more than 5/8 inch in thickness shall be planed to a depth of 1/4 inch.

Structural steel may be flame cut provided a smooth surface free from cracks and notches is achieved and that an accurate profile is achieved by the use of a mechanical guide. The Contractor will be allowed to free-hand cut only where approved by the Engineer.

(f) **Facing of Bearing Surfaces:** The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall conform to the following surface roughness requirements as defined in ANSI B46.1:

Member	**Roughness Height (microinches)**
Steel slabs	2,000
Heavy plates in contact in shoes to be welded	1,000
Milled ends of compression units, stiffeners, and fillers	500
Bridge rollers and rockers	250
Pins and pin holes	125
Sliding bearings	125

(g) **Bent Plates:** The radius of bends shall be such that the plate does not crack. The minimum bend radii, measured to the concave face of the metal, shall be as follows:

Thickness (t) (inches)				
Up to 1/2	**Over 1/2 to 1**	**Over 1 to 1 1/2**	**Over 1 1/2 to 2 1/2**	**Over 2 1/2 to 4**
2*t*	2 1/2*t*	3t	3 1/2*t*	4*t*

Low-alloy steel more than 1/2 inch in thickness may require hot bending for small radii. If a shorter radius is essential, the plates shall be bent hot at a temperature of not more than specified in Section 407.04(b) 2.

Before bending, the Contractor shall round the corners of the plate to a radius of 1/16 inch throughout the portion of the plate where the bending is to occur.

(h) **Annealing and Stress Relieving:** Structural units that are indicated on the Plans, the Specifications, or elsewhere in the Contract to be annealed or normalized shall have finished machining, boring, and straightening done after heat treatment. The fabricator shall uniformly maintain temperatures throughout the furnace during heating and cooling cycles so that the temperature of any two points on the unit will not differ at any time by more than 100 degrees F.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used. Proper instrumentation, including recording pyrometers, shall be provided for determining the temperature of units in the furnace at any time. The fabricator shall keep and maintain records of the treatment operation for inspection by the Engineer.

(i) **Pins and Rollers:** Pins and rollers shall be forged or fabricated of cold-finished carbon steel shafting. In pins larger than 9 inches in diameter, a hole at least 2 inches in diameter shall be bored full length along the axis. Threads for pins shall conform to the *American National Coarse Thread Series, Class 2,* free fit, except that pin ends having a diameter of 1 3/8 inches or more shall be threaded six threads to the inch.

Pinholes shall be bored at right angles with the axis of the unit. Boring holes in fabricated units shall be performed after welding is completed. The diameter of the pinhole shall not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter or by 1/32 inch for larger pins.

(j) **Stud Shear Connectors:** The diameter of the connectors shall be 7/8 inch, and the length shall be at least 4 inches. Heads shall project at least 2 inches above the plane of the bottom of the deck slab and shall be 3 inches below the plane of the top of the deck slab. In determining the required length of the shear connectors, the computed dead-load deflection, vertical curve correction, and actual (measured) camber of the fabricated beam shall be taken into consideration. Studs 3/4 inch in diameter may be substituted for 7/8-inch studs, or vice versa, by making an adjustment in the pitch proportionally to the cross-sectional area of the studs with a spacing of not more than 24 inches. Studs shall be adjusted as necessary to provide clearance for bolts in bolted splices. The fabricator's shop plans shall show the location (spacing) and heights of the stud shear connectors regardless of whether they will be welded in the shop or in the field. Studs shall be end welded automatically or semi-automatically to the steel beams. The method and equipment used shall be as recommended by the manufacturer of the studs and must be preapproved by the Engineer. Studs to be field welded shall be welded after structural steel is erected and metal decking or other walking or working surface is in place; however, structural steel with shop-applied studs may be erected provided erection is performed in accordance with Section 107.17.

(k) **Shop Assembly:** Assembly shall be in accordance with the following:

1. **Holes for field connections and field splices** in the following main units shall be drilled with units assembled or numerically controlled drilled. Holes shall not be punched full size in the following main units or their connecting plates and angles:

   a. Girders and rolled beams.

   b. Trusses, arches, and towers.

   c. Bent and rigid frames.

   d. Diaphragms, crossframes, or bracing attached to straight steel box girders or attached to curved rolled beams, curved I girders, or curved steel box girders.

   e. Any member designated on the plans or in other contract documents as "fracture critical."

   f. Any other main (primary) member(s) or unit(s) identified as such in the Plans, Special Provisions, or elsewhere in the Contract.

2. **Holes for floor-beam and stringer-end connections** shall be subpunched or subdrilled and reamed to a template or reamed while assembled. Templates used for connections on like parts shall be located so that the parts are identical and require no match marking.

3. **Surfaces of metal in contact** shall be cleaned before assembly. Parts shall be drawn together and securely clamped before drilling or reaming. Units shall be free from twists, bends, or other deformation.

4. **Drift pins** may be used only to bring parts into position. If any holes must be enlarged to admit bolts, the hole shall be reamed only to the extent permitted in these specifications.

5. **Connecting parts assembled in the shop** for the purpose of reaming holes shall be match marked. Miscellaneous parts that are not completely bolted in the shop shall be secured by partial bolting to prevent loss or damage in shipment and handling.

(l) **Inspection:** The Contractor shall perform quality control inspection, including, but not limited to, visual inspection and nondestructive testing. Visual inspection shall be performed in accordance with VTM-33 by inspectors qualified in accordance with *ANSI/AASHTO/AWS Bridge Welding Code D1.5 or other appropriate AWS welding code,* as applicable. Radiographic and magnetic particle testing shall be performed in accordance with VTM-29 and VTM-31, respectively. Ultrasonic testing, when specified, shall be performed in accordance with VTM-30. Railroad structures and fracture-critical units shall be given radiographic and ultrasonic inspections in accordance with VTM-44.

The Engineer reserves the right to perform quality assurance inspection. The Contractor shall provide and furnish a Type III field office in accordance with Section 514 for use in the Engineer's inspection of material and workmanship within the fabrication shop. In addition to the requirements specified therein, the Contractor shall provide telephone service by a direct access line, a telephone, and maintenance thereof. Costs for installation of the direct access line, the telephone, maintenance, and local service shall be borne by the Contractor. The cost for long-distance will be borne by the Department. The Engineer shall be allowed free access to the necessary parts of the work. One reinspection of corrective action taken on defective material or fabrication will be performed by the Department without cost to the Contractor; the cost of further reinspections shall be borne by the Contractor. The cost of any retests made necessary by the replacement of rejected welds shall be borne by the Contractor. When requested, the Contractor shall provide working space for radiographic examination of welds and shall make such space available for at least 6 hours per inspection visit.

407.05—Handling, Storing, and Shipping Materials

Materials and units shall be placed at least 4 inches above the ground on platforms, skids, or other supports. They shall be supported in such a manner that they will not be overstressed or become deformed or otherwise damaged. High-strength bolts, nuts, and washers shall be stored in identifiable original containers in protective storage subject to the approval of the Engineer. Materials shall be kept free from dirt, grease, and other foreign materials; protected from corrosion; and properly drained.

(a) **Material Furnished by Others:** If the Contract is for erection only, the Contractor shall check the material delivered against the shipping lists and promptly report to the Engineer, in writing, any shortage or damage. The Contractor shall be responsible for the loss of any material in the Contractor's care or for any damage incurred after the shipment is received.

(b) **Marking and Shipping:** Each unit shall be identified with an erection mark, and an erection diagram shall be furnished.

The Contractor shall furnish as many copies of shipping statements and erection diagrams as the Engineer may require. The weight of each unit shall be shown on the statements. Units having a weight more than 3 tons shall have the weight marked thereon. Structural units shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or damaged. Main structural units shall be supported at their bearings or at such other supports as may be approved or directed by the Engineer.

Bolts of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins; small parts; and packages of bolts, washers, and nuts shall be shipped in boxes, crates, kegs, or barrels. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

407.06—Erection Procedures

If the Contract is for erection only, the Contractor will receive the materials designated for use in the finished structure, free of charges, at the place designated, loaded or unloaded as specified. The Contractor shall promptly unload material the Contractor is required to unload and shall be responsible for demurrage charges.

Before starting the work of erection, the Contractor shall fully inform the Engineer as to the method proposed to be followed and the size or capacity, amount and type of equipment to be used, which shall be subject to the Engineer's approval. No work shall be started until such approval has been obtained. The approval of the Engineer shall not relieve the Contractor of the responsibility for ensuring the safety of the Contractor's methods or equipment or performing the work in accordance with the plans and these specifications.

When new steel beams are connected to existing steel beams, the Contractor shall temporarily connect the diaphragms to the beams, in a manner to allow for the deflection of the new beams after placement of the deck slab concrete. After the deck slab concrete has cured, the Contractor shall connect the diaphragms as shown on the plans.

The Contractor shall erect steel, remove temporary construction, and perform all work required to complete the structure(s) as specified in the Contract, including removing the old structure(s), if specified, in accordance with the plans and the specifications.

(a) **Field Welding:** When erection includes field welding, field welding and inspection shall be performed in accordance with Section 407.04.

(b) **Misfits Field Assembly:** Correction of misfits will be considered a legitimate part of erection provided corrective work is necessary on not more than 10 percent of the holes in a continuous group of 10 or more holes or 10-percent of the number of individual pieces with fewer than 10 holes.

Drift pins may be used only to bring parts into position. Misaligned holes shall be corrected, where allowed by the Engineer, by reaming. However, no hole shall be elongated in any separate part to more than 1/8 inch larger than the nominal bolt size when a reamer not more than

1/16 inch larger than the nominal bolt size is used. The misalignment of holes before reaming shall not be more than 1/8 inch.

Necessary work for alignment and assembly exceeding these tolerances will be considered caused by shop errors and will be promptly reported to the responsible party. Damage resulting from handling or transportation shall be promptly reported to the Engineer.

When the Contract provides for complete fabrication and erection, the Contractor shall be responsible for misfits and errors and shall make the necessary corrections or replacements. When the Contract is for erection only, the Engineer, with the cooperation of the Contractor, will keep a record of labor and material used, and the Contractor shall render, within 30 days, an itemized bill approved by the Engineer.

(c) **Assembly of Structural Connections Using High-Strength Bolts:** Field connections shall be made with high-strength bolts 7/8 inch in diameter fabricated in accordance with ASTM A325 unless otherwise specified. The Engineer will give consideration to the substitution of adequately designed welded connections if requested in writing by the Contractor.

1. **Bolts, nuts, and washers:** Bolts, nuts, and washers shall conform to Section 226 and shall each be from one manufacturer on any one structure unless otherwise approved by the Engineer. In addition, each bolt, nut, and washer combination, when installed, shall be from the same rotational-capacity lot. Prior to installation, the Contractor shall perform a field rotational-capacity test on two nut, bolt, and washer assemblies for each diameter and length in accordance with Section 226.02(h)3. Bolts fabricated in accordance with ASTM A490 and galvanized bolts fabricated in accordance with ASTM A325 shall not be reused. Retightening previously tightened bolts, which may have been loosened by the tightening of adjacent bolts, shall not be considered a reuse. Other bolts may be reused only if approved by the Engineer. Threads of plain (uncoated) bolts shall be oily to the touch when installed. Galvanized nuts shall be lubricated by lubricant containing a visible dye. Threads of weathered or rusted bolts shall be cleaned of loose rust, scale, and debris and relubricated. Lubricant shall be as recommended by the fastener manufacturer.

2. **Bolted parts:** Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

   Before assembly, connecting surfaces, including areas adjacent to the washers, shall be free from scale (except tight mill scale) and shall also be free of burrs, dirt, and other foreign material that will prevent solid seating of the parts. Surfaces for bolted splices in main units fabricated from weathering steel and joint surfaces for other connections, when required on the plans, shall be blast cleaned in accordance with Section 411.04(a) 5. The minimum area to be blast cleaned shall be 12 inches beyond the outermost row of bolts in the flanges and web and shall include the entire contact surfaces of the splice plates and filler plates. Contact surfaces shall be free from dirt, loose scale, burrs, oil, lacquer, and rust inhibitor.

3. **Installation:** Only as many fasteners as are anticipated to be installed and tightened during a work shift shall be taken from protected storage. Uninstalled fasteners not used shall be returned to protected storage at the end of the shift. Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening.

When bolts fabricated in accordance with ASTM A490 are used with steel having yield points less than 40 kips per square inch, hardened washers shall be installed under the nut and bolt head.

An approved tension-indicating device shall be at all job sites where high-strength fasteners are being installed and tightened. Bolt tensioning devices and complete bolt assemblies shall be tested with this device at the start of construction and as required during the installation procedure. The calibrating device shall be capable of indicating actual bolt tension within a tolerance of 2 percent. The manufacturer or an approved testing agency shall have checked the device for the accuracy specified herein within the previous 12 months. Record of calibration testing and certification shall be available to the Engineer if requested. When turn-of-nut or direct tension indicators are used, a representative sample of at least three complete bolt assemblies of each diameter, length, and grade shall be tested. For short grip bolts, direct tension indicators with solid plates may be used to perform the required testing. However, the direct tension indicator shall be checked with a longer grip bolt in the approved tension-indicating device prior to testing with short grip bolts.

A flat washer may be used when the surface adjacent to the bolt head or nut does not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism. The threaded ends of bolts shall be placed on the inside, where practicable, for protection from weather.

The length of bolts shall be such that the end of the bolt will be flush with or outside the face of the nut when completely installed without overtensioning the bolt.

Fasteners shall be tightened to provide, when all fasteners in the connection are tight, at least the minimum bolt tensions shown in Table lV-3 for the size of the fastener used. Tightening shall be performed by the turn-of-nut method or by the use of a direct tension indicator using a load indicator washer. Power wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

If required because of bolt-entering and wrench-operation clearances, tightening by either procedure may be done by turning the bolt while the nut is prevented from rotating provided both the head and nut bear against surfaces having slopes not greater than 1:20.

The required minimum bolt tension is equal to 70 percent of specified minimum tensile strengths of bolts rounded to the nearest kip as specified in ASTM A325 and ASTM A490. *Snug tight* is defined as the tightness attained when a power wrench begins to impact solidly or when the bolts are firmly hand tightened with a spud wrench such that the complete area of the connecting surfaces are brought into firm contact with each other. Snug tightening shall progress systematically from the most rigid part of the connection to the free edges, and then the bolts of the connection shall be retightened in a similar systematic manner as necessary until all bolts are simultaneously snug tight and the connection is fully compacted.

a. **Turn-of-nut tightening:** Turn of the nut method shall not be used for tightening high-strength bolts. This prohibition can only be waived by written approval of the

TABLE IV-3
Bolt Tension

	Required Min. Bolt Tension (lb.)	
Bolt Size	**ASTM A 325 Bolts**	**ASTM A 490 Bolts**
1/2	12,000	15,000
5/8	19,000	24,000
3/4	28,000	35,000
7/8	39,000	49,000
1	51,000	64,000
1 1/8	56,000	80,000
1 1/4	71,000	102,000
1 3/8	85,000	121,000
1 1/2	103,000	148,000

District Bridge Engineer or if specifically required by the Contract. Request to use turn of the nut method in lieu of Direct Tension Indicator (DTI) washers shall be accompanied by an explanation as to why use of this method is in the best interest of the Department.

When the turn-of-nut method for tightening high-strength bolts is approved for use, bolts shall be installed in all holes and tightened to a snug tight condition to ensure that all parts of the joint are brought into contact with each other. Bolts shall be given a suitable match-mark and tightened additionally by the applicable amount of nut rotation specified in Table IV-4, progressing systematically from the most rigid part of the joint to its free edges. During this operation, there shall be no rotation of the part not turned by the wrench. Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance is minus 0 plus 30 degrees; for bolts installed by 2/3 turn and more, the tolerance is minus 0 plus 45 degrees.

b. **Direct Tension Indicators (DTI):** Direct tension indicator washers shall be used for all high strength bolts, and installation shall be in accordance with Section 407.06(c)3; however, the indicator washer shall not be considered a substitute for the required hardened washer under the turned element. The indicator washer may be considered a substitute for the hardened washer required under the unturned element when bolts conforming to ASTM A490 are used with steel conforming to ASTM A709, Grade 36. Direct tension-indicator washers shall not be painted or coated with any epoxy or similar material prior to installation. The normal installation shall consist of the load indicator washer being placed under the unturned bolt head or unturned nut. However, if conditions require installation under the turned bolt portion, a hardened flat washer or nut face washer shall be fitted against the tension-indicating protrusions. Tension-indicating washers shall not be substituted for the hardened washers required with short-slotted or oversized holes but may be used in conjunction with them.

The initial installation shall be to a snug tight condition, after which final tightening shall be performed by progressing systematically from the most rigid part of the connection to its free edges until the tension indicators on all bolts are closed to at least the required gap.

TABLE IV-4
Nut Rotation From Snug Tight Condition

Bolt Length Measured From Underside of Head to Extreme End of Point	Disposition of Outer Faces of Bolted Parts		
	Both Faces Normal to Bolt axis	One Face Normal to Bolt Axis and Other Face Sloped Not More Than 1:20 (Bevel Washer Not Used)	Both Faces Sloped Not More Than 1:20 From Normal to Bolt Axis (Bevel Washers Not Used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
More than 4 but not more than 8 diameters	1/2 turn	2/3 turn	5/6 turn
More than 8 but not more than 12 diameters	2/3 turn	5/6 turn	1 turn

The required gap shall be 0.015 inch or less between the indicator and the underside of the bolt head or nut when no washer is used with the indicator. If a hardened flat washer is used, the required gap shall be 0.010 inch or less between the indicator and the hardened flat washer. If the indication gap is closed completely, do not continue with additional tightening.

4. **Inspection:** The Engineer will observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and will determine that all bolts are appropriately tightened.

   a. Inspection of installations using tension-indicating washers will normally be accomplished by checking the residual gap with a metal feeler gage. Installations will be considered satisfactory if the average gap per bolt installation does not exceed 0.012 inch for a tension-indicating washer installed under the bolt head or 0.010 inch for a tension-indicating washer installed in conjunction with a hardened, flat washer or, if the gap has been reduced to zero, at any point around the indicator.

      The Engineer may verify by calibrated torque wrench that the work conforms to Table IV-3 regardless of the method of installation.

   b. Turn of the Nut Method: When the Engineer approves the turn of the nut method for use, the Contractor, in the presence of the Engineer, shall use an inspection wrench to inspect the tightened bolts. No fewer than three typical bolts from the lot to be installed having a length representative of bolts used in the structure shall be placed individually in a calibration device capable of indicating bolt tension at least once each working day. There shall be a washer under the part turned in tightening each bolt if washers are so used on the structure. If no washer is used, the material abutting the part turned shall be of the same specification as that used on the structure.

      When the inspection wrench is a torque wrench, each calibration test bolt shall be tightened in the calibration device to the minimum tension specified for its size in Table lV-3. The inspection wrench shall then be applied to the tightened bolt, and

the torque necessary to turn the nut or bolt head 5 degrees (approximately 1 inch at 12-inch radius) in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job-inspection torque. The torque wrench shall be a dial torque wrench and shall have been checked for accuracy within 1 year of its current use by the manufacturer or an approved testing agency.

Bolts that have been tightened in the structure shall be inspected in the presence of the Engineer by applying, in the tightening direction, the inspection wrench and its job-inspection torque to 10 percent of the bolts but not fewer than two bolts selected at random in each connection. If no nut or bolt head is turned by this application of the job-inspection torque, the connection will be accepted as properly tightened. If any nut or bolt head is turned by the application of the job-inspection torque, this torque shall be applied to all bolts in the connection. Bolts whose nut or head is turned by the job-inspection torque shall be retightened and reinspected, or all the bolts in the connection may be retightened and the connection resubmitted for the specified inspection.

A written record of the inspection results, indicating the location, test dates, and the results of each inspection shall be submitted to the Engineer as a condition for payment when the turn of the nut method is used.

(d) **Abutting Joints:** Abutting joints in compression units and in tension units where so shown on the plans shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not be more than 3/8 inch.

(e) **Alignment at Bearings and Transverse Connections:** Beam ends, bearing stiffeners, and webs of girders and rolled structural shapes and other beam sections shall be vertical.

Diaphragms or cross struts composed of channel sections not attached to bearing stiffeners may be fitted with the planes of their webs perpendicular to the planes of the flanges of longitudinal beams on gradients provided the channel flanges are turned to the downgrade side where practicable.

Rolled beams and plate girders and their bearing assemblies shall be fabricated so that their bottom bearing surfaces lie in horizontal planes when in their erected positions. Steel plates for use with flexible bearing pads shall be beveled to conform to this requirement.

(f) **Falsework:** Falsework shall be designed, constructed, and maintained for the loads that will rest upon it. The Contractor shall prepare and submit to the Engineer, for review and acceptance, plans for falsework or for changes to an existing structure necessary for performing the work and maintaining traffic. The Department's review of the Contractor's plans shall not relieve the Contractor of any responsibility relative to safely performing the work.

The Contractor shall have a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia inspect the completed falsework assembly supporting a bridge superstructure prior to placing loads. The Professional Engineer shall provide a certification based upon visual inspection of the completed falsework assembly that the falsework assembly conforms to the approved working drawings. However, such certification shall not require an exhaustive inspection or testing or make the Professional Engineer liable for any

deficiencies in workmanship or materials by the Contractor or for such conditions that cannot be ascertained from a visual inspection.

(g) **Straightening Material in the Field:** Straightening plates and angles or other shapes shall be done by methods that will not produce fracture or damage. Metal shall not be heated unless permitted by the Engineer, in which case the heating shall not exceed the temperatures specified in Section 407.04(b)2 as measured by temperature-indicating crayons or other approved means. After heating, the metal shall be cooled naturally.

The surface of the metal shall be carefully inspected for evidence of fracture following straightening of the shape. If damage is caused by the Contractor, the cost of inspection shall be borne by the Contractor. Any damage attributable to the Contractor will be handled in accordance with Section 108.09(a).

(h) **Assembling Steel:** Bearing surfaces that will be in permanent contact in the finished structure shall be cleaned before units are assembled.

Permanent bolts in splices of butt joints of compression units and permanent bolts in railings shall not be tightened until blocking and falsework have been removed. Immediately after erection, splices, and field connections shall have at least one-half of the holes filled with bolts or cylindrical erection pins, of which at least one-half of those connections shall be bolts. Bolts shall be placed in such a manner that they are evenly distributed throughout the spliced connection. Splices and connections carrying traffic during erection shall have holes filled with high-strength bolts that have been tensioned and checked prior to opening the structure to traffic.

Erection bolts shall be of the same nominal diameter as the high-strength bolts, and cylindrical erection pins shall be 1/32 inch larger.

(i) **Finishing:** Unpainted weathering steel units shall be abrasive blast cleaned in the shop after fabrication. Abrasive blast cleaning shall conform to SSPC-SP6/NACE No. 3, *Commercial Blast Cleaning.* Upon completion of erection and concrete work, the fascia of exterior beams and girders of unpainted weathering steel shall be cleaned in accordance with Section 411.04(a) 3.

Wherever a depressed area is formed where water can be trapped or held, such as the juncture between a beam or girder web and splice plate on a bottom flange, the area shall be completely sealed with polyurethane, or other approved sealant, conforming to *FS TT-S-00230C, Type II, Class A,* prior to painting. When the sealant is used in conjunction with weathering steel, the sealant shall be integrally pigmented to a dark bronze color.

Weathering steel shall be cleaned and coated in accordance with Section 411.

(j) **Protective Coatings:** Non-stainless ferrous metal surfaces shall be cleaned and painted in accordance with Section 411. Galvanizing shall conform to Section 233.

When new steel beams are connected to existing steel beams, the Contractor shall temporarily connect the diaphragms to the beams in a manner to allow for the deflection of the new beams after placement of the deck slab concrete. After the deck slab concrete has cured, the Contractor shall connect the diaphragms as shown on the plans

407.07—Measurement and Payment

Structural steel, including beams, girders, and miscellaneous steel will be paid for at the contract lump sum price or, when specified, in pounds of the specified metal in the fabricated structure, including bolts shipped, as weighed on a shop scale. However, any weight more than 1.5 percent above the computed weight for the entire structure will not be included for payment. The weight of erection bolts, field paint, boxes, crates, and other containers used for packing and materials used for supporting units during transport will not be included.

In contracts having a pay item for structural steel, structural steel components, including shear connectors, bearing plates, bearing assemblies and pads, anchorages, expansion joints, bolts, and pedestals, whether embedded in concrete or not, and other metals or materials shall be included in the price for structural steel unless paid for as a separate pay item(s). Prices for structural steel shall include furnishing, fabricating, galvanizing, transporting, storing, erecting, and field painting. Prices for structural steel shall also include welding where required, costs for services of certified welding inspectors, and costs for the services of non-destructive testing technicians where required.

If specified in the Contract or permitted by the Engineer, weights of specific metals may be computed, in which case the computations shall be made on the following basis:

(a) The unit weights of metal shall be as follows:

Material	Lb./Cu Ft
Aluminum, cast or wrought	173.0
Brass	536.0
Bronze, cast	536.0
Copper alloy	536.0
Copper, sheet	558.0
Iron, cast	445.0
Iron, malleable	470.0
Iron, wrought	487.0
Lead, sheet	707.0
Steel, cast, copper-bearing, carbon, silicon, nickel, and stainless	490.0
Zinc	450.0

Pay items and pay units for specific metals will be as specified in the contract.

(b) The weight of rolled shapes and plates up to and including 36 inches in width shall be computed on the basis of their nominal weights and dimensions as shown on the approved working drawings, deducting for copes, cuts, and open holes except bolt holes.

The allowed percentage of overrun in weight specified in AASHTO M 160 shall be added to the nominal weights of plates more than 36 inches in width.

(c) The weight of high-strength bolt heads, nuts, and washers shall be included on the basis of the following:

Diameter (in)	Weight Per 100 (lbs.)
1/2	18
5/8	31
3/4	52
7/8	78
1	111
1 1/8	152
1 1/4	206

The weight of high-strength bolts includes the head, the nut, the projection of the bolt through the nut, and one flat washer per bolt.

(d) The weight of castings shall be computed from the dimensions shown on the approved working drawings, deducting for open holes. To this weight shall be added 10 percent for fillets and overrun.

(e) As an allowance for shop paint, 0.4 percent shall be added to the total computed weight of metal.

(f) The weight of metal railing shall be included unless it is a separate pay item.

(g) Steel grid flooring will be measured and paid for in accordance with Section 409.

(h) The weight of steel or brass shims required shall be included.

Fabrication of structural steel, when a pay item, shall include fabricating; cleaning and shop painting structural units; bolts; nuts; washers; and transporting and storing units at the designated location.

Erection of structural steel, when a pay item, shall include equipment and incidentals required to transport units from their designated storage location to the erection site, unloading and storing, erecting, cleaning, and field painting.

The cost of testing unit(s) required by the specifications shall be included in the price for the structural unit(s).

Payment will be made under:

Pay Item	Pay Unit
Structural steel (Type)	Lump sum or Pound
Fabrication of structural steel (Type)	Lump sum
Erection of structural steel (Type)	Lump sum

SECTION 408—BEARING DEVICES AND ANCHORS

408.01—Description

This work shall consist of furnishing and installing bearing plates, pads, rockers, expansion devices, anchors, or other devices used in conjunction with bearings or anchorages at superstructure supports

in accordance with these specifications and in conformity with the plans or as established by the Engineer.

408.02—Materials and Fabrication

(a) **Bearing material and bearing pads** shall conform to Section 237 and those specified herein.

(b) **Metal plates, shapes, bolts, and bars** shall be of structural steel conforming to Section 226 and those specified herein.

(c) **Metal parts** shall be fabricated in accordance with Section 407.

(d) **Painting** shall conform to Section 411.

(e) **Galvanizing** shall be performed in accordance with Section 233.

408.03—Procedures

(a) **High-Load Multi-Rotational Bearings:** High-load multi-rotational bearings including sole and masonry plates shall be any type shown on the plans and shall be provided by only one manufacturer.

Other high-load multi-rotational bearing designs may be acceptable provided they are supported by engineering analysis, engineering calculations, data and evidence of acceptable service life for the proposed materials, tests, and proven experience for the proposed bearing designs acceptable to the Engineer for the loads, forces, movements, and service conditions specified. Engineering analysis shall be performed by a Professional Engineer holding a valid current license to practice engineering in the Commonwealth of Virginia.

Notations: All dimensions are in inches:

C	= Clearance between pot and surface immediately above or below it.
Dp	= Diameter of elastomeric disc, inside diameter of pot bearing.
Ds	= Projected diameter of loaded spherical segment.
G	= Depth of pot bearing cavity.
k	= Depth of chamfer on pot bearing piston.
Fy	= Yield strength of steel in ksi.
Lh	= Horizontal design load on bearing in kips.
Lv	= Vertical design load on bearing in kips.
Θ	= ArcTan (Lh/Lv min)
Rb	= Minimum design rotation requirement of bearing in radians.
Rc	= Maximum construction tolerance rotation in radians.
Rs	= Minimum design rotation requirement of structure in radians.
Rmax	= Maximum radius to prevent unseating of spherical surfaces.
S	= Side of a square pot bearing plate.
t	= Thickness of elastomeric disc.
w	= Piston face width, pot bearing.
OD	= Outside diameter of a round pot.

1. **Design:** High-load multi-rotational bearings shall be designed to accommodate the loads, forces, and movements specified in the bearing schedule. Particular care shall be taken to ensure that all components of the bearings provide adequate capacity for the horizontal loads and forces specified.

   Maximum design stresses for bearing components shall not exceed the allowable design stresses of the applicable issue of the *AASHTO Standard Specifications for Highway Bridges* and the applicable sections of these specifications.

   Minimum rotation capacity, Rb, shall be the sum of Rc + Rs. Rc equals 0.02 radians. Rs equals the larger of 0.01 radian or the actual design rotations.

   The minimum horizontal bearing design capacity for fixed and guided expansion bearing types shall be 10 percent of the vertical capacity or as specified in the plans. The minimum horizontal bearing design for non-guided expansion bearing types shall be equal to the frictional resistance of bearing slide surfaces or as specified in the plans.

   Expansion bearings shall be designed for additional total movement capacity in each direction specified under "Design Movement" in the "Bearing Schedule." The additional total movement capacity shall be 10 percent of the design movement or 1 inch, whichever is greater. Spacing between the guides of the bearing does not require this additional movement capacity.

   Bearings shall be designed so that rotational and sliding elements can be replaced with a minimum of jacking movement not greater than 1 inch.

2. **Rotational elements—Pot bearings:**

   a. Pot: Pot inside diameter, Dp, shall be the same as that of the elastomeric disc.

      Depth of pot cavity, G, shall be equal to or greater than:

      [(DP/2) x (Rs + Rc)] + 0.1 inch + k + t + w

      where:

      k = 0 for flat sealing

      k = 1.7 x the ring cross-section diameter for round sealing rings where rings sit 100 percent in the chamfer

      k = 1.2 x the ring cross-section diameter for round sealing rings where rings sit half recessed in the elastomeric disc and half in the piston chamfer. The details for the k dimension are provided in the plans.

      Section thickness of the pot beneath the elastomer shall be a minimum of 3/4 inch or Dp x 0.06 for bearings directly on concrete and 1/2 inch or Dp x 0.045 for bearings directly on steel masonry plates.

      Minimum outer plan dimensions of pots shall be determined by analyzing horizontal loads, internal elastomer pressure, and piston force due to friction in shear, bending,

and tension, but the wall thickness shall in no case be less than the greater of 3/4 inch, 1.02 x Lv / (Dp x Fy) or the square root of (40 x Lh x Rb/Fy).

b. **Elastomeric disc:** Thickness of elastomeric disc, t, shall be equal to or greater than Rb x Dp/0.3.

Area of elastomeric disc shall be designed for an average stress of 3,500 pounds per square inch.

When using flat sealing rings, the upper edge of the disc shall be recessed to receive the rings so that they sit flush with the upper surface of the elastomeric disc.

The disc shall be lubricated with a silicone compound conforming to MIL-S-8660 (Military Specification) or other approved equal. Polytetrafluoroethylene (PTFE) "shear-reducer discs" shall not be used with flat rings.

c. **Piston:** Outside diameter of piston shall be Dp – 0.04 inch. Piston thickness shall be adequate to resist the loads imposed on it but shall not be less than 0.06 x Dp.

Piston thickness shall be adequate to provide clearance, C, between the top of the pot and the surface immediately above it as follows:

(1) C = Rb x (0.7 x S) + 0.12 inch for pots square in plan.

(2) C = Rb x (OD / 2) + 0.12 inch for pots round in plan.

Piston face width, w, is the part of the edge of the piston that contacts the pot wall. When designing pistons for horizontal forces, w shall not be less than the greater of 0.03 x Dp, 1/4 inch or 1.59 x Lh/(Dp x Fy).

Pistons for round seals shall have the lower corner chamfered at 45 degrees for a depth equal to 1.7 times the diameter of the seal where the seal is wholly within the piston thickness and 1.2 times the diameter where it extends into the elastomer for half its diameter.

d. **Elastomer sealing rings:**

Flat sealing rings shall conform to the following:

(1) Width shall be equal to or greater than the larger of 0.02 x Dp or 1/4 inch but shall not exceed 3/4 inch.

(2) Minimum thickness of each sealing ring shall be equal to or greater than 0.2 times the width.

(3) Three rings shall be used. Rings shall be a snug fit to the pot wall and have their ends cut at 45 degrees to the vertical and to the tangent of the circumference with a maximum gap of 0.050 inch when installed. Ring gaps shall be staggered equally around the circumference of pots. Rings shall be free of nicks, burrs, or sharp edges.

Round sealing rings shall conform to the following:

(1) Rings shall be rolled into a circle from rod and brazed or welded. They shall fit the pot snugly so that they are in full contact with the pot wall when installed.

(2) Ring diameters shall be equal to or greater than the larger of 0.0175 x Dp or 5/32 inch.

3. **Rotational elements—Spherical bearings with PTFE/stainless steel surfaces:**

a. **Rotational elements—Spherical concave surfaces—PTFE:** The spherical radius shall be determined such that the resulting geometry of the bearing is capable of withstanding the greatest ratio of horizontal load to vertical load under all loading conditions to prevent unseating the concave element. If required during construction, mechanical safety restraints shall be incorporated to prevent overturning of the bearing. Unseating of the curved surfaces relative to each other shall be prevented by transferring horizontal forces through specifically designed restraints or by control of the radius. Acceptable radius control is given when $R_{max} = D_s/[2 \times \sin(\Theta + R_c + R_s)]$. Calculations showing the determination of the radius shall be submitted to the Engineer for approval.

The projected area of the PTFE shall be designed for the following maximum average working stress:

Maximum Contact Stress for PTFE at the Service Limit State (ksi)

Material	Average Contact Stress		Edge Contact Stress	
	Permanent Loads	All Loads	Permanent Loads	All Loads
Unconfined PTFE:				
Unfilled Sheets	1.5	2.5	2.0	3.0
Filled Sheets with Maximum Filler Content	3.0	4.5	3.5	5.5
Confined Sheet PTFE	3.0	4.5	3.5	5.5
Woven PTFE Fiber over a Metallic Substrate	3.0	4.5	3.5	5.5
Reinforced Woven PTFE over a Metallic Substrate	4.0	5.5	4.5	7.0

The concave shall face down whenever possible.

Thickness of PTFE fabric in the compressed state shall be a minimum of 1/16 inch when measured in accordance with ASTM D 1777. Recessed sheet PTFE shall be at least 3/16-inch thick when the maximum dimension of the PTFE is less than or equal to 24 inches and 1/4 inch when the maximum dimension of the PTFE is greater than 24 inches. Woven fabric PTFE that is mechanically interlocked over a metallic substrate shall have a minimum thickness of 1/16 inch and a maximum thickness of 1/8 inch over the highest point of the substrate.

The minimum center thickness of the spherical surfaces shall be 3/4 inch.

Vertical clearance between rotating and non-rotating bearing parts shall be no less than 1/8 inch at maximum rotation.

b. **Rotational elements—Spherical concave surfaces—Bronze:** The spherical radius shall be determined such that the resulting geometry of the bearing is capable of withstanding the greatest ratio of horizontal force to vertical load under all loading conditions to prevent unseating the concave element. If required, mechanical safety restraints shall be incorporated to prevent overturning of the bearing. Bearing rotation of Rs + Rc radians shall be considered in the bearing design to prevent overturning or uplift of the bearing. Calculations showing the determination of the radius shall be submitted for the Engineer's approval.

The spherical element shall be made from the following or other approved bronze alloys:

(1) Type 1: ASTM B 22, Alloy C90500

(2) Type 2: ASTM B 22, Alloy C91100

(3) Type 3: ASTM B 22, Alloy C86300

The maximum design compressive stress for the projected area shall be:

- Type 1: 2,000 pounds per square inch.
- Type 2: 2,500 pounds per square inch.
- Type 3: 8,000 pounds per square inch.

The bearing surfaces shall have lubricant recesses consisting of either concentric rings, with or without central circular recesses with a depth at least equal to the width of the rings, or recesses. The recesses or rings shall be arranged in a geometric pattern so that adjacent rows overlap in the direction of motion.

The entire area of all bearing surfaces that have a provision for relative motion shall be lubricated by means of the lubricant-filled recesses. The lubricant-filled areas shall comprise not less than 25 percent of the total bearing surface. The lubricating compound shall be integrally molded at high pressure and compressed into the rings or recesses and project not less than 0.010 inch above the surrounding bronze plate.

The minimum center thickness of the spherical surface shall be 3/4 inch.

c. **Rotational elements—Spherical convex surfaces:** The convex element shall be designed for rotation, Rb = Rc + Rs.

The edge thickness shall be a minimum of 3/4 inch for bearings directly on concrete or 1/2 inch for bearings directly on steel masonry plates.
For PTFE/stainless and bronze/stainless rotational surfaces, the stainless surface shall conform to one of the following:

(1) Cold-formed stainless steel sheet complying to ASTM A 167 or A 240, Type 304, 0.060- to 0.090-inch thick, with a finish equal to or less than 20 micro-inch rms, connected to a structural steel substate by a continuous weld.

(2) Solid stainless steel conforming to ASTM A 240, Type 304 or 304L, with a finish equal to or less than a 20 micro-inch rms connected to a structural steel substate by a continuous weld.

(3) Stainless steel weld overlay a minimum of 3/32 inch thick with a finish equal to or less than 20 micro-inch rms on a structural steel substrate.

If sheet PTFE is used for guided surfaces, it shall be pigmented.

For bronze/carbon steel sliding surfaces, the surface finish shall be not more than 125 micro-inches rms.

4. **Rotational elements—Disc bearings:** Thickness of the disc, t, shall be equal to or greater than the larger of $\Delta + [(Rs + Rc) \times Dd \times 0.5]/\varepsilon$ max or $3.33 \times Dp \times (Rs + Rc)$

where:

Δ = deflection due to total compressive load
ε max = strain due to all effects except for long-term creep.

The instantaneous deflection of the disc under total load at the service limit state shall not exceed 10 percent of the thickness of the unstressed disc, and the additional deflection due to creep shall not exceed 8 percent of the thickness of the unstressed disc. Deflection caused by rotation shall not exceed the lesser of the instantaneous deflection under total load at the service limit state or 10 percent of the thickness of the unstressed disc.

The disc shall be designed for an average stress of:

(a) 3,700 pounds per square inch for Polyether Urethane Compound A.

(b) 5,000 pounds per square inch for Polyether Urethane Compound B.

The section thickness of the plate beneath the disc shall be a minimum of 3/4 inch or Dp x 0.06 for bearings on concrete and 1/2 inch or Dp x 0.045 for bearings directly on steel masonry plates.

Vertical clearance between rotating and non-rotating bearing parts shall be no less than 1/8 inch at maximum rotation.

The urethane disc shall be held in place by a shear restriction mechanism that is designed to allow free rotation of the bearing. The mechanism shall be designed to withstand the design forces on the bearing without exceeding the allowable shear stress of 0.4 Fy, bending stress of 0.55 Fy, and bearing stress of 0.8 Fy, not including shear resistance of the disc. The mechanism shall be connected to the bearing plates by welding, bolting, or machining out of the solid.

5. **Non-rotational bearing elements:**

a. **PTFE sliding surfaces:** The PTFE surface shall be made from pure virgin PTFE resin conforming to ASTM D 4745. It shall be fabricated as unfilled sheet, filled

sheet, or fabric woven from PTFE and other fibers. Unfilled sheets shall be made from PTFE resin alone. Filled sheets shall be made from PTFE resin uniformly blended with glass fibers or other chemically inert filler. The maximum filler content shall be 15 percent. Sheet PTFE shall be a minimum of 1/8 inch thick, epoxy-bonded into a square-edge recess 1/16 inch deep.

Woven fiber PTFE shall be made from pure PTFE fibers. Reinforced woven fiber PTFE shall be made by interweaving high strength fibers, such as glass, with the PTFE in such a way that the reinforcing fibers do not appear on the sliding face of the finished fabric. Woven fiber PTFE in the free state shall be a minimum of 1/16 inch thick when measured in accordance with ASTM D 1777 and shall be epoxy-bonded and mechanically fastened to the substrate using a system that prevents migration of epoxy through the fabric. Edges, other than the selvage, shall be oversown or recessed so that no cut fabric edges are exposed.

PTFE sliding surfaces shall be designed for the maximum stresses specified in (a) 3 a.

b. **Stainless steel sliding surfaces:** The stainless surface shall cover the mating surface in all operating positions plus 1 inch in each direction of movement. This is to conform to (a)1. herein. Sheet stainless steel shall be 16- to 13-gage thick and connected to the substrate by a continuous weld around the entire perimeter. The sheet shall be in full contact with the substrate. Stainless steel welded overlay shall be a minimum of 3/32-inch thick after welding, grinding and polishing and be produced using Type 309L electrodes. Stainless steel sliding surfaces shall, preferably, face downward.

c. **Guide bars and central guide keys:** Central guide keys may be made integral by machining from the solid. Where a separate key or guide bar is used, it shall be fitted in a keyway slot machined to give a press fit and bolted or welded to resist overturning.

Guide bars may be made integral by machining from the solid or fabricated from bars welded, bolted, and/or recessed at the manufacturer's option.

Guide bars and central guide keys shall be designed for the horizontal force from applicable strength load and extreme event limit state load combinations, but not for less than 15 percent of the total vertical force from applicable service load combinations on the bearing. Bolted connections shall be designed in accordance with the applicable AASHTO Specifications. Frictional resistance of bearing slide surfaces shall be neglected when calculating horizontal load resistance.

The total clearance between the key/guide bars and guided members (both sides) shall be 1/16 inch maximum. Guided members must have their contact area within the guide bars in all operating positions. Guiding off the fixed base or any extensions of it where transverse rotation is anticipated shall be avoided.

d. **Sole and masonry plates:** For masonry plates, the concrete nominal bearing stress on the loaded area shall not exceed 0.85 f'c. When the supporting surface is wider on all sides than the loaded area, the allowable bearing stress on the loaded area may be

increased by the square root of (A2/A1), but not by more than 2. When the supporting surface is sloped or stepped, A2 may be taken as the area of the lower base of the largest frustrum of the right pyramid or cone contained wholly within the support and having for its upper base the loaded area A1 and having side slopes of 1 vertical to 2 horizontal.

Sole and masonry plates shall be designed for applicable service, strength and extreme event limit state loadings.

The minimum thickness of sole and masonry plates shall be 3/4 inch.

When designing recesses in masonry plates for horizontal forces, the depth of the recess shall be designed assuming the contact area as one-third of the circumference. Minimum recess depth shall be 3/16 inch.

6. **PTFE on guiding surfaces:** PTFE on guiding surfaces, when they are used, shall be designed for stresses given in (a) 3.a. herein:

   PTFE, when used on guiding surfaces, shall be bonded to and recessed in their substrate. In addition, PTFE shall be at least 3/16 inch thick and mechanically fastened by a minimum of two screws to the substrate. The centerline of the screws shall be located a distance equal to twice the nominal screw diameter from the end of the PTFE strip. The top of the screws shall be recessed a minimum of 50 percent of the amount of protrusion of the PTFE above the guiding surface.

   Unfilled sheet PTFE used on guide bars shall contain an ultraviolet (U.V.) inhibitor/screen.

7. **Materials:** Steel, except stainless steel, steel for guide bars, and shear-restriction pins and sleeves, shall conform to ASTM A 709, with a minimum yield stress of 36 ksi. Exposed steel surfaces shall be painted. Guide bars and shear-restriction devices shall be as specified by the manufacturer.

   Elastomeric disc for pot bearings shall be a Shore A 50 durometer hardness and the base polymer shall be either 100 percent virgin natural polyisoprene (natural rubber) or 100 percent virgin chloroprene (neoprene) having the following physical properties as determined by the applicable ASTM tests:

Property	Test Procedures	Natural Rubber	Neoprene
Tensile Strength, psi, min.	ASTM D 412	2250	2250
Elongation at Break, %, min.	ASTM D 412	450	400
Hardness, Durometer A	ASTM D 2240	50 ± 5	50 ± 5
Oven Aging, 70 hr/158°F for natural rubber, 70 hr/212°F for neoprene			
Tensile Strength, change, max. %	ASTM D 573	–25	–15
Elongation, change, max. %		–25	–40
Hardness, points change, max.		+10	+15
Compression Set, 22 hr/158°F for natural rubber, 22 hr/212°F for neoprene, max. %	ASTM D 395 Method B	25	35
Ozone Resistance, 20% strain 100°F ± 2°F, Mounting Procedure D 518, Method B			
48 hr @ 25 pphm ozone by vol.	ASTM D 1149	No Cracks	
100 hr @100 pphm ozone by vol.	ASTM D 1149	–	No Cracks
Low-Temperature Test Brittleness @ –40°F	ASTM D 2137 Procedue B	No Failure	No Failure

PTFE sliding surfaces shall be virgin PTFE resin-filled or unfilled PTFE sheets or PTFE fabric, all made from virgin PTFE resin.

PTFE resin shall be virgin material, not reprocessed, conforming to ASTM D 4894 and D 4895. Specific Gravity shall be 2.13 to 2.19. Melting point shall be 327 degrees C ± 10 degrees C. Filler material, when used, shall be milled glass fibers, carbon, or other inert filler materials.

Adhesive material shall be an epoxy resin conforming to FS MMM-A-134, PEP film or equal, as approved by the Engineer.

Unfilled PTFE sheet shall be made of virgin PTFE resin and shall conform to the following:

(1) Tensile strength, 2,800 pounds per square inch minimum, ASTM D 4894.

(2) Elongation, 200 percent minimum, ASTM D 4894.

Filled PTFE sheet shall be made from virgin PTFE resin uniformly blended with inert filler material and shall conform to the following:

Property	Test Procedures	15% Glass Fibers	25% Carbon
Tensile Strength, psi, min.	ASTM D 4894 and D 4985	2000	1300
Elongation, min. %	ASTM D 4894 and D 4985	150	75
Specific Gravity, min.	ASTM D 792	2.2	2.1
Melting Point	ASTM D 4894 and D 4985	327°C	±10°C

Fabric PTFE shall be made from virgin PTFE oriented multifilament and other fibers. The minimum thickness under the application of vertical load shall be:

a. 1/16 inch up to 3,500 pounds per square inch load

b. 3/64 inch from 3,500 pounds per square inch to 6,000 pounds per square inch load.

Where the PTFE is to be epoxy bonded, it shall be etched by the sodium naphthalene or sodium ammonia etching process by an approved manufacturer.

Stainless steel sliding surfaces shall conform to ASTM A 167 or A 240, Type 304, with a surface finish 20 micro-inches rms or less. Welded stainless steel overlay shall be produced using Type 309L electrodes.

Sealing rings may be made only of metal and shall conform to the following:

- Flat brass rings, ASTM B 36, half hard.
- Round cross-section rings, FS QQB626, composition 22, half hard.

Bronze elements shall conform to the following:

- Type 1, ASTM B 22, Alloy C90500.
- Type 2, ASTM B 22, Alloy C91100.
- Type 3, ASTM B 22, Alloy C86300.

Solid lubricant shall consist of a combination of solids having nondeteriorating characteristics, as well as lubricating qualities, and shall be capable of withstanding long-term atmospheric exposure, de-icing materials, and water. Molybdenum disulfide and other ingredients that may promote electrolytic or chemical action between the bearing elements shall not be used. Shellac, tars and asphalts, and petroleum solvents shall not be used as binders.

Socket head cap screws shall conform to ASTM A 574, High Strength, 1960 Series.

Adhesive material for bonding PTFE to steel shall be an epoxy resin conforming FS MMA-A-134, FEP film or approval equal.

8. **Construction:**

a. **Flatness of bearings:** The flatness of bearings after welding and fabrication shall be determined by the following method:

A precision straightedge longer than the nominal dimension to be measured shall be placed in contact with the surface to be measured or as parallel to it as possible.

An attempt shall be made to insert a feeler gage having a tolerance of plus or minus 0.001 inch under the straightedge. Since layering of feeler gages tends to degrade accuracy, the least number of blades shall be used.

Flatness is acceptable if the feeler does not pass under the straightedge.

Flatness tolerances are arranged in the following classes:

(1) Class A, 0.0005 inch x nominal dimension.

(2) Class B, 0.00l inch x nominal dimension.

(3) Class C, 0.002 inch, x nominal dimension.

Nominal dimension shall be interpreted as the actual dimension of the plate, in inches, under the straightedge.

In determining flatness, the straightedge may be located in any position on the surface to be evaluated, not necessarily at 90 degrees to the edges.

b. **Rotational elements—Pot bearings:** Pot bearings may, preferably, be made from a solid plate by machining or fabricated by welding a flame cut shape to a plate. Fabricated pots shall be manufactured in conformance with the *AASHTO/AWS D1.5 Bridge Welding Code.* The outside diameter of pots fitting into a machined recess shall be ±0.015 inch. For pots not so recessed, the tolerance on plan dimensions shall be +1/8 inch, –0 inch. The inside diameter of pots shall be machined to a tolerance of ±0.005 inch up to and including 20 inches and ±0.007 inch over 20 inches The tolerance on the depth of the pot cavity shall be +0.01 inch, –0 inch. The underside of pots shall be machined parallel to the inside to a Class A tolerance. Machined surfaces in contact with elastomer shall have a finish of 63 rms or better. Other machined surfaces shall have a finish of 125 rms or better.

Elastomeric disc tolerance shall be:

(1) Diameters greater than 20 inches, ±3/32 inch.

(2) Diameters less than or equal to 20 inches, ±1/16 inch.

(3) Discs may be made from up to three pieces, but the thinnest piece shall not be less than 1/2 inch.

(4) Total thickness of all pieces shall be –0 inch +1/8 inch.

Piston tolerances shall be:

(1) Diameter greater than 20 inches, ±0.007 inch.

(2) Diameter less than 20 inches, ±0.005 inch.

(3) Sliding side, Class A tolerance.

(4) Elastomer side, Class B tolerance.

(5) Piston flange thickness, +1/8 inch, –1/32 inch.

(6) Piston flange diameter, +1/8 inch, –1/32 inch.

c. **Rotational elements—Spherical bearings:** Spherical bearing machined diameters shall be ±0.015 inch. Convex radius dimensions shall be +0.000 inch –0.010 inch. Concave radius dimensions shall be +0.010 inch, –0.000 inch. Mating surfaces shall be as in Design section; external edges may be as cast or flame-cut. Lower surface of convex element shall be Class C tolerance. The tolerance on the overall thickness of concave or convex plates shall be ±0.03 inch.

d. **Non-rotational elements—All bearings:**

Masonry and distribution plate tolerances shall be:

(1) Plan dimensions less than or equal to 30 inches, -0 inch +3/16 inch.

(2) Plan dimensions over 30 inches, –0 inch +1/4 inch.

(3) Thickness tolerance shall be -0.030 inch +0.060 inch.

Masonry plates used with pot or spherical bearings shall be Class C for the underside and Class A for the upperside tolerance.

PTFE sheet sliding surfaces shall be bonded by the bearing manufacturer under controlled conditions and in accordance with the manufacturer of the approved adhesive system. After completion of bonding, the PTFE surface shall be smooth and free from bubbles. Filled PTFE surfaces shall be polished after bonding until smooth.

PTFE fabric sliding surfaces shall be mechanically attached to a rigid substrate. The fabric shall be capable of carrying loads of 10,000 pounds per square inch without cold-flow.

Tolerances of PTFE surfaces shall be:

(1) Plan dimensions total design area, +5 percent –0 percent.

(2) Substrate flatness, Class A.

Stainless steel sheets shall be seal-welded around the entire perimeter using techniques that ensure it remains in contact with the backing plate. Finish shall be at least 20 micro-inches rms. Flatness shall be to Class A tolerance.

Sole plates shall conform to:

(1) Plan dimensions less than or equal to 30 inches, –0 inch +3/16 inch.

(2) Plan dimensions over 30 inches, –0 inch +1/4 inch.

(3) Centerline thickness, –1/32 inch +1/8 inch.

(4) Flatness of surface in contract with steel beams, Class B:, in contact with poured in place concrete, none, in contact with stainless steel sliding surface, Class A: in contact with another steel plate, Class B.

(5) No part shall be thinner than 3/4 inch.

(6) Bevels shall be machined to an angular tolerance of ±0.002 radian.

(7) Flatness of bevelled surfaces shall be Class A.

Guide bars shall conform to:

(1) Length, unless integral with plate, ±l/8 inch.

(2) Section dimensions, ±1/16 inch.

(3) Flatness where it bears on another plate, Class A.

(4) Bar-to-bar, nominal dimensions, ±1/32 inch.

(5) Not more than 1/32 inch out of parallel.

The overall bearing height shall not be more than 1/8 inch or less than 1/16 inch under nominal dimensions. Edges shall be broken and not sharp.

9. **Testing:**

a. **General:** Testing shall be performed on test bearings as specified herein to ensure compliance with the specification. As soon as all bearings have been manufactured for the project, the Contractor shall notify the Engineer, who will select test bearing(s) at random from the lot. Manufacturer's certification of conformance with applicable requirements for the steel, elastomeric pads, preformed fabric pads, PTFE and other materials used in the construction of the bearings shall be furnished along with notification of fabrication completion. Testing shall be performed at the manufacturer's plant. Bearing capacities that exceed the manufacturer's testing capacity shall be tested at an approved testing laboratory. If suitable test equipment is not available in the United States, alternative testing/inspection shall be agreed upon between the Engineer and the manufacturer. The Engineer may witness the testing.

b. **Sampling:** Tests shall be performed on randomly selected samples from the production bearings. One bearing per lot shall be tested. A lot shall be defined as the smallest number of bearings as determined by the following criteria:

(1) One lot shall not exceed a single contract or project quantity.

(2) One lot shall not exceed 25 bearings.

A lot shall consist of those bearings of the same type within a load category. Bearing types shall be fixed type bearings or expansion type bearings. Guided and non-guided expansion bearings will be considered a single type.

One load category shall consist of bearings of differing vertical load capacity within a load range as follows:

- Bearings less than or equal to 1000 kips, the load category shall be based on a range of capacity of 500 kips.

- Bearings greater than 1000 kips capacity but less than or equal to 3000 kips capacity, the load category shall be based on a range of 1000 kips.

- Bearings in excess of 3000 kips capacity, the load category shall be based on a range of 2000 kips.

c. **Friction test:** A sample from each lot of expansion bearings shall be tested. Specially made bearings shall not be used; only actual bearings to be used in the project shall be tested. The test method and equipment shall be approved by the Engineer and include the following:

(1) The test shall be arranged so that the coefficient of friction on the first movement of the manufactured bearing can be determined.

(2) The bearing surface shall be cleaned prior to testing.

(3) The test shall be conducted at the maximum working stress for the PTFE surface with the test load applied for 12 hours prior to measuring the friction.

(4) The first movement static and dynamic coefficients of friction shall be determined at a sliding speed of 1 inch per minute or less and shall not exceed the following:

Materials	**Bearings Pressure (psi)**		
	500	**2000**	**3500**
Unfilled PTFE, Fabric containing PTFE Fibers, PTFE-Perforated Metal Composite	0.08	0.06	0.04
Filled PTFE	0.12	0.10	0.08
Interlocked Bronze and Filled PTFE Structures	0.10	0.07	0.05

The bearing specimen shall be subjected to a minimum of 100 movements of at least 1 inch of relative movement and if the facility permits, the full design movement, at a speed of less than 12 inches per minute. After cycling, the static and dynamic coefficients of friction shall be determined again at a speed of less than 1 inch per minute and shall not exceed the specified coefficient of friction. The bearing shall show no appreciable sign of bond failure or other defects.

d. **Proof load test:** One bearing shall be tested from each production lot of fixed and expansion bearings. Load shall be applied to the test bearings equal to 150 percent of the rated design capacity of the bearing and simultaneously rotated 0.02 radians or the design rotation, whichever is greater, for 1 hour. During test or subsequently upon disassembly, the bearing shall show no sign of deformation or extrusion of elastomer or PTFE.

e. **PTFE bond test:**

Bearings with sheet PTFE primary surfaces: At the option of the Engineer, one bearing from each production lot shall have a 180-degree peel test performed on the primary PTFE sliding surface in accordance with ASTM D 903. The minimum peel strength shall be 20 pounds per inch.

Bearings with fabric PTFE primary sliding surfaces: One bearing from each production lot shall have the primary PTFE tested in shear as follows: The component carrying the fabric PTFE (or complete bearing at the option of the manufacturer) shall be subjected to the maximum vertical service limit state design load of the bearing and simultaneously, but transversely, a load equal to 13 percent of the vertical

service limit state design load for a period of 1 minute. Slip or creep shall not exceed 1/8 inch during the test.

f. **Bearings represented by test specimens complying with these requirements:** Such bearings will be approved for use in the structure.

10. **Shipping and packing:** Bearing assemblies including sole and masonry plates shall be securely fixed together as units so that they may be shipped to the jobsite and stored without relative movement of the bearing parts or disassembly at any time. Bearings shall be wrapped in moisture-resistant and dust-resistant material to protect against shipping and jobsite conditions. Care shall be taken to ensure that bearings at the jobsite are stored in a dry sheltered area free from dirt or dust until installation. Each completed bearing shall have its components clearly identified and marked on its top as to location in each structure in the project in conformity with the plans.

    When bearings are to be inspected on site, they shall be inspected within 1 week of arrival and may not be disassembled except under the supervision of the manufacturer. Following inspection, the protective wrapping shall be reapplied and the bearings kept clean until installation.

    Removal of sole and top plates of bearings for separate attachment to the structure is not permitted except under the direct supervision of the manufacturer and with the permission of the Engineer.

11. **Installation:** Bearings shall be evenly supported over their upper and lower surfaces under all erection and service conditions. Bearings shall be lifted by their undersides only or by specially designed lifting lugs. When installing bearings, care shall be taken to avoid damage to and contamination of bearing surfaces.

    The centerlines of the bearing assembly shall be aligned with those of the substructure and superstructure. On guided bearings, special care must be taken to align the guiding mechanism properly with the designated expansion direction of the structure.

    Bearing straps or retaining clamps shall be left in place as long as possible to ensure that the parts of bearings are not inadvertently displaced relative to each other. Care shall be taken to remove straps or clamps before normal structural movement takes place, such as post-tensioning.

    The upper part of expansion and guided expansion bearings shall be located relative to the base of the bearing to compensate for deviations from normal atmospheric temperature.

    When bearings will sit directly on concrete with only an elastomeric, preformed fabric or lead sheet beneath the bearing, concrete bearing seats shall be prepared at the correct elevation and bush-hammered or dressed to the following flatness tolerance:

    a. Bearing seats less than or equal to 30 inches long, 1/16 inch.

    b. Bearing seats over 30 inches but less than or equal to 45 inches long, 3/32 inch.

    c. Bearing seats over 45 inches in length, 1/8 inch.

d. There shall be no projecting irregularities exceeding 1/32 inch.

e. Bearing seats shall be level within 1:200 slope.

Where grouted bearing seats are used, the grout shall be the non-shrink type and of the strength specified on the contract drawings but not less than the concrete strength in the main support. Grout shall be placed at even density beneath the entire bearing surface without any voids or hard spots. Grout shall be allowed to reach optimum strength before placing any load on the bearing.

The mating surface of the superstructure shall be level within a slope of 1:200. There shall be no local projecting irregularities exceeding 1/32 inch.

The Contractor shall repair any damage to bearing finishes following installation.

Welding procedures shall be established by the Contractor to restrict the maximum temperature reached by the bonded PTFE surfaces to a maximum of 300 degrees F and to restrict the maximum temperature reached by the elastomer (neoprene or natural rubber) to 250 degrees F. Temperatures shall be determined by temperature-indicating wax pencils or other suitable means. No load shall be transmitted to the bearings until erection of structural steel for spans contiguous to the bearing is substantially complete. Field welding of bearing plates shall be accomplished under the no load condition.

Particular care shall be exercised to mask and protect the PTFE and polished stainless steel surfaces to protect them from blast abrasives and paint application during construction.

12. **Shop drawings:** Shop drawings shall be submitted to the Engineer for review in accordance with Section 105.10. These drawings shall include, but not be limited to, the following:

a. Plan and elevation view and section elevation of the bearing.

b. Complete details of all components and sections showing all materials incorporated into the bearing.

c. The maximum design coefficient of friction as noted in the Contract.

d. All ASTM or other material designations.

e. Vertical and horizontal load capacity.

f. Rotation and movement capacity.

g. Compression stress on all sliding surfaces, and elastomeric surfaces, at maximum and minimum design loads.

h. Complete design calculations.

i. Shop paint or coating requirements.

(b) **Steel Plates, Shapes, and Bars:** Unless galvanizing is specified, items shall be painted in accordance with the plans.

(c) **Bronze Plates:** Sliding surfaces of bronze plates shall be polished.

(d) **Copper-Alloy Plates:** Finishing of rolled copper-alloy plates will not be required provided their surfaces are plane, true, and smooth.

(e) **Self-Lubricating Plates:** Plates shall be fabricated from cast bronze or rolled copper alloy.

Sliding surfaces of plates shall be provided with annular grooves or cylindrical recesses or a combination thereof, which shall be filled with a lubricating compound. The lubricating compound shall be compressed into recesses under sufficient pressure to form a nonplastic lubricating inset. The inset shall comprise at least 25 percent of the total area of the plate. The frictional coefficient shall be not more than 0.10. The compound shall be free from material that will cause abrasive or corrosive action on metal surfaces and able to withstand extremely high pressures and atmospheric elements over long periods of time.

Items shall be the standard products of the manufacturer of such materials for the application.

Prior to assembly, the steel surface that will bear on the self-lubricating bearing plate shall be thoroughly lubricated with additional antioxidant lubricant furnished by the manufacturer. Coatings shall be removed before application of antioxidant lubricant.

(f) **Elastomeric Pads:** Care shall be taken in fabricating pads and related metal parts so that effects detrimental to their proper performance, such as uneven bearing and excessive bulging, will not occur.

(g) **Placement:** Bearing plates or pads shall have a uniform bearing over the entire area. Provision shall be made to keep plates or pads in the correct position during erection of beams or placement of concrete.

Elastomeric pads and other flexible bearing materials shall be placed directly on masonry surfaces that have been finished to a roughness equivalent of a No. 36 to No. 46 grit. Pads, bearing areas, or bridge seats and metal bearing plates shall be thoroughly cleaned and free from oil, grease, and other foreign materials. Metal bearing plates or bottoms of prefabricated beams that are to bear on elastomeric pads shall be coated with epoxy, Type EP-4 or EP-5, conforming to Section 243 and then surfaced with a No. 36 to No. 46 silicon carbide or aluminum oxide grit. Bearing areas shall be finished to an equivalent roughness.

Metal bearing plates shall be bedded on bridge seats as follows: The bridge seat bearing area shall be thoroughly swabbed with No. 1 paint, and three layers of duck, 12 to 15 ounces per square yard, shall be placed on it, each layer being thoroughly swabbed with paint on its top surface.

Superstructure shoes or pedestals shall be placed in position while paint is plastic. As an alternate to duck and paint, sheet lead of at least 0.1 inch in thickness or preformed fabric bedding material at least 1/8 inch in thickness may be used when called for on the plans or approved in writing by the Engineer.

Expansion devices shall be centered and aligned so that the vertical axis will be vertical at 60 degrees F.

(h) **Anchors:** Anchors shall be designed for loads at the strength limit state and for the maximum loads at the extreme event limit state. Anchor bolts, nuts, and washers shall be painted or galva-

nized on superstructures having steel beams or girders. When superstructure units are concrete, anchor bolts, nuts, and washers, including bearing assemblies and insert plates, shall be galvanized. Shop paint shall cover the threaded end to 1 inch below the surface of masonry. Anchors shall be positioned to provide the required fit with bearing plates. Anchors shall be cast into the masonry and positioned by means of templates or other methods that will hold them securely in the correct position until concrete has set. The method of setting shall allow for proper finishing of concrete bearing areas. When permitted by the Contract or approved by the Engineer, anchor bolts may be placed in galvanized steel sleeves. Diameter and length of sleeves shall be as specified by contact documents or the Engineer but in no case shall diameter be greater than 4 times the diameter of the anchor bolt nor less than 2 times the diameter of the anchor bolt. Length of sleeves shall extend at least 2 inches below the plan elevation of the bottom of the anchor bolt. Sleeves shall be centered at the plan location of the anchor bolts. Top of sleeves shall be set at least 1/4 inch below the bridge seat elevation so as to prevent contact between the sleeves and the bearing assembly. Each sleeve shall include a 1 inch vent to permit air to escape from the tube during grouting. Vent tube shall connect to bottom of sleeve no more than 2 inches from the bottom of the sleeve. After girder and deck placement, the sleeves shall be filled with a non-shrink, high strength grout in accordance with Section 218. After the grout has set, the top surface of the grout shall be waterproofed with epoxy in accordance with Section 416.

Anchors that are not designed to project through bearing plates shall be checked for proper projection above the masonry bearing area immediately prior to placement of bearing plates and beams. Nuts on anchor bolts at expansion ends shall be adjusted to permit free movement of the span.

Angles for anchor assemblies to be attached to sides of concrete beams shall not be installed until beams have received their full dead load and supporting falsework has been removed.

408.04—Measurement and Payment

Metal bearing and expansion plates and anchors will be measured by shop scales in pounds of actual material placed in accordance with the plans. When not a separate pay item the Department will include the weight of plates and anchors in the weight of structural steel or reinforcing steel for payment. When a pay item, bearing plates will be paid for at the contract unit price per pound and shall include elastomeric and other flexible bearing pads. The cost of bedding and preparation for metal bearing plates shall be included in the prices for superstructure items. This price shall include furnishing all materials, galvanizing, painting, lubricating, and testing.

Payment will be made under:

Pay Item	Pay Unit
Bearing device	Pound

SECTION 409—STEEL GRID FLOORS

409.01—Description

This work shall consist of constructing a steel grid floor as shown on the Plans or elsewhere in the Contract in accordance with these Specifications or as directed by the Engineer.

409.02—Materials

Materials shall conform to Section 227.

409.03—Procedures

The floor shall conform to the design requirements for steel grid floors in the AASHTO LRFD Bridge Design Specifications.

(a) **Arrangement of Sections:** Where main elements are normal to the centerline of the roadway, units shall generally be of such length as to extend over the full width of any roadway up to 40 feet. In every case, units shall extend over at least three panels. Where joints are required, ends of main floor units shall be welded at joints over their full cross-sectional area or otherwise connected to provide full continuity in conformance with the manufacturer's recommendations.

Where main elements are parallel with the centerline of the roadway, sections shall extend over at least three panels and ends of abutting units shall be welded over their full cross-sectional area or otherwise connected to provide full continuity in accordance with the Department's approved design.

(b) **Provision for Camber:** Steel units so rigid that they will not readily follow the camber required shall be cambered in the shop. The stringers shall be canted or provided with shop-welded beveled bearing bars to provide a bearing surface normal to the crown of the roadway. If beveled bars are used, they shall be placed along the centerline of the stringer flange, in which case the design span length shall be governed by the width of the bearing bar instead of the width of the stringer flange.

Longitudinal stringers shall be cambered at the mill or provided with bearing strips so that the completed floor after dead-load deflection shall conform to the longitudinal camber shown on the plans.

(c) **Field Assembly:** The Contractor shall assemble areas of considerable size before the floor is welded to its supports. Main elements shall be made continuous, and sections shall be connected together along their edges by the welding of bars. The Engineer must approve connections before acceptance.

(d) **Connection to Supports:** The floor shall be connected to its steel supports by welding. The Contractor shall load the floor to make a tight joint with full bearing or clamp the floor down before any welding is performed. The Contractor will not be allowed to clamp the floor in any manner to compensate for distorted, warped, or improperly welded units in order to secure a connection. The locations, lengths, and sizes of the welds shall be as approved by the Engineer, but in no case less than the manufacturer's standards.

Ends of main steel units of the slab shall be securely fastened together at sides of the roadway for the full length of the span by means of steel plates or angles welded to ends of main units or by encasing ends with concrete.

(e) **Welding:** Welding shall conform to Section 407.

(f) **Damaged Galvanized Coatings:** Damaged coatings shall be repaired in accordance with Section 233.

(g) **Concrete Filler:** Floors with open bottom flanges shall be provided with bottom forms of metal or wood to retain the concrete filler.

If the Contractor uses metal form strips, they shall fit tightly to bottom flanges of floor units and be placed in short lengths extending approximately 1 inch beyond the edge of each support. The form shall be such as will result in the adequate bearing of the slab on the support.

Concrete shall be placed and cured in accordance with Section 404 and thoroughly consolidated by vibrating the steel grid floor. The Engineer will approve the vibrating device and manner in which it is operated.

(h) **Painting:** Steel grid flooring furnished without galvanizing but with a shop coat of paint shall be cleaned, prepared, and painted in accordance with Section 411.

If the Contractor elects to use a structural steel plate on the bottom of a filled floor, the Contractor shall clean, prepare, and paint the bottom surface of the plate in accordance with Section 411.

409.04—Measurement and Payment

Steel grid floors will be measured in square feet of surface area and will be paid for at the contract unit price per square foot. This price shall include fabrication including connections and galvanizing and painting when specified.

Payment will be made under:

Pay Item	Pay Unit
Steel grid floor	Square foot

SECTION 410—RAILINGS AND PARAPETS

410.01—Description

This work shall consist of furnishing and installing railings, bridge median barriers, and concrete parapets true to the line, grade, and dimensions shown on the plans or as established by the Engineer.

410.02—Materials

(a) **Concrete** shall conform to Section 217. If the Engineer approves the Contractor placing concrete by the extrusion method, The slump of the concrete may be less than 2 inches, the air content shall be no less than 4 percent, and the size of the coarse aggregate shall be no less than No. 7.

(b) **Steel reinforcement** shall conform to Section 223.

(c) **Steel for metal parapets** shall conform to Section 226.

(d) **Hydraulic cement mortar and grout** shall be nonshrinking and shall conform to Section 218.

(e) **Aluminum railings and materials** shall conform to Section 229.

(f) **Anchor bolts** shall conform to Section 226.02(c).

(g) **Grounding materials** shall conform to Section 238.

410.03—Procedures

(a) **Post Alignment:** Posts shall be perpendicular to the profile grade and plumb in the transverse direction regardless of the cross slope.

(b) **Metal Railings:** Fabrication and erection shall be performed in accordance with Section 407. The Contractor shall submit working drawings in accordance with Section 407. In welded railing, exposed joints of welded railings shall be finished by grinding or filing to give a neat and smooth appearance prior to the application of any galvanizing or coatings.

Bridges under any one contract shall have the same type of railing when alternate metal railings are permitted.

The Contractor shall carefully adjust metal railings prior to being fixed in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled wherever possible with railing in place at the proper grade and alignment.

Abutment ends of metal railings and metal parapets shall be grounded. Grounding conductor shall be bare or insulated (green) copper. Grounding electrode(s) shall be installed in accordance with Section 700 and shall conform to the NEC. All sections of metal railings, movable joints of metal railings, metal parapets, and the gaps in the metal railings created by concrete pole supports or other design modifications shall be bonded internally to maintain continuity. Grounding conductors shall pass through bridge parapets and backwalls in 1 inch conduit or raceway to a point 4 to 8 inches below the finished grade and attach to a grounding electrode(s) with a minimum of 8 feet contact with soil. Each run of grounding conductor shall be provided with a 4-inch exposed loop at expansion joints and at termination points. The Contractor shall test each metal rail section adjacent to the next metal railing for continuity to ensure system grounding. The Contractor shall test the grounding electrode(s) after installation using the fall of potential (three-point measurement) method. The Contractor shall document the testing and submit the documentation to the Engineer.

1. **Painting:** Steel or iron railing that is not galvanized shall be given one shop coat and three field coats of paint after erection. Painting shall be performed in accordance with Section 411.

2. **Anchorages:** Metal-railing anchorages in concrete shall be placed in accordance with of Section 404 and Section 408.

3. **Aluminum railings:** Components of railing shall be designed for adequate structural strength. Castings shall have a thickness of at least 1/4 inch, and other units shall have a thickness of at least 3/16 inch.

Aluminum in contact with concrete shall be coated with an approved aluminum-impregnated caulking compound. Aluminum surfaces in contact with metals other than stainless or galvanized steel shall be insulated with approved materials.

(c) **Concrete Railings, Bridge Median Barriers, and Parapets:** The Contractor shall not construct concrete railings or parapets until centering or falsework for the span has been released, rendering the span self-supporting.

Railings, bridge median barriers, and parapets shall be constructed in accordance with Section 404 for the class of concrete specified on the plans and shall be given a Class I finish. The Contractor shall take care to construct and secure smooth and tight-fitting forms that can be rigidly held to line and grade during all phases of construction and curing and then removed without damage to concrete. Concrete parapets and median barriers shall be constructed within an allowable tolerance of ±1/2 inch for overall depth and overall width, ±1/4 inch for the width of the upper portion of the barrier, and ±1/4 inch per 10 feet for horizontal alignment.

Forms for concrete railing shall be fabricated of single-width boards lined with Department approved material. The Engineer will not permit form joints in plane surfaces.

The Contractor shall build moldings, panel work, and bevel strips with neatly mitered joints. Corners in finished work shall be true; sharp; clean cut; and free from cracks, spalls, or other defects.

Reinforcing steel shall be placed in accordance with Section 406.

Expansion joints shall be constructed so as to permit freedom of movement. The Contractor shall remove loose or thin shells of mortar likely to spall under movement from expansion joints by means of a sharp chisel after all other work is completed.

Use of the extrusion method for concrete placement requires the Engineer's approval. If the Contractor is approved construct railing, parapet, or median barrier by the extrusion method, construction shall conform to the following:

1. The Contractor shall submit all necessary details for approval if the bridge deck needs to be widened or additional reinforcing steel placed in the railing, parapet, or median barrier to accommodate the extrusion machine. Widening the bridge deck or placing additional reinforcing steel shall be at the Contractor's risk and expense.

2. The extrusion machine shall be equipped with internal vibrators to consolidate concrete along the face and adjacent joints in one complete pass of the machine. The extrusion machine shall be operated in such a manner that a minimum of hand finishing will be required to produce a dense homogenous finish, free from voids and honeycomb.

3. The Contractor shall submit his proposed method of forming drains to the Engineer for approval when the plans require horizontal drains in the railing, parapet, or median barrier.

4. Deflection and expansion joints shall be grooved in accordance with the plans immediately after the extrusion process, and any required saw cutting shall be completed the same day the concrete is placed.

The Engineer may require the Contractor to discontinue this type of construction if the Contractor's methods and means do not produce satisfactory results commensurate with cast-in-

place construction until such time as the Contractor can modify or alter the means of extrusion to satisfactorily address the Engineer's concerns. If such modifications do not satisfactorily remedy the concerns of the Engineer the Engineer may withdraw approval to continue construction of railing, parapet, or median barrier by the extrusion method.

410.04—Measurement and Payment

Railing will be measured in linear feet along the centerline of the top rail between the extremities of each railing without deductions for breaks or interruptions. When railing is not a pay item, the cost thereof shall be included in the price for other appropriate items. When railing is a pay item, railing will be paid for at the contract unit price per linear foot for the type specified. This price shall include constructing, fabricating, and furnishing rails, rail posts, post bearing pads, anchor assemblies, and sleeves; furnishing and installing grounding materials; painting; galvanizing; reinforcing steel necessary; and concrete where applicable.

Parapets will be measured in linear feet along the face of the parapet, and bridge median barrier will be measured in linear feet along the barrier centerline. Parapets and bridge median barriers will be paid for at the contract unit price per linear foot for the type specified t. This price shall include furnishing and installing materials designated above the bridge deck surface, including anchorage material, reinforcing steel, junction boxes, conduits, and/or raceways used for rail grounding.

Payment will be made under:

Pay Item	Pay Unit
Railing (Type)	Linear foot
Parapet (Type)	Linear foot
Bridge median barrier (Type)	Linear foot

SECTION 411—PROTECTIVE COATING OF METAL IN STRUCTURES

411.01—Description

This work shall consist of preparing and coating ferrous metal surfaces on new and existing structures, including, but not limited to, main units, diaphragms, bearing assemblies, shop and field contact surfaces, surfaces in contact with concrete, parts designed to be embedded in concrete, railings, expansion joints, drainage systems, utility lines, and attachments in accordance with these specifications.

Classification of Structures: Existing structures will be classified on the plans by the Department as follows:

Type A: Steel structures that have no existing coatings.

Type B: Steel structures that have existing coatings.

Should the bid proposal involve a structure that requires application of a coating and no classification is specified in the bid documents, the bidder shall assume the structure to be Type B and bid accordingly.

Galvanized surfaces and surfaces protected with other coatings shall not be coated unless specified otherwise in the contract. Cast, ductile, and nodular iron castings need not be coated. Application procedures not specified herein shall be as specified by the coatings manufacturer and approved by the Engineer.

411.02—Materials

(a) **Coatings** shall conform to Section 231.

(b) **Water used in cleaning operations** shall be potable. If water is recycled, it shall be filtered prior to reuse. Recycled water shall be used only on the bridge from which it was generated and shall be subsequently tested after cleaning operations but prior to disposal in accordance with Section 411.04(a) and then properly disposed of.

(c) **Soluble Salt Remover** shall be added to wash water in order to remove chlorides, sulfates and nitrates from surfaces when cleaning operations are performed. Soluble salt removers shall be submitted to the Engineer for acceptance prior to use.

(d) **Abrasives used in cleaning operations** shall be one of the following categories:

1. **Expendable** abrasives shall conform to SSPC-AB 1, Type I or Type II, Class A, except that the Engineer will not permit the use of silica and quartz sands. The abrasive shall not contain total levels of any of the heavy metals listed in 40 CFR 261.24, Table 1, in excess of 20 times the specified regulatory leachable limits. Expendable abrasives shall be selected from the VDOT Materials Division Approved Products List 18, and shall not contain chemical additives that render the waste non-hazardous under the Toxicity Characteristic Leaching Procedure.

2. **Recyclable** abrasives, newly manufactured or re-manufactured steel, shall conform to SSPC-AB 3. Recycled abrasive shall be examined by the Contractor for oil contamination prior to start up and at least once per 8-hour shift in accordance with VTM-82. Recycled abrasive shall not contain non-abrasive residue in excess of that specified in SSPC-AB 2.

411.03—Certifications

(a) **SSPC QP-1 Requirement:** The Contractor must be certified to perform coating applications according *SSPC QP-1, Standard Procedure for Evaluating Qualifications of Industrial/Marine Painting Contractors, Field Applications in Complex Structures* prior to performing coating operations on all new and existing steel structures. The Contractor shall submit, to the Engineer, proof of such current certification prior to starting the work. The Engineer will not enforce this certification requirement on structural steel repairs and the replacement of structural components including, but not limited to, diaphragms, bearing assemblies, cross frames, stiffeners, connector plates, and beam repairs provided such work is performed in accordance with all applicable OSHA and environmental requirements for the type and scope of work.

(b) **SSPC QP-2 Requirement:**

When contract work involves the removal of greater than 100 square feet of coating from a Type B structure, the Contractor shall be certified and submit proof of current certification

complying with the criteria of *SSPC QP-2, Standard for Evaluating Painting Contractors, Removal of Hazardous Coatings from Industrial/Marine Steel Structures* prior to performing coating removal operations. The SSPC QP-2 certified contractor shall assign a SSPC QP-2 qualified Competent Person to oversee removal activities to protect the environment and workers safety and health while performing removal activities under the contract. For the purposes herein a Competent Person is an individual who meets the qualifications defined in the document SSPC-QP2 – Qualifications, Section 2. The Environmental Protection Plan and worker safety and health plan described in Sections 411.09 and 411.10 shall be prepared by the SSPC QP-2 certified organization. The SSPC QP-2 Competent Person shall be present during startup, surface preparations, removal operations, and waste removal/disposal activities to ensure and verify environmental protection and worker safety and health practices and procedures comply with the prepared plans.

The SSPC QP-2 Competent Person shall submit written certification that the Contractor's work operations are meeting the environmental and worker safety and health plans requirements each week. The SSPC QP-2 Competent Person shall submit written certification at the completion of the project that the environmental and worker safety and health plans fully complied with all applicable regulations and was fully implemented by the Contractor. If there are any emissions or discharges noted, the Competent Person shall submit in writing, within 24 hours of the time of the discharge, corrective actions taken by the Contractor to remedy the noncompliance.

If the project work involves the removal of less than 100 square feet of coating from a Type B structure for structural steel repairs and/or replacement of structural components, the SSPC QP-2 requirement is not required. All work performed for repairs and/or replacement shall be accomplished in accordance with all applicable environmental and worker health and safety requirements for the type and scope of work specified. The 100 square foot requirement applies to each structure on the project.

(c) **Professional Engineer:** If the project involves the erection of any waste or emissions containment structure with the bridge serving as the primary means of support, the Contractor shall describe such system as specified in Section 411.09(a) and provide certification by a Professional Engineer, holding a valid license to practice structural design engineering in the Commonwealth of Virginia. The certification shall verify the structural integrity of the containment structure and that the containment system does not adversely affect any portion of the bridge. This requirement will not apply to any containment structure with a total weight-bearing capacity of less than 1,000 pounds.

411.04—General Surface Preparation and Application Standards

Prior to being coated, the Contractor shall ensure surfaces are clean and free from rust, loose or brittle paint, chalking, oil, grease, salt contaminants, dirt, and other substances that would prevent coatings from tightly adhering to the intended surfaces. Surfaces shall be prepared in accordance with SSPC specifications. Surface conditions and finished surface profiles shall conform to SSPC-Vis Standards or National Association of Corrosion Engineers (NACE) Comparators.

When blast cleaning is specified for surface preparation, the Contractor shall use SSPC PA-17, Procedure for Determining Conformance to Steel Profile Requirements, including information in Appendix B, Determining Compliance Based on Process Control Procedure. Surface profile shall be measured in accordance with Section 411.04(c)6.

Should an area of steel that has previously been cleaned become soiled, contaminated, or rusted, the Contractor shall reclean the area to the satisfaction of the Engineer prior to the application of coating at no additional cost to the Department.

Regardless of the method of cleaning, surface imperfections described in the "Procedures Following Blast Cleaning and Immediately Prior to Painting Section" of SSPC-SP 10 and any other matter that will prohibit a smooth unobstructed surface for the application of the specified coating, shall be removed.

(a) **Application Conditions:**

Preparing Surfaces To Be Coated: The Contractor shall prevent contaminants coming in contact with surfaces during surface preparation and coating operations. Unsealed connections, small cracks, cavities, and depressed areas on flanges shall be filled in accordance with Section 407. Depressions found on flanges or other structural components where water can pond shall be filled using a material recommended by the coating manufacturer and approved by the Engineer.

The Contractor shall prepare the surfaces scheduled to be coated in accordance with one or more of the following methods prior to the application of coating(s). Surfaces to be coated shall be cleaned in accordance with Method 1 followed by Method 7 prior to the use of other surface preparation methods, except as provided herein.

When surface preparation is performed in the field, the Contractor shall collect and contain solid and liquid wastes. Waste shall be characterized and properly disposed of in accordance with Section 411.09(c) for a Type B structure or for galvanized surfaces, prepared using zinc phosphate treatments in accordance with 411.07(b).

Any additional cost for surface preparation, waste collection, waste characterization, and disposal associated with the coating of quenched or chromate-treated galvanized material as authorized and directed by the Engineer will be made in accordance with the provisions of Section 109.05.

1. **Method 1:** Solvent, emulsion, or steam shall remove oil, dust, dirt, grease, concrete, chalking, and salt in accordance with SSPC-SP-1. The Contractor shall remove emulsions and/or contaminated solvent before they evaporate by wiping or rinsing with clean solvents to prevent a film of contaminants from remaining on the surface. The Engineer may require solvent wiping between coats. Solvents used in the work shall be those recommended by the coating manufacturer.

2. **Method 2:** The Contractor shall employ hand-tool cleaning shall remove loose coating, loose rust, and loose mill scale in accordance with SSPC-SP-2.

3. **Method 3:** The Contractor shall employ power-tool cleaning to remove loose coatings, loose rust, and loose mill scale in accordance with SSPC-SP-3. After cleaning, locations cleaned to bare metal shall have a minimum 1 mil profile.

4. **Method 4:** The Contractor shall employ power-tool cleaning to remove coating, rust, and mill scale to bare metal in accordance with SSPC-SP-11. Surface profile shall be a minimum of 1 mil with continuous pattern with no smooth unprofiled areas.

5. **Method 5:** The Contractor shall employ abrasive blast cleaning to remove visible coating, rust, and mill scale in accordance with SSPC-SP-10/NACE No. 2. When surface prepa-

ration involves less than 1,000 square feet per structure, expendable abrasives may be used, otherwise abrasives shall be recyclable unless otherwise specified or approved by the Engineer. The Contractor shall collect, remove and properly dispose of all expendable abrasives after use. The Engineer will not allow the use of recyclable abrasive containing rust that adversely affects the cleanliness of the blasted surface.

After blast cleaning, the surface profile shall be an average from 2 to 4 mils with no individual readings below 1.5 mils or above 4.5 mils in a dense uniform pattern of depressions and ridges. Shop-blasted and field-blasted surfaces shall be coated within 8 hours. If rust bloom develops before coating, the Contractor shall repeat blast cleaning at no additional cost to the Department.

6. **Method 6:** The Contractor shall employ brush-off blasting to remove loose or brittle coatings, loose rust, and loose mill scale in accordance with SSPC-SP-7/NACE No. 4. Bare steel locations shall have a uniform 1 mil minimum profile.

7. **Method 7:** The Contractor shall use low-pressure water cleaning to remove dust, debris, and salt contaminants. A soluble salt remover shall be added to the wash water in accordance with the manufacturer's instructions for concentration, washing, and rinsing processes. Method 7 can be used exclusively (i.e., in lieu of Method 1) and without a soluble salt remover for the cleaning of new shop-primed or new field-primed steel provided that no salt, oil or grease is present or when oil and grease are removed separately by Method 1. However, tests shall be performed to verify no oil or grease is present and that chloride, sulfate and nitrate levels are at or below manufacturer's recommendations prior to coating application.

   The pressure washer shall be capable of achieving a minimum of 3,000 pounds per square inch at the nozzle when used prior to blast cleaning, and a minimum of 5,000 pounds per square inch at the nozzle when used to remove loose or brittle coatings. The Contractor shall maintain the nozzle no more than 10 inches from the surface, and consistently hold it at 90 degrees to each surface being cleaned. Any detergents or cleaners used in conjunction with this cleaning method shall be those allowed or recommended by the coating manufacturer and as approved by the Engineer. All water generated by this washing technique must be collected and tested in accordance with Section 411.09(c), and disposed of in accordance with Section 411.09(d). The exception to this requirement, provided no detergents or cleaners are used, is any water generated from cleaning new shop-primed or new field-primed steel by this technique may be directed to the bridge approaches or stream bank but shall not be directly discharged into any waterway. This exception does not apply to waste generated from surface preparation of galvanized steel.

8. **Method 8:** Commercial grade power tool cleaning shall remove rust, coatings, oxides, mill scale, corrosion products and other foreign matter in accordance with SSPC SP-15. After cleaning, locations cleaned to bare metal shall have a minimum 1 mil profile of continuous pattern with no smooth un-profiled areas.

9. **Method 9:** Commercial blast cleaning shall remove all mil scale, rust, coatings, oxides, corrosion products and other foreign matter in accordance with SSPC SP-6/NACE, No. 3. When surface preparation involves less than 1,000 square feet per structure expendable abrasives may be used, otherwise abrasives shall be recyclable unless otherwise specified or approved by the Engineer. After blast cleaning, the surface profile shall be an average 2 to 4 mils with no individual readings below 1.5 mils or above 4.5 mils in a dense uniform pattern of depressions and ridges.

The waste material(s) generated from work performed on Type B structures shall be tested in accordance with EPA Method 1311, Toxicity Characteristic Leaching Procedure (TCLP), and corresponding EPA 6000 or 7000 series metals analytical method for, but not limited to, the following metals to determine if the waste material(s) requires management as hazardous waste: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. The exception to this testing protocol is that waste generated from abrasive blasting with recycled steel abrasives for Method 5 or Method 9 shall be tested for total concentrations of the aforementioned heavy metals in lieu of the TCLP analysis. Waste material(s) shall be properly disposed of in accordance with all federal, state, and local regulations.

(b) **Coating Application:** The Contractor shall apply coatings in accordance with SSPC-PA 1. Coatings shall not be applied under any of the following conditions unless recommended by the manufacturer and approved by the Engineer:

1. When air, coating, or metal temperature is below 35 degrees F when applying solvent based coatings.

2. When air, coating, or metal temperature is expected to fall below 35 degrees F before the solvent based coating has cured.

3. When snow, sleet, or rain is falling.

4. When moisture is visible on metal.

5. When humidity is above 85 percent.

6. When the temperature of the steel or metal surface to be coated may cause blistering of the coating as indicated in the manufacturer's product data sheet.

7. When the steel surface temperature is less than 5 degrees F above the dew point or is expected to fall to that point before the coating has dried or cured.

In no case shall System W as shown in Table IV-6 or other approved waterborne coatings be applied unless the air, steel surface, and material temperature is above and maintained above 50 degrees F and rising during application and curing.

Prior to application of coatings, the surface shall be dry. The Contractor shall apply coatings in a neat and orderly manner by brushing, rolling, or spraying as recommended by the manufacturer.

The Engineer will not allow the Contractor to use rollers, daubers, or sheepskins to apply zinc-rich coatings. Zinc-rich coatings may be applied by brush, limited to isolated areas of 1 square foot or less and shall be re-stirred just prior application at each location.

Coatings shall be applied in a manner to provide a tight film of specified uniform thickness well bonded to metal or underlying coating, including crevices and corners, and shall be free from laps, lint from rollers, bristles from brushes, streaks, sags, runs, overspray, dryspray, shadow-through, skips, pin holes, holidays, excessive film build-up, mud cracking, misses, and other defects.

The Contractor shall apply a stripe coat prior to the full coat application on beams, girders, diaphragms, cross frame edges, bolts, washers, and nuts. If the Contractor has to

apply a multicoat system, beams, girders, diaphragms, cross frame edges, bolts, and nuts shall be striped prior to each coat except that the application of a stripe coat will not be required by the Engineer for a zinc-rich primer. Stripe coatings shall dry or cured to touch before overcoating.

Deficient, impaired, or damaged areas of each coat shall be repaired according to the coatings manufacturer's recommendations or by using appropriate material from the VDOT Materials Division's Approved Products List. Two-component, solvent-based, inorganic zinc shall have a minimum rating of 4 when tested in accordance with ASTM D4752.

The Contractor shall not apply successive coatings until each preceding coat has dried and cured in accordance with the manufacturer's recommendations and has been approved by the Engineer. Coatings shall be applied in accordance with Table IV-6.

TABLE IV-6
Coating Systems

System (Approved List No.)	Coat	Coating	Color	Min Dry Film Thickness (DFT) (Mil)
B	Primer	Zinc-Rich		As Specified
(List 13)	Intermediate	Per List	White	As Specified
	Finish	Per List	As Specified*	As Specified
F	Primer	No. 14	Aluminum	5.0
(List 21)	Finish	No. 14	As Specified*	5.0
	Alternate Finish	Per List	As Specified*	As Specified
W	Primer	No. 101	Brown 595-30045	2.0 – 4.0
(List 40)	Intermediate	No. 102	White	2.0 – 4.0
	Finish	No. 103	As Specified*	2.0 – 4.0**

* Color as specified. If not specified, color shall be Federal No. 595-26307.
** DFT of finish coats shall be no less than the specified thickness and shall completely cover the intermediate coat. The Dry Film Thickness of any coat when Systems B, F or W is applied shall be in accordance with Restriction Level 3 of SSPC PA-2, these specifications and the manufacturer's instructions unless otherwise specified in the Contract.

Mixing: Coatings shall be mixed in strict accordance with the manufacturer's instructions. Zinc-rich coatings shall be applied from containers equipped with a mechanical agitator, which shall be in motion throughout the application period unless otherwise specified by the manufacturer. Coatings shall not be thinned beyond the volatile organic compound (VOC) limit or the manufacturer's recommendation, whichever is the most restrictive. Individual components of multicomponent coatings shall be mixed separately prior to mixing with other components of the kit. The Contractor shall use a power mixer to perform mixing. Multicomponent material shall not be mixed in proportions less than the packaged quantities.

(c) **Quality Control Measurements:**

1. **Water and/or Oil in Compressed Air:** The Contractor shall perform a Blotter Test in accordance with ASTM D 4285 with equipment at operating conditions, prior to the start of work and once per 8 hour shift. The Contractor shall perform this test daily in the

presence of the Engineer, record the findings, and provide a copy to the Engineer for inclusion to the project records.

2. **Illumination in containment:** The minimum illumination in foot candles stated in SSPC Guide 12 shall be confirmed in the general work areas and task specific areas such as surface preparation, inspection, and coating application activities prior to start of each shift's operations when working in containment areas.

3. **Presence of Oil or Grease:** The Contractor shall check surfaces for oil and/or grease contamination prior to coating application by verifying surfaces using a water break test. A black light may also be used to confirm the presence of hydrocarbons.

4. **Chloride, Sulfate and Nitrate Testing:** Chloride concentrations shall be no greater than 7µg/cm2 on new or existing structures. Sulfate and nitrate concentrations shall be at or below the coating manufacturer's recommended levels. The Contractor shall perform chloride, sulfate and nitrate tests at a frequency of three tests per span after surface preparation is completed. Sampling (retrieval) and analysis of chloride, sulfate and nitrate shall be performed using an acceptable method in accordance with SSPC Guide 15. The Engineer will select test locations on existing structures to represent the greatest amount of corrosion in the span. Should chloride, sulfate, and nitrate concentrations not be in compliance with 7µg/cm2 for chlorides or manufacturer's maximum levels for sulfates and nitrates, the location(s) of non-conformance shall be re-cleaned and re-tested along with two additional test locations. Should the re-cleaned location(s) or any additional test not meet the compliance requirements, the entire span shall be rewashed using a soluble salt remover and retested as stated above until the span is in compliance. New structures shall be tested in three random locations per span as chosen by the Engineer.

5. **Blast Cleaning Process Control:** When the contract or plans designate Method 5 or Method 9 surface preparation, the Contractor shall identify and document the processes used at the start of each shift, or blasting operation, in the presence of the Engineer in accordance with SSPC PA-17, including information in Appendix B.

   When establishing the blasting process, the Contractor shall inspect surfaces for surface profile produced and the degree of cleanliness as specified. This information shall be daily recorded into the project records.

6. **Surface Profile Measurements:** When the contract or plans designate Method 5 or Method 9 surface preparation, surfaces shall be measured in 3 locations per span using a compressible foam tape in accordance with ASTM D 4417, Method C and in accordance with the tape manufacturer's instructions. Should surface profile tests not conform to specification profile range, the Contractor shall measure the extent of non-conforming profile in accordance with SSPC PA-17. The Contractor shall correct any non-conforming location(s) at no additional cost to the Department.

   When measuring surface profile for methods other than Method 5 or Method 9, the Contractor shall take readings in accordance with ASTM D 4417, Method B at a sufficient number of locations to verify profiles conform to the specifications requirements.

7. **Coating Preparation/Mixing:** Procedures used for mixing coatings shall be included in daily project records. These records shall also include product name, batch number,

material temperatures, ambient temperatures, relative humidity, time of day mixed, dwell times, pot life and product number of thinner and quantities, if used.

8. **Film Thickness:** The Contractor shall measure the dry film thickness (DFT) of each coating applied using a Type 2 film thickness gage. The Type 2 gage shall be calibrated according to the frequency and procedure specified by the manufacturer and in accordance with ASTM 7091. Prior to taking measurements, a verification of combined accuracy shall be performed in accordance with SSPC PA-2, Appendix 8. The combined accuracy shall be within the manufacturer's tolerance of the gage and the tolerance of the standard shim(s) used. If the gage does not meet the combined tolerance, it shall not be used. The Contractor shall furnish another gage which passes accuracy testing for use.

   Coatings shall be measured in accordance with SSPC PA-2 and comply with thickness Restriction Level 3 after they have dried or cured. In the event coatings are applied and individual coat thicknesses are not documented by the Contractor and confirmed by the Engineer, the undocumented surfaces shall be re-cleaned and coatings reapplied at no additional cost to the Department.

   When plans or contracts state work on an existing structure is designated as Prepare and Overcoat Existing Structure, the dry-film thickness of coatings will be determined by the Engineer or the Department's Representative with a Tooke gage when the thicknesses of previous coatings are not known.

(d) **Hold Point Inspections:** The following hold point inspections shall be required for all coating methods and all field surface preparation and coating applications performed. Before moving to the next phase of work, each of the following activities must be confirmed by the Engineer and documented by the Contractor's representative as it applies to the work specified per the plans or the Contract on new and existing structures (Confirmation will be as required by the paint process used to verify compliance):

1. Cleanliness of surfaces prior to surface preparation

2. Surface preparation and cleanliness prior to primer application

3. Full coat primer prior to intermediate stripe coat

4. Intermediate stripe coat prior to full intermediate coat

5. Full coat intermediate coat prior to finish stripe coat

6. Stripe coat finish prior to full finish coat

7. Full finish coat inspection

The Engineer will verify each of the seven step hold point inspections by means of visual and instrumentation methods. The Contractor shall be responsible for documenting the completeness of the work. The Contractor shall employ a Paint Quality Control Officer to accompany the Engineer during all hold point inspections. The Paint Quality Control Officer shall schedule and coordinate all hold point inspections with the Engineer and complete all required documentation.

If deficiencies are detected during a hold point inspection, such deficiencies shall be corrected to conform to the Specifications requirements. All hold point inspections shall be signed by the Engineer and the Contractor's designated Paint Quality Control Officer.

(e) **Record Keeping and Protective Coating Identification:** The Contractor shall maintain a record that establishes and describes the location and limits of the work area where protective coating removal or application of a protective coating has been performed. Such records shall be maintained and completed on a daily basis and shall provide, at a minimum, the following information: Contractor's name, date, time work began, time work completed, ambient air and structure temperatures, relative humidity ranges during coating and curing operations, all quality control measurements, signed hold point inspections, and manufacturer and name of coating system applied.

The record shall include a map detailing work designated as Prepare and Spot Coat and Prepare and Over-coat Structures indicating areas where the protective coating has been applied as accurately located on the actual bridge structure. The Engineer must approve the daily record and map format prior to commencement of work. The Contractor shall maintain the daily records and maps in a three-ring binder throughout the duration of the project. Prior to final acceptance, the Contractor shall submit to the Engineer the completed three-ring binder and shall certify that all information contained therein is factual and correct.

The Contractor shall stencil on the structure a legend indicating the coating system(s) applied per Table IV-6, using manufacturer's name, product names (abbreviated) or number of each coat, the month and year applied, and the Contractor's name after the final coat has cured on new steel and after recoating or over-coating of an existing structure. The legend shall be black in color, and placed inside a fascia stringer near an abutment at a location approved by the Engineer. The legend's location shall be shown on the bridge map.

411.05—Existing Structures

Coated steel structures built before 1978 and weathering steel structures may contain mill scale. Coatings applied to existing structures are qualified as systems and therefore shall be applied as listed. Mixing and matching of coatings is not allowed unless permitted in writing by the coatings manufacturer(s) and approved by the Engineer.

(a) **Bare Steel:** The Contractor shall clean uncoated weathering steel in accordance with Method 5 and shall coat the structure with System B. The following areas of weathering steel shall be coated:

1. Areas within 5 feet of a deck joint, including, but not limited to, cross frames, diaphragms, stiffeners, connector plates, girders, and beams.

2. The entire outside surface of fascia girders and beams, including the underside of the bottom flange.

These areas shall be thoroughly cleaned to no less than 6 inches outside the area to be coated and shall be coated with System B.

(b) **Steel Re-Embedded in Concrete:** When concrete decks are removed, top flanges of beams or girders including edges and top surfaces of diaphragms, cross frames or other structural

steel that is within 4 inches of the bottom of the deck after replacement shall be prepared using Method 1, Method 7 and Method 9 respectively. These surfaces shall be coated using the specified repair primer. If the bridge is designated as a Type B structure, Section 411.03 (b) shall apply to this work.

(c) **Coating Remaining: Coating application will be performed as follows:**

The Contractor shall test for chloride, nitrate and sulfate contaminants when preparing surfaces in accordance with Method 7. Chloride, nitrate and sulfate levels shall be tested on bare steel and/or completely prepared surfaces in accordance with the manufacturer's test instructions for each contaminant.

1. **Prepare and spot coat existing structure:** The Contractor shall prepare surfaces being coated in accordance with Method 1 followed by Method 7 using a pressure of 5,000 pounds per square inch at the nozzle. Rust shall be removed in accordance with Method 4 or Method 5. Prepared areas shall be spot-primed with primer from the system specified. Intermediate and finish coats shall be applied to spot-primed areas only and shall be feathered into the existing finish coat to produce a uniform homogeneous appearance on the existing structure. The coating system shall be as specified on the plans. If no system is specified, the Contractor shall apply System W in accordance with Table IV-6.

2. **Prepare and overcoat existing structure:** The Contractor shall clean the entire structure in accordance with Method 1 followed by Method 7 using a pressure of 5,000 pounds per square inch at the nozzle. Areas to be primed and coated shall be prepared in accordance with Method 5 or Method 4.

   Prepared areas shall be spot-primed with primer from the system specified. Intermediate and finish coats shall be applied to the entire structure. The coating system shall be as specified on the plans. If no system is specified, the Contractor shall apply System W in accordance with Table IV-6.

3. **Recoat existing structure:** The Contractor shall clean the entire structure in accordance with Method 1 followed by Method 7 using a pressure of 3,000 pounds per square inch at the nozzle. The entire structure shall be cleaned to bare metal in accordance with Method 5 unless otherwise specified in the contract. The structure shall be recoated using System B in accordance with Table IV-6.

4. **Coating new steel members used to repair existing structure:** Unless otherwise directed on the plans or approved by the Engineer, the Contractor shall clean the newly installed steel members to bare metal in accordance with Method 5. Prepared areas shall extend 6 inches beyond new steel member into the existing structure at the point of repair and shall be spot-primed with primer from the system specified. Intermediate and finish coat shall be applied to spot-primed areas only and shall be feathered into the existing finish coat to produce a uniform homogeneous appearance on the existing structure. If the existing coating is a zinc-rich primer, the Contractor shall apply System B. The coating system shall be as specified on the plans. If no system is specified, the Contractor shall apply System W in accordance with Table IV-6.

5. **Zone coating:** Surfaces shown on the plans or in the Contract to be zone coated shall be cleaned in accordance with Method 1 followed by Method 7 using a pressure of 3,000

pounds per square inch at the nozzle. The entire area designated for zone coating shall be prepared in accordance with Method 5 unless otherwise specified in the Contract.

The Contractor shall coat areas designated for zone coating using System B.

If a winter season elapses between applications of coats, the Contractor shall prepare the structure again in accordance with Method 1 prior to resuming application of additional coatings at no additional cost to the Department.

Existing steel on structures to be widened shall not be prepared and coated unless otherwise specified on the plans. When specified on the plans for coating, the Contractor shall clean the entire surface in accordance with Method 1 followed by Method 7. Coatings shall be removed in accordance with Method 5 and the existing structure shall be coated with the same system as required on the new steel portion of the structure.

411.06—New Structures

The Contractor shall coat non-stainless ferrous metal using System B, Group I coatings as specified in Table IV-6. System B coatings are qualified as systems and therefore shall be applied as listed. Mixing and matching of coatings is not allowed unless permitted in writing by the coatings manufacturer and approved by the Engineer.

(a) **Shop Coating:** The fabricator shall abrasive blast clean metal surfaces to be coated in accordance with Method 5 prior to the application of primer. Material shall not be handled or shipped prior to the time(s) established by the coating manufacturer's handling and shipping instructions.

Machine-finished surfaces and/or areas that are to bear on other surfaces of the structure in a sliding movement shall not receive an applied protective coating as specified in Table IV-6 but shall be coated with a multipurpose grease or other specified coating prior to shipment. The fabricator shall be careful not to get such grease or other specified coating on other painted surface areas.

Unless otherwise specified on the plans or directed by the Engineer, the top surfaces of top flanges of beams and girders where shear connectors are to be field applied shall only receive a mist coat of zinc primer to prevent surface corrosion of subsequent shear connector application.

The fabricator shall stencil or paint erection and weight marks on structural steel subsequent to application of shop primer. The Department will not permit any other lettering.

The following areas of weathering steel shall be coated:

1. Areas within 5 feet of a deck joint, including, but not limited to, cross frames, diaphragms, stiffeners, connector plates, girders, and beams.

2. The entire outside surface of fascia girders and beams, including the underside of the bottom flange.

These areas shall be thoroughly cleaned to no less than 6 inches outside the area to be coated and shall be coated with an approved System B, Group I coating system.

The fabricator shall correct deficiencies and nonconformities to the specification requirements prior to shipment.

(b) **Field Coating:** The Contractor shall not perform field application of coatings until concrete work is completed and forms are removed. The Contractor shall remove concrete, concrete dust, zinc salts, chlorides, sulfates and nitrates or any other debris deposited on coated steel surfaces. Surfaces shall be cleaned in accordance with Method 7 as described in Section 411.04(a) using a pressure of 3,000 pounds per square inch at the nozzle. The Engineer will not require the use of a soluble salt remover when Method 7 is performed on new steel providing transportation of the steel unit has not occurred during winter months. However, confirmation of the level of chlorides is still required in accordance with Section 411.04(c)4. If a winter season elapses between the applications of coats, the Contractor shall prepare the structure again in accordance with Method 7 and test it in accordance with Section 411.04(c)4. at no additional cost to the Department.

The Contractor shall clean uncoated surfaces and deficient or damaged areas in accordance with the coating manufacturer's instructions or recommendations and touch-up primed areas with a primer from the selected System B coating system.

After installation and approval by the Engineer, galvanized bolts, nuts, and washers shall be cleaned and prepared to remove any coating or sealer that may be present in accordance with the coating manufacturer's instructions. The Contractor shall wire brush the galvanized bolts, nuts and washers followed by a potable water rinse. The galvanized bolts, nuts and washers shall then be coated with the identical intermediate and top coats being applied to the rest of the structure.

All other erection bolts shall be prepared in accordance with Method 1 and abrasive blasted in accordance with Method 5. After preparation, the Contractor shall coat bolts, nuts, and washers using the zinc-rich primer, with intermediate and finish coats being applied to the rest of the structure. Suitable precautions shall be taken to mask off the surrounding primed area to prevent over-blasting. Cleaning agents and rinse water shall be collected and disposed of in accordance with applicable local, state, and federal regulations.

Surfaces that will be inaccessible after assembly and erection shall be coated prior to assembly.

When the superstructure is weathering steel, the topcoat shall be Brown, Federal No. 595-20059. The topcoat color for other structures shall be Gray, Federal No. 595-26307 unless otherwise specified on the plans. When only portions of a structure are designated for coating, the edges of proposed coated areas shall be masked to a straight line.

411.07—Galvanized Surfaces

(a) **Existing Uncoated:** The Contractor shall prepare the surface in accordance with Method 1 or Method 7. Rust shall be removed using Method 2 or Method 3. If no coating is specified, the Contractor shall apply an epoxy prime coat and urethane top coat selected from System F as specified in Table IV-6.

(b) **New Surfaces:** When coating new galvanized steel is specified in the Contract or plans, galvanizing shall be accomplished in accordance with Section 233 and the following.

1. **Galvanizing Facility:** Prior to galvanizing operations, the galvanizing facility shall inspect and remove all sharp edges on rolled, pressed or forged steel, railings, tubing or other assemblies by grinding or filing edges to a radius of 1/8 inch. The galvanizer shall not quench or chromate treat surfaces that are to be coated. After galvanization, surfaces shall be uniform and smooth. Should any locations be found to have excessive liquid zinc run-off, dross, or zinc oxide particles, these locations shall be smoothed using hand or power tools until such locations are level with the surrounding area.

   The galvanizing facilities quality control personnel shall measure the applied galvanizing layer using a Type II film thickness gage as described in Section 411.04(c)8. The galvanizing facility shall prepare a report providing the gage manufacturer, model number, serial number, record of last calibration, verification of combined accuracy results. The report shall also include the specified coating thickness grade by material category for parts and/or assemblies shipped, the dates when work was completed and reported thicknesses of the galvanized layer in accordance with ASTM A123. The facility shall also include a written statement certifying the materials have not been quenched or chromate treated after the hot dip process. Copies of this report shall be sent to the Contractor, the Painting Contractor and the Department.

   After galvanizing and inspection, the facility shall protect materials from rain or moisture during storage and subsequent shipment. Precautions shall be taken when handling material by using appropriate straps and spacing material in shipping to minimize damage.

2. **Painting Contractor:** The painting contractor's quality control personnel shall inspect materials received for sharp edges, dross, excessive zinc run-off, damaged locations from shipping and zinc salts that may have formed during storage or transport. Painting personnel shall verify film thicknesses reported by the galvanizing facility, prior to performing surface preparation. The galvanized layer and subsequent application of coatings shall be measured using a Type II film thickness gage as described in Section 411.04(c)8. Galvanized surfaces shall be prepared using Method 1 followed by sweep blasting in accordance with SSPC SP-16, including all information noted in Appendix A.

   The resultant profile shall be from 1.0 to 1.5 mils in a uniform pattern with no smooth un-profiled areas. Surface profile shall be measured in accordance with ASTM D 4417, Method C. After sweep blasting the painting contractor's quality control personnel shall measure the galvanized layer in 3 random locations per shift, for a total of 9 readings, to ensure thicknesses are at or above the specified coating thickness grade by material category reported by the galvanizing facility. Locations found to have insufficient coating thickness shall be repaired in accordance with ASTM A780 and prepared in accordance with the coating manufacturer's instructions. Coatings shall be applied as soon as possible within 8 hours after the start of sweep blast preparation.

   The painting contractor's quality control personnel shall measure each coating applied in accordance with SSPC PA-2. The painting contractor shall submit, in a report, information of the Type II gage manufacturer, model number, serial number, record of last calibration, verification of combined accuracy tolerance and thickness readings of the galvanized layer prior to and after sweep blasting. The report shall also include all surface profile measurements, air, surface, material temperatures, relative humidity's during preparation and painting, dry film thickness of coating(s) applied with dates and times each phase of work was performed.

If new galvanized material is supplied to the project and no written documentation exists that it has not been quenched, chromate treated, or other passivating treatment has been used, surfaces must be tested in accordance with SSPC SP-16 to confirm no chromates or other oxidizing treatment is present. If present, surfaces shall be tested after sweep blasting to ensure chromates or other oxidizing treatments have been removed prior to coating application. Surfaces shall be prepared by sweep blasting as stated above. If treated members or materials have been erected and it is deemed sweep blasting is inappropriate due to access or surroundings, the Contractor shall prepare the surfaces using a zinc-phosphate treatment in accordance with the manufacturer's recommendations and ASTM D6386. Prepared surfaces shall be coated as soon as possible within 8 hours of preparation.

411.08—Observation Period

The Contractor shall maintain responsibility for the coating system for a 12 month observation period beginning on the date of acceptance of the coating work specified on plans or in the Contract. The Contractor shall guarantee the preparation and installation of the coating system under the payment and performance bond. To successfully complete the observation period, the coating system must meet the following requirements after 12 months in service:

(a) No visible rust or rust stains from coated surfaces.

(b) No blisters, peeling, cracking or other abnormalities of any coat applied.

(c) Have uniform color and gloss and be within the retention values established when tested for acceptance.

(d) Have an adhesion rating of at least 80 percent of the initial adhesion when tested for acceptance in accordance with ASTM D4541

411.09—Environmental Protection

In accordance with Section 107, the Contractor shall protect the public and the environment from leaded paint or hazardous material resulting from coating preparation, cleaning, removal operations, blast abrasives, rust, and overspray.

The Engineer will not allow the depositing or dropping of waste materials into water, onto the ground, onto roadways, or outside the containment system. Tarpaulins shall cover all pavements and surfaces underneath removal and recycling operations including equipment or other equipment handling hazardous materials and storage during active and inactive operations such as retention or storage until characterization analysis and disposal.

Waterways, travel-ways and the public shall be protected against coating drift and overspray. Equipment and containment devices shall arrive at the site in a decontaminated condition and shall be decontaminated prior to relocating or moving unless otherwise properly disposed. Residues from decontamination and any associated disposable items shall be properly disposed of in accordance with all applicable federal, state, and local regulations.

The Contractor shall at all times be in compliance with these specifications and the regulations of, but not exclusive to, the following agencies: U.S. Environmental Protection Agency, U.S. Department of Transpor-

tation, Virginia Department of Environmental Quality, Virginia Department of Labor and Industry, and the U.S. Coast Guard. The Contractor shall immediately report all instances of non-compliance to the Engineer.

(a) **Environmental Protection Plan:** Where surface preparation operations are required, the Contractor shall submit a detailed site-specific Environmental Protection Plan to the Engineer for and the Engineer's review and acceptance. The accepted site-specific Environmental Protection Plan shall become part of the Engineer's records for the project. The Contractor shall not construe submittal acceptance as implying any approval of means and methods by the Engineer. The Contractor shall provide one comprehensive Plan that covers all facets of operation. No work shall proceed until the Engineer has notified the Contractor of Plan acceptance. The Environmental Protection Plan shall include controls for capture, containment, collection, air monitoring, storage, and transportation of waste material generated by the work. The Contractor shall use the most effective method possible for capture, collection, containment, and transportation operations. The Plan shall include measures for accidental spill cleanup and spill reporting to the appropriate regulatory agencies.

The Environmental Protection Plan shall be certified by an SSPC QP-2 Competent Person. If the containment design involves the erection of a supported or suspended containment system from the bridge structure with a total weight-bearing capacity of greater than 1,000 pounds, the Plan shall also be reviewed and certified by a Professional Engineer licensed to practice engineering in the Commonwealth of Virginia. The certification shall include the structural integrity of the containment structure and verification that the containment system does not adversely affect any portion of the bridge.

After project award but not less than 3 weeks prior to commencing operations covered by this Plan, the Environmental Protection Plan shall be submitted to the Engineer. Within 2 weeks of the date of receipt, the Engineer will review the submitted Plan for completeness. Should deficiencies in the Plan exist, the Plan will be returned to the Contractor for incorporation of revisions as noted by the Engineer. The Contractor shall make such revisions and submit a completed corrected Plan for the Engineer's record prior to commencing operations. In no case shall the Contractor begin work prior to the Engineer's receipt and review of a satisfactorily complete Environmental Protection Plan.

(b) **Monitoring:** The Contractor shall perform continuous visual inspections of the containment structures, the dust collector system and abrasive recycling equipment to detect and control the release of any emissions into the unconfined air space. Emissions will not be permitted outside the containment system. The Contractor shall immediately correct any visual emissions outside the containment system to comply with emission standards. If there are any emissions or discharges noted, the SSPC QP-2 Competent Person shall submit in writing, within 24 hours of notice, what corrective actions were taken to contain the errant emissions or discharges.

The SSPC QP-2 Competent Person shall submit written certification each week to the Engineer that removal operations and coating work is being performed in compliance with the accepted Environmental Protection Plan and that the project is meeting the environmental requirements therein. Further the SSPC QP-2 Competent Person shall submit certification to the Engineer at the completion of the project that the Environmental Protection Plan fully complied with all applicable regulations and was fully implemented.

Minimal visible air emissions will be allowed for properly operating vacuum-assisted power tools provided that a secondary means for collecting large particles is employed and the technology is applied using usual and customary industry practices inherent to such work. Excessive emissions

caused by improperly operating or functioning equipment shall be immediately corrected. Any exhausts from gasoline or diesel equipment used shall be located outside or directed outside of the containment area. The Contractor shall provide adequate lighting as necessary to aid proper performance of the work and visual inspections in accordance with the minimum requirements for illumination as stated in SSPC, Guide 12.

The Contractor shall be responsible for performing perimeter air monitoring for all projects requiring removal of greater than 100 square feet of coating, using high-volume air samplers equipped for the collection of Total Suspended Particulate (TSP) samples. Air monitoring equipment used shall be employed, maintained and calibrated in accordance with the manufacturer's instructions. The filters shall be replaced daily in the presence of the Engineer and analyzed for lead in accordance with EPA 40 CFR Part 50, Appendix G. Air monitoring equipment shall be in operation for a minimum of 8 hours per day while blasting operations are being performed. The Contractor shall place air monitors within 500 feet downwind of the structure at the point of maximum potential environmental impact of paint abatement, dust collection, and abrasive recycling equipment and at other locations of potential public or environmental exposure as directed by the Engineer. Monitors shall be maintained at downwind positions at all times during the work in the event of shifting wind patterns.

As measured by perimeter monitoring, the Contractor shall be responsible for maintaining emissions levels below the National Ambient Air Quality Standard for lead (40 CFR Part 50) using the Adjusted Daily Allowance (ADA) procedure outlined in SSPC-Guide 6, Method D. Should emissions exceed the limits set herein or material begins to reach the ground or enter State waters, the Contractor or the SSPC QP-2 Competent Person shall notify the Engineer and operations shall be halted until such time that corrective actions are implemented. The results of all sample analyses shall be submitted to the Engineer within 48 hours for the first two days of monitoring, and within 5 business days thereafter.

(c) **Waste Characterization and Storage:** Material removed from a Type A structure shall be disposed of as a non-hazardous waste in accordance with (d)1 herein.

Solid material removed from a Type B structure shall be contained, collected, and stored in closed 55-gallon USDOT approved steel drums or portable metal roll-off containment refuse disposal bins. For small quantities of waste, approved 5-gallon containers may be used.

The Contractor shall, with the oversight of the Engineer; collect and provide to the Department samples for analysis at the following frequency:

Containers	Samples
1	1
2-6	2
Over 6	1 for every 3 containers

The Contractor shall supply containers used to provide the Department waste characterization samples. Containers shall be wide mouth screw top high density Polyethylene or Polypropylene (HDPE or PP) bottles. Solid waste characterization samples shall be submitted in a full 500 ml container and liquid waste characterization samples shall be submitted in a full 1,000 ml container.

Solid waste samples shall be randomly collected and shall be representative of the contained waste. The solid waste generated from work performed on Type B structures will be tested by

the Department in accordance with EPA Method 1311, Toxicity Characteristic Leaching Procedure (TCLP), and corresponding EPA 6000 or 7000 series metals analytical method for, but not limited to, the following metals to determine if the waste material(s) requires management as hazardous waste: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Exception to this testing protocol is that waste generated from abrasive blasting with recycled steel abrasives for Method 5 or Method 9 will be tested for total concentrations of the aforementioned heavy metals in lieu of the TCLP analysis. The Department shall pay the cost of all tests performed by the laboratory on solid wastes. Waste generated from abrasive blasting with recycled steel abrasive shall be classified as hazardous if the total lead level exceeds 0.01 percent. If the material is declared to be a hazardous waste by the Department, the Contractor shall dispose of the material in accordance with Section 411.09(d)3. The Contractor is not relieved from performing waste characterization in accordance with the aforementioned procedures by using test results from samples of coatings collected while adhered to the structural steel.

All liquid waste from Type B structures shall be tested by the Contractor in accordance with EPA Method 1311, Toxicity Characteristic Leaching Procedure (TCLP) to determine waste disposal requirements. All liquid wastes from Type A structures shall be tested in accordance with any requirements of the disposal facility. Contractor shall pay all costs for laboratory testing and provide the test results to the Department prior to disposal.

The Contractor shall provide a separate lockable storage area for each structure for waste material located immediately adjacent to the structure. The storage area shall provide access and egress through a gate or door. The Contractor shall collect the material at the end of each workday and shall transport the waste material to the storage area in a closed container that will not permit leakage. Each container shall be marked indicating the origin of the material; the date the material was placed in the storage area; and a 24-hour telephone number for the Contractor and the Department representative. Prominent warning signs shall be displayed around the perimeter of the storage area. The signs shall be located at a distance from the storage area that will allow personnel to read the sign and take the necessary protective actions required before entering the storage area. Warning signs and notices shall be posted in accordance with CFR 29 Part 1926, Section 62.

One centralized storage site may be used to store waste materials from structures at adjacent projects provided that transport of waste over roads open to the public is not required and that the materials is labeled and stored separately.

The site for the temporary storage of the waste material shall be approved by the Engineer prior to its establishment and shall not be located within a flood plain, drainage area, or where water will pond. Containers of waste material shall at all times have tops secured and be covered with waterproof coverings. The site shall be secured against unauthorized entry. If such a site is not available immediately adjacent to the structure, an alternate location on state property shall be submitted as a requested amendment to the Environmental Protection Plan and approved by the Engineer prior to use. The Contractor shall be responsible for ensuring any over-the-road transport of hazardous waste complies with all local, state, or federal permitting, licensing, manifesting, and/or fee requirements.

(d) **Disposal:**

1. Solid waste material from a Type A structure or waste from a Type B structure that is determined by the Department not to be a hazardous waste shall be disposed of in a sanitary landfill Resource Conservation and Recovery Act (RCRA) Subtitle D or licensed

industrial landfill that has a permit from the Virginia Department of Environmental Quality or an equivalent state or federal agency for out-of-state disposal facilities. The Contractor shall identify the landfill used by name, address, and permit number and shall certify that the waste material actually submitted for disposal met the above criteria and was properly disposed.

2. Liquid waste from Type A and Type B structures that is determined not to be a hazardous waste shall be legally disposed of in a publicly owned treatment works facility (POTW). The Contractor shall identify the POTW used by name, address, and permit number and shall certify that the waste material actually disposed of was not hazardous and was properly disposed.

3. If waste material from a Type B structure is classified as hazardous, the Contractor shall obtain a provisional hazardous waste generator number from the Virginia Department of Environmental Quality in accordance with applicable federal and state regulations and shall legally store, package, label, and ship such material by a transporter with an RCRA Hazardous Waste Transporter permit to a RCRA, Subtitle C, Treatment Storage and Disposal Facility (TSDF) for treatment and disposal. The Contractor shall prepare a hazardous waste shipping manifest(s) with the site identified by the federal structure ID or if no federal structure ID, then the state structure ID with the Route and County shall be used; the manifest shall be provided to the Engineer for signature. The Engineer's signature on the waste shipping manifest does not relieve the Contractor of the Contractor's obligations as co-generator of the waste.

4. The Contractor shall dispose of all surface preparation and coating removal wastes within 90 days of the time it is generated and no waste shall remain on site more than 60 days following completion of all coating removal operations.

(e) **Certifications:** The Environmental Protection Plan shall be implemented in accordance with the provisions contained therein; any deviations from the Plan shall be separately submitted by the Contractor and approved by the Engineer. The SSPC QP-2 Competent Person providing the Plan certification shall at a minimum be present during startup and removal operations to ensure that the Plan is fully implemented. Within 1 week following completion of final waste disposal activities, the Contractor shall submit for the Engineer's record a written certification by the SSPC QP-2 Supervisor/Competent Person, including notations of any areas of non-compliance and corrective actions taken, that all work has been completed in full compliance with all applicable regulations and requirements as set forth in these specifications and that the Plan on record was fully implemented. The Contractor shall forward for the Engineer's record one copy of the Environmental Protection Plan complete with all revisions and results from the air monitoring activities, including notations of any areas of non-compliance and corrective actions taken.

411.10—Health and Safety Protection

In accordance with Section 107, the Contractor shall protect the health and safety of the workers, the public, and the environment from all hazardous material resulting from coating preparation (cleaning) removal operations, blast abrasive, rust treatment, pre-cleaning, surface preparation, coating preparation, coating application, and overspray.

(a) **Plan:** The Worker Health and Safety Plan shall be in accordance with the Virginia Occupational Safety and Health Administration, 29 CFR 1926.62 requirements and the applicable

requirements of 29 CFR 1910.1025, and other applicable toxic metal standards, whichever is more restrictive.

The Worker Health and Safety Plan shall be approved by a SSPC QP-2 certified organization and their Competent Person assigned to the project.

This Plan shall not be submitted to the Engineer for approval but shall be submitted for the Engineer's review and record. After project award but not less than 3 weeks prior to commencing operations, the Worker Health and Safety Plan shall be submitted to the Engineer.

Within 2 weeks of receipt, the Engineer will review the submitted Plan for completeness. Should deficiencies in the Plan exist, the Plan will be returned to the Contractor for incorporation of revisions as noted by the Engineer. The Contractor shall make such revisions and submit a completed corrected Plan for the Engineer's record prior to commencing operations. In no case shall the Contractor begin work prior to the Engineer's receipt, review, and acceptance of a satisfactorily completed Plan.

(b) **Monitoring:** The SSPC QP-2 Competent Person providing plan approval shall be present during startup, during surface preparation periods, and as needed during removal operations throughout the duration of the project to ensure the provisions of the Worker Safety and Health Plan are properly implemented.

(c) **Certification:** At completion of the project, the SSPC QP-2 Competent Person shall submit a written statement of certification for the Engineer's record, complete with all revisions including notations of any areas of non-compliance and corrective actions taken, that the Worker Safety and Health Plan fully complied with all regulations and that the Plan was fully implemented.

411.11—Measurement and Payment

Coating of new metal on structures will not be measured for separate payment but shall be included in the price for structural steel or metal items. When a pay item, coating of new metal on structures will be paid for at the contract lump sum price per structure.

Prepare and spot coat existing structure, when a pay item, will be measured in square feet of surface area and will be paid for at the contract unit price per square foot.

Prepare and overcoat existing structure, when a pay item, will be paid for at the contract lump sum price per structure.

Recoat existing structure, when a pay item, will be paid for at the contract lump sum price per structure.

Zone coating of existing structure, when a pay item, will be paid for at the contract lump sum price per structure.

These prices shall include washing, surface preparation, and applying protective coating.

Environmental protection and health and safety will be paid for at the contract lump sum price per structure. This price shall include setting up, maintaining and dismantling, execution, and acceptance, environmental protection plan and worker safety and health plan preparation and approval, providing SSPC QP-2 Competent Person monitoring services, environmental and worker protection quipment and

containment, and all other related costs. Payment for the Environmental Protection Plan and Worker Safety and Health Plan and execution will be made on the basis of two installments per structure. The first installment will be made at 90 percent of the contract lump sum price per structure and will be made on the next progress estimate after an acceptable Environmental Protection and the Worker Safety and Health Plan are received by the Department. Payment of the remaining 10 percent will be made on the progress estimate following the submission of the certifications of compliance for the environmental protection and the worker health and safety plans.

Disposal of material will be paid for at the contract lump sum price per structure. This price shall include storing, transporting, and disposal. No payment will be made for this item until the Contractor provides the signed return manifests from the disposal facility(s).

Payment will be made under:

Pay Item	Pay Unit
Coating of new metal on structures (B or Str. No.)	Lump sum
Prepare and spot coat existing structure (B or Str. No. and type)	Square foot
Zone coating of existing structure (B or Str. No. and type)	Lump sum
Prepare and overcoat existing structure (B or Str. No. and type)	Lump sum
Recoat existing structure (B or Str. No. and type)	Lump sum
Environmental protection and health and safety (B or Str. No.)	Lump sum
Disposal of material (B or Str. No. and type)	Lump sum

SECTION 412—WIDENING, REPAIRING, AND RECONSTRUCTING EXISTING STRUCTURES

412.01—Description

This work shall consist of widening, repairing, or reconstructing existing concrete structures in accordance with the lines, dimensions, plan details, and these specifications or as directed by the Engineer.

412.02—Materials

(a) **Epoxy and mineral fillers** shall conform to Section 243. Epoxy for epoxy mortar shall be Type EP-5. Epoxy used for crack repair shall be Type EP-4 or EP-5, low viscosity. Epoxy for epoxy injection shall be Type EP-4 LV Modified and shall have a viscosity of 5 poises or less at 75 degrees F.

(b) **Hydraulic cement concrete** shall conform to Section 217, except that the coarse aggregate shall be size No. 7, No. 8, or No. 78 for depths and steel clearances less than 2 inches and shall be size No. 57, No. 7, No. 8, or No. 78 for depths more than 2 inches. A Department approved accelerator from the Materials Division's Approved Products List 2 may be permitted by the Engineer when justified by work restrictions, traffic limitations, or closure timeframes.

Concrete specified as High Early Strength (HES) shall be either a high early strength Class A4 ready mixed concrete, or an approved hydraulic cement concrete patching material from

the Materials Division's Approved Products List 31. The type of material to be used shall be approved by the Engineer prior to the beginning of the work at each location.

When a HES patching material is approved for use at the specific location by the Engineer, the patching material volume may be extended with coarse aggregate in accordance with the manufacturer's recommendations. Surface preparation, placement, and curing of the patching material shall be in accordance with the manufacturer's instructions and this specification.

Patching materials must obtain a minimum compressive strength of 2500 psi when tested in accordance with ASTM C1074 prior to permitting vehicular traffic on patched areas.

The Contractor shall make trial batches under the observation of the Engineer for each type of patching material used during this project to verify that concrete of the required workability and consistency is obtained within the specified water content. Concrete test cylinders shall be made from the trial batches to verify the compressive strength obtained within the time intervals designated by the Engineer is acceptable.

Self-consolidating concrete shall conform to Section 217.

(c) **Reinforcing steel** shall conform to Section 406. Deformed reinforcing bars shall conform to ASTM A615 Grade 60, ASTM A1035/A1035M, or ASTM A955/A955M, as specified on the plans or as directed by the Engineer.

(d) **Accelerators** shall conform to Section 215, be noncorrosive, and must be approved by the Engineer prior to use.

(e) **Materials for shotcrete** shall be either a prepackaged material from the Materials Division's Approved Products List 33 or delivered by a transit mixer and conform to the following:

1. **Portland and blended cements** shall conform to Section 214.

2. **Fly ash, slag, and silica fume** shall conform to Section 215.

3. **Water** shall conform to Section 216.

4. **Air-entraining admixtures** shall conform to Section 215.

5. **High-range and regular water reducers** shall conform to Section 215.

6. **Accelerators** shall conform to Section 215 but may be used only if approved by the Engineer. If approved, they shall be added at the nozzle.

7. **Fine aggregates** shall conform to Section 202 for Grading A. Coarse aggregates shall be No. 8 aggregate conforming to Section 203.

8. **Steel fibers and Synthetic fibers** shall be from the Materials Division's Approved Products List 35.

(f) **Welded wire fabric** shall conform to Section 223 and shall be galvanized or stainless steel.

(g) **Expansion bolts** shall be selected from the Materials Division's Approved Products List 29 and shall conform to these specifications.

(h) **Carbon Fiber Mesh Materials** shall conform to Section 250.

(i) **Embedded Galvanic Anodes** shall conform to Section 251.

(j) **Gravity fill polymer crack sealers** shall conform to Section 252.

(k) **Concrete surface color coating** shall be from the VDOT Materials Division's Approved Products List 30.

(l) **High Strength Grout** shall conform to Section 218.

(m) **Fiber Reinforced Polymer Wraps** shall meet the requirements of the specific conditions of the project as determined by the Engineer. Material requirements for acceptable systems will be included in the Contract.

(n) **Anchor Bolts** shall conform to Section 226.

412.03—Procedures

Repairing concrete structures shall consist of removing deteriorated material, thoroughly cleaning exposed concrete surfaces and reinforcing steel, and replacing reinforcing steel where required, and replacing removed unsound or unnecessary concrete with new material. Prior to placement of new material, cleaning shall be performed by abrasive blast cleaning, or other means approved by the Engineer to remove unsound concrete, rust, oil, and other foreign materials detrimental to achieving a bond. The areas and depths of repairs shall be as directed by the Engineer.

Dimensions of existing structures shown on the plans are approximate, and those that are pertinent to the construction of the new portion shall be verified in the field by the Contractor. Where details of new portions of the structure shown on the plans are not adaptable to the shape of the existing structure, the Contractor may make practical modifications during construction with the Engineer's approval provided neither the existing nor the new portions are impaired in structural strength.

Before proceeding with any work within or adjacent to the existing structures, the Contractor shall become familiar with existing conditions. During construction operations, it shall be the Contractor's responsibility to maintain the integrity of the existing structures where the existing structures are modified to accommodate new construction, and to protect from damage those portions of the structures which are to remain.

(a) **Preparation of Concrete Patches**

In any areas where existing concrete is to be removed and replaced by new concrete the following requirements shall apply:

- In the presence of the Engineer the Contractor shall sound the surface of the concrete element to be repaired in accordance with ASTM D4580. The Contractor shall then outline areas to be repaired with paint or other marker in rectangular patterns. Prior to performing repairs, obtain verification from the Engineer that marked areas are the appropiate areas requiring repair.

- Sawcut edges of area to be repaired to a depth of at least 1 inch or to a depth that shall clear the top of the reinforcing steel.

- Remove loose and unsound materials by the use of hand tools or pneumatic hammers weighing a nominal 35 pounds or less. Hammer weight applies to the weight of the pneumatic hammer alone. Pneumatic hammers shall be worked at an angle of 45 to 60 degrees to the plane of the concrete surface being removed.

- Whenever existing reinforcing bars are exposed, concrete shall be removed to a depth of no less than one inch beyond the reinforcing bars. Existing concrete shall be removed as shown on the plan details or as directed by the Engineer, to horizontal and vertical planes only, and to sound concrete, taking care not to damage any existing reinforcing steel.

- Within 24 hours prior to the placement of new concrete, exposed reinforcing steel and the faces of existing concrete shall be cleaned by abrasive blast cleaning.

- Repair and replace damaged or corroded reinforcement as required by this section.

- Place at least one zinc anode in the opening of each area to be patched or repaired, in accordance with Section 412.03 (c) for Embedded Galvanic Anodes

- Immediately prior to placing new concrete, exposed reinforcing steel and faces of existing concrete shall be cleaned of all dust and debris by blowing with oil free compressed air or hosing with water. A fine spray of moisture shall be applied to the exposed concrete surfaces. Faces of existing concrete shall be in a saturated surface dry condition prior to placing new concrete.

- Prior to placement of repair material the Contractor shall capture clear digital images/ photographs of all repair areas. Images shall clearly demonstrate that the area to be repaired was prepared to the proper depth and with appropriate surface preparation. Images shall include measuring devices that clearly demonstrate the length, width, and depth of the repair area. Images shall be submitted to Engineer for inclusion in project records and shall be a condition for payment.

When reinforcing bars are exposed, the exposed length shall be cleaned by abrasive blast cleaning. Care shall be taken to prevent striking reinforcing bars with hammer points. Reinforcing steel that has lost 1/4 or more of its original cross-sectional area shall be lapped with new bars of the same material type, size, and shape. New bars shall lap existing bars a length of 30 diameters on each side of the damaged portion if a sufficient length of the existing bar is exposed. Otherwise, new bars shall be welded with a 6-inch arc-welded lap on each side of the damaged portion with a double-flare V-groove weld in accordance with Section 407 or mechanically connected in accordance with Section 406.

The Contractor shall support unsupported areas with forms or falsework.

The Contractor shall remove and dispose of excess material and debris resulting from repairs in an approved disposal area in accordance with Section 106.04.

Wherever new concrete is scheduled to be placed against existing concrete, the two concrete masses shall be connected as indicated in the plans. Where no plan details are provided, dowels at least 3/4 inch in diameter shall be placed at no more than 2 feet 6 inches center to center over the entire joining surface and 6 to 12 inches from the edge. Dowels shall be placed perpendicular to the surface of existing concrete by drilling and grouting and shall project into both new concrete and existing concrete to a depth as great as the thickness of the concrete will allow but

need not project more than 9 inches into either surface. The Contractor will not be required to install dowels if other acceptable means for connecting new concrete to existing are available. Acceptable alternative methods include lapping of reinforcing steel protruding from the existing concrete surface or use of approved mechanical splices to provide continuity between new and existing reinforcing steel.

For footings and neat work of substructures where joining planes are vertical, 3/4-inch headed expansion bolts shall be used instead of dowels. Bolts shall project at least 9 inches into new concrete and shall extend sufficiently far into existing concrete to develop their rated pullout strength but not less than 6 inches. The Contractor shall exercise care so that existing reinforcing steel is not damaged when drilling holes for expansion bolts.

Where necessary to prevent featheredges, existing concrete shall be removed to ensure a thickness for new concrete of at least 6 inches.

All of the concrete within a span lane that is to be removed shall be removed before recasting any concrete within that span lane, unless otherwise approved by the Engineer.

No concrete repairs, including removal and recasting of superstructure and substructure concrete, shall be performed within a span lane that is under traffic unless approved by the Engineer.

For full depth deck repair or expansion joint elimination or reconstruction that is not protected by concrete traffic barrier, the work shall be limited to that amount which can be performed within the duration of the scheduled lane closure unless alternate means of temporarily protecting the opening are provided. Any method for allowing traffic to ride over a temporary construction opening shall be designed by the Contractor, and working drawings conforming to Section 105.10 shall be submitted to the Engineer for approval prior to use.

Where steel plates are provided to protect damaged or patched areas from traffic, the steel plate shall be of sufficient size, thickness, and strength to temporarily support traffic. Additionally, temporary anchorages between the steel plate and deck shall be adequate to prevent movement of the plate under traffic.

The Contractor shall notify the Engineer a minimum of three (3) working days prior to the beginning of any concrete repairs so that the areas to be repaired can be sounded in the presence of the Engineer.

To preserve structural integrity and prevent unsafe structural conditions, the Contractor shall develop a plan for the removal of deteriorated concrete in superstructure and substructure elements. The plan shall be submitted to the Engineer for review after the elements are sounded and prior to beginning the work. The plan shall specify the order and size limits of areas of deteriorated concrete that may be removed at any one time. Concrete in the newly repaired areas shall attain a minimum design compressive strength of 3000 psi before adjacent concrete is removed. The cost of preparing the plan shall be included in the price bid for the appropriate items. Unless otherwise approved by the Engineer, the plan shall include the following limitations on concrete removal:

- **Reinforced Concrete Beams** - the removal of concrete in the tension zone of a beam shall be limited to not more than 30 percent of the span length at any one time.

- **Prestressed Concrete Beams** - the removal of concrete in the tension zone of a beam shall be limited to not more than 30 percent of the span length at any one time.

- **Caps for Column Piers** - the removal of concrete in the tension zone of a cap shall be limited to not more that 30 percent of the span between adjacent columns at any one time.
- **Cap Cantilevers for Column and Hammerhead Piers** - the removal of concrete in the tension zone of a cap cantilever shall be limited to not more that 30 percent of the length of the cantilever at any one time.

- **Pier Columns** - the removal of concrete in a pier column shall be limited to not more than 30 percent of the height of the column at any one time.

- **Columns in Multi-Column Piers** - no more than 50 percent of the columns may be under repair at any given time

The Contractor shall provide appropriate work platforms, scaffolds, under bridge access vehicles, and other equipment that is required to obtain access to areas of work. The Engineer shall be provided access to work areas to determine the extent of repairs and to inspect the work. The cost of access equipment and materials shall be included in the price bid for the appropriate items.

When self-consolidating concrete (SCC) is used in lieu of Class A4 concrete for superstructure or substructure repairs, the following procedures shall be adhered to:

The Contractor shall demonstrate that he can produce satisfactory SCC that meets the specification and other requirements by submitting documentation indicating the Contractor's successful experience in furnishing and placing SCC on similar size projects or structural elements or by successful trial batching at least three weeks prior to beginning placement operations. Such documentation shall list projects by date of completion, name or project reference number, client or owner, structural elements or type of unit placed, quantity of SCC furnished, names and experience of personnel and current contact (owner or client) information for verification. The Contractor shall also demonstrate that SCC can be placed without segregation of the mix by a mock-up simulating the actual elements. The cost of the mock-up shall be included in the price bid for the appropriate items.

Formwork shall be designed for the full static head of concrete and shall be in accordance with Section 404.

Additional measures shall be taken to seal the formwork to prevent leakage of cement paste and mortar.

A Concrete Technologist (such as the admixture supplier) experienced in the production of SCC representing the Contractor or a representative of the SCC producer shall be present during placement. Concrete shall stay plastic and within the slump flow specified during placement operations. Concrete placement shall be conducted in such a manner that air is not encapsulated, segregation does not occur, and the SCC flows freely to thoroughly occupy the formwork throughout the duration of the placement.

The Contractor shall field test concrete slump flow in accordance with ASTM C1611. Cone can either be used upright or inverted. The same procedure shall be followed throughout the project. Slump flow shall be 26 +/- 3 inches.

Rate the Visual Stability Index (VSI) in accordance with ASTM C1611. VSI shall not exceed 1.

Test passing ability in accordance with ASTM C1621. Cone shall be used in the same way as in the slump flow test.

Record all concrete test data including slump flow, VSI, and passing ability; and submit the test data to the Engineer.

Consolidation is typically not necessary for SCC. However, the Contractor shall have internal vibrators on site in case internal vibration is needed due to delays in placement or the concrete has lower than expected slump flow and has to be placed to prevent the formation of a cold joint.

The Contractor shall obtain prior approval by the Engineer if it is anticipated minimal vibration (external or internal) is required for proper consolidation due to congested reinforcement or space restrictions.

Equipment for job site mixing of hydraulic cement concrete and HES concrete shall be approved by the Engineer prior to the start of the work. Concrete mixed at the job site shall be mixed in a High Performance Volumetric Mixer (HPVM) in accordance with Section 217.05 (d) when the quantity of repair material is greater than six (6) cubic feet.

Concrete shall be constructed in accordance with Section 404 except that surfaces shall be finished and shaped to match existing adjacent surfaces. Concrete shall be Class A4 when used for superstructure work, and Class A3 when used for substructure work.

(b) **Bridge Superstructure and Deck Repairs:**

1. **Type A patching and Type A Patching (HES)** shall consist of repairing the deck from the existing deck surface or milled surface to a depth that will not expose reinforcing steel. Material placed in the patch shall be vibrated in place and shall be broom-finished. Prior to initial set, the material shall be scraped or cut with a trowel followed by a broom finish then immediately covered with moist burlap, which shall be kept moist until the deck is opened for traffic. Do not overfinish or place additional water on top of patch during finishing.

2. **Type B patching and Type B Patching (HES)** shall consist of repairing the deck from the existing deck surface or milled surface to a depth at least 1 inch below the top mat of reinforcing steel. Material placed in the patch shall be vibrated in place and shall be broom-finished. Prior to initial set, the material shall be scraped or cut with a trowel followed by a broom finish then immediately shall be covered with moist burlap, which shall kept moist until the deck is opened for traffic. Do not overfinish or place additional water on top of patch during finishing.

3. **Type C patching and Type C Patching (HES)** shall consist of repairing the deck from the existing deck surface or milled surface to its full depth. Forms may be suspended from reinforcing steel by wire ties for areas of less than 3 square feet. In the case of larger area openings, forms shall be supported by blocking. Sound concrete shall be removed to obtain a somewhat vertically shaped surface at the edges of the patch. Material placed in the patch shall be vibrated in place and shall be broom-finished. Prior to initial set the material shall be scraped or cut with a trowel followed by a broom finish then immediately covered with moist burlap, which shall kept moist until the deck is opened for traffic. Do not overfinish or place additional water on top of patch during finishing.

4. **Epoxy-mortar patching** shall be performed in accordance with the requirements for Type A patching to a depth up to and including 3/4 inch. The Engineer will approve the proportions of sand and epoxy to be used in the patching material. Surface areas to be patched shall be dry and primed with neat epoxy just prior to mortar placement. Mortar may be troweled into place to featheredges. The patched surface shall be sprinkled with sand before the epoxy sets or sandblasted just prior to placement of the seal to ensure bonding. When epoxy mortar is to be the finished riding surface, patches exceeding 8 feet in any longitudinal direction shall be tested in that direction in accordance with Section 404.04.

5. **Crack repairs** shall be performed using one of the following methods as specified on the plans:

   a. **Crack Repair Type A (V grooving)** - Structural cracks and dormant cracks shall be V-grooved to a depth of approximately 1/2 inch and blown clean. The groove shall be filled with neat epoxy. At the Contractor's option, hydraulic cement concrete overlay material may be brushed into the groove in lieu of epoxy when hydraulic cement concrete overlay material is monolithically placed for Type A, B, or C patching or joint repairs.

   b. **Crack Repair Type B (Epoxy injection)** - The Contractor shall subject cracks to several blows with a five-pound hammer. At locations where a hollow sound is detected with the hammer, the Contractor shall remove loose, spalled or otherwise deteriorated unsound concrete. The crack shall then be blown clean with oil free compressed air and injection ports installed along the crack at 18 inches on center. The crack shall be surface sealed with Epoxy, Type EP-6 and allowed to fully cure according to manufacturer's instructions prior to pressure sealing. After surface curing the crack, the Contractor shall internally pressure seal the crack with Epoxy, Type EP-4 LV Modified using slow, steady pressure from an injection gun capable of producing a fluid pressure of at least 100 psi.

      Injection of EP-4 LV Modified epoxy shall begin at the lowest injection port and shall be pumped until the epoxy reaches the next higher port. This process shall be repeated until the full length of the crack is pressure sealed. After the entire crack has been pressure sealed, injection port fittings shall be removed and the resulting holes filled with Epoxy, Type EP-6.

   c. **Crack Repair Type C (Gravity Filled Polymer Sealing)** - Gravity fill polymer sealers shall be a high molecular weight methacrylate, epoxy or urethane material from the Materials Division's Approved Products List 28.

      Concrete cracks in new work to be filled shall have reached the 28-day design compressive strength requirement, shall be dry and free of dust, dirt and other debris prior to filling. Cracks shall be air blasted with oil free compressed air prior to application of the sealer. The concrete surface temperature shall not be less than 55 degrees F when the sealer is applied. The sealer shall be applied during the lowest temperature period of the day, usually between 1 a.m. and 9 a.m., when the cracks are open to their greatest extent. Cracks wider than 1/25 inch shall be filled with dry No. 50 sieve size silica sand prior to placement of the polymer. The polymer shall than be applied directly to the cracks allowing time for the polymer to seep down into the cracks, then making additional applications until cracks are filled.

The polymer material may also be spread over designated crack areas and worked into the cracks with a broom or squeegee. Excess polymer shall be brushed off the surface prior to the polymer hardening. Regardless of the application method used, the polymer shall be applied in sufficient quantity and applications to fill cracks level. An application rate of 1 gallon per 100 linear feet or 100 square feet is usually adequate. Application of the polymer crack sealer shall be completed prior to grooving of the deck surface and grooving shall not be performed until the polymer has cured a minimum of 48 hours.

The Contractor shall plan and prosecute the work in such a manner to protect persons, vehicles and the bridge structure from injury or damage. Armored joints shall be covered, scuppers plugged and cracks sealed from underneath or other protective measures implemented as necessary to protect traffic, waterways and bridge components. If polymer materials or solvents harm the appearance of bridge components, removal of such materials will be required as directed by the Engineer. Traffic will not be permitted on treated surfaces until tracking will not occur as determined by the Engineer.

d. **Crack Repair Type D (Epoxy and Carbon Fiber Mesh)** – The Contractor shall seal linear cracks and construction joints in hydraulic cement concrete bridge decks and overlays with epoxy and open grid carbon fiber mesh as directed by the Engineer.

Cracks shall be located and sealed at the oldest age that is practical as determined by the Engineer and prior to the final acceptance of the project and prior to opening the surface to traffic.

Crack width shall be measured using a transparent crack comparator placed on the surface of the concrete. The width shall be at the oldest age that is practical as determined by the Engineer prior to opening the surface to traffic and prior to the final acceptance of the project. The width shall be measured and recorded within 3 hours after sunrise. Cracks with a width equal to or greater than 0.2 millimeter shall be marked for sealing.

The surface of the concrete on which the carbon fiber mesh will be placed shall be cleaned in accordance with Section 431. The epoxy and aggregate shall be placed in accordance with the requirements for the first layer for Epoxy Concrete Overlay. The Contractor shall then dump and spread the mixed epoxy resin on the designated area for the placement of the 4-inch carbon fiber strip. Apply the epoxy at a minimum rate of 2-1/2 gallons per 100 square feet. Immediately place the 4-inch carbon fiber strip, precut to the required length, into the placed epoxy allowing the epoxy to saturate the carbon strip so as to penetrate through the openings in the carbon strip and thoroughly encapsulate the strip. A roller or squeegee may be used to assist penetration and to ensure the strip is pressed to the substrate and the epoxy is evenly spread. Use a squeegee to move adjacent epoxy over the strip for complete encapsulation. Broadcast aggregate to excess over all surfaces covered with epoxy.

The Contractor shall plan and prosecute the work in such a manner to protect persons, vehicles and the bridge structure from injury or damage. In the event epoxy materials or solvents harm the appearance of bridge components, removal of such materials will be required as directed by the Engineer. Traffic will not be permitted on the treated surface during the curing period which is specified in Section 431.

6. **Concrete superstructure surface repair** shall include repairing raised medians, median barriers, beams, diaphragms, parapets, posts, rails, curbs, sidewalks, and other areas as designated on the plans. Superstructure surface repair shall be performed in accordance with the requirements herein.

   For unreinforced concrete elements where 2 inches or more of existing concrete is removed, the Contractor shall place 2 x 2-W1.4 x W1.4 welded wire fabric over the entire patch area. Welded wire fabric shall be anchored to expansion bolts at least 3/8 inch in diameter, which the Contractor shall place along the edges of the patch. The expansion bolts shall be spaced not more than 18 inches apart and shall be embedded at least 2 inches into the concrete. The minimum thickness of repair material over reinforcing steel, including expansion bolts and welded wire fabrics, shall be 2 inches unless otherwise specified.

   Unless otherwise specified, the Contractor shall have the option of using conventional hydraulic cement concrete or self-consolidating concrete for concrete superstructure surface repairs. Shotcrete will only be allowed when specified on the plans or approved in writing by the Engineer.

7. **Joint opening repairs** shall be performed as follows:

   a. **Expansion joint removal** shall consist of removing and disposing of concrete, repairing and replacing reinforcing steel, and cleaning exposed surfaces by abrasive blasting.

   b. **Expansion joint reconstruction and Expansion joint reconstruction (HES)** shall consist of removing and disposing of existing concrete and any existing joint armor, repairing and replacing reinforcing steel as may be required by this section, preparing the contact surfaces, and furnishing and placing new concrete and reinforcing steel, in accordance with the plan details and the requirements herein.

   c. **Expansion joint preparation** shall consist of removing and disposing of existing joint material, cleaning the joint by abrasive blasting, and saw cutting the joint when necessary. A saw guide shall be provided for all saw cutting. Sawing to a line or mark by visual unassisted means only will not be permitted. The saw guide shall be a template or track capable of controlling the saw in the desired direction to produce a clean, straight and true line.

   d. **Backwall reconstruction and Backwall reconstruction (HES)** shall consist of removing and disposing of existing concrete and any existing joint armor, repairing and replacing existing reinforcing steel as may be required by this Section, preparing the contact surfaces, and furnishing and placing new concrete and reinforcing steel, and restoring backfill and disturbed pavement in accordance with the details and requirements herein or shown on the plans. The new concrete backwall shall have the same dimensions as the existing backwall being replaced. Exposed undamaged existing backwall reinforcing steel shall be abrasive blast cleaned and reused.

      When not included in other joint repairs, saw cutting of the joint shall consist of saw cutting concrete to the limits detailed in the plans.

8. **Existing joint resealing** shall be performed in accordance with Section 316 unless otherwise specified in the plans.

(c) **Embedded Galvanic Anodes** shall consist of furnishing and installing galvanic anodes in deck patching, superstructure repairs, or substructure repairs as shown on the plans or as directed by the Engineer, confirming the electrical connection between anode tie wire and reinforcing steel, confirming/establishing the electrical continuity of all of the exposed reinforcing steel, wiring, and testing for the successful installation and performance of galvanic anodes.

Unless otherwise shown on the plans or directed by the Engineer, galvanic anodes shall be placed in all deck patches, deep hydro-demolition applications, superstructure repairs, and substructure repairs.

The removal of deteriorated concrete and placement of repair material shall be measured and paid for under the appropriate items for deck patching, superstructure repairs, and substructure repairs.

At least 2 weeks prior to installation the Contractor shall submit to the Engineer for review a detailed plan for installation and placement of the anodes subsequent to the removal of the deteriorated concrete during each construction stage. Anodes shall be spaced no greater than 18 inches on center along the periphery of the repair/patch area or as specified by the manufacturer. Final anode placement and incorporation into the work shall not proceed until the Engineer has accepted the Contractor's anode installation plan. The Engineer's acceptance of the Contractor's installation plan shall in no way relieve the Contractor of his responsibility for furnishing and installing a fully functional anode corrosion protection system that meets the criteria established in this specification and the other contract requirements.

A technical representative from the anode manufacturer shall be on site for a minimum of two (2) days during the initial startup of the anode installation for instruction and advice. The technical representative shall be available for subsequent visits as deemed necessary by the Engineer to insure continued compliance with the installation process.

A technical representative from the anode manufacture shall be on site for final testing of the system.

1. **Concrete Removal:**

The Contractor shall undercut all exposed reinforcing steel by removing concrete from the full circumference of the steel. The minimum clearance between the concrete substrate and galvanic anode shall be 3/4 inch to allow sufficient room for embedding mortar between the anode and concrete substrate.

Concrete removal shall continue along the existing reinforcing steel until there are no visible signs of corrosion.

Edge and surface conditioning of concrete:

a. Concrete patches shall be square or rectangular in shape with squared corners.

b. Saw cut the patch boundary 1/2 inch deep or less if required to avoid cutting reinforcing steel.

c. Create a clean, sound substrate by removing bond-inhibiting materials from the concrete substrate by high pressure water blasting or abrasive blasting.

2. **Cleaning and Repair of Reinforcing Steel:**

   a. Clean exposed reinforcing steel of rust, mortar, etc. by abrasive blasting or other methods acceptable to the Engineer to provide sufficient electrical connection and mechanical bond.

   b. If significant reduction in the cross section of the reinforcing steel has occurred, replace or install supplemental reinforcement as directed by the Engineer.

   c. Secure loose reinforcing steel by tying tightly to other bars with steel tie wire.

3. **Galvanic Anode Installation:**

   Galvanic anodes shall be installed along the perimeter of the repair or interface at spacing as specified in the manufacturer's specifications or instructions, however, in no case shall the distance between anodes exceed 18 inches.

   The minimum concrete cover between the anode and the surface shall be 1 1/2 inches. The minimum distance between the anode and the concrete substrate shall be 3/4 inch.

   a. Secure the galvanic anodes as close as possible to the patch edge using the anode tie wires. The tie wires should be tightened to allow little or no free movement.

   b. If the anode is to be tied onto a single bar, or if less than 1 inch of concrete cover is expected, place anode behind the bar and secure to clean reinforcing steel.

   c. If sufficient concrete cover exists, the anode may be placed at the intersection between two bars and secured to each clean bar.

4. **Electrical Continuity:**

   a. Confirm electrical connection between anode tie wire and reinforcing steel by measuring DC resistance (ohm, Ω) with a multi-meter.

   b. Confirm electrical continuity of the exposed reinforcing steel within the repair area. If necessary, electrical continuity shall be established with steel tie wire.

   c. Electrical continuity is acceptable if the DC resistance measured with multi-meter is less than 1Ω.

5. **Concrete Placement:**

   a. Embed the anodes in individual pockets of embedding mortar to form a conductive bridge to the concrete substrate. Embedding mortar shall completely surround the anode, filling all voids between the anode and the concrete substrate and reinforcing steel over a minimum area of 4 inches in diameter.

   b. Insulating materials such as epoxy bonding agents shall not be used.

   c. Following normal concrete repair procedures complete the repair with concrete, taking care not to create any air voids around the anode. Concrete material and installation shall conform to all anode manufacturer's specifications and instructions.

(d) **Deck Slab Closure** shall consist of repairing bridge decks for link slabs at piers and deck extensions at abutments in accordance with the plan details and the requirements herein. This work shall consist of removing and disposing of existing concrete and any existing joint armor, removing and disposing of stud shear connectors within the limits of the slab closure for steel beams/girders, removing and disposing of stirrup bars within the limits of the slab closure for concrete beams/girders, repairing or replacing existing reinforcing steel as may be required by the work described in this Section, preparing the contact surfaces, furnishing and placing expanded polystyrene, and furnishing and placing new reinforcing steel and concrete in accordance with the details and requirements herein. Exposed undamaged existing reinforcing steel shall be abrasive blast cleaned and reused.

The Contractor shall develop a sequence of construction for deck slab closures to be used in conjunction with other related work items (bearing modification, etc.) which shall be submitted to the Engineer for review prior to performing the work. The cost of preparing the sequence of construction shall be included in the price bid for deck slab closure.

(e) **Concrete Substructure Surface Repairs** shall include repairing piers, wing blocks, abutments and other areas as designated on the plans and shall consist of removing and disposing of existing concrete, repairing or replacing existing reinforcing steel where required by the work described in this Section, preparing the contact surfaces, furnishing and placing a bond breaker when required, and furnishing and placing new reinforcing steel and concrete in accordance with the with the details and requirements herein. Exposed undamaged existing reinforcing steel shall be abrasive blast cleaned and reused.

Limits of repair and removal of damaged concrete shall be determined in accordance with Section 412.03(a) herein. Removal of concrete shall be to a depth as required by Section 412.03(a) herein or as specified on the plans or as directed by the Engineer. Welded wire fabric shall be installed in accordance with Section 412.03(b) 6. herein.

Concrete for substructure surface repair shall be Class A4 concrete or self-consolidating concrete cast within forms placed to match the original geometry of the substructure element. Finished and repaired concrete shall be flush with pre-existing concrete and no blisters or protrusions will be accepted. Shotcrete shall not be permitted unless approved by Engineer in writing. Repair materials shall conform to Section 217 and this specification.

(f) **Jacking and Blocking Beams** shall consist of supporting beams during construction and may include jacking, blocking, and other approved methods of support in accordance with the requirements herein.

The Contractor shall develop a plan for jacking, blocking, and supporting beams which shall be submitted to the Engineer for review and approval. The plan shall be designed, prepared and sealed by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia. The cost of preparing the plan shall be included in the price bid for Jacking and Blocking Beams.

Unless approved by the Engineer in writing or specified on the plans, temporary support systems shall be designed to sustain traffic loadings in addition to dead load and temporary construction loads and all other anticipated loading while performing the work.

(g) **Shotcrete** will be permitted only when specified for repairs or approved in writing in lieu of conventional hydraulic cement concrete or self-consolidating concrete. Shotcrete repairs shall be performed in accordance with Sections 412.03(b) 7d. and 412.03 (e) herein.

The shotcrete mixture shall be prepackaged material from the Materials Division's Approved Products List 33, or ready mixed concrete containing at least Portland cement, silica fume, aggregates, and synthetic fibers. Admixtures and Class F fly ash or slag cement will be permitted. Any mixture other than approved mixtures shall have trial batch or historic data showing compliance with the specifications and will require approval by the Engineer before use. Synthetic fibers shall be 3/4 inch long polypropylene present in small quantities (minimum 1.5 lb/yd^3) to control plastic shrinkage cracking. Any other type of fiber requires the prior approval of the Engineer. The minimum 28-day design compressive strength of shotcrete shall be 5,000 psi and the maximum permeability, 1000 coulombs. Before construction, the Contractor shall submit for the Engineer's approval, the compressive strength and permeability data obtained from samples shot using the job material and equipment scheduled for use for the actual structure. Wire mesh shall not be required to hold the shotcrete in place. Shotcrete contractor shall have at least 3 years of experience in similar applications or shall be required to demonstrate qualification as required by the Engineer. Polymer modified shotcrete shall not be used unless permitted by the Engineer.

Shotcrete cover over reinforcing steel shall be a minimum 2 inches except in transition areas where shotcrete is feathered to existing concrete with less than 2 inches of cover or where patches are made on existing concrete with less than 2 inches of cover over reinforcing steel.

The Contractor shall submit for the Engineer's approval shotcrete mixture proportions and performance test data based on the materials to be used in the project. If appropriate recent test data do not exist, the Contractor shall prepare trial mixtures and submit the test results as obtained from tests specified in Section 412.03(g) 6.

Wet Process: Shotcrete subject to freezing and thawing shall have an air content of 7.0 percent ± 1.5 percent as delivered to the job site. The materials for wet process shotcrete shall be mixed in accordance with Section 217 and applied within 90 minutes after batching.

Dry Process: Solid ingredients for dry-mix shotcrete shall be predampened as needed and mixed in a batch type or continuous mixer. Most of the mixing water shall be added at the nozzle. Dry-mix shotcrete material shall be applied within 45 minutes after batching or predampening.

1. **Equipment and Personnel:**

   a. **Equipment:** Shotcrete delivery equipment shall be approved by the Engineer before the commencement of the work. It shall be capable of discharging the shotcrete mixture in a continuously smooth stream of uniformly mixed ingredients. Air added at the nozzle shall be free from oil or other contaminants, and the air pressure shall be capable of delivering and maintaining sufficient nozzle velocity to all parts of the work.

   b. **Personnel:** Nozzlemen with at least 100 hours of recent similar shotcrete application experience and supervisors with at least 3 years of recent similar shotcreting experience who can provide references showing satisfactory performance on at least three similar jobs may be approved as being qualified without gunning prequalifying panels.

      When proposed nozzlemen do not have the required experience or when the Engineer deems the work to be done of a sufficiently critical nature to require prequalify-

ing tests for nozzlemen, approval will be based on the acceptance of shotcreting test panels as described in Section 412.03(g) 6 prior to the commencement of the work. The Engineer will observe the gunning of such test panels and judge the qualifications of the nozzleman on the basis of the texture, uniformity of work, and adequacy of the encasement of shotcrete around the reinforcement.

2. **Surface Preparation:**

a. The perimeter of all areas where concrete is removed shall be tapered at approximately a 45-degree angle except that the outer edges of all areas removed by chipping shall be saw cut perpendicular to the surface to a minimum depth of 1/2 inch to prevent featheredging unless otherwise approved by the Engineer.

b. Earth surfaces shall be trimmed to line and grade and shall have adequate support to prevent displacement during shotcrete placement. Shotcrete shall not be placed on an earth surface that is frozen, spongy, or subject to free running water at the time of the application of the shotcrete. Active seeps, drips, and flowing water shall be controlled by installation of suitable drain systems such that water pressure does not build behind shotcrete linings. The Contractor shall prevent excessive loss of mixing water from the shotcrete. This shall be accomplished by one of the following procedures:

(1) Wet the soil prior to the time of gunning to the extent that it is damp but with no visible free water on the surface. Puddling, ponding, or freestanding water shall be eliminated from areas to be shotcreted.

(2) As an alternative or when specified, install a moisture barrier system to inhibit the movement of moisture from the newly placed shotcrete into the earth. Wrinkling and folding of moisture barrier will not be permitted.

c. Rock surfaces shall be free of loose material, debris, chips, mud, dirt, and other foreign matter. Surfaces shall be damp at the time of gunning, but puddling, ponding, or freestanding water will not be permitted.

d. Wood forms that are to be removed after use shall have a form release agent applied to prevent the absorption of moisture and inhibit the bond between shotcrete and the form.

3. **Application:**

a. When applied, shotcrete shall have a temperature of at least 50 degrees F but not more than 85 degrees F. The ambient and surface temperature shall be 50 degrees F and rising. At ambient air temperatures above 85 degrees F, the Engineer may require placement to be made at night or during early morning hours.

b. Shotcrete to be applied to uneven and previously repaired surfaces shall first be applied to any deep hole, deeply excavated sections, corners, or areas where rebound cannot escape or be blown free. The thickness of the shotcrete layer shall be such that no sloughing, sagging, tearing, or debonding will occur. Existing concrete shall be sandblasted within 24 hours of application, and the surface shall be damp just prior to application.

c. Where a layer of shotcrete is to be covered by a succeeding layer, it shall be first allowed to develop its initial set. Then, loose, uneven, or excess material, glaze and rebound shall be removed by brooming, scraping, or other means. Any surface deposits that take a final set shall be removed by abrasive blast cleaning, and the surface cleaned with an air-water blast from the nozzle. Curing compounds shall not be applied to surfaces that will be covered by an additional layer of shotcrete.

d. Shooting wires, ground wires, or other devices acceptable to the Engineer shall be used to control the line, grade, and thickness of the shotcrete.

e. During the shotcrete application, the nozzle shall be held perpendicular to and, when possible, 3 to 5 feet away from the receiving surface and rotated steadily in series of small oval or circular patterns. Whenever possible, sections shall be gunned in one layer to the full design thickness. However, for multiple layers of reinforcement, gunning of one layer of shotcrete may be required for each layer of reinforcement.

f. When encasing reinforcement, the nozzle shall be held closer than normal and at a slight, upward angle. The mixture may be wetter than normal but not so wet that sloughing behind the reinforcement will occur.

g. Vertical surfaces shall be gunned starting at the bottom. Rebound or previously expended material shall not be incorporated in the applied layer, and all such material shall be removed from the surface and work area prior to final set and before placement of shotcrete on adjacent surfaces. Shotcrete shall not be placed if drying or stiffening of the mixture is occurring.

4. **Finishing:** Prior to the initial set, the shotcrete surface shall be scraped or cut with a trowel or metal template to obtain an even and aesthetically acceptable appearance. The final finishing shall be with a wet sponge unless otherwise specified. Trowel or float smoothing will not be allowed.

5. **Curing:** After gunning, the surfaces of shotcrete shall be protected from drying or cracking. When necessary, fogging shall be used prior to the application of moist curing or a curing compound. Shotcrete shall be moist cured for a period of at least 7 days or cured using a curing compound containing silane or siloxane conforming to Section 220. The rate of application shall be not less than 1 gallon of curing compound per 100 square feet of surface. The color of the curing compound shall be approximately that of the existing concrete.

6. **Quality Assurance and Testing:**

a. Preconstruction testing may not be required by the Engineer if documented that the crew to be used is qualified by virtue of previous long term experience or certification by the equipment manufacturer and that the mixture has been successfully used in recent similar work. Where required, preconstruction testing shall conform to the following:

Test panels 24 inches by 24 inches by 4 inches deep containing steel reinforcement representative of that to be used on the project shall be prepared. Each crew shall gun two test panels with the mix design to be used on the project and for each gunning orientation to be encountered on the job. Panels shall be cured in the field in

the same manner as the structure for 1 day and transported to the laboratory, where curing shall be continued until the time of testing. For shotcrete jobs of less than 200 square feet, the Contractor shall cut one of the test panels with a trowel or a metal template before the initial set in the presence of the Engineer to check visually for possible voids under the reinforcement. For larger jobs where specific evidence of good encasement of reinforcing bars is needed, the Contractor shall cut cores from the test panels after the concrete has hardened for at least 3 days. Cores shall be cut through the steel.

The second panels for all jobs shall be used to determine the compressive strength of the applied shotcrete. Cores shall be 2 inches to 4 inches in diameter and shall be taken between the reinforcement. The cores will be tested by the Department at the specified age in accordance with ASTM C42.

b. In-place shotcrete shall be of uniform quality and free from segregation, honeycombing, sand pockets, sand lenses, sagging, dry patches, overspray, rebound, or incomplete encasement of reinforcement. Shotcrete shall also be free from delamination, cracking, or single voids with dimensions in excess of 1/4 inch.

The Department reserves the right to test any section and reject shotcrete that does not conform to the specification requirements in terms of test values, soundings, and visual examination. The cost of any additional testing of suspect or disputed shotcrete that results in rejection shall be borne by the Contractor.

The Contractor shall remove and replace or correct defective shotcrete to the satisfaction of the Engineer.

c. For compressive strength tests, one test panel shall be prepared for each day's production or for each 200 square feet of shotcreting by each crew using the same ingredients and gunning orientation as the shotcrete applied to the job. These panels shall be cured and delivered to the designated testing laboratory as specified earlier in this section.

Test values on such panels shall equal or exceed the required 28-day strength requirements. Should failures occur, acceptance of the material will be determined by tests on cores from the installed work. A minimum of three cores shall be taken from the area in question. The average compressive strength of the cores taken from the work shall equal or exceed the specified strength for the class of shotcrete applied, and no single core shall have strength less than 85 percent of the specified value. If deemed necessary by the Engineer, the adequacy of the bond between the existing concrete and the shotcrete shall be determined by pull-off tests in accordance with ACI 503. A minimum bond strength of 250 psi will be accepted as satisfactory. Bond failure at less than 250 psi attributable to the failure of existing concrete will not be cause for rejection. The cost of up to three pull-off tests shall be the responsibility of the Contractor; additional pull-off tests will be the responsibility of the Department.

(h) **Anchor Bolt Replacement** shall consist of temporary removal of the existing bearing assembly, core drilling, removing and disposing of existing bearing anchor bolts, furnishing and placing new anchor bolts with nuts and washers and grout, re-installation of existing bearing assembly, and providing any required environmental, worker and safety protection, and disposal of material in accordance with the details and requirements herein and Section 408.

New anchor bolts shall be swedged type bolts of the same size and material as the anchor bolts being replaced.

The new anchor bolts shall be grouted in place using a high-strength grout conforming to Section 218.03 (d).

A plan for removing existing anchor bolts and installing new anchor bolts shall be submitted to the Engineer for review prior to performing the work.

The cost of jacking and supporting beams that may be required to accomplish this work will be paid for under the pay item Jacking and Blocking Beams.

(i) **Concrete Beam Repair** shall consist of removing and disposing of existing concrete, repairing or replacing existing reinforcing steel where required by this Section, preparing the contact surfaces, furnishing and placing a bond breaker when required, and furnishing and placing concrete in accordance with the details and requirements herein. Exposed, undamaged existing reinforcing steel shall be abrasive blast cleaned and reused.

Limits of repair and removal of damaged concrete shall be determined in accordance with Section 412.03(a) herein.

Concrete for beam repair shall be Class A4 or self-consolidating concrete cast within forms placed to match the original geometry of the beam. Shotcrete will not be permitted unless approved by Engineer in writing.

No beam repair shall be performed in a span lane that is under traffic unless supported by an approved temporary support system or unless approved in advance by the Engineer. The repaired Beam shall not be subject to live load until the new concrete has obtained a minimum compressive strength of 3,000 psi as determined by control cylinders. Cylinders used for control purposes shall be cured under conditions that are not more favorable than the most unfavorable conditions for the portions of concrete the cylinders represent.

When repairing beam ends, the bearing area of the beam repair shall be placed against the existing bearing plate or the bridge seat if no bearing plate is present. If no bearing plate is present, a bond breaker shall be placed at the interface of the beam end and the seat.

The cost of any required temporary supports, including jacking and supporting beams that may be required to accomplish this work will be paid for under the pay item Jacking and Blocking.

(j) **Replace Concrete Curb** shall consist of removing and disposing of existing concrete, repairing or replacing existing reinforcing steel as may be required by this Section, preparing the contact surfaces, and furnishing and placing new Class A4 concrete and reinforcing steel in accordance with the details and requirements herein. The new concrete curb shall have the same dimensions as the existing curb that is being replaced. The locations of curb replacement shall be determined by the Engineer.

Exposed undamaged existing curb reinforcing steel shall be abrasive blast cleaned and reused.

The following incidental items shall be performed (when necessary) as part of the curb replacement work:

1. When curb replacement is being performed wooden blocks shall be used to support adjacent sections of curb that are not being replaced.

2. When concrete curb blocks are located under a section of curb that is being replaced, the concrete blocks shall be replaced.

The cost of this incidental work shall be included in the price bid for Replace Concrete Curb.

(k) **Replace Concrete Rails, Type A** shall consist of removing and disposing of existing rails and furnishing and placing new rail expansion boxes, new reinforcing steel, and new Class A4 concrete in accordance with the details shown on the plans and the requirements herein. The locations of rail replacements shall be as shown on the plans or as determined by the Engineer.

Replacement rails shall aesthetically match the lines, architecture and length of the existing rail. Four new #4 conventional reinforcing bars shall be placed in all new rails, and these bars shall have 1 inch (minimum) cover between end of bar and end of rail.

Rail expansion boxes shall be used at end of all new replacement rail sections.

(l) **Replace Concrete Rails, Type B** shall consist of removing and disposing of existing concrete, repairing or replacing existing reinforcing steel as may be required by the work described in this Section, preparing the contact surfaces, and furnishing and placing new Class A4 concrete and reinforcing steel in accordance with the details in the Contract and requirements herein. The locations and lengths of rail replacements shall be determined by the Engineer. The dimensions of the rail shown in the contract may vary slightly from field conditions, and any differences noted shall be included in price bid for this item.

All existing rail concrete shall be removed from the limits of a rail replacement length. Existing rail concrete shall be removed by the use of hand tools or pneumatic hammers weighing 15 pounds or less.

Undamaged existing rail reinforcing steel shall be abrasive blast cleaned and reused.

When rail replacement is being performed, wooden blocks shall be used to support adjacent sections of rail that are not being replaced. The cost of this work shall be included in the price bid for Replace Concrete Rails, Type B.

(m) **Replace Concrete Post** shall consist of removing and disposing of existing concrete, repairing or replacing existing reinforcing steel as may be required by the work described in this Section, preparing the contact surfaces, and furnishing and placing new Class A4 concrete and reinforcing steel in accordance with the details in the Contract and requirements herein. The new posts shall be constructed to the same detail and dimensions as the existing posts that are being replaced. The locations of post replacements shall be determined by the Engineer.

Undamaged existing post reinforcing steel shall be abrasive blast cleaned and reused.

The following incidental items shall be performed (when necessary) as part of the concrete post replacement work:

1. Rails adjacent to replacement posts shall be supported.

2. New rail expansion boxes shall be placed inside new posts that support Type A concrete rails.

3. Any existing name or date plates that are located in replacement posts shall be removed and reset in the new posts as directed by the Engineer.

The cost of this incidental work shall be included in the price bid for Replace Concrete Posts.

(n) **Replace High Strength Grout** shall consist of removing and disposing of existing grout, abrasive blast cleaning of the area, preparing the contact surfaces, and furnishing and placing new high strength grout in accordance with Section 218.03 (d) in the shear keys of pre-stressed concrete slab superstructures and/or pre-stressed concrete box beam superstructures in accordance with the details in the Contract and requirements herein and Section 405.

(o) **Reconstruct Bridge Seat (Type)** shall consist of removing and disposing of existing concrete, repairing or replacing existing reinforcing steel as may be required by this Section, furnishing and placing new reinforcing steel, preparing the contact surfaces, and furnishing and placing new concrete in accordance with the details in the Contract and requirements herein and on the plans. Exposed undamaged existing reinforcing steel shall be abrasive blast cleaned and reused.

Reconstruction of an existing beam seat shall not be performed in a span lane that is under traffic. The repaired beam seat shall not be subject to live loads until the new concrete has obtained a minimum design compressive strength of 3,000 psi as determined by control cylinders. Cylinders used for control purposes shall be cured under conditions that are not more favorable than the most unfavorable conditions for the portions of concrete the cylinders represent.

The cost of jacking and supporting beams that may be required to accomplish this work will be paid for under the pay item Jacking and Blocking Beams.

(p) **Concrete Surface Color Coating** shall consist of furnishing and applying concrete surface color coating in accordance with this Section and in conformity with the details in the Contract and locations indicated on the plans. The color of the coating shall be similar to the Federal Standard Color Number specified on the plans or as approved by the Engineer. The Concrete Surface Color Coating shall be selected from the Material Division's Approved Products List 30.

Except as otherwise specified on the plans, the concrete surface color coating shall be applied to the following surfaces of the bridge structure:

1. Pier stems and caps from 6 inches below finished grade to the upper limits of the pier caps but excluding the top of the cap.

2. Exposed surfaces of abutment walls from finished grade of adjacent concrete slab slope protection or 6 inches below finished grade of embankment to and including the top of the wingwall, excluding bridge seats and portion of back wall between limits of exterior structural members.

3. All surfaces of parapet walls, the edge of deck slab and the underside of the bridge deck overhangs from the deck edge to the structural member.

   Concrete surface color coating shall be applied to exposed surfaces of other concrete structures as specified on the plans.

Surface preparation and application shall be in accordance with the manufacturer's instructions, unless otherwise specified on the Plans or elsewhere in the Contract. The concrete surface color coating shall not be applied until all concrete placement operations for the particular structure have been completed. The concrete surface shall be clean, free of any curing agents, form release agents, foreign substances, or signs of efflorescence at the time of application.

All work shall be performed by experienced workmen familiar with performing concrete finishing work and applying the materials specified. Surfaces not to be treated shall be protected from splatter.

Color coating materials shall be delivered to the job site in sealed containers bearing the manufacturer's labels. Materials shall be mixed and applied in accordance with the manufacturer's printed instructions, two copies of which shall be furnished the Engineer.

(q) **Reinforcing Steel Bar Splicer (Bar Size)** shall consist of furnishing and placing mechanical splicers for the specified reinforcing bar size in accordance with the details and requirements herein, Section 406 and as shown on the plans.

(r) **Parapet Closure (Type)** shall consist of removing and disposing of existing concrete, repairing or replacing existing reinforcing steel as may be required by the work specified in this Section, preparing the contact surfaces, and furnishing and placing new concrete and new reinforcing steel in accordance with the details in the Contract and requirements herein. Exposed undamaged existing reinforcing steel shall be abrasive blast cleaned and reused.

(s) **Fiber Reinforced Polymer System** shall consist of furnishing and installing a carbon fiber reinforced polymer (FRP) wrap system for repairing and/or strengthening of designated superstructure or substructure members.

The Plans or Contract will provide the flexural, shear, or axial strength requirements for the member to be repaired or strengthened.

The Contractor shall submit the following documents to the Engineer for approval prior to beginning the work:

1. **Working Drawings** shall be submitted to the Engineer for review in accordance with Section 105.10. The working drawings shall be certified by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia. Working drawings shall include the type of FRP system, number of layers and orientation of all FRP materials, repair locations, relevant dimensions of the system and the work plan including the necessary preparations of the existing structure. The drawings must be accompanied by the design calculations, the MSDS and the manufacturer's system data sheet identifying mechanical, physical and chemical properties of all components of the FRP system; application guide, including the installation and maintenance procedures; and time schedule for various steps in the repair process. The installation procedure must clearly identify any environmental and substrate conditions that may affect the application and curing of the FRP system. The design calculations shall be performed in accordance with the current AASHTO and ACI specifications and guidelines for FRP systems.

2. **Quality Assurance Plan -** The Contractor shall be responsible for developing and implementing a quality assurance plan for all FRP materials and processes scheduled for use

on the project. The quality assurance plan must be submitted to and approved by the Engineer prior to beginning FRP operations on the project. The plan shall include specific procedures for personnel safety, tracking and inspection of all FRP components prior to installation, inspection of all prepared surfaces prior to FRP application, inspection of the work in progress to assure conformity with specifications, quality assurance samples, inspection of all completed work including necessary tests for approval, repair of any defective work, and disposal and clean-up. Any part of the work that fails to comply with the Contractor's approved Quality Assurance Plan and the Contract requirements will be rejected by the Engineer, and shall be remedied, or removed and replaced by the Contractor at his own expense.

3. **Qualifications of Contractor** - Contractor/Sub-Contractor shall be approved by the Engineer for each FRP system scheduled for use on the project after providing the following necessary information:

   a. Minimum of 3 years of documented experience in installing the designated FRP system or 15 documented similar field applications within the last 5 years with acceptable reference letters from respective Owners; and

   b. Certificate of completed training from Manufacturer/Supplier for at least one field representative who will be present on site throughout the project

4. **Manufacturer's Representative:** The Contractor shall have present during the installation of the FRP system, a manufacturer's representative, knowledgeable in the methods of installation of the FRP system, for technical expertise and to certify that the Contractor's personnel installing the system are knowledgeable and are installing the system's components in accordance with the manufacturer's instructions. The Contractor shall also arrange to have the manufacturer's representative present during testing of the material by the Engineer. The manufacturer's representative shall certify that the system was properly installed at the completion of the insrtallation prior to final payment to the Contractor.

   All components of the FRP system must be delivered and stored in the original factory-sealed unopened packaging or containers with proper labels identifying the manufacturer, brand name, system identification number and date. Store catalysts and initiators separately. All components must be protected from dust, moisture, chemicals, direct sunlight, physical damage, fire, and temperatures outside the range specified in the system data sheets. Any component that has been stored in a condition different from that stated shall be considered unacceptable for use and must be properly disposed of.

   All components of the FRP system, especially resins and adhesives, that have been stored longer than the shelf life specified on the system data sheet, shall not be used, and must be properly disposed of.

   All components of the FRP system, especially fiber sheets, must be handled with care according to the manufacturer's instructions to protect them from damage and to avoid misalignment or breakage of the fibers by pulling, separating, wrinkling, or folding the sheets. After cutting, sheets shall be either stacked dry with separators, or rolled gently at a radius no tighter than 12 inches or as recommended by the manufacturer.

   All components of the FRP system, especially resins and adhesives, must be handled with care to avoid safety hazards, including but not limited to skin irritation and sensitization,

and breathing vapors and dusts. Mixing resins shall be monitored to avoid fuming and inflammable vapors, fire hazards, or violent boiling. The Contractor is responsible to ensure that all components of the FRP system at all stages of work conform to the local, state, and federal environmental and worker's safety laws and regulations.

All deteriorated concrete shall be repaired in accordance with Section 412.03 (b) or Section 412.03 (e) as directed by the Engineer. Repair of deteriorated concrete in these areas will be measured for payment as Concrete Superstructure Surface Repair or Concrete Substructure Surface Repair as appropriate.

All defective reinforcing steel shall be repaired in accordance with the requirements herein.

All cracks in the surface of the concrete wider than 0.01 inch and with a spacing less than 1'-6" or cracks wider than 1/8" shall be repaired in accordance with Section 412.03 (b)5b. Repairing cracks using epoxy injection will be measured for payment as Crack Repair, Type B.

All irregularities, unevenness, and sharp protrusions in the surface profile shall be ground to a smooth surface with less than 1⁄32 inch deviation. Disk grinders or other similar devices shall be used to remove stain, paint, or any other surface substance that may affect the bond.

Voids with diameters larger than 1⁄2 inch and depressions on the concrete surface deeper than 1⁄16 inch measured from a 12 inch straight edge placed on the surface, shall be filled with epoxy filler or other equal material as recommended by the FRP system manufacturer or approved by the Engineer.

All inside and outside corners and sharp edges shall be rounded or chamfered to a minimum radius of 1⁄2 inch. Ridges, form lines, and sharp or roughened edges greater than 1⁄4 inch shall be ground down or filled with putty, as specified by the manufacturer of the FRP system. Obstructions and embedded objects shall be removed before installing the FRP system, as directed by the Engineer.

Substrate concrete and finished surface of concrete shall be cleaned in accordance with the instructions or recommendations of the manufacturer of the FRP system and to the satisfaction of the Engineer. Cleaning shall remove any dust, laitance, grease, oil, curing compounds, wax, impregnations, stains, paint coatings, surface lubricants, foreign particles, weathered layers or any other bond-inhibiting material. If power wash is used, the surface shall be allowed to dry thoroughly before installing the FRP system. The cleaned surface shall be protected against re-deposit of any bond-inhibiting materials. Newly repaired or patched surfaces that have not cured a minimum of 7 days shall be coated with a water-based epoxy paint or other approved sealers.

The contact surfaces shall be completely dry at the time of application of the FRP system.

The FRP system shall be installed in accordance with the recommendations of the manufacturer of the FRP system.

During installation of the FRP materials, the installer shall maintain a daily log. This log shall provide material tracking and process records for each installation and shall include the following information:

- Structural element identification with project name, contract number, and installation date.

- Materials information including product name, description, date of manufacture, time of expiration, and lot or batch numbers.

- Fabrication, inspection and verification data for the manufacturing and construction operations including square footage of fabric and volume of epoxy used each day, number of layers, thickness measurements, ambient temperature and humidity readings at the beginning, middle and end of each casing installation shift.

One sample per lot or batch of composite material used on the project shall be provided to the Engineer to verify compliance with the specification requirements of the Contract. The sample(s) shall be at least 12" x 12" and 1 ply thick. It shall be fabricated in the same manner as the field-installed material and cured straight and flat under moderate tension and pressure. At the discretion of the Engineer, the sample may be fabricated at the construction site or in advance at the installer's facility in the presence of the Engineer or the Engineer's designee. The sample shall be cured at 70 degrees F (min.) for a period of 7 days prior to testing. In addition, a material specimen shall be taken as a thickness and glass transition temperature sample from each installed column casing after curing and prior to final epoxy coating.

Field sample(s) shall be taken, in the presence of the Engineer, no sooner than 7 days after installation from a location on the structure designated by the Engineer. A copy of the test results shall be furnished to the Engineer within 60 days following sample fabrication. If test values fail to conform to any of the project specific requirements, the Engineer will make a determination regarding the disposition of the affected element. Such determination may include complete removal and reapplication at no cost to the Department.

After at least 24 hours for the initial cure of the resin, the Engineer will perform a visual inspection of the structure surface for any swelling, bubbles, voids, or delamination. If an air pocket is clearly evident or suspected, an acoustic tap test will be carried out with a hard object to identify delaminated areas by sound, with a frequency of at least one strike per one square foot. Defects will be addressed as follows:

a. **Epoxy Injection of Small Defects** - Small entrapped voids or surface discontinuities no larger than 1⁄4 inch in diameter shall not be considered defects, and will not require corrective action, unless these occur next to edges or when there are more than 5 such defects in an area of 10 square feet or otherwise directed by the Engineer. Small defects of sizes between 1⁄4 and 1 1⁄4 inches in diameter shall be repaired using low pressure epoxy injection, as long as the defect is local and does not extend through the complete thickness of the laminate in case of multiple ply FRP systems. If any delamination growth is suspected between the FRP plies due to injection, the procedure shall be halted, and repair shall follow the requirements for Patching of Minor Defects.

b. **Patching of Minor Defects** - Minor defects are those with diameters between 1 1⁄4 and 6 inches, and a frequency of less than 5 per any unit surface area of 10 square feet. The area surrounding the defect(s) to an extent of at least 1 inch on all sides shall be carefully removed. The area shall be wiped cleaned and thoroughly dried. The area shall then be patched by adding an FRP patch of the same type of the orig-

inal laminate extending at least 1 inch on all sides of the removed area. Repair can also be conducted using the procedure for Replacement of Large Defects.

c. **Replacement of Large Defects** - Defects larger than 6 inches in diameter shall be carefully marked and scarfed out extending to a minimum of 1 inch on all sides. Scarfing shall be progressive through the layers, in the case of multi-ply FRP systems until past the defective area. In case the defect extends to the first FRP ply adjacent to the concrete, the entire thickness of FRP and primer shall be removed. The substrate shall be appropriately prepared and primer re-applied after ensuring that the surface and FRP are clean and dry. Application of a new FRP system within the scarfed area shall follow procedures for the original FRP system, except that an additional layer extending a minimum of 6 inches on all sides of the scarfed area shall be added as a patch. Once cured, the protective coating shall be applied over the entire area.

After at least 24 hours for the initial cure of the resin and before applying the protective coating, the Engineer will perform direct pull-off tests on the structure following ASTM D4541 procedures to verify tensile bond between the FRP system and concrete. Test locations and sampling frequency shall be as specified on the Contract documents, or as recommended by the manufacturer and approved by the Engineer. At a minimum, three pull-off tests with at least one test per span or one test per 1000 square feet of the FRP system, and one test per substrate concrete type will be performed. Inspect failure surface of the core specimen to ensure that it is by cohesive failure within concrete. Failure at the bond line at tensile stresses below 200 psi is unacceptable. If one or more of the pull-off tests is found unacceptable, the work will be rejected, and repair will follow Replacement of Large Defects. Repair cored areas will follow Patching of Minor Defects. Test locations shall be filled with thickened epoxy as recommended by the manufacturer of the FRP system after all testing is completed and verified.

Exposed surfaces of the FRP material, including surfaces 2 feet below ground, shall be cleaned and then epoxy-coated with a minimum of two coats of Epoxy Type EP-3T. The coated material shall be protected from rainfall or water for a minimum of 24 hours following epoxy application.

412.04—Measurement and Payment

Volumes outlined by the completed excavation, formwork, and surfaces of the existing concrete will be measured prior to concrete placement so that quantities can be accurately computed.

Hydraulic cement concrete for the class specified will be measured and paid for in accordance with Section 404.

Types A, B, and C patching; Types A, B, and C patching (HES); and concrete substructure or superstructure surface repair for the type specified will be measured in square yards of surface area and will be paid for at the contract unit price per square yard for the type specified. This price shall include furnishing and placing concrete to fill the prepared areas.

Deck slab closure will be measured in square yards of deck area on which the slab closure occurs and will be paid for at the contract unit price per square yard.

Epoxy-mortar patching will be measured in gallons of epoxy-mixed system used as a binder for mortar in place and for priming prior to application of epoxy mortar and will be paid for at the contract unit price per gallon.

Expansion joint removal, expansion joint reconstruction, expansion joint reconstruction (HES), expansion joint preparation, backwall reconstruction, and backwall reconstruction (HES) will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include furnishing and placing high early strength concrete to fill the prepared areas for expansion joint reconstruction and backwall reconstruction.

Saw cutting, when a pay item, will be measured in linear feet of concrete sawed and will be paid for at the contract unit price per linear foot. **Saw cutting that is incidental to the removal of concrete for repairs will not be measured for separate payment, and the cost thereof shall be included in the contract unit price of the appropriate items.**

Jacking and blocking beams as specified on the plans or as directed by the Engineer, when a pay item, will be measured in units of each and will be paid for on an each basis per bearing location regardless of the number of lifting operations per jack.

Crack repair (Type A, B, & D) will be measured in linear feet and will be paid for at the contract unit price per linear foot.

Crack repair, Type C will be measured in linear feet or square yards as specified on the plans and will be paid for at the contract unit price per linear foot or square yard.

Shotcrete (Type), when specified as a pay item, will be measured in square feet or cubic feet of surface to which it is applied and will be paid for at the contract unit price per square foot or per cubic foot for the type specified.

Embedded galvanic anode will be measured in units of each and paid for at the contract unit price per each. This price shall include furnishing and installing anode, furnishing and installing tie wires and reinforcing steel where necessary, all surface cleaning and preparation to perform the work, testing, and on-site services of the galvanic anode manufacturer's technical representative.

Anchor Bolt Replacement will be measured in units of each and will be paid for at the contract unit price per each.

Beam End Repair will be measured in units of each beam end and will be paid for at the contract unit price per each.

Replace Concrete Curb will be measured in linear feet and will be paid for at the contract unit price per linear foot.

Replace Concrete Rails (Type) will be measured in linear feet and will be paid for at the contract unit price per linear foot for the type specified.

Replace Concrete Post will be measured in units of each and will be paid for at the contract unit price per each.

Replace High Strength Grout will be measured in linear feet and will be paid for at the contract unit price per linear foot.

Reconstruct Bridge Seat (Type) will be measured in units of each and will be paid for at the contract unit price per each for the type specified.

Concrete Surface Color Coating will be will be measured in square yards of surface area and will be paid for at the contract unit price per square yard which price shall be full compensation for preparation of surfaces and for furnishing and applying coating.

Replace High Strength Grout will be measured in linear feet and paid for at the contract unit price per linear foot.

Reinforcing Steel Splicer (Bar Size) will be measured in units of each and will be paid for at the contract unit price per each for the bar size specified.

Parapet Closure (Type) will be measured in units of each and will be paid for at the contract unit price per each for the type specified.

Fiber Reinforced Polymer Wrap will be measures in units of square feet and will be paid for at the contract unit price per square foot.

These prices shall include cutting, drilling, hammering, and all other work involved in the completely removing and disposing of existing concrete and other materials necessary to provide for joining the new and old portions of the structure in accordance with the plans or as directed by the Engineer. The contract unit price shall also include dowels or other approved anchoring devices, disposing of debris, surplus, or other unsuitable material, cleaning and repairing reinforcing steel, and welded wire fabric if necessary. If shotcrete is used, the price shall also include furnishing and incorporating fibers.

Payment will be made under:

Pay Item	**Pay Unit**
Patching (Type)	Square yard
H. E. S. Patching (Type)	Square yard
Deck slab closure	Square yard
Epoxy-mortar patching	Gallon
Concrete substructure surface repair	Square yard
Concrete superstructure surface repair	Square yard
Expansion joint removal	Linear foot
Expansion joint reconstruction	Linear foot
Expansion joint reconstruction (HES)	Linear foot
Back wall reconstruction	Linear foot
Back wall reconstruction (HES)	Linear foot
Expansion joint preparation	Linear foot
Saw cutting	Linear foot
Jacking and blocking beams	Each
Crack repair (Type)	Linear foot or square yard
Pneumatically applied mortar	Square foot
Shotcrete (Type)	Square foot or cubic foot
Embedded galvanic anode	Each
Anchor bolt replacement	Each
Beam end repair	Each
Replace concrete curb	Linear foot
Replace concrete rails Type ( )	Linear foot
Replace concrete post	Each
Reconstruct Bridge Seat Type ( )	Each

Pay Item	Pay Unit
Replace High Strength Grout	Linear foot
Reinforcing Steel Splicer (Bar Size)	Each
Parapet Closure (Type)	Each
Fiber Reinforced Polymer Wraps	Square foot
Concrete Surface Color Coating	Square yard

SECTION 413—DISMANTLING AND REMOVING EXISTING STRUCTURES OR REMOVING PORTIONS OF EXISTING STRUCTURES

413.01—Description

This work shall consist of dismantling and removing all or portions of existing structures in accordance with these specifications and in conformity with the lines, grades, and details shown on the plans or as established by the Engineer. The Contractor shall make all necessary notifications, including, but not limited to, the National Emission Standards for Hazardous Air Pollutants (NESHAPs) demolition/renovation notification to the Virginia Department of Labor and Industry, amended notifications, and obtain any necessary permits in accordance with all applicable local, state, and federal laws and regulations. The Contractor shall protect the public and the environment from leaded paint or other hazardous material encountered in the work.

413.02—Procedures

(a) **Dismantling and Removing Existing Structures:** Dismantling and removing existing structures shall include removing the entire superstructure, substructure, and slope protection. The substructure shall be removed down to the streambed or to an elevation of at least 2 feet below the natural ground or finished grade of embankment that is to remain in place unless otherwise indicated on the plans. Removal shall include any part of the substructure or foundation piling that will interfere with the new construction. The substructure shall be removed to or below the bed of the stream as required by the U.S. Coast Guard for bridges crossing streams under the jurisdiction of the U.S. Coast Guard.

1. **Dismantling structures for retention by the Contractor:** Removed materials shall become the property of the Contractor and shall be removed from the project. The Contractor shall assume all personal and property liability associated with such materials and shall protect and save harmless the Department from any and all damages and claims associated with the dismantling, handling, transportation, storage, or use of such materials. The Department does not warrant the nature, condition, or the physical or chemical characteristics of the materials.

2. **Dismantling structures for retention by the Department:** The Contractor's dismantling operations shall be according to a method approved by the Engineer and shall be performed in a manner that will preserve the existing condition of the materials.
Units shall be match marked for re-erection according to an approved diagram provided by the Department.

Material shall be stored as directed by the Engineer within 1/2 mile of the site of the existing structure.

(b) **Removing Portion of Existing Structures:** The portions to be removed shall be the areas designated on the plans. Removal operations shall conform to work as specified in Section 412 or detailed elsewhere in the Contract. The Contractor shall not remove any portion of the structure by blasting or other methods that may damage any portion of the structure that will remain in place.

When pneumatic hammers are used to remove concrete, the weight of the hammer alone shall not be more than a nominal 90 pounds for widening work, or a nominal 35 pounds for deck repair or replacement work. This limitation shall not apply to concrete removal to facilitate deck replacement. Except in the case of bulb T or box beam spans structures, the Engineer will allow the use of tractor-mounted demolition hammers with a maximum manufacturer's rated striking energy of 1,000 foot-pounds for the removal of concrete parapets down to the top of deck including that portion of the deck where the reinforcing steel must be removed to complete removal of the parapets. The Engineer will not permit the use of tractor-mounted demolition hammers or pneumatic hammers weighing more than a nominal 35 pounds to remove any portion of the deck that is within 6 inches of the top flange of beams/girders that will remain in the structure.

The use of hydraulically actuated jaw type concrete crushers or any equipment not listed above to remove concrete and reinforcing steel within 10 inches of beams and girders in the bridge deck is prohibited unless otherwise approved by the Engineer. Approval will be determined based on the Contractor submitting a plan of operations for performing the work and a demonstration of successfully using such equipment with no damage to the remaining portions of the structure. If damage occurs to the remaining portions of the structure as a result of the Contractor's demonstration, the damage shall be repaired at the Contractor's expense.

In the case of bulb T or box beam span structures, the Engineer will limit the removal of concrete parapet to nominal 90 pound pneumatic hammers from the top of the parapet to within 2 inches of the top of the deck. The remainder of the concrete parapet shall be removed by the use of nominal 35 pound pneumatic hammers unless otherwise approved by the Engineer.

The Contractor shall uniformly grade disturbed areas to natural ground contours in a manner that shall promote drainage and prevent the impoundment of water.

Salvaged materials or portions of existing structures that have been removed shall be handled in accordance with (a)1. herein.

(c) **Environmental and Worker Protection:** Heating, welding, flame cutting, grinding, chipping, needle gun cleaning, manual scraping, heat gun cleaning, drilling, straightening, and other construction operations, or demolition of Type B structures, as defined in Section 411.01, that disturbs areas coated with a hazardous material shall require environmental and worker protection.

1. **Environmental protection** shall be in accordance with Section 411.09 except the Department will not require the Contractor to submit and implement an environmental protection plan as specified in Sections 411.09(a) and 411.09(b) for work involving the removal of 100 square feet or less of protective coating from a Type B structure. However, the Contractor shall comply with appropriate local, state, and federal codes and regulations and shall employ appropriate measures to prevent the release of hazardous materials into the environment. Determination of the total square footage of removal area shall not include the cumulative area of

coating disturbance from removal of bolts. The Contractor shall dispose of hazardous materials generated from his demolition according to Sections 411.09(c) and 411.09(d).

2. **Worker health and safety protection** shall be accomplished according to Section 411.10 except the Department will not require the Contractor to submit and implement a worker health and safety protection plan as specified in Sections 411.10(a) and 411.10(b) for work involving the removal of 100 square feet or less of protective coating from a Type B structure. The Contractor shall, however, be required to comply with other applicable codes and regulations regarding public and worker health and safety.

Except when not required by size of removal areas, the Contractor shall submit a written statement to the Engineer, complete with all revisions including notations of any areas of non-compliance and corrective actions taken, that certifies both the Environmental Protection Plan and the Worker Health and Safety Plan were fully implemented as detailed during the performance of the work covered by this specification upon completion of the project.

413.03—Measurement and Payment

Dismantling and removing an existing structure will be paid for at the contract lump sum price.

Removing a portion of an existing structure will be paid for at the contract lump sum price.

Environmental and worker protection, when a pay item, will be paid for at the contract lump sum price per structure. This price shall include containment operations, regulation compliance, plan approval services, worker protection, and other related costs.

Material disposal, when a pay item, will be paid for at the contract lump sum price per structure. This price shall include storing, transporting, and legal disposal of material. Material disposal will only be paid when request for payment is submitted with a manifest showing that the material has been legally disposed of.

If not shown as a pay item, the cost for worker and environmental protection and material disposal shall be included in with the cost of other appropriate bid items.

Payment will be made under:

Pay Item	Pay Unit
Dismantle and remove existing structure (B or Str. No.)	Lump sum
Remove portion of existing structure (B or Str. No.)	Lump sum
Environmental and worker protection (B or Str. No.)	Lump sum
Material Disposal (B or Str. No. and type)	Lump sum

SECTION 414—RIPRAP

414.01—Description

This work shall consist of placing the specified type of riprap in accordance with the plans, Standard Drawings where applicable, and these specifications.

414.02—Materials

(a) **Riprap** shall conform to Section 204.

1. **Dry Riprap** is classified as follows:

   a) **Class I:** Stones shall weigh between 50 and 150 pounds each. At least 60 percent shall weigh more than 100 pounds, and approximately 10 percent may weigh 50 pounds or less.

   b) **Class II:** Stones shall weigh between 150 pounds to 500 pounds each. At least 50 percent shall weigh more than 300 pounds, and approximately 10 percent may weigh 150 pounds or less.

   c) **Class III:** Stones shall weigh from 500 pounds to 1,500 pounds each. At least 50 percent shall weigh more than 900 pounds, and approximately 10 percent may weigh less than 500 pounds.

   d) **Class AI:** Stones shall weigh between 25 and 75 pounds each, except that approximately 10 percent may weigh 25 pounds or less and 10 percent may weigh 75 to 100 pounds.

2. **Dumped riprap** is classified according to the following types:

   a) **Type I:** Core riprap shall be composed of compact angular pieces of derrick stone weighing from 3/4 ton to 2 tons each with an average weight of approximately 1 ton. Approximately 10 percent by weight may weigh less than 3/4 ton.

   b) **Type II:** Heavy riprap shall be composed of compact angular pieces of derrick stone weighing from 3 to 10 tons each with an average weight of approximately 4 tons. Approximately 10 percent by weight may weigh less than 3 tons.

3. **Mortared Riprap stone** shall be the same size as specified for Dry Riprap, Class II, and shall be selected to obtain fairly large, flat-surfaced stones that will produce a true and even surface with a minimum of voids.

4. **Grouted Riprap for Slopes:** Stones shall be of the same sizes and placed in the same manner as specified for Dry Riprap, Class I. Grout shall consist of 1 part hydraulic cement and 3 parts sand, thoroughly mixed with water to produce grout having a thick, creamy consistency.

5. **Erosion Control Stone for Culvert Outlet Protection** shall conform to the requirements for Dry Rip Rap Class AI, I, & II respectively of (a) herein for weight.

6. **Erosion Control Riprap:** Riprap shall consist of sound, nonerodible shot rock or rock excavation, which may be obtained from within the excavation for the typical sections on the project. Erosion control riprap rock shall be not more than 15 inches in its greatest dimension and shall contain a sufficient percentage of smaller rocks to provide a reasonably dense mass with a thickness of at least 8 inches.

7. **Concrete Riprap in Bags** shall be either wet or dry mixtures as follows:

a) **Wet mixture:** Riprap shall consist of Class C1 concrete in suitable burlap bags except in brackish or tidal water, where concrete shall be Class A3. Bags shall weigh approximately 100 pounds when 2/3 filled with concrete.

b) **Dry mixture:** Riprap shall conform generally to the requirements for wet mixtures except that the mixture shall consist of the dry ingredients and the Engineer will not enforce the requirements for water, consistency, and air.

The Engineer will permit dry riprap in burlap or paper bags. Riprap shall be a rectangular solid enclosure approximately 3 inches in thickness and shall weigh approximately 80 pounds per bag. Paper bags shall be perforated throughout on approximate 1-inch centers and shall be of adequate seal, thickness, and strength to maintain the integrity of the riprap until the concrete mixture sets. Bags shall be biodegradable.

8. **Stone Riprap for Foundation Protection:** Riprap for pier, abutment, and bridge spill slope protection shall conform to the applicable specifications requirements shown on the Plans or elsewhere in the Contract.

9. **Concrete Slab Riprap for Stream Crossings** shall consist of Class A3 concrete, cast-in-place, 6 inches in thickness. Concrete shall have a consistency that will permit placement without the use of top forms.

Welded wire fabric shall be No. 6 gage wire, spaced 6 inches center to center.

(b) **Sand** shall conform to Section 202. Grading A, B, or C sand may be used in mortared or grouted riprap.

(c) **Mortar and grout** shall conform to Section 218.

(d) **Geotextile riprap bedding material** shall conform to Section 245.

(e) **Welded wire fabric** shall conform to Section 223.

(f) **Concrete** shall conform to Section 217.

414.03—Procedures

(a) **Dry riprap** shall be placed as follows:

Grading: The Contractor shall grade and finish slopes to a reasonably smooth and compact surface within a tolerance of 6 inches from the surface lines shown on the plans.

Immediately prior to placement of riprap bedding, the Engineer will inspect the prepared base. The Contractor shall not place riprap or bedding until the Engineer has approved the prepared base.

Bedding: Riprap bedding shall be placed on the embankment to form a backing for riprap. Riprap bedding shall be spread uniformly on the prepared base. The Engineer will not require the Contractor to compact the bedding material, but the material shall be graded to a reasonably even surface, free from mounds or depressions.

The entire perimeter of the geotextile riprap bedding material shall be turned down and buried at least 9 inches for anchorage when geotextile bedding material is required. Adjacent strips of material shall run only up and down the slope and shall overlap at least 18 inches. Geotextile bedding material shall not be used on slopes greater than 1:1. If sewed, strips shall overlap at least 4 inches and shall be double stitched with a prayer seam, Type SSa 1. The Contractor shall replace or repair damaged material with a patch of the same material overlapping the damaged area by at least 18 inches on all sides. The patch shall be double stitched on all sides. Displaced material shall be repositioned, including, if necessary, removing and replacing riprap stone, at the Contractor's expense. Geotextile riprap bedding material shall be placed loosely so that positioning or repositioning riprap will not stretch or tear it.

Placing stones: The Contractor shall place riprap on the embankment as soon as practicable after bedding has been finished, but not later than 15 days, in a manner that will produce a reasonably well-graded mass of rock with the minimum practicable percentage of voids. Riprap shall be placed to its full course thickness in one operation and in a manner to avoid displacing underlying material. Riprap stone shall not be dropped onto bedding fabric from a height greater than 1 foot. Smaller-sized material shall not be dropped onto bedding fabric from a height greater than 3 feet. Larger stones shall be reasonably well distributed.

Finished riprap shall be free from objectionable pockets of small stones and clusters of larger stones. Hand placing may be required to the extent necessary to secure the results specified and form uniform slopes.

The Engineer will permit a tolerance of ± one quarter of the thickness of the maximum-size stone from the lines and grades shown on the plans in the finished surface; however, the Contractor shall ensure during placement the extremes of such tolerance shall be not continuous over an area of more than 200 square feet. The Engineer must approve the manner riprap is keyed into the natural ground to a depth equal to the bed thickness or to solid rock.

The Contractor may obtain the desired distribution of various sizes of stones throughout the mass by selective loading at the source, controlled dumping of successive loads during final placement, or a combination of these methods. The Engineer will not allow placing riprap by dumping into chutes or similar methods likely to cause segregation of the various sizes.

The Contractor shall protect and maintain riprap until the riprap is accepted by the Engineer. Displaced material shall be replaced to the lines and grades shown on the plans or in the Road and Bridge Standards at the Contractor's expense.

(b) **Dumped Riprap:** Dumped riprap shall be placed in the same manner described for dry riprap in (a) herein. The Contractor shall not place dumped riprap in layers.

(c) **Mortared Riprap for Slopes:** The Contractor shall place stone on a slope not steeper than the natural angle of repose of the fill material. Fifty percent (50%) of the mass shall be broad flat stones placed with the flat surface uppermost and parallel to the slope. Stones shall be placed first and roughly arranged to be in close contact, with the larger stones placed near the base of the slope. Spaces between larger stones shall be filled with stones of suitable size, leaving the surface reasonably smooth, tight and conforming to the contour required. Stones shall be placed in a manner so as to ensure a maximum variation from a true plane of not more than 1 1/4 inches in 4 feet is achieved for plane surfaces. Warped and curved surfaces shall have the same accuracy as specified for plane surfaces.

As each larger stone is placed, it shall be surrounded by fresh mortar, and adjacent stones shall be shoved into contact. After larger stones are in place, the Contractor shall fill spaces or openings between them with mortar, and smaller stones shall then be placed by shoving them into position, forcing excess mortar to the surface, ensuring that each stone is carefully, fully and firmly embedded laterally.

After the work is complete, excess mortar forced up between voids shall be spread uniformly to fill surface voids completely. Surface joints shall then be pointed roughly with flush or shallow smooth-raked joints.

(d) **Grouted Riprap for Slopes:** The Contractor shall exercise care during placing to keep earth or sand from filling spaces between stones. After stones are in place, spaces between them shall be filled with grout from bottom to top and the surface swept with a stiff broom. The Contractor shall not grout riprap in freezing weather. In hot, dry weather, the work shall be protected from sunlight and kept moist for at least 3 days after grouting by the use of water saturated burlap.

(e) **Erosion Control Stone for Culvert Outlet Protection:** Erosion Control Stone for Class AI, I, and II culvert outlet protection as shown in the Standard Drawings shall be placed in a manner to present an irregular or rough surface.

(f) **Erosion Control Riprap:** The Contractor shall place riprap where shown on the plans or as directed by the Engineer in accordance with Section 303.04(h).

(g) **Concrete Riprap in Bags** shall be placed as either a wet or dry mixture.

1. **Wet mixture:** Each bag shall be securely tied and immediately placed in the work. When used for foundation protection, bags shall be placed in accordance with the provisions governing placement of stone riprap for foundation protection as specified. When used for slope protection, riprap shall be placed in conformance with the provisions herein governing the placement of dry riprap.

2. **Dry mixture:** Dry mixture ingredients shall be placed in burlap or paper bags and installed as specified for wet mixture applications.

(h) **Stone Riprap for Foundation Protection:** Riprap for pier, abutment, and bridge spill slope protection shall conform to the applicable specifications.

(i) **Concrete Slab Riprap for Stream Crossings:**

The finished embankment slope shall be reasonably smooth and dense. The Contractor shall excavate a trench at the toe of the slope to accommodate the toe of the slab. The Contractor shall not place the slab riprap until the Engineer has approved the slope.

Riprap shall be constructed in accordance with Section 404 as applicable except as modified herein and shall be cured according to Section 316.04(j). Welded wire fabric shall be positioned at the center of the slab, shall run continuously throughout the slab, and shall lap approximately 6 inches at the edges of each sheet of fabric.

The berm portion of the slab shall be placed on a slope of approximately 12:1, draining away from the abutment. Where the edge of the slab is placed against the abutment, the joint shall be sealed to a depth of at least 1/2 inch with hot-poured joint sealer conforming to Section 212.

The toe of the slab shall extend to an elevation at least 3 feet below the elevation of the toe of fill, and the lower edge of the slab shall be increased approximately 6 inches in thickness, tapering to its nominal thickness 3 feet up the slope from the lower edge of the slab. The tapering shall be on the underside of the slab. The Contractor shall place the slab using one of the following methods:

1. **Block method:** The slab shall be placed in alternate blocks approximately 4 feet by 4 feet.

2. **Strip method:** The slab may be placed in alternate, continuous strips having scored or formed joints perpendicular to construction joints. Strips shall be placed in alternating widths of 4 feet and 5 feet, or 4 feet 6 inches each. Joints shall be at least 1 inch in depth and spaced approximately 4 feet 6 inches apart. The width of the joint shall be as small as possible.

Successive courses or strips shall not have joints that line up with the joints in the preceding courses or strips. Horizontal joints shall be normal to the slope. Joints shall be closed without filler.

After concrete is placed, it shall be consolidated and the surface struck off by means of a strike board. Concrete shall be float finished with a wooden or cork float. The surface shall not vary more than 1/2 inch under a 10-foot straightedge.

414.04—Measurement and Payment

Dry riprap will be measured in square yards of surface area or tons as specified.

Mortared riprap will be measured in square yards of surface area.

Grouted riprap will be measured in square yards of surface area or tons as specified.

Stone riprap for foundation protection will be measured in square yards of surface area or tons as specified.

Dumped riprap will be measured in square yards of surface area or tons as specified.

Concrete riprap in bags will be measured in cubic yards.

Concrete slab riprap will be measured in square yards. When an optional riprap is used in lieu of concrete slab riprap, bedding material will not be measured for payment and the riprap will be paid for at the contract unit price for concrete slab riprap.

Erosion control riprap will be measured in square yards of surface area or tons as specified.

Erosion Control Stone used for Culvert Outlet Protection will be measured in square yards of surface area or tons for the Class and Standard specified and will be paid for at the contract unit price per square yard or ton. This price shall include excavating, backfilling, preparing the surface, furnishing and installing geotextile bedding material including overlaps, repair work, excavating and backfilling toe-ins, and placing the required materials.

The price for the various types of riprap shall include, as appropriate, furnishing and placing riprap, including welded wire fabric or geotextile bedding material including overlaps when required, mortar or

grout; excavation; and riprap bedding. The price shall also include preparing the surface, repair work, and excavating and backfilling toe-ins.

Payment will be made under:

Pay Item	Pay Unit
Dry riprap (Class and depth)	Square yard or ton
Mortared riprap (Depth)	Square yard
Grouted riprap (Depth)	Square yard or ton
Stone riprap (Depth)	Square yard or ton
Dumped riprap (Type and depth)	Square yard or ton
Concrete riprap in bags	Cubic yard
Concrete slab riprap	Square yard
Erosion control riprap (Depth)	Square yard or ton
Erosion control stone (Class, Std)	Square yard or ton

SECTION 415—CONCRETE SLOPE PROTECTION

415.01—Description

This work shall consist of furnishing and installing precast concrete blocks in a bed of coarse sand or installing a concrete slab on embankments at or near bridge abutments as shown on the plans or as specified by the Engineer.

415.02—Materials

(a) **Precast concrete blocks** shall conform to Section 222.

(b) **Mortar** shall be nonshrinking and shall conform to Section 218 as applicable.

(c) **Foundation course** shall be Grading B sand conforming to Section 202 or approved local material similar in nature as approved by the Engineer.

(d) **Concrete** shall be Class A3 conforming Section 217.

(e) **Welded wire fabric** shall be No. 6 gage, 6 inches center to center each way, conforming to Section 223.

(f) **Herbicide** shall conform to Section 244.

415.03—Procedures

(a) **Precast Concrete Block Slope Protection:** The Contractor shall construct the subgrade at the required distance below the finished surface of the slope. Soft yielding sections and unsuitable material shall be removed and replaced with useable subgrade material. The subgrade shall be compacted and shaped to a smooth, uniform surface.

The foundation course shall be spread on the subgrade to a depth of 2 inches and treated with a Department approved highly insoluble soil sterilent herbicide. Material shall be in a dry form and have a maximum solubility rate of 250 parts per million. Material shall be uniformly applied at the maximum rate recommended by the manufacturer.

The Contractor shall bed the blocks in the foundation course perpendicular to the finished surface in straight rows, with the longest dimension aligned horizontally. Blocks shall be placed with continuous joints extending horizontally on the face of the slope and with broken (staggered) joints extending perpendicular thereto, up or down the slope. Blocks shall be rammed until firmly seated and the surface conforms to the finished slope. Joints shall be filled with mortar.

Cast-in-place edging for block slope protection shall be placed as specified in (b) herein.

(b) **Concrete Slab Slope Protection:** The subgrade shall be prepared as for block slope protection. The cast-in-place concrete slab shall be 4 inches in thickness and shall be placed in accordance with Section 414.03(i).

Except at railroad grade separations, the Contractor may provide a combination concrete slab and stone slope protection in lieu of the specified concrete slab slope protection. Protection shall be in accordance with the following:

1. Concrete portions, consisting of a paved ditch and a strip of concrete approximately 3 feet in width placed on the berm along the face of the abutment, shall be furnished as required for concrete slab slope protection. Stone shall be placed at a depth of 7 to 9 inches over the remaining area to be covered with slope protection.

2. The Contractor shall prepare the subgrade for concrete and stone in accordance with Section 414.03(i). The portion of the slope to be protected with stone shall be treated with a herbicide in accordance with (a) herein. Care shall be taken to confine application to areas designated for sterilization.

3. Stone shall be crushed gravel or stone conforming to Section 204.02 (b). Gradation of aggregate shall not be smaller than the sizes specified in Table II-3 for aggregate size No. 1 nor larger than 8 inches in their greatest dimension. Stone shall be in a sufficient range of sizes to create a stable (choked and locked) and reasonably uniform slope.

   The condition of the subgrade and method of placing stone shall be such that pieces of stone in contact with the subgrade shall be partially embedded where practicable. Stone immediately adjacent to concrete shall not project more than 3 inches above the concrete.

   Engineer approved splash blocks connecting with the paved ditch shall be provided under downspouts draining onto the slope protection.

415.04—Measurement and Payment

Concrete slope protection will be measured in square yards of surface area and will be paid for at the contract unit price per square yard. If limits are not shown on the plans, measurements will be taken from the outside edge to outside edge, including curb, and from the edge of slope protection at abutment to the bottom of the curtain wall or outside edge of the paved ditch as appropriate. This price shall include the slope protection, foundation course, welded wire fabric, herbicide treatment and splash blocks.

Payment will be made under:

Pay Item	Pay Unit
Concrete block slope protection	Square yard
Concrete slab slope protection (Depth)	Square yard

SECTION 416—WATERPROOFING

416.01—Description

This work shall consist of furnishing and applying waterproofing material on concrete bridge decks or other surfaces as shown on the plans.

416.02—Materials

Epoxy-resin compounds and aggregates for surface application shall conform to Section 243. Epoxy resin shall be Type EP-5, low viscosity, or Type EP-7 for concrete bridge deck applications and Type EP-3B/EP-3T for other bridge elements such as concrete beam ends and concrete substructure seat applications. Epoxy Type EP-3B shall be dark grey in color, unless otherwise specified on the Plans or elsewhere in the Contract.

416.03—Procedures

Epoxy-resin: Containers, tools, and mechanical equipment shall be free from solvents, loose material, and deposits of hardened material.

The Contractor shall not apply epoxy resin when the concrete surface or the ambient air temperature is below 50 degrees F unless otherwise permitted by the manufacturer's instructions.

(a) **Surface preparation:** Surfaces on which epoxy compounds are to be applied shall be free from grease, dirt, dust, paint, mill scale, curing compound, laitance, and other foreign material which may prove deleterious to bonding.

Concrete surfaces on which epoxy compounds are to be used shall be abrasive blast cleaned sufficiently to expose the sound concrete. Surfaces that are not to receive epoxy compounds shall be protected from abrasive blast cleaning. Immediately following abrasive blast cleaning, the surface shall be thoroughly cleaned according to the epoxy resin manufacturer's instructions.

Before epoxy compounds are applied to metal surfaces, surfaces shall be abrasive blast cleaned to a bright metallic luster according to Method 5 of Section 411.

Wood surfaces shall be abrasive blast cleaned as needed to obtain proper adhesion of the epoxy.

(b) **Mixing:** Epoxy mortar shall be made by blending sand, epoxy resin, and hardener in accordance with the manufacturer's instructions.

Batch sizes shall be limited to the maximum batch size recommended by the manufacturer. Mixed epoxy compounds shall be used within the manufacturer's specified pot life. The Engineer will not permit the addition of solvents or other materials to the mixture.

(c) **Application:** Masking shall be used to form straight edges. The Contractor shall prevent epoxy resin from flowing into or over expansion joints. The first coat of epoxy resin shall be applied at the rate of 1 gallon per 75 square feet. Sand shall be broadcast in sufficient quantity, approximately 11 pounds per square yard, to cover the epoxy completely. Sand shall be firmly embedded so that at least 95 percent of the deck area displays a sand surface after brooming. The Contractor shall not broom the epoxy until the epoxy resin has cured sufficiently to prevent tearing. After curing, unbonded sand shall be broomed from the surface and may be reused if uncontaminated and has acceptable gradation.

The second coat of epoxy resin shall be applied at the rate of 1 gallon of epoxy per 50 square feet. Requirements pertaining to masking, epoxy, flow, sand broadcasting, percentage of embedment, curing, and brooming shall also apply to the second coat of epoxy resin. The Engineer will not require sand to be broadcast into applications of Epoxy Type EP-3B/EP-3T used for concrete beam ends and concrete substructure seat applications.

The Contractor shall make suitable provisions to prevent water from getting between the waterproofing and the waterproofed surface at the edges of the waterproofing system and at any point where it is punctured or interrupted by appurtenances such as drains or pipes.

The waterproofing system shall be applied to areas noted on the Plans or elsewhere in the Contract.

When applied to prestressed concrete slab and box beam units for new construction, application shall be made at the prestressing plant. Joints and damaged areas shall be waterproofed after erection.

(d) **Curing:** Curing time shall conform to the manufacturer's recommendations. During this time, both pedestrian and vehicular traffic shall be barred from freshly placed epoxy surfaces.

416.04—Measurement and Payment

Waterproofing – Epoxy Resin (Type) will be measured in square yards and will be paid for at the contract unit price per square yard of completed surface as shown on the plans for the type specified.

The cost of waterproofing applied to prestressed concrete members before erection and the cost of waterproofing joints and damaged areas shall be included in the price bid per member.

Payment will be made under:

Pay Item	Pay Unit
Waterproofing – Epoxy Resin (Type)	Square yard

SECTION 417—DAMP-PROOFING

417.01—Description

This work shall consist of furnishing and applying damp-proofing material to concrete surfaces in accordance with the plans and these specifications.

417.02—Materials

Materials shall conform to Section 213 as applicable.

417.03—Procedures

(a) **Surface Preparation:** Surfaces shall be cleaned of loose, foreign material or other substances, materials, etc. than may inhibit or prohibit successful continuous application and shall be dry. The Engineer may require the surface to be scrubbed with water and a stiff brush, after which it shall be allowed to dry before application of primer.

(b) **Application:** The cleaned surface shall be brush painted or spray painted with at least two coats of primer, using at least 1/8 gallon per square yard of surface area per coat. On the primed surface, one application of an asphalt seal coat shall be applied by brush, using at least 1/10 gallon per square yard.

Asphalt shall be confined to areas to be damp-proofed and shall not be dripped or spread on any other parts of the structure. The Contractor shall take protective measures and exercise care to prevent asphalt from being applied to non-designated areas.

417.04—Measurement and Payment

Damp-proofing, when a pay item, will be measured in square yards and will be paid for at the contract unit price per square yard. The price shall include damp-proofing materials, surface preparation, protective measures, and application. When not a pay item the cost of damp-proofing shall be included in the price for other appropriate pay items.

Payment will be made under:

Pay Item	Pay Unit
Damp-proofing	Square yard

SECTION 418—TIMBER STRUCTURES

418.01—Description

This work shall consist of furnishing and erecting timber materials required to complete a structure in accordance with these specifications and in conformity with the lines and grades shown on the plans or as established by the Engineer.

418.02—Materials

(a) **Lumber and Timber** shall conform to Section 236.

(b) **Structural Shapes:** Rods, plates, shapes, and eyebars shall conform to Section 226.

(c) **Castings:** Castings shall be cast steel or gray iron, as shown on the plans, conforming to Section 224.

(d) **Hardware:** Machine bolts, drift bolts, and dowels shall conform to Section 226. Washers may be ogee gray iron or malleable castings or may be cut from mild steel plate as shown on the plans.

Machine bolts shall have square heads and nuts. Nails shall be cut or round wire of standard form. Spikes shall be cut, wire, or boat spikes as shown on the plans.

Nails, spikes, bolts, dowels, washers, and lag screws shall be black or galvanized, as specified on the plans.

Other hardware, except malleable iron connectors, shall be galvanized in accordance with Section 233 or cadmium plated in accordance ASTM A165, Type OS.

(e) **Paint** shall conform to Section 231 and shall be the color as shown on the plans.

418.03—Procedures

(a) **Storing Material:** The Contractor shall store lumber and timber on the work site in well-arranged stacks or ricks.

Material shall be stacked at least 12 inches above the ground surface and sloped to drain off condensation or precipitation. It shall be continuously protected from weather by an intact suitable covering. The ground underneath and in the vicinity of material shall be cleared and kept free of weeds and rubbish.

Untreated material shall be open stacked, and treated material shall be close stacked.

(b) **Treated Timber:** The Contractor shall handle treated timber by means of rope slings to prevent sudden dropping, breaking of outer fibers, or bruising or penetrating of the surface with tools such as cant hooks, peaveys, pikes, or hooks.

Cutting, framing, and boring of treated timbers shall be performed before treatment insofar as is practicable. The Contractor shall avoid making untreated cuts, borings, or other joint framings below the high water elevation when treated timbers are to be placed in water infested by marine borers, as determined by the Engineer.

Cuts in treated piles or timbers and abrasions, after having been carefully trimmed smooth, shall be brush coated with at least two applications of the same preservative used in the treatment of the timbers or piles.

Bolt holes bored after treatment shall be treated with a preservative conforming to Section 236 for the conditions of exposure in the finished work. The Contractor shall plug unfilled bolt

holes after they have been treated. Plugs shall fit tightly for the full opening of the hole and be driven into place.

Whenever forms or temporary braces are attached to treated timber with nails or spikes, holes shall be filled by driving galvanized nails or spikes flush with the surface or by plugging as required for bolt holes.

(c) **Untreated Timber:** The Contractor shall thoroughly treat ends, tops, and contact surfaces of sills, caps, floor beams, stringers, and bracing and truss units with two coats of preservative before assembly. The back faces of bulkheads and other timber that will be in contact with earth, metal, or other timber shall be similarly treated prior to erection or incorporation into the work.

(d) **Treatment of Pile Heads:** After required cutting to receive caps and prior to placement of caps, pile heads shall be treated to prevent decay. The Contractor shall protect the heads of timber piles by one of the following methods, as indicated on the plans. If not otherwise indicated, Method A shall be used.

1. **Method A—zinc covering:** The sawed surface shall be brush coated with three applications of a preservative. Before the cap is placed, a sheet of 12 gage (0.028 inch) zinc shall be placed on each pile head. The sheet shall be of sufficient size to project at least 4 inches outside the pile and shall be bent down, neatly trimmed, and securely fastened to the face of the pile with large-headed galvanized roofing nails.

2. **Method B—fabric covering:** Heads of piles shall be covered with alternate layers of hot pitch and cotton fabric for waterproofing, using four applications of pitch and three layers of fabric. The cover shall measure at least 6 inches more in dimension than the diameter of the pile and be neatly folded down over the pile and secured by large-headed galvanized nails or by binding with at least seven complete turns of galvanized wire securely held in place by large-headed galvanized nails and staples. Edges of fabric projecting below the wire wrapping shall be trimmed to present a neat finished appearance.

(e) **Holes for Bolts, Dowels, Rods, and Lag Screws:** The Contractor shall bore holes for round drift bolts and dowels with a bit 1/16 inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift holes or dowels shall be equal to the least dimension of the bolt or dowel. The Contractor shall bore holes according to the following:

1. Holes for machine bolts shall be bored with a bit the same diameter as the bolt.

2. Holes for rods shall be bored with a bit 1/16 inch greater in diameter than the rod.

3. Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

(f) **Bolts and Washers:** The Contractor shall install a washer under bolt heads and nuts that would otherwise come in direct contact with wood. Bolts shall be checked after nuts have been finally tightened.

(g) **Countersinking:** The Contractor shall countersink bolts and screws wherever smooth faces are required. Recesses in horizontal surfaces shall be painted with a preservative and filled with hot pitch after the bolt or screw is in place.

(h) **Framing:** Lumber and timber shall be cut and framed to a close fit so that the resultant joints will have an even bearing over the contact surfaces. Mortises shall be true to size for their full depth, and tenons shall fit snugly to all surfaces. The Engineer will not permit shimming in making finished joints, and open joints will not be accepted.

(i) **Pile Bents:** Preparing and driving piles shall be in accordance with Section 403.

The Contractor shall carefully select piles for any one bent to avoid undue bending or distortion of the sway bracing. Care shall be taken in distributing piles of varying sizes to secure uniform strength and rigidity in bents of any given structure.

Cutoffs shall be accurately made to ensure a uniform bearing between the cap and piles of a bent.

(j) **Framed Bents:**

1. **Mud sills:** Untreated timber used for mud sills shall be of heart cedar, heart cypress, redwood, or other naturally durable timber. Mud sills shall be firmly and evenly bedded to solid bearing and tamped in place.

2. **Concrete pedestals** for the support of framed bents shall be finished so that sills or posts will take an even bearing. Dowels or anchor bolts at least 3/4 inch in diameter shall be set in pedestals when they are cast for anchoring sills or posts.

3. **Sills** shall have a true and even bearing on mud sills, piles, or pedestals. They shall be drift bolted to mud sills or piles with bolts at least 3/4 inch in diameter and extending into the mud sills or piles at least 6 inches. When possible, the Contractor shall remove earth from contact with sills so that there will be free air circulation.

4. **Posts** shall be fastened to pedestals with dowels at least 3/4 inch in diameter, extending at least 6 inches into the posts.

   Posts shall be fastened to sills by one of the following methods, as indicated on the plans:

   - by dowels at least 3/4 inch in diameter extending at least 6 inches into posts and sills or

   - by drift bolts at least 3/4 inch in diameter driven diagonally through the base of the post and extending at least 9 inches into the sill.

(k) **Caps:** Timber caps shall be placed with ends aligned in a manner to secure an even and uniform bearing over the tops of supporting posts or piles. Caps shall be secured by drift bolts at least 3/4 inch in diameter extending at least 9 inches into the posts or piles. Drift bolts shall be located in the approximate center of the post or pile.

(l) **Bracing:** Ends of bracing shall be bolted through the pile, post, or cap with a bolt at least 5/8 inch in diameter. Intermediate intersections shall be bolted and spiked with wire or boat spikes, as indicated on the plans. In all cases, the Contractor shall use spikes in addition to bolts.

(m) **Stringers** shall be sized at bearings and placed in position so that knots near edges will be in the top portions of stringers.

Outside stringers may have butt joints with ends cut on a taper, but interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. Lapped ends of untreated stringers shall be separated at least 1/2 inch for the circulation of air and securely fastened by drift bolting where specified. Where stringers are two panels in length, joints shall be staggered.

Cross bridging between stringers shall be neatly and accurately framed and securely toenailed with at least two nails in each end. Cross-bridging units shall have full bearing at each end against the side of stringers. Cross bridging shall be placed at the center of each span.

(n) **Plank Floors:** Planks shall be surfaced on four sides (S4S).

Single-plank floors shall consist of a single thickness of plank supported by stringers or joists. Planks shall be carefully graded as to thickness for uniformity and placed so that no two adjacent planks shall vary in thickness by more than 1/8 inch. Each plank shall be placed heart side down, firmly jacked together, and securely fastened to each joist.

(o) **Wheel Guards and Railings** shall be erected true to line and grade. Wheel guards, rails, and rail posts shall be surfaced on four sides (S4S). Wheel guards shall be laid in sections at least 12 feet in length.

(p) **Coating:** Rails and rail posts, untreated timber, and timber treated with a preservative shall be painted with three coats of preservative unless otherwise specified in the Contract.

Metal parts, except hardware, shall be given one coat of shop paint and, after erection, three coats of field paint as specified on the Plans or elsewhere in the Contract.

If timber is to be painted, paint color and elements to be coated shall be as indicated on the Plans or elsewhere in the Contract.

418.04—Measurement and Payment

Lumber and timber will be measured in units of 1,000 foot-board-measure (MFBM) for materials placed in the finished structure and will be paid for at the contract unit price per MFBM. Computations for lumber quantities will be based on nominal sizes, complete-in-place. No other allowance for waste will be made.

Structural steel will be paid for in accordance with Section 407.

Painting timber structures, when a pay item, will be paid for at the contract lump sum price. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

These prices shall include preparing surfaces, furnishing and applying preservative treatment, concrete pedestals for frame bents, zinc or fabric pile head protection, wooden dowels, nails, spikes, and other hardware.

Payment will be made under:

Pay Item	Pay Unit
Lumber (Treated or untreated)	MFBM
Painting timber structures	Lump sum

SECTION 419—BRIDGE CONDUIT SYSTEMS AND LIGHTING SYSTEMS

419.01—Description

This work shall consist of furnishing and installing bridge conduit systems and/or bridge lighting systems in accordance with these specifications and in conformity with the lines and details shown on the plans or as established by the Engineer.

419.02—Materials

Conduit, boxes, and fittings shall conform to Section 238.

419.03—Procedures

The Contractor shall verify or locate the origin of power sources when modifying or relocating existing electrical systems and shall advise the Engineer at least 48 hours prior to the anticipated time of de-energizing the electrical system. Materials and workmanship shall conform to the standards of NEC and the requirements of the local power company.

Conduit, fittings, and electrical items shall be installed in accordance with their respective requirements in Section 700.

419.04—Measurement and Payment

Bridge conduit systems, when a pay item, will be paid for at the contract lump sum price per structure. When not a pay item the cost thereof shall be included in the price for other appropriate pay items.

Bridge lighting systems will be paid for at the contract lump sum price per structure.

Payment will be made under:

Pay Item	Pay Unit
Bridge conduit system (B or Str. No.)	Lump sum
Bridge lighting system (B or Str. No.)	Lump sum

SECTION 420—ADHESIVE-BASED JOINT SEALING SYSTEMS

420.01—Description

This work shall consist of furnishing and installing preformed elastomeric joint sealer in accordance with these specifications and in conformity with the lines shown on the plans or as established by the Engineer.

420.02—Materials

Adhesive based joint sealers shall include three classes of joint sealing systems:

(a) **Class I joint system** shall be comprised of a preformed, extruded polychloroprene (neoprene) material having serrated sidewalls, which is air pressurized and bonded in place with a structural epoxy adhesive.

(b) **Class II joint system** shall be comprised of inverted 'V' shaped, preformed, extruded silicone rubber or EPDM (ethylene propylene diene monomer rubber) seal material bonded in place with a structural adhesive.

(c) **Class III joint system** shall be comprised of preformed, pre-compressed, self-expanding joint system with silicon pre-coated surface bonded in place with a structural epoxy adhesive.

Adhesive-based joint sealer and structural adhesive shall conform to Section 212.

420.03—Procedures

(a) **Joint Preparation:** The joint shall be formed to provide the nominal opening at the specified temperature as shown on the plans. For no-plan projects, the Contractor shall request information concerning the nominal opening and the specified temperature from the Engineer. Sides of the joint shall be parallel to each other. Edges of concrete or epoxy mortar adjacent to the joint shall be rounded to a radius of not more than 1/4 inch or constructed with a chamfer. The Engineer may require joints having an insufficient opening to be sawed or ground to the proper size. The Contractor may furnish a larger-size sealer, up to 4 inches in its uncompressed width as determined by the Engineer, if a joint opening is larger than specified. If the joint opening is larger than that which will accommodate the larger sealer, the Contractor shall cut back the end of the slab at least 6 inches and rebuild it with Class A4 concrete to obtain the required joint opening. The Contractor shall bear the cost of such additional work or material unless designated in the Contract as a pay item.

Existing joints shall be prepared or reconstructed in accordance with Section 412. The work required to prepare or reconstruct existing joints will be measured and paid for under the appropriate items as shown in Section 412.

The Contractor shall thoroughly clean the joint by abrasive blast cleaning followed by brushing and or oil free compressed air, so that it is free from dust, oil, grease, or other foreign materials.

(b) **Installation:** The Contractor shall install the joint sealer system using methods and procedures recommended by the manufacturer of the system. A lubricant adhesive shall be used. The finished joint shall provide a watertight expansion joint seal system according to the manufacturer's instructions. The joint seals shall be installed along the entire width of the deck and shall extend at least 18 inches up each side of the bridge barrier or parapet. Bridges with curbs rather than barriers or parapets shall have joint material installed in the entire width of the curb.

No field splices will be allowed unless recommended by the manufacturer and approved in writing by the Engineer.

The sealer shall be installed for proper depth below the surface of the adjacent roadway as detailed on the plans or as directed by the Engineer. The top surface of the sealer, after installation, shall remain recessed below the surface of the adjacent roadway during its full movement cycle.

The joint system shall seal the deck surface, gutters, curbs, and parapets to prevent water and other contaminants from seeping onto the superstructure or the substructure. Prior to the work being accepted by the Department the Contractor shall perform a leak test on tranverse joints in bridge decks and joints between decks and backwalls unless otherwise directed on the plans. The leak test shall consist of flooding the deck surface with water and observing the underside of the joints for evidence of leaks. The detailed procedure for the leak test shall be developed by the Contractor, in conjunction with the manufacturer, and submitted to the Engineer for review and approval prior to performing the test. The leak test shall expose the observed portion of the joint to positive hydraulic pressure for a period of no less than 30 minutes. In the event of a leak, the joint shall be repaired in accordance with the manufacturer's recommendations. Joints other than transverse joints in bridge decks or between decks and backwalls do not require leak testing.

Working drawings showing the complete details and dimensions of the adhesive based joint sealer system and other pertinent information, such as required special shop fabrication necessary for installation of practical watertight joints in the deck, gutters, curbs, and parapets, shall be submitted to the Engineer for review in accordance with the requirements of Section 105.10. The Contractor shall provide a factory-trained representative on the job site prior to and during the initial installation of the joints. Joints of all classes shall be installed only within temperature ranges recommended by the manufacturer.

1. **Class I Joint Systems**

   The joint sealer shall be bonded with a two component epoxy adhesive and pressurized during the adhesive cure time.

   Install all components utilizing the manufacturer's recommended adhesive for complete installation.

   Pressurization shall be performed through a valve with cap system. The profile is pressurized during installation and curing time of the adhesive to assure complete bonding throughout gap/profile surfaces. Air pressure will bleed itself with time or air valve can be released at any time after 24 hours of installation.

2. **Class II Joint Systems**

   The joint sealer shall be bonded to the joint interface with a structural adhesive as recommended by the manufacturer. A primer shall be used if recommended by the manufacturer. All joint interfaces must be completely dry prior to application of the structural adhesive. The joint seal cannot be installed immediately after precipitation or if precipitation is forecasted for the day.

   Install the joint seal in one continuous length.

   Prior to installation, clean the seal profile using a solvent approved by the manufacturer.

   Position the seal at the proper depth and apply structural adhesive along each side of the seal and fill per the following general procedure:

   - A backer rod may be installed to set the correct depth for the seal.

- Apply a continuous 3/8” to 1/2” bead of adhesive to both sides of the joint interface. Apply adhesive approximately 1 1/2” from top of roadway.

- Fold seal and insert into the joint. Release seal and ensure full continuous contact with joint interfaces and the adhesive.

- Apply a second bead of adhesive along each side of seal and fill to the top of the serrations. Do not apply adhesive above the serrated areas.

The joint manufacturer’s installation guidelines shall be consulted for the specific procedure in order to insure complete contact with joint interface and seal.

3. **Class III Joint System**

The joint seal shall be bonded with field-applied epoxy adhesive.

Install the joint seal system recessed from the surface such that when the field-applied injection band of silicone is installed between the substrates and the foam-and silicone-bellows, the system will be 1/2 inch down from the substrate surface.

Changes in plane and direction shall be executed using factory-fabricated “universal 90” or custom transition assemblies supplied by the manufacturer.

(c) **Observation Period**

The Contractor shall be responsible for the functionality of the joint sealing system for a 12 month observation period beginning at the date of completion and acceptance of work. The Contractor must guarantee the functionality of the joint sealing system. To successfully complete the observation period, the joint sealing system must not exhibit any evidence of leakage during the first 12 months of service. If leakage develops as determined by the Department the Contractor will be notified and shall reseal or replace that section of the seal that leaked within 30 days of notification. The Contractoor shall be responsible for all labor, materials, tools and equipment necessary to effect the repair or replacement. The Contractor shall coordinate repair or replacement operations with the district Structure and Bridge office.

420.04—Measurement and Payment

Adhesive based joint sealer (class) (width), when a pay item, will be measured in linear feet along the pavement surface from out to out of the deck slab, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing the joint material in accordance with this section and the manufacturer’s recommendations and all costs associated with the manufacturer’s representative, leak testing, and observation period requirements. When not a pay item the cost thereof shall be included in the price for other appropriate pay items.

Payment will be made under:

Pay Item	Pay Unit
Adhesive based joint sealer (Class) (Width)	Linear foot

SECTION 421—ELASTOMERIC EXPANSION DAMS

421.01—Description

This work shall consist of furnishing and installing elastomeric expansion dams in accordance with these specifications and in conformity with the lines, elevations, and locations shown on the plans or as established by the Engineer.

421.02—Materials

Materials shall conform to Section 212.

421.03—Procedures

The Contractor shall submit working drawings showing the complete details and dimensions of the expansion dam and other pertinent information, such as required special shop fabrication necessary for installation of practical leak-proof joints, to the Engineer for review and acceptance in accordance with Section 105.10. The Contractor shall provide a factory-trained representative on the job site prior to and during the initial installation of the expansion dam.

Dams shall consist of elastomeric material and metal components arranged to provide for expansion and contraction movement of the bridge deck.

Expansion and contraction movements between adjacent spans of the bridge deck shall be compensated for entirely by deformation of the elastomer component, without detriment to it, and shall cause no appreciable change in the elevation of the deck surface. The opening between the rigid portions of dams at the roadway level shall be not more than 3 1/2 inches at maximum expansion.

Dams shall seal the deck surface, gutters, curbs, and parapets to prevent water and other contaminants from seeping onto the substructure.

Dams shall have a continuous elastomeric membrane. The Engineer may allow field-vulcanized joints for each dam in accordance with plan details.

Dams shall be cast in place, with top surfaces parallel to the bridge deck. Concrete shall be placed beneath the dam in a manner to prevent the formation of air pockets or segregation in the concrete.

The Contractor shall complete final sealing of the finished expansion dam as soon as possible after installation. Bolt cavities shall be wire brushed and filled with sealant. Edges of the dam, exposed ends, and other areas of possible leakage shall be filled with sealant. Sealant shall be smoothed to make seamless and flush contact with mating surfaces, and any excess scraped off before the initial set.

421.04—Measurement and Payment

Elastomeric expansion dams will be measured in linear feet of dam, complete-in-place, for the movement range specified and will be paid for at the contract unit price per linear foot. The movement ranges are 0 to 2, 2 to 3, and 3 to 4 inches. This price shall include furnishing, installing, components, and

anchoring devices. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

Payment will be made under:

Pay Item	Pay Unit
Elastomeric expansion dam (Movement range)	Linear foot

SECTION 422—NAVIGATION LIGHTS

422.01—Description

This work shall include furnishing, installing, and wiring navigation lights complete and ready for service on structures shown on the plans or as directed by the Engineer.

422.02—Materials

(a) **Conduit, boxes, and fittings** shall conform to Section 238.

(b) **Conductors and electrical components** shall conform to Section 238. The Contractor shall use No. 8 single-conductor wire from the connection at the service pole to the first junction box on the structure, and No. 10 single-conductor wire for other related wiring.

422.03—Procedures

(a) **Electrical Service:** Power will be furnished within 100 feet of the end of the bridge by 120/240-volt single-phase, 60-hertz, three-wire service. The Contractor shall furnish and install a wooden pole on which the power company will terminate its service lines. The Contractor shall install service entrance equipment on the wooden pole in accordance with the details and requirements of Standard Drawing SE-8. The safety switch shall be rated at 30 amp, 240 volts, two pole, solid neutral 120 volt AC, and fused for 15 amps.

(b) **Conduit, Boxes, and Fittings:** These items shall be installed in accordance with Section 700, as applicable.

(c) **Lights:** The Contractor shall furnish and install lights in accordance with the latest rules and regulations for lighting bridges furnished by the U.S. Coast Guard and such lighting shall be subject to their approval. Materials and workmanship shall conform to the standards of NEC and the requirements of the local power company. Lights shall be equipped with an automatic lamp changer with a capacity of four lamps and a step-down transformer to operate standard low-voltage prefocused lamps. Lights shall turn on and off automatically so that they will burn continuously from sunset to sunrise.

Lights shall be controlled by a photoelectric control. The control shall operate a two-pole, 30-amp, normally open, magnetic relay mounted in a NEMA 3R control center cabinet. The Contractor shall mount the control for the lights on the service pole.

422.04—Measurement and Payment

Navigation lights will be paid for at the contract lump sum price, wherein no measurement will be made. This price shall include furnishing and installing conduit, conductor cable, service entrance equipment, junction boxes, navigation lights, lamp changer, photoelectric control and step-down transformer, control center cabinet, and safety switch.

Payment will be made under:

Pay Item	Pay Unit
Navigation lights	Lump sum

SECTION 423 – TOOTH EXPANSION JOINT ASSEMBLY

423.01—Description

This work shall consist of furnishing and installing tooth expansion joint assemblies, including associated neoprene troughs and connections to outlet devices, in accordance with these specifications and in conformity with the lines, grades and locations shown on the plans or established by the Engineer.

423.02—Materials

Materials shall conform to Sections 212 and 226.

Neoprene troughs shall be made of continuous material. Field splices shall not be permitted unless approved by the Engineer.

Structural steel shall be hot-dipped galvanized in accordance with Section 233.

423.03—Procedures

Working drawings showing complete details and dimensions of the tooth expansion joint and other pertinent information shall be submitted to the Engineer for review in accordance with Section 105.10.

Where indicated on the plans, the Contractor shall remove and replace portions of the existing deck and backwall to facilitate anchorage and installation. Such removal and replacement shall be performed and measured and paid for in accordance with Section 412.

Fabrication shall conform to Sections 407 and 212. Tooth thickness shall be specified on the plans.

All dimensions of the tooth expansion joint assemblies shall be checked after they are galvanized and before they are delivered to the field. The Contractor shall be responsible for misfits and errors and shall make necessary corrections or replacements at the Contractor's expense.

Tooth expansion joint assemblies shall seal the deck surface, gutters, curbs, sidewalks, parapets, and raised medians to prevent water and other contaminants from seeping onto the superstructure and

substructure members and shall include provision for connection to drainage outlets to prevent leakage of collected rainwater at any point along the joint or outlet.

Final sealing of the finished joint shall be completed as soon as practicable after installation.

Surfaces exposed to roadway traffic shall have antiskid provisions as indicated on the plans.

423.04—Measurement and Payment

Tooth expansion joint assembly will be measured in linear feet measured along the pavement surface from out to out of the deck slab for the tooth thickness specified and will be paid for at the contract unit price per foot. This price shall include furnishing and installing tooth expansion joint assembly, all necessary components and anchoring devices.

Payment will be made under:

Pay Item	Pay Unit
Tooth Expansion Joint Assembly (Tooth thickness)	Linear foot

SECTION 424 - ASPHALT PLUG JOINTS

424.01—Description

This work shall consist of supplying and installing a blended polymer modified asphaltic binder and aggregate system in layers into a prepared expansion joint block-out on an asphalt concrete overlay on a concrete bridge deck. After installation and curing, the system will provide a flexible waterproof bridge joint which will allow for a joint movement of 1 inch in expansion and 1 inch of compression. The joint shall be placed at a nominal width of 20 inches and a thickness of no less than 2 inches.

424.02—Materials

(a) **Backer rod** shall be expanded closed cell polyethylene foam capable of withstanding the elevated installation temperature (390°F) of the hot binder material and meet the specification requirements of ASTM D 5249.

(b) **Asphalt binder** shall be thermoplastic polymeric- modified asphalt conforming to Table 1 of ASTM D 6297.

(c) **Aggregate** shall be non-polishing of the Basalt, Gabbro or Granite group. All aggregates shall be crushed, double washed, dried and delivered to the job site pre-weighted in weatherproof, labeled bags. The gradation must meet the requirements of joint system manufacturer.

(d) **Steel backing plate** shall conform to the specification requirements of ASTM A36/A 36M, and shall be galvanized in accordance with Section 233. The plate shall have a minimum thickness of 1/4 inch and a minimum width of 8 inches, unless otherwise noted by the joint system manufacturer.

(e) **Asphalt plug joint systems** shall conform to ASTM D6297 and shall be selected from the Materials Division's Approved Products List No. 77

424.03—Procedures

(a) **General:** The Contractor shall submit complete and detailed working drawings of the asphalt plug joint system the Contractor proposes to use for review by the Engineer. The working drawings shall include materials, materials properties, installation procedures, storage, and handling requirements, and materials safety data sheets.

The asphalt plug joint shall extend from face-of-curb to face-of-curb. The method for sealing joints in curbs or parapets shall be developed by the Contractor and approved by the Engineer prior to installation. The method for sealing joints in curbs or parapets shall be detailed on the working drawings.

Asphalt plug joint systems shall be installed in accordance with the manufacturer's instructions. A manufacturer's representative shall be present during the entire installation to ensure satisfactory results are obtained.

Asphalt plug joint systems shall allow total joint movement of up to 2 inches. The installation shall be centered over the expansion joint gap.

The joint shall not be installed when the ambient or substrate temperatures are predicted to be below 40 degrees F at any time during the installation, when precipitation is imminent, or when otherwise prohibited by the manufacturer or the Engineer.

(b) **Installation:** Existing pavement and/or existing joints shall be saw cut to the full depth required for installation of the new plug joint and removed in accordance with the plan details or as directed by the Engineer in order to form the joint block-out. Existing pavement and/or existing joints shall be removed with pneumatic hand tools. Waterproofing membranes, if present, shall also be removed.

Small areas of deteriorated concrete in the block-out area shall be repaired with an approved material as directed by the Engineer.

The entire joint block-out area shall be cleaned by abrasive blast cleaning and dried using a hot compressed air lance.

Backer rods shall be installed in expansion joint openings at a minimum of one (1) inch depth as indicated on the installation details. Backer rod dimensions shall be as required by the manufacturer.

Immediately after cleaning and installing backer rod, coat the bottom of the block-out area with a layer of hot binder that has been heated in accordance with the manufacturer's instructions. If there is a greater than one hour delay between cleaning and placement of the binder material, the joint shall be re-cleaned using a hot compressed air lance.

Steel backing plates shall extend from face of curb to face of curb on the bridge deck portion of the expansion joint. There shall be at least 2 inches between the edge of the backing plate and the wall of the joint block-out. Backing plates shall be steel and dimensions shall be as required

by the manufacturer. Locating pins shall only be used when required by the manufacturer of the joint system. When required by the manufacturer, locating pins shall be spaced in accordance with the manufacturer's instructions.

The walls of the joint block-out and the backing plates shall be coated with binder immediately after the steel backing plates are placed, making sure that that the plates are entirely encapsulated by the binder.

Aggregate shall be heated in a rotating drum mixer to a temperature between 375 degrees F and the maximum safe binder temperature as specified by the manufacturer. After the aggregate is heated, binder shall be added to the mixer to pre-coat the aggregate.

Coated aggregate shall be placed and compacted in the block-out in layers as recommended by the manufacturer. The block-out shall be overfilled with coated aggregate as required to compensate for compaction.

Compaction shall begin immediately after placement of the material in the block-out and the joint surface shall be made approximately flush with the existing asphalt surface. The material shall be compacted longitudinally and transversely to the joint using a roller or plate compactor, which delivers a minimum centrifugal force of 3400 pounds.

After compaction, lines of 3 inches tape shall be placed one inch beyond the joint width on each side of the joint to insure evenness of appearance. The joint and at least one inch of the road surface shall be top-coated with the hot binder until the surface is smooth and absent of voids.

Immediately after top-coating, an anti-skid material shall be spread evenly over the joint to eliminate material tracking.

Vehicular traffic must not pass over finished joints until at least two hours after completion of compaction or longer when recommended by the manufacturer.

When specified on the plans or directed by the Engineer, an adhesive based joint sealer shall be installed in conjunction with the asphalt plug joint. The details for the installation shall be as shown on the plans. The adhesive based joint sealer shall conform to Section 420. When specified, the adhesive based joint sealer will be measured for separate payment in accordance with Section 420.

424.04—Measurement and Payment

Furnish Asphalt Plug Joint will be measured in cubic feet of material recommended by the joint system manufacturer and approved by the Engineer, and will be paid for at the contract unit price per cubic foot. This price shall include furnishing and delivering the asphalt binder material and aggregate to the project site.

Place Asphalt Plug Joint will be measured in linear feet along the centerline of the joint for a nominal width of 20 inches, and will be paid for at the contract unit price per linear foot. This price shall include removing and disposing of existing overlay or pavement material and existing joints and membranes; repairing small areas of concrete deterioration in the block-out area; preparing contact surfaces; placing asphalt binder material and aggregate; furnishing and placing backer rod, anti-skid material, steel backing plates, sealing joints in curbs or parapets; working drawings; and services of the manufacturer's representative.

Payment will be made under:

Pay Item	Pay Unit
Furnish Asphalt Plug Joint	Cubic Foot
Place Asphalt Plug Joint	Linear Foot

SECTION 425—RIGID CONCRETE BRIDGE DECK OVERLAYS

425.01—Description

This work shall consist of preparing bridge deck surfaces, and furnishing and placing rigid concrete overlays on concrete bridge decks. The Department will specify the overlay material to be used and the overlay depth on the Plans or elsewhere in the Contract.

425.02—Materials

Silica fume concrete, latex-modified concrete, high early strength latex modified concrete, and very-early-strength latex-modified concrete shall conform to Section 217, except that the coarse aggregate shall be size No. 7, No. 8, or No. 78 for depths and steel clearances less than or equal to 2 inches, and size No. 57, No. 7, No. 8, or No. 78 for depths greater than 2 inches. The use of fly ash or slag will be permitted in silica fume concrete. Class A4 Bridge Deck Concrete used in deep overlays shall conform to Section 217 for Class A4 Concrete, Modified to Minimize Cracking with Shrinkage Reducing Admixture.

425.03—Procedures

(a) **Deck Surface Preparation:**

Preparation of a reinforced concrete deck will require one or more of the following operations: removal of asphalt concrete overlay, Type A milling, and/or Type A or B hydro-demolition, as follow.

1. **Removing Asphalt Concrete Overlay:** The Contractor shall remove the asphalt wearing surface (where applicable) from bridge decks and approach slabs in a manner such that underlying sound concrete will not be damaged and can be prepared to receive necessary treatment. The Contractor shall dispose of the removed asphalt material in a manner approved by the Engineer. Sound concrete damaged as a result of the Contractor's operations shall be repaired in accordance with Section 412 at the Contractor's expense. The Contractor shall not allow fuel oils or other materials that will prevent bonding of the overlay to remaining sound concrete to come into contact with the prepared surface.

2. **Type A milling** shall consist of milling the surface of the bridge deck and concrete approaches to the depth specified.

   Equipment shall be capable of removing hydraulic cement concrete material to the required depth resulting in a reasonably uniform surface without damaging adjacent areas

or the remaining material. Milling equipment shall be capable of removing at least 1/2 inch of existing material per pass. The Contractor shall use power-driven hand tools to remove concrete on vertical surfaces of curbs, parapets, unsound concrete around reinforcing steel, and in confined areas.

3. **Hydro-demolition:**

The Contractor shall perform hydro-demolition in accordance with the hydro-demolition equipment manufacturer's instructions, this Section, and as directed by the Engineer.

Any bituminous patches shall be removed and the debris cleaned from the deck prior to the commencement of hydro-demolition operations. Patches may be removed using localized hydro-demolition or milling, hand tools, or pneumatic hammers.

The Contractor shall exercise caution during concrete removal operations to prevent damaging or cutting the reinforcing steel. Heavy equipment shall not be allowed in areas where the reinforcing steel is unsupported, unless otherwise approved by the Engineer. Any bars damaged as a result of the hydro-demolition operations shall be repaired or if necessary replaced in accordance with Section 412.03 at no additional cost to the Department. Reinforcing steel shall be replaced in-kind, matching existing steel bar sizes, unless otherwise directed or approved by the Engineer. Any reinforcing steel that is left unsupported after the hydrodemolition operations shall be adequately tied and supported as soon as practical before beginning overlay operations.

The Plans or other Contract documents will specify one of the following types of hydro-demolition:

a. **Type A Hydro-demolition** - Type A Hydro-demolition shall consist of removing concrete to a depth of 1/2 inch below the milled surface of hydraulic cement concrete decks in areas of sound concrete, and removing concrete to a depth of 1 inch below the bottom of the top mat of reinforcing steel in areas of deteriorated concrete (e.g., spalls or delaminations at or below top mat reinforcement). In areas where the reinforcing steel is partially exposed for fifty (50) percent or less of the perimeter of the bar, concrete removal is not required if the concrete is sound.

b. **Type B Hydro-demolition** - Type B Hydro-demolition shall consist of removing concrete to a depth of 1 inch below the bottom of the top mat of reinforcing steel over the entire surface of the deck.

c. **Work plan** - Prior to beginning the work, the Contractor shall submit a hydro-demolition work plan to the Engineer for approval. This work plan shall include complete details of the following items:

    1. The means of controlling runoff water. The Contractor shall prevent the runoff water from flowing onto lanes of traffic adjacent to or below the work and into any body of water. The Contractor shall be responsible for compliance with all environmental laws and regulations regarding the discharge of runoff water. The Contractor shall provide specific details of the method of runoff water treatment and collection, and shall obtain all necessary permits required for its legal disposal or discharge into the environment.

2. The method of safety shielding to prevent overspray into traffic. Shielding shall be installed as necessary to ensure the containment of all dislodged concrete and debris in order to protect workers and the traveling public from flying debris both under and on the work site.

3. The method for handling expected and unexpected blow-through of the deck. This method shall provide for containment of runoff water, debris, Type B coatings (as described in Section 411), and the protection of the area under the bridge deck. If an unexpected blow-through occurs, the Contractor shall immediately stop the hydro-demolition equipment and implement containment and protection procedures if these are not already in place. The Contractor shall ensure the equipment is correctly calibrated prior to restarting the hydro-demolition operation. The Engineer may require the Contractor to recalibrate the equipment at no additional cost to the Department if multiple unexpected blow-throughs occur.

d. **Equipment** - Hydro-demolition equipment shall be a computerized, self propelled machine that utilizes a high pressure water jet stream to provide a rough and bondable surface while removing all unsound concrete, rust, and concrete particles from exposed reinforcement during the initial pass. Hydro-demolition equipment shall consist of a water supply system, high-pressure water pumping system, and a demolition unit. The demolition unit shall be fully automated and provide precise control of the water jet(s) to facilitate a thorough and consistent removal operation. If required, the hydro-demolition equipment shall be capable of removing concrete from around and below the reinforcing steel. Such removal may require several passes of the equipment; however, payment shall be based on the square yards of deck surface at the depth of removal specified on the plans regardless of the number of passes necessary to achieve the depth specified. The hydro-demolition equipment shall clean all exposed reinforcing steel of rust, concrete fragments, laitance, loose scale, and other coatings that may inhibit or prevent bonding with the new concrete. Reinforcing steel not thoroughly cleaned during hydro-demolition concrete removal shall carefully be hand-tool cleaned.

The Contractor shall maintain an adequate supply of wear items, repair parts, and service personnel onsite to insure that the hydro-demolition operations will not be interrupted for more than 24 consecutive hours in the event of breakdown or malfunction. No contract time adjustment due to delays associated with repairs or obtaining replacement equipment will be considered.

e. **Personnel** - Qualified personnel certified by the equipment manufacturer shall operate the hydro-demolition equipment. Operator certification shall be submitted to the Engineer for review prior to beginning the hydro-demolition operations.

The Contractor shall supply the water and all other materials necessary to do the specified work. The Contractor shall dispose of all removed concrete and other debris in accordance with Section 106.04.

f. **Test area** - The Engineer will designate a trial area where the Contractor shall demonstrate that the equipment, personnel, and method of operation are capable of producing results satisfactory to the Engineer. The trial area shall consist of two patches, each approximately 50 square feet. The first trial patch shall consist of sound concrete as determined by the Engineer. The second trial patch shall consist of deteriorated concrete as determined by the Engineer.

1. **Test Area for Type A Hydro-demolition** - The hydro-demolition equipment shall first be calibrated on the sound trail patch to remove concrete to a depth of 1/2 inch. The hydro-demolition equipment shall then be used to remove concrete from the deteriorated trial patch using the operating parameters established from the sound trial patch. If all the deteriorated concrete is removed as determined by the Engineer, the hydro-demolition equipment will be considered as calibrated. If all deteriorated concrete is not removed as determined by the Engineer, the process shall be repeated until satisfactory results are obtained. The operating parameters from the successful tests shall be used as the basis for the production removal.

2. **Test Area for Type B Hydro-demolition** - The hydro-demolition equipment shall first be calibrated on the sound trial patch to remove concrete to a depth of 1 inch below the bottom of the top mat of reinforcing steel. The hydro-demolition equipment shall then be used to remove concrete from the deteriorated trial patch using the operating parameters established from the sound trial patch. If all the deteriorated concrete is removed as determined by the Engineer, the hydro-demolition equipment will be considered as calibrated. If all deteriorated concrete is not removed as determined by the Engineer, the process shall be repeated until satisfactory results are obtained. The operating parameters from the successful tests shall be used as the basis for the production removal.

The Contractor shall record the calibrated hydro-demolition equipment's operating parameters and provide the Engineer with a copy. The record shall include at least the following information:

- Water pressure (gauge)
- Machine staging control (step)
- Nozzle size
- Nozzle travel speed

The Contractor shall monitor and periodically adjust equipment to meet the level of removal demonstrated during the initial calibration process. Any changes in operating parameters that result from post-calibration monitoring must be approved by the Engineer.

In lieu of this method of calibration, the hydro-demolition equipment manufacturer's representative may propose an alternate method of calibration the representative believes more suited to the work. Any proposed alternate calibration method shall be subject to the Engineer's approval.

After hydro-demolition operations, the Contractor shall clean up all debris before it dries on the deck. Clean-up operations shall directly follow the hydro-demolition process to prevent the debris from resettling or reattaching itself to the surface of the sound concrete. Should the hydro-demolition debris dry on the surface of the sound concrete or reinforcing steel, the Contractor shall clean the concrete, reinforcing steel or other surfaces to the Engineer's satisfaction at no additional cost to the Department.

Immediately after hydro-demolition and clean-up operations, the Contractor shall sound the deck in the presence of the Engineer and remove any remaining loose and unsound concrete as approved by the Engineer. Loose and unsound concrete shall be removed to a depth of 1 inch below the bottom of the top mat of reinforcing steel but not more than 2 1/2 inches below the top mat of reinforcing steel. If hydro-demolition operations are consistently exposing the bottom mat of steel, the Contractor shall review the Contractor's procedures, including machine settings and make required adjustments. If required, a hand-held hydro-demolition wand or 30 lb. pneumatic hammer(s) may be used to perform additional removal. Areas of blow-through to receive full-depth deck repair shall be squared-up and additional concrete removed to obtain a minimum edge thickness of 1 1/2 inches of sound concrete at the bottom of the deck. Areas of full-depth deck repair will be measured and paid for as Type C Patching.

If the concrete overlay is placed within 48 hours of the hydro-demolition operation, additional cleaning of the exposed steel reinforcement will not be required for deck areas treated by hydro-demolition. Additional cleaning of the exposed steel reinforcement and concrete deck surface by abrasive blasting or high-pressure water blasting shall be performed if steel reinforcement and/or concrete deck surface is exposed for longer than 48 hours prior to placing the concrete overlay. Deck areas prepared by processes other than hydro-demolition shall also be cleaned by abrasive blasting or high-pressure water blasting when exposed for longer than 48 hours prior to placing the concrete overlay.

The final prepared surface shall be free of dirt, oil, concrete fragments, abrasive blast residue, standing water, or any other deleterious material that may adversely affect the bond of the overlay. If the Contractor uses compressed air, it shall be oil-free. Any areas of the prepared deck surface contaminated with oil, grease or other materials detrimental to good bonding of the concrete as a result of the Contractor's operations shall be removed to such depth as is necessary to achieve satisfactory bond as determined by the Engineer. Cleaning and removal necessitated by contamination caused by the Contractor's operations shall be performed at no additional cost to the Department.

(b) **Overlays**

The Contractor shall place construction joints as necessary in rigid concrete overlays that are not detailed on the plans as directed or approved by the Engineer. Construction joints in rigid concrete overlays shall be sealed in accordance with the requirements for Crack Repair, Type A as detailed in Section 412.03 (b)5a.

The standard methods of preparation and placement of a rigid overlay are as follows:

1. Type A Milling to a depth of 1/2 inch and placement of a silica fume or latex modified concrete overlay as specified on the Plans or elsewhere in the Contract.

   Prior to placement of the overlay, a portion of the latex or silica fume concrete shall be brushed onto the prepared surface. Care shall be taken to ensure that both vertical and horizontal surfaces receive a thorough even coating and that the rate of progress is limited so that the brushed material does not become dry before it is covered with additional material and brought to final grade. Excess coarse aggregate remaining after brushing shall be removed.

When Type A Milling to a depth of 1/2 inch and placement of an overlay are specified, the Contractor may use a combination of Type A Milling and\or Type A Hydro-demolition with the Engineer's written approval to prepare the deck provided both operations are performed at no additional cost to the Department.

2. Type A Milling to the depth specified, or to the depth called for in the Contractor's Plan of Operations, as approved by the Engineer, followed by Type A Hydro-demolition, and placement of a silica fume or latex-modified concrete overlay.

   Prior to milling, the Contractor shall evaluate the concrete cover over the existing reinforcing steel and adjust the depth of milling to prevent damage to the reinforcing steel. Reinforcing steel damaged as a result of the Contractor's operations shall be repaired or replaced in accordance with Section 412.03 at no additional cost to the Department. Reinforcing steel shall be replaced in-kind, matching the bar sizes of existing steel, unless otherwise directed or approved by the Engineer.

   After concrete removal, a silica fume or latex modified concrete overlays shall be placed as specified on the plans.

   Brushing portion of concrete overlay onto prepared surface is not required when the surface is prepared by Type A Milling to the specified depth followed by Type A hydro-demolition.

3. Type B Hydro-demolition and placement of a Class A4 Bridge Deck Concrete Overlay

   Type B Hydro-demolition shall be performed in accordance with the requirements herein and a deep overlay shall be constructed using Class A4 Bridge Deck Concrete Modified to Minimize Cracking with Shrinkage Reducing Admixture. The deep overlay shall be constructed to the depth indicated on the Plans or elsewhere in the Contract in accordance with Section 404.

   When Type B Hydro-demolition is specified, the Contractor shall, when approved by the Engineer in writing, have the option of using Type A Milling to remove the concrete to within 1/2 inch of the top mat of reinforcing steel with the remainder of the concrete removal performed by Hydro-demolition.

Overlay concrete shall be placed within the range of depth specified in the Contract or directed by the Engineer, and verified by the Engineer during placement operations.

Overlays shall not be placed until deck repair concrete has attained 90 percent of the minimum design compressive strength. Vehicular traffic will not be permitted on the bridge until the overlay has attained a compressive strength of 3,500 pounds per square inch.

Expansion joints and dams shall be maintained through the overlay. A bulkhead equal in thickness to the width of the joint shall be installed to the required grade and profile prior to concrete placement.

A construction dam or bulkhead shall be installed in the case of a major delay in placement operations. During minor delays of 1 hour or less, the end of the placement shall be protected from drying.

The Contractor shall shot-blast the entire milled surface to be overlaid, the edge of the previously placed overlay, and an area of the face of the curb no less than the thickness of the overlay within twenty-four (24) hours of the beginning of the overlay operations. Where applicable, this shall include the widened portion of bridge decks that are specified to be overlaid with latex-modified or silica fume concrete.

For at least 1 hour prior to placement of overlay concrete, the surface shall be continuously and thoroughly water soaked. After soaking, the surface shall be covered with plastic sheeting to prevent loss of moisture and to keep the surfaces clean. Puddles of standing water shall be removed before the overlay is placed.

The overlay shall be placed only when the ambient air temperature is 50 degrees F and rising. At temperatures above 85 degrees F, the Engineer may require placement to be made at night or during early morning hours if a satisfactory surface finish is not being achieved.

Mixers for latex-modified concrete shall be batch mixers or automatic mobile continuous mixers conforming to Section 217. The mixing capacity shall be such that placing and finishing operations can proceed at a uniform rate, with final finishing completed before formation of the plastic surface film. A yield test shall be performed by the Contractor prior to deck placement for each mixing unit, when each unit is moved from the job site for recharging, when the source of stockpiled materials is changed, or when there is reason to believe that the calibration may be erroneous.

Mixers for silica fume concrete shall be truck mixers conforming to Section 217. The amount mixed shall be such that the placing and finishing operations can proceed at a uniform rate. The silica fume concrete shall be uniform in composition and consistency when discharged from the mixer.

The overlay shall have a thickness of at least 1 1/4 inches of latex-modified or silica fume concrete. At the Contractor's option, latex-modified or silica fume concrete may be used in lieu of hydraulic cement concrete as required for Type A, B, or C patching or joint and crack repairs, and such material shall be placed monolithically with the overlay.

If the rate of evaporation of surface moisture from the latex-modified or the silica fume concrete exceeds 0.05 pound per square foot per hour during placement, measures shall be taken to reduce the rate of evaporation, such as by fogging.

Moist-curing – The surface shall be protected from prematurely drying or cracking by prompt application of wet burlap. Care shall be taken to ensure that the burlap is well drained and that it is placed as soon as possible, but no later than 15 minutes after screeding to ensure that the surface is wet at all times during curing. The burlap and surface of the concrete shall be maintained in a continuously moist condition during the initial curing period. Unless otherwise specified in the Contract or directed by the Engineer the curing periods shall be as follows:

The initial moist curing periods for latex modified concrete and high early strength latex modified concrete overlays shall be 48 hours followed by an additional 48 hours of air curing before opening to traffic.

Overlays of very-early strength latex-modified concrete shall be moist cured from the time they are placed until they can be opened to traffic.

The initial moist curing period for silica fume concrete shall be 72 hours, unless otherwise specified or directed by the Engineer, followed by the immediate application of a liquid membrane-forming curing compound conforming to Section 220. The curing compound shall be completely dry before opening the overlay to traffic.

425.04—Measurement and Payment

Remove asphalt concrete overlay will be measured in square yards of surface area and will be paid for at the contract unit price per square yard. This price shall include removing, handling, and disposing of waste.

Type A milling will be measured in square yards of surface area and will be paid for at the contract unit price per square yard for the depth specified. This price shall include performing milling, handling, and disposing of waste, replacing any damaged reinforcing steel, and determining steel cover to avoid damaging steel.

(Type) Hydro-demolition will be measured in square yards for the depth specified and will be paid for at the contract unit price per square yard. This price shall include preparing a work plan and containment system; shielding protection; test patches for and calibration of the hydro-demolition equipment and re-calibration (if necessary); removing and disposing of all unsound and loose concrete; sounding the deck after hydro-demolition; removing any additional concrete necessary after sounding; cleaning reinforcing steel; replacing any damaged reinforcing steel; collecting, filtering, and disposing of waste water in accordance with all applicable environmental laws and regulations; any required environmental permits and documentation to comply with such laws and regulations.

Furnish silica fume concrete, latex modified concrete, high early strength latex modified concrete, very-early-strength latex-modified concrete, or Class A4 bridge deck concrete will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. Measurement for overlay concrete produced by batch mixers will be determined by truck tickets, assuming a 95 percent yield or, when produced by automatic mobile mixers, measurement will be by metered ticket. Reduction in the quantity of overlay concrete eligible for payment will be made for any volume of waste. This price shall include producing the mixture, all handling, delivering to the work site, and trial batching. Additional concrete beyond the depth range of the pay item that is requested to address cross slope and other surface irregularities and rideability issues shall be at the direction of the Engineer. Only those volumes of additional concrete that are approved by the Engineer prior to placement of the overlay will be considered for payment.

Place silica fume concrete, latex modified concrete, high early strength latex modified concrete, very-early-strength latex-modified concrete, or Class A4 bridge deck concrete overlay will be measured in square yards and will be paid for at the contract unit price per square yard on a plan quantity basis. This price shall include preparing the surface, placing, handling, finishing, and curing the concrete. No additional compensation will be made for placing concrete beyond the depth range specified.

Payment will be made under:

Pay Item	Pay Unit
Remove asphalt concrete overlay	Square yard
Type A milling (Depth)	Square yard
(Type) Hydro-demolition (Depth)	Square yard
Furnish (Type) concrete (Depth Range)	Cubic yard
Place (Type) concrete overlay	Square yard

SECTION 426—REPAIRING EXISTING STEEL STRUCTURES

426.01—Description

This work shall consist of repairing existing steel structures in accordance with these specifications and in conformity with the details shown on the plans or established by the Engineer.

426.02—Materials

(a) Structural steel and bolts shall conform to Section 226.

(b) Bearing material and bearing pads shall conform to Section 237.

(c) Coating materials shall conform to Section 231.

(d) Welding Electrodes shall be selected from the VDOT Materials Division's Approved List 9 or as approved by the State Materials Engineer in writing.

426.03—Procedures

Welding shall consist of field welding of structural steel bridge elements.

(a) All welding shall be performed in accordance with AWS D1.5, Section 407, and the AWS D1.1. requirements for cyclically loaded structures. This shall include requirements for joint geometry, surface preparation, electrodes, processes, preheating, inspection and acceptance.

(b) Areas to be welded shall be preheated to a minimum temperature of 150 degrees F. Preheat, interpass temperature maintenance, and post-heat shall be contiguous operations.

(c) Welding shall utilize the Shielded Metal Arch Welding (SMAW) process with low hydrogen electrodes.

(d) Upon completion of welding, members that are designated as fracture critical shall be post-weld heat-treated in accordance with AWS D1.5, Chapter 12.

(e) All welds shall be inspected by an AWS-certified welding inspector (CWI) in accordance with the bridge welding code, AWS D1.5. Acceptability of welds shall be a condition for payment. Fillet welds shall be tested by magnetic particle testing (MT) in accordance with AWS requirements and VTM 31. All other welds shall be tested with radiography (RT) in accordance with AWS and VTM 29. The inspections shall be performed by a non-destructive testing technician certificated, at a minimum, as Level II by the Society for Non Destructive Testing. Reports of the results of weld tests shall be provided to the Engineer at the time of acceptance. Imperfections, inclusions, or other defects shall be corrected and the weldmet shall be retested until the weld has been shown to be free of defects. All inspection, testing, and subsequent welding shall be at the Contractor's expense.

(f) All new welds and areas where existing coating is disturbed shall be cleaned and re-coated using the Coating System specified on the plans.

Surface Preparation:

Prior to performing repairs to structural steel members, all areas that will be ground, heated, or welded shall be cleaned so that the existing coating system will be removed to bare metal. The minimum area to be cleaned shall be 12 inches beyond the outermost point that will be ground, heated, or welded. This cleaning shall be performed in accordance with the Environmental Protection and Health and Safety requirements of Section 411.

After completion of repairs, affected areas shall be cleaned and coated using the coating system specified on the plans and in accordance with Section 411. Color shall match existing as approved by the Engineer.

(a) **Grinding Minor Defects** shall consist of removing burrs, nicks, gouges, scrapes, etc. from designated structural steel members by grinding.

Burrs, nicks, gouges, dings, scrapes, etc. on structural steel members requiring repair shall be ground down to a surface finish of 125 microinches per inch rms and tapered to the original surface using a 10:1 slope. Grinding shall be performed in a direction that is parallel to the centerline of the member. Surface quality shall conform to ASTM A6. Nondestructive testing methods (magnetic particle and or dye penetrant) shall be utilized to confirm that the repaired areas do not contain any cracks and or tears in the base metal or welds. This testing is to be performed by the Contractor (or his representative) in the presence of the Engineer. If cracks and or tears are still evident, these areas shall be repaired in accordance with these specifications until all observed defects are repaired. Removal of base metal by this technique shall be limited to no more than 2% of the cross-sectional area of the element (e.g. flange) being repaired. Areas requiring additional removal of base material shall be repaired in accordance with the Engineer's instructions.

Areas where existing coating is disturbed shall be cleaned and re-coated using the Coating System specified on the plans.

(b) **Damaged Structural Steel Heat-Straightening** shall consist of heat-straightening damaged sections of the existing structural steel beams and girders as shown in the Contract, or as designated by the Engineer. Heat-straightening shall be performed in accordance with the provisions herein and FHWA-IF-99-004 (with ERRATA). Prior to commencement of this work the Contractor shall submit proposed straightening procedures, including jacking forces, locations, and heating patterns to the Engineer for approval. Heat shall be applied to no more than one beam/girder at any given time.

1. **Heat-Straightening Construction Requirements**

The repair of the damaged steel girders shall be performed by a Contractor with written demonstrated experience in the heat-straightening of impact damaged bridge members. Prior to beginning the work, the Contractor, or the Contractor's subcontractor, shall provide recent heat-straightening project experience performed on similar type bridge structures within the last five years including the owner's contact name(s) and telephone number(s). In addition to this project experience, the Contractor shall submit the résumés of key personnel designated to perform the heat-straightening repairs. The repair shall be directly supervised by a person with at least 5 years successful experience in heat-straightening repairs of comparable bridge structures. The Contractor shall provide

the Engineer with written documentation of past experience before beginning the repair work. No work shall be scheduled for the repair of the damaged steel girders until the Engineer approves the designated contractor and/or personnel proposed to complete the repairs.

Following approval of the proposed contractor, a work plan for the heat-straightening shall be submitted to the Engineer for review and approval. The work plan shall be developed after the Contractor has conducted a field inspection to include determination/verification of measurements necessary to prepare the heat-straightening plan. No work shall commence until the work plan submittal has been reviewed and accepted by the Engineer. This work plan shall include, at a minimum, the following information:

- Proposed schedule of repairs including the locations, time and anticipated duration of each repair. Schedule shall include a statement that field measurements have been made.

- Equipment and material lists including, but not limited to, heating torches and tips (type and diameter), oxygen and gas fuel tanks, hoses, timber blocking/wedges, hydraulic jacks, access scaffolding, and any necessary safety equipment.

- The proposed steel temperature monitoring devices such as contact thermometers, pyrometric sticks, etc.

- Details of the type and method of proposed heat-straightening including the heat patterns (vee, strip, line, etc.) and their limits. Vee heats shall have a maximum base width of 6”. Included with this information also shall be the number of cycles/heats and the number of heats occurring simultaneously.

- Location, number, and magnitude of the restraint forces supplied by jacks.

- Method and equipment for repairing impact dings, gouges, and nicks.

- Proposed method and material(s) for repairing any spalled concrete and edge gap between the top flange and deck soffit.

Procedures using forces that result in stresses over the yield stress of the material at the applied temperature, such as Hot Mechanical Straightening and Hot Working, are prohibited.

The heat-straightening shall be performed in a manner such that the final straightened girder retains as little residual stresses as possible. Heat-straightening shall not commence under periods of precipitation unless a suitable waterproof enclosure is provided subject to the approval of the Engineer.

Following the heat-straightening procedure, nondestructive testing methods (magnetic particle and/or dye penetrant) shall be utilized to confirm that the repaired areas do not contain any cracks and/or tears in the flanges, webs, cover plates, welds or connections. This testing shall be performed by the Contractor (or his representative) in the presence of the Engineer.

2. **Equipment**

Fuel for heating shall be an oxygen-fuel combination. The choice of the fuel may be propane, acetylene or a similar fuel. Heat application shall be by either single or multiple orifice tips only. The maximum tip size is limited to 1 inch diameter.

The Contractor shall verify temperatures during heat-straightening with temperature sensitive crayons, a pyrometer, or an infrared non-contact thermometer. The Contractor shall provide the heat indicating device, and make it immediately available to the Engineer when the Engineer requests it to monitor the work.

Use either hydraulic or mechanical jacks, come-alongs or other force application devices for restraining movement.

3. **Crack And Gouge Repairs**

All burrs, nicks, gouges, dings, scrapes repairs shall be performed in accordance with Section 426.03(a).

All web cracks shall be arrested by drilling in accordance with Section 426.03(l) or (m) as specified on the plans or directed by the Engineer.

4. **Application of Heat**

Apply heat to the member with vee (triangular shaped) heats or line heats to the flange and with vee, line or strip heats to the web. The base (the open end) of individual vee heats shall not exceed one-half of the plate width or 6 inches, whichever is less.

A series of heats applied consecutively to different elements of the member at the same cross section is referred to as a heating pattern. Select heating patterns and sequences to match the type of damage and cross section shape of the element.

Temperature of the steel during heat-straightening shall not exceed 1100°F. The steel temperature shall be monitored continuously. All plastic yield zones, and only plastic yield zones, shall be heated using the approved heating patterns. The heating torches shall be manipulated to guard against overheating. Occasional heating interruptions of one minute or more may be required for thick flanges to allow the heat to distribute evenly into the flange. After each successive heating cycle, the steel shall be allowed to cool to below 250°F prior to beginning the next heating cycle. Forced cooling (e.g., water, compressed air, etc.) will not be permitted. The heat-straightening shall be accomplished with as little force as possible. Mechanical hot straightening will not be allowed. Restraints shall not resist contraction during the cooling phases and shall not produce local buckling of a compression element during the heating phases. All bends, creases, folds, and dents of the member shall be eliminated.

Vee heats shall be shifted over the zone of yielded material on successive heating patterns. Simultaneous vee heats may be used provided that the clear spacing between vees is greater than the width of the plate element.

Following the heat-straightening procedure, the Contractor shall provide the Engineer with a record of all the heat patterns applied to each girder under repair.

5. **Application Of Restraining Forces**

Only use restraining forces to restrain the members or elements against undesired movement associated with expansion during the cycles of applying heats. Place restraining forces to restrain the member during the heating process. As the straightening occurs during cooling, the forces should be relieved.

The maximum allowable jacking force for members shall be calculated in accordance with the methods outlined in US DOT report no. FHWA-IF-99-004, "Heat-Straightening Repairs of Damaged Steel Bridges" (with ERRATA). Before work begins the Contractor shall submit all details and calculations of restraining forces, signed and sealed by a Professional Engineer currently licensed to practice engineering in the Commonwealth of Virginia, to the Engineer for approval. Details shall include, but not be limited to, a plan showing the location of the restraining forces, details for the restraining devices and their connectivity/contact with the structure. Submittal shall also include a statement from the Engineer of Record indicating that the calculations and details are based on field measurements performed by the Contractor or Contractor's representative.

No increasing in the restraining force will be allowed during heating or until the steel is cool to the touch between heats.

Assume that the existing steel has a yield strength of 36,000 psi, unless bridge was built prior to 1940, or use a different yield strength if it is specified in the Contract.

No deflection shall be allowed for other bridge members being used as supports for the restraining force.

For repairs of local flange bending, the restraining force is limited to that which produces no visible deflection of the unheated flange.

6. **Tolerances**

Completed tolerances for straightness of the bottom flange shall be within 1/2 inch of horizontal at the flange edge and 5/8 inch of horizontal sweep in 20 feet at the point of impact. The completed tolerances for the web shall be less than the smaller of 1/100th of the web depth or 3/8 inch, out of vertical alignment. Localized deflections or deviations in web shall be no more than 1/4 inch as measured with a straightedge held vertically and horizontally against the web. These tolerances shall be met before any cross frames are replaced. In no case shall the beams/girders be forced into position and then attached to the cross frame to hold the member in position.

7. **Inspection**

After the completion of straightening, the surface shall be carefully inspected for evidence of fracture by dye penetrant, magnetic particle, or other approved non-destructive testing method. The inspection shall be performed by a Non-destructive testing technician certified, at a minimum, as Level II by the Society for Non Destructive Testing. The Contractor shall ensure that the testing is scheduled so that the Engineer will be available to witness this testing. The Engineer shall be immediately notified if there is any evidence of fracture. Remove minor (< 1/2 inch long) cracks found by this inspection by grinding in accordance with procedures

specified here-in. Larger cracks found will be reviewed by the Engineer and repaired as directed by the Engineer.

8. **Coating**

Restore the coating on the damaged areas in accordance with Section 411 as directed by the Engineer. Match the color of the finish coat to the existing paint color.

(c) **Ultrasonic Impact Treatment** shall consist of applying ultrasonic impact treatment (UIT) to certain locations of welds on the bridge where indicated in the plans.

1. UIT Contractor Qualifications

The Contractor shall engage a firm competent and proficient in the use of ultrasonic impact treatment. The UIT firm shall have had experience with similar types of work on treatment of bridge details in previous projects. To that end a list of projects, their locations, key personnel directly involved in performance and supervision of the work and the names of a current contact person for each of the projects shall be submitted for approval by the Engineer prior to beginning the work.

2. Equipment Requirements

The UIT firm shall furnish complete UIT tooling requirements, including, but not limited to 2 electronic control units with power source (one of these units shall be backup unit), 2 UIT tools, all required tool tip sets; additional treatment pins, as required; closed circuit cooling system; complete set of extension cables and cooling hoses; all necessary adjustment and maintenance tools for the UIT system; and all equipment consumables required during the application of UIT. The UIT shall be performed using equipment with a frequency of either 27 kHz or 36 kHz, using a power output rating of at least 800 Watts.

The Contractor shall furnish all necessary safety equipment, including, but not limited to, safety harnesses, vests, glasses, earplugs, etc. to safely perform the work. The Contractor shall furnish all necessary permits, means of access, and 110 V, 60 Hz, 3 HW AC with a minimum of three outlets power supply.

3. Training

If the Contractor's personnel have not been previously certified and trained as operators of the UIT equipment by the UIT firm, then the UIT firm shall provide training for the Contractor's personnel. The training includes the setup of all necessary equipment and the establishment of quality control procedures. Specifically, the UIT firm shall provide:

a. A technical procedures manual defining the treatment methodology and parameters for the successful operation of the tool to achieve the desired results.

b. A technical procedure inspection guide covering the details of the quality assurance (QA) program to be conducted to ensure that the treatment methodology has been applied in accordance with the instructions given in the technical procedures manual.

c. UIT treatment training of Contractor personnel. A minimum of two individuals shall be trained on-site with a comprehensive training program on the general operation of the tool and the guidelines for the technical treatment application for this project.

d. Quality inspection training of Contractor personnel. A minimum of two individuals, other than those applying the treatment, shall be trained to carry out complete and thorough inspections of the treatment being undertaken.

e. On-site expertise and presence, to certify the treatment methodology, the training of the Contractor personnel, and for technical support.

The Contractor shall furnish adequate personnel assigned to the UIT work and shall devote these resources exclusively to the work to its completion.

4. Procedures

The application of UIT shall follow the weld toe. The entire weld body and weld toe regions at any ends of the weld shall be treated within a radial distance of 1".

Prior to the application of UIT the welds must be inspected. The Contractor shall notify the Engineer immediately of any visible weld defects or cracks at or near the weld.

(d) **Modify Steel Beam/Girder End** shall consist of trimming (flame cutting) and removing the ends of steel beams and/or girders, in order to obtain the proper clearance from the ends of steel beams and/or girders to the abutment backwall, in accordance with Section 413, the plans, and the requirements herein.

The proper clearance between the end of the steel beam and/or girder and the abutment backwall shall be as specified on the plans or as directed by the Engineer.

After trimming, the end of the beam/girder shall be parallel to the face of the backwall. Newly cut beam end shall be straight, true and free of burs.

The cost of jacking and supporting beams shall be paid for under the pay item, Jacking and Blocking.

The coating on the beam and/or girder ends shall be restored, including coating damaged by the repair process using the Coating System specified on the plans and in accordance with Section 411 as directed by the Engineer. Match the color of the finish coat to the existing paint color.

(e) **Replace Bearing** shall consist of removing existing bridge bearings and placing new elastomeric bridge bearings.

This work shall be performed in accordance with Sections 408 and 413, the details herein, and the following:

1. This work shall consist of removing existing welds, removing and disposing of existing bearing components and anchor bolts, furnishing, painting and installing new bearing assemblies (sole plate, elastomeric bearing pad, anchor bolts, washers and nuts), placing and inspecting new welds, cleaning and applying paint to new bearings and any disturbed

areas, and providing environmental, worker health and safety protection, and disposal of material.

2. The Department will classify existing structures on the plans as either a Type A or Type B structure according to Section 411. If not specified on the Plans or elsewhere in the Contract as a Type A structure, the Contractor shall assume the existing structure is classified as a Type B structure.

3. A plan for installing new anchor bolts shall be submitted to the Engineer for review and approval.

4. Beams shall be jacked a minimum distance as specified on the plans in order to relieve the load on the bearings. The cost of jacking and supporting beams shall be paid for under the pay item Jacking and Blocking.

5. Remove fillet weld between beam flange and sole plate, and remove the existing bearing assembly. Remove a portion of existing anchor bolts in accordance with the details.

6. Grind bottom of bottom flange to remove burrs. Clean bottom of flange in accordance with Section 411.04(a) Method 5.

7. Place the new laminated elastomeric bearing.

8. Install new anchor bolts, nuts, and washers.

9. Fillet-weld sole plate to beam flange. The Contractor shall inspect new welds by magnetic particle testing in the presence of the Engineer.

10. The bearing assemblies shall be painted in the shop with the system specified on the plans. The new welds and all disturbed areas shall be cleaned and coated using the Coating System specified in the plans. Sole plate shall not be painted on the surface in contact with the elastomeric bearing.

11. Materials and fabrication shall be in accordance with the applicable requirements of Section 408. Steel in sole plates and other steel components of the bearings, except as noted on the details, shall be ASTM A709 Grade 36. Grout and adhesive material for anchor bolts shall be from the VDOT Materials Division's Approved Product List 29.

12. The Contractor shall verify heights of existing bearing assemblies prior to preparing shop drawings.

13. Immediately before casting the new anchor bolts in the high-strength grout and mortar, the holes shall be thoroughly cleaned to the satisfaction of the Engineer.

(f) **Reset Existing Rocker Expansion Bearing** shall consist of removing existing welds connecting sole plate to girder; grinding girder flange to remove burrs; positioning rocker bearing assembly in a truly plumb position; welding sole plate to girder; inspecting new welds; cleaning and applying paint to new welds and disturbed areas; and providing environmental, worker and safety protection, and disposal of material in accordance with Sections 408 and 413, and the details herein.

The following procedure shall be adhered to when resetting the bearings:

1. Each of the girders shall be jacked enough to relieve pressure from bearing, by an amount specified on the plans. The cost of jacking and supporting beams shall be paid for under the pay item Jacking and Blocking.

2. Remove existing filet welds connecting sole plate to girder.

3. Grind bottom flange to remove burrs. Clean bottom of flange in accordance with Section 411.04(a) Method 5.

4. Position the rocker assembly in a truly plumb position at 60 degrees F.

5. Release jacks at that girder.

6. Using a fillet weld as specified on the plans, re-weld sole plate to girder flange. New welds shall be inspected by magnetic particle testing to be performed by the Contractor.

7. All new welds and areas where existing coating is disturbed shall be cleaned and re-coated using the Coating System specified on the plans.

8. The existing structure is designated a Type B structure in accordance with Section 411.

(g) **Modify Existing Rocker Expansion Bearing** shall consist of changing a bearing from expansion to fixed by welding a 3/4 inch diameter round stock bar between the rocker and the rocker plate; cleaning and applying paint to new welds and disturbed areas; and providing environmental, worker health and safety protection, and disposal of material in accordance with Sections 408 and 413 and the details herein.

All new welds and areas where existing coating is disturbed shall be cleaned and re-coated using the Coating System specified on the plans.

(h) **Modify Existing Fixed Bearing** shall consist of changing a bearing from fixed to expansion by removing nuts and washers; removing existing welds as necessary; cutting the pintle; enlarging slots in sole plate; adjusting the position of the bearing; placing and testing new welds as necessary; re-installing existing washers; furnishing and placing new nuts; cleaning and applying paint to new welds and disturbed areas; and providing environmental, worker health and safety protection, and disposal of material in accordance with Sections 408 and 413 and the details herein.

The following procedure shall be adhered to when modifying existing fixed bearings:

1. Remove existing nuts and washers.

2. Remove existing welds as necessary.

3. Jack each of the girders enough to relieve pressure from bearing, for a distance as shown on the plans. The cost of jacking and supporting beams shall be paid for under the pay item Jacking and Blocking.

4. Cut pintle.

5. Enlarge slots in sole plate.

6. Adjust position of bearing so that it is at the midpoint of movement at 60 degrees F.

7. Release jacks at that girder.

8. Place new welds as necessary. New welds shall be inspected by magnetic particle testing to be performed by the Contractor.

9. Re-install existing washers.

10. Install new nuts.

11. The new welds and all disturbed areas shall be cleaned and coated using the Coating System specified on the plans.

(i) **Field Welding** – Fillet Welds shall consist of removing and disposing of existing welds (when required), cleaning and preparing surfaces to be welded, furnishing all necessary equipment and supplies, furnishing and placing new fillet welds of the specified size, cleaning and re-painting new welds and disturbed areas, and providing environmental and worker health and safety protection and disposal of material in accordance with the plans, Sections 407 and 413, and the AASHTO/AWS D1.5 Bridge Welding Code.

Weld size shall match existing weld size or be as specified on the plans. Welds shall only be performed by welders certified in the type and position being performed. Weld positions include flat, horizontal, overhead, and vertical. Preheat, interpass temperature maintenance, and postheat shall be contiguous operations in order to ensure weld soundness.

All new welds and areas where existing coating is disturbed shall be cleaned and re-coated using the Coating System specified on the plans.

(j) **Field Welding** – Full Penetration Groove Welds shall consist of removing and disposing of existing welds (when required), cleaning and preparing surfaces to be welded, furnishing all necessary equipment and supplies, furnishing and placing new full penetration groove welds of the specified size, cleaning and re-painting new welds and disturbed areas, and providing environmental and worker health and safety protection, and disposal of material in accordance with the plans, Sections 407 and 413, and the AASHTO/AWS D1.5 Bridge Welding Code.

Weld size and joint preparation shall be as specified on the plans. Prior to placement of welds, an AWS certified welding inspector shall inspect the joint penetration and certify that the gap and geometry are in accordance with the prequalified AWS weld specified. Welds shall only be performed by welders certified in the type and position being performed. Weld positions include flat, horizontal, overhead, and vertical. Preheat, interpass temperature maintenance, and postheat shall be contiguous operations in order to ensure weld soundness. Contractor shall use run-on and run-off tabs for full penetration welds. All weld backings shall be completely removed prior to acceptance of the work.

All new welds and areas where existing coating is disturbed shall be cleaned and re-coated using the Coating System specified on the plans.

(k) **Partial Beam/Girder Replacement** shall consist of providing temporary support, removing and disposing of portions of existing beams/girders, furnishing and placing new structural

members and full penetration groove welds in accordance with the plans, Section 407, Section 413, and the AASHTO/AWS D1.5 Bridge Welding Code.

In order to obtain a straight, smooth, and proper fit for partial replacement sections, the contractor shall use a mechanical-guide when cutting and removing the damaged portion of the web or flanges in order to minimize the grinding or re-cutting of the same. Cope hole in the web may be needed to obtain a satisfactory flange weld. Cope hole shall be filled.

The Contractor shall develop a plan for temporary support of the beam/girder which shall be submitted to the Engineer for review. The plan shall be signed and sealed by a Professional Engineer in accordance with Section 105.10 (c). Contractor may not support the beam section using tack welds without support tabs. Welded support/alignment tabs may be utilized with the approval of the Engineer. Temporary support welds used in conjunction with support/alignment tabs shall be ground flush after erection of partial beam replacement in accordance with Section 426.03 b.

Where the partial replacement beam meets the existing beam and a full or partial access hole is required in order to facilitate welding, the Contractor shall not fill the hole with welding or replacement metal. Fillet welds terminating in the vicinity of the access hole shall be terminated in accordance with these specifications and AWS D1.5.

Carrier beams, when required, shall be installed prior to removal of the existing beam or girder section and shall not be removed until all work, including welding has been tested and accepted. Carrier beams shall be installed in accordance with the plans and shall be supported on spans adjacent to the span under repair. Carrier beams shall be supported immediately above the bearings of adjacent spans. Prior to removal of the damaged girder section the Contractor shall measure the relative elevations of the deck adjacent to the carrier beam at the 10th points along the span. These measurements shall be taken again after the beam has been repaired. All relative deck elevations shall be recorded and submitted to the Engineer.

All new structural steel and welds and areas where existing coating is disturbed shall be cleaned and re-coated using the Coating System specified on the plans.

(l) **Crack Repair** – Drilling Crack Arrest Holes shall consist of drilling crack arrest holes at the tips of cracks using the size specified on the Plans or elsewhere in the Contract.

The tip of the crack shall be identified using the magnetic particle or dye penetrant method.

The drill/coring bit shall be positioned such that the trailing edge of the bit removes the crack tip.

The hole shall be cylindrical and perpendicular to the surface of the steel.

After drilling the hole, the surfaces around the hole shall be ground smooth to an ANSI roughness of 500 of less.

The inside surface of the hole shall be coated using the coating system specified on the plans.

Flame cut holes shall not be used.

After completion of the repair the edge of the hole shall be examined using magnetic particle or dye penetrant methods to ensure that the crack is not extended beyond the repair area.

(m) **Crack Repair** – Drilling Cold Expanded Holes shall consist of drilling cold expanded holes at the tips of cracks using the size specified on the Plans or elsewhere in the Contract.

The tip of the crack shall be identified using the magnetic particle or dye penetrant method.

The holes shall have a metal ring placed in the hole. Metal rings shall be cold expanded as necessary to create a compression field in the immediate vicinity of the crack. Metal ring and devices utilized to create compression fields shall be pre-approved by the Department for this purpose. Placement of metal ring and creation of compression field shall be performed in accordance with the equipment manufacturer's recommendations.

After completion of the repair, the edge of the hole shall be examined using the magnetic particle or dye penetrant method to ensure that the crack has not extended beyond the repair area.

(n) **Crack Repair -** Welding shall consist of repairing designated cracks by welding.

Crack repair welding shall be performed in accordance with Section 426.03 and the following.

1. Cracks shall be fully removed by hand grinding, arc or flame gouging.

2. The root of the ground or gouged area shall be inspected by magnetic particle testing to ensure complete removal of the crack before welding.

3. If arc or flame gouging is used, the groove that is produced shall be ground to remove cutting scale before welding.

(o) **Jacking and Blocking Beams** shall consist of supporting beams during construction and may include jacking, blocking, and other approved methods of support in accordance with the requirements herein.

The Contractor shall develop a plan for jacking, blocking, and supporting beams which shall be submitted to the Engineer for review and approval. The plan shall be signed and sealed by a Professional Engineer in accordance with Section 105.10 (c). The cost of preparing the plan shall be included in the price bid for Jacking and Blocking.

Unless approved by the Engineer in writing or specified on the plans, temporary support systems shall be designed to sustain traffic loadings in addition to dead load and temporary construction loads and all other anticipated loading during work requiring the jacking and blocking of beams.

426.04—Measurement and Payment

These prices shall include surface preparation, welding where required, certified welders and welding inspectors, non-destructive testing by certified technicians, welding inspection, and other types of non-destructive testing where required, disposal of removed material, environmental and worker health and safety protection, testing, and coating steel members.

Grinding Minor Defect will be measured in units of each and will be paid for at the contract unit price per each.

Structural Steel Heat-Straightening will be paid for at the contract lump sum price per structure.

Ultrasonic Impact Treatment will be measured in linear feet and will be paid for at the contract unit price per linear foot.

Modify Steel Beam/Girder End will be measured in units of each and will be paid for at the contract unit price per each.

Replace Expansion Bearing will be measured in units of each and will be paid for at the contract unit price per each.

Reset Existing Rocker Expansion Bearing will be measured in units of each and will be paid for at the contract unit price per each.

Modify Existing Rocker Expansion Bearing will be measured in units of each and will be paid for at the contract unit price per each.

Modify Existing Fixed Bearing will be measured in units of each and will be paid for at the contract unit price per each.

Field Welding – (Type and Size) will be measured in linear feet and will be paid for at the contract unit price per linear foot for the type and size specified.

Partial Beam/Girder Replacement will be measured in pounds of structural steel and will be paid for at the contract unit price per pound.

Crack Repair (Type) will be measured in units of each or in linear inches and will be paid for at the contract unit price per each or per linear inch for the type of repair specified.

Jacking and Blocking Beam, when a pay item, will be measured in units of each per bearing location for all jack lifts at any location and will be paid at the contract unit price per each.

Payment will be made under:

Pay Item	Pay Unit
Grinding Minor Defect	Each
Structural Steel Heat-Straightening	Lump Sum
Ultrasonic Impact Treatment	Linear Foot
Modify Steel Beam/Girder End	Each
Replace Bearing	Each
Reset Existing Rocker Expansion Bearing	Each
Modify Existing Rocker Expansion Bearing	Each
Modify Existing Fixed Bearing	Each
Field Welding – (Type and Size)	Linear Foot
Partial Beam/Girder Replacement	Pounds
Crack Repair (Type)	Each or Linear Inch
Jacking and Blocking Beam	Each

SECTION 427—SILICONE JOINT SEALANTS

427.01—Description

This work shall consist of sealing joints, with rapid curing silicone sealant in accordance with this section and in conformity with the lines shown on the plans or as established by the Engineer.

427.02—Materials

(a) **Silicone Joint Sealant:** Self-leveling and other silicone joint sealants shall be a Class D silicone sealant conforming to Section 212 and shall be selected from the VDOT Materials Division's Approved Products List 27.

(b) **Backer Rod:** Backer Rod shall conform to Section 212.

(c) **Primer:** Primer shall be in accordance with the silicone joint manufacturer's recommendations.

427.03—Procedures

(a) **Manufacturer's Representative:** The Contractor shall have present at the beginning of the initial joint sealing operation for each structure a manufacturer's representative, knowledgeable in the methods of installation of the sealant, to certify that the Contractor's personnel installing the material are knowledgeable and can demonstrate an ability to install the material in accordance with the manufacturer's recommendations. The Contractor shall also arrange to have the manufacturer's representative present during testing of the joint material by the Department.

(b) **Forming New and Reconstructed Joints:** The Contractor shall form new and reconstructed joints to provide the nominal opening at the specified temperature as shown on the plans. Sides of the joints shall be parallel to each other. Edges of the joint shall be rounded to a radius of 1/4 inch. The Contractor may be required to saw or grind any new or reconstructed joint having an insufficient opening to the proper size at no additional cost to the Department. If a new or reconstructed joint is larger than specified, and is too large to accommodate the silicone sealant, the end of the slab shall be cut back at least 12 inches from the edge of the joint, to a depth of 1 inch below the top mat of reinforcing steel, and rebuilt with Class A4 concrete to obtain the specified joint opening. New concrete shall cure for a minimum of 14 days before joint sealing operations will be allowed to continue. Reconstructing new or reconstructed over width joints to the specified size shall be at no additional cost to the Department.

(c) **Preparing Joint:** The Contractor shall abrasive blast clean joint surfaces in a sweeping motion to remove all non-adherent laitance, oil, grease or other foreign or deleterious matter before placement of sealant. Joints may require saw cutting to obtain the specified width and depth.

The Contractor shall blow joint surfaces clean with dry, clean compressed air of sufficient pressure (min. 90 psi) so that the joint is dust free after abrasive blasting. If more than one hour lapses between the joint cleaning and silicone sealant installation, the joint shall be re-cleaned with compressed air to ensure a dust free surface.

Existing joints shall be prepared or reconstructed according to Section 412. Preparing or reconstructing existing joints will be measured and paid for under the appropriate items in Section

412. Abrasive blast cleaning and dust removal shall be included in the contract unit price of silicone joint sealant.

(d) **Installing Material:** The Contractor shall only install silicone sealant when the ambient air temperature is between 50°F and 80°F.

The Contractor shall apply silicone sealant with pneumatic extrusion guns or industrial caulk guns in accordance with the sealant manufacturer's instructions or approval.

The Contractor shall apply a primer recommended by the sealant manufacturer to the joint surfaces in accordance with the silicone manufacturer's recommendations and allow the primer to completely dry prior to installing the backer rod. The backer rod shall be oversized a minimum of 25% and shall be installed to a depth that will allow the finished sealant to be 1/2 inch below the top of the slab. The backer rod should be continuous, however, if this is not possible, the two ends must be butted together and taped with a bond breaking tape.

The joint seals shall be installed along the entire width of the deck and shall extend at least 1 foot 6 inches up each side of the bridge barrier or parapet. Bridges with curbs rather than barriers shall have joint material installed in the entire width of the curb.

Silicone sealant shall be installed in accordance with the manufacturer's instructions.

(e) **Testing:** After the silicone sealant has properly cured and before the work has been accepted, the Contractor shall perform a field adhesion test on the in-place sealant. The Engineer shall designate all areas for field adhesion tests and all testing shall be performed in the presence of the Engineer and the manufacturer's representative. A minimum of one field adhesion test shall be performed per 20 linear feet of joint or fraction thereof. If joints are less than 20 linear feet in length, then one field adhesion test shall be performed per joint. The field adhesion test shall be performed as follows:

1. Make a knife cut perpendicular to the joint from one side of the joint to the other.

2. Make 2 parallel cuts approximately 2 inches long, along each side of the joint.

3. Place a mark on the sealant 1 inch from the free end.

4. Grasp the end of the sealant firmly at the 1-inch mark and pull at a 90° angle to the slab. Hold a ruler alongside the sealant.

5. The test will be considered passing if the 1 inch mark on the sealant can be pulled 4-1/2 inches and held for a minimum of 60 seconds with no failure of sealant.

6. Sealant shall be repaired in the test areas, where good adhesion was obtained, by applying more sealant in accordance with this section. Care should be taken that the original sealant surfaces are clean so that good bond between the new and old sealant will be obtained. Repairing test areas shall be at no additional cost to the Department.

If any sample area fails the adhesion test then the Contractor shall perform two (2) additional tests, one on each side of the failed area at approximately 2-foot spacing. Failure of either of the two additional adhesion tests shall be cause for the rejection of that 20-foot section or fraction thereof of the joint that was tested.

Failed Area Joint Repair: Failed portion of the joint sealant shall be removed and joint opening shall be prepared and the sealant installed in accordance with this section. New sealant in the repair areas shall be tested after curing. Repairing or replacing defective joint material shall be at no additional cost to the Department.

After field adhesion testing, and prior to the work being accepted by the Department the Contractor shall perform a leak test on transverse joints in bridge decks and joints between decks and backwalls, unless otherwise directed on the plans. The leak test shall consist of flooding the deck surface with water and observing the underside of the joints for evidence of leaks. The detailed procedure for the leak test shall be developed by the Contractor, in conjunction with the manufacturer, and submitted to the Engineer for review and approval prior to performing the test. The leak test shall expose the observed portion of the joint to positive hydraulic pressure for a period of no less than 30 minutes. The Contractor shall repair leaking joints in accordance with the manufacturer's recommendations at no additional cost to the Department. Joints other than transverse joints in bridge decks or between decks and backwalls do not require leak testing.

(f) **Warranty:** The Contractor shall warrant silicone joint sealing systems against adhesion loss and leakage for 12 months beginning on the project acceptance date or upon the completion of the joint sealing work, as determined by the Engineer. The Contractor shall replace any joint sealant system exhibiting adhesion loss or leakage during the first 12 months of service at no additional cost to the Department.

427.04—Measurement and Payment

Silicone joint sealant, when a pay item, will be measured in linear feet along the pavement surface from out to out of the deck slab, complete-in-place, and will be paid for at the contract unit price per linear foot for the width specified. This price shall include furnishing and installing the joint material in accordance with this specification and the manufacturer's instructions, all costs associated with the manufacturer's representative, testing, and warranting the joint sealant's performance.

Payment will be made under:

Pay Item	Pay Unit
Silicone joint sealant (width)	Linear foot

SECTION 428—CONCRETE SURFACE PENETRANT SEALER

428.01—Description

This work shall consist of furnishing and applying a water repellant concrete surface penetrant in accordance with this section and in conformity with the details and locations indicated on the plans. The color of the penetrant sealer shall be clear.

428.02—Materials

Penetrant sealer shall be from the VDOT Materials Division's Approved Products List 30.

428.03—Procedures

The Contractor shall apply penetrant sealer in accordance with the manufacturer's instructions, except as otherwise specified herein. The penetrant sealer shall not be applied until all adjacent or superimposed concrete placements have been completed. The Contractor shall abrasive blast clean all surfaces to receive the penetrant sealer to provide a clean uniform texture, free of foreign substances such as oils, release agents, curing agents, or efflorescence. All abrasive blasting residue shall be completely removed and disposed of away from the area of application prior to application of the penetrant sealer.

The Contractor shall thoroughly mix each container of penetrant sealer material according to the manufacturer's recommendations. The penetrant sealer material shall be applied by experienced persons using spray, brush or roller and shall not be thinned or reduced, except as may be specifically required by the manufacturer.

Application rates and number of coats shall be in accordance with the manufacturer's recommendations.

All construction debris and abrasive blast residue shall be properly disposed of offsite in accordance with Section 106.04 once this work is completed.

428.04—Measurement and Payment

Concrete surface penetrant sealer will be measured in square yards and will be paid for at the contract unit price per square yard. This price shall include preparing surface, and furnishing and applying the sealer.

Payment will be made under:

Pay Item	Pay Unit
Concrete Surface Penetrant Sealer	Square Yard

SECTION 429—BRIDGE DECK WATERPROOFING MEMBRANE SYSTEMS

429.01—Description

This work shall consist of furnishing and applying waterproofing membrane systems for use on concrete bridge decks that will receive an asphaltic concrete overlay.

The work shall include the following items:

- Removing existing asphalt concrete overlay
- Preparing the bridge deck
- Applying primer just prior to placing the membrane
- Applying Membrane
- Installing Membrane Reinforcement (Type II only)
- Installing Protection Board (Type II only)
- Applying Tack coat
- Placing new asphalt concrete wearing surface

429.02—Types of Waterproofing Membranes

Waterproofing membranes shall consist one of the systems below in accordance with ASTM Standard D6153. The type of system to be used shall be as specified on the Plans or elsewhere in the Contract. Submittals for all systems shall specify their individual components, the individual temperatures and rates of applications for the components, solvents, primers, cure times, etc. for review by the Engineer.

(a) **Type I – Cold Applied Elastomeric** is a cold applied elastomeric membrane system.

(b) **Type II – Hot Applied Elastomeric** is a hot applied elastomeric membrane system.

(c) **Type III – Preformed Sheet Membrane** is a preformed membrane system.

429.03—Materials

Materials specified by the manufacturer of the waterproofing membrane shall prevent the passage of water from the asphalt concrete surface course to or through the bridge deck.

(a) **Primer** shall conform to ASTM D41, Standard Specification for Asphalt Primer used in Roofing, Damp-proofing, and Water-proofing. Primer shall be suitable for use in above or below ground applications.

(b) **Membrane for Type I** systems shall conform to Section 213, and shall consist of cold liquid applied chemically curing membrane materials.

(c) **Membrane for Type II** systems shall conform to Section 213, and shall consist of hot applied elastomeric membrane materials. Material for Type II membrane shall be supplied to the job site in cakes in the manufacturer's sealed and labeled containers ready for melting and application.

(d) **Membrane for Type III** systems shall conform to Section 213, and shall consist of a preformed membrane system.

(e) **Membrane Reinforcement for Type II** systems shall be spun bonded sheet structure composed of 100% continuous filament polyester fibers bonded together at their crossover points acceptable to the Engineer. The membrane shall be supplied in 18 inch minimum width. The material shall be unaffected by the heat generated by the waterproofing membrane and the hot mix installation. The membrane reinforcement shall conform to ASTM D173, Standard Specification for Bitumen-Saturated Cotton Fabrics Used in Roofing Waterproofing and ASTM D3515 Standard Specifications for Woven Glass Fabric Treated with Asphalt.

(f) **Membrane Protection Board for Type II** systems shall conform to ASTM D6506, Asphalt Based Protection Board for Below-Grade Waterproofing.

(g) **Tack Coat** shall be as recommended by the manufacturer of the membrane system.

(h) **Asphalt** shall conform to ASTM D449 Standard Specification for Asphalt Used in Dampproofing and Waterproofing and Section 211 as applicable

429.04—Equipment

All methods employed in performing the work as well as all equipment, tools, and machinery used for handling and testing the materials and executing any part of the work shall be listed in the submittals.

Heating and mixing kettles shall be used in applying Type II Waterproofing Membrane Systems. The kettles shall be of the double boiler oil heat transfer type with a built-in agitator and equipped with two functional permanently installed dial type thermometers, accurate to within ± 3.5 degrees F, for measuring the temperature of the melted compound and oil.

Equipment used to apply Type II Waterproofing Systems shall also include two separate calibrated thermometers, accurate to within ± 3.5 degrees F, to verify the material temperatures on the job site.

Air Compressors employed in the work shall provide oil and water free compressed air. The compressed air shall be tested according to ASTM D4285.

429.05—Traffic Restrictions

After shot blasting cleaning operations have commenced, traffic (including mechanical spreaders) shall not be allowed on the cleaned area until after the hot mix binder course has been placed and cooled to ambient temperature. This restriction applies to all traffic other than the construction equipment not directly associated with the waterproofing and paving operations as approved by the manufacturer of the waterproofing membrane and the Engineer. Only vehicles with rubber tires or that have rubber-covered treads will be permitted. Sudden starts, stops, or turns by equipment shall be prevented.

If any damage to the waterproofing system is found, the Contractor shall immediately cease all construction operations on the deck, and repair the waterproofing system to the satisfaction of the Engineer and the system manufacturer's field representative at no cost to the Department.

429.06—Procedures

(a) **Field Representative**

The Contractor shall furnish the services of the selected waterproofing system manufacturer's Field Representative at the work site prior to using any materials. The Field Representative shall have at-least five years of demonstrated experience with the installation of waterproofing systems. The representative shall remain on the job site until the work is completed.

(b) **Submittals**

The Contractor shall submit the following to the Engineer for review and approval at least two weeks prior to placement of the waterproofing membrane system:

- Technical information, including product data sheets, on all materials to be used for the waterproofing system including the primer, membrane, membrane reinforcement, protection board, tack coat, and rubberized asphalt joint sealing compound.

- Experience of the Applicator or manufacturer's Field Representative. Applicators shall be certified by the system's manufacturer.

- Documentation indicating that the proposed membrane system contractor or subcontractor is fully qualified to perform the work. Documentation shall demonstrate at least 5 years experience in installing the system proposed for use, including clients, project or work designations, year installed, type and size of installation, and current contact information.

- Equipment to be used for the preparation and installation of the waterproofing system.

- Equipment that will be permitted atop of the waterproofing system prior to the wearing surface being installed.

- Delineate areas where membrane reinforcement will be placed.

- Schedule for placement of primer, membrane, protection board, tack coat, and asphalt concrete wearing surface – including multiple day placement of any of the above and/or staged construction.

- For Type I and II membranes, application procedures to be taken to ensure the membrane thickness will be as required. How the Contractor will complete the following:

    - o measure the thickness of the waterproofing system as soon as possible after application of the membrane,

    - o steps that will be taken to increase the thickness of the membrane if it is found to be deficient.

The Field Representative shall review and approve the Contractor's submittal for completeness and accuracy prior to providing the package to the Engineer. The submittal package shall be signed by the manufacturer's Field Representative and shall represent the system applicator's qualifications and proposed means and methods for successfully performing the work. The Field Representative shall confirm that the proposed membrane applicator is fully qualified to perform the work. The Department will review the submittals in accordance with Section 105.10.

(c) **Placement Meeting and Instructions**

The Contractor shall hold a Pre-Waterproofing System Placement meeting at least three weeks prior to commencing any waterproofing system installation. The meeting shall include all relevant Contractor staff, the Field Representative, Engineer, and any other significant staff involved in the waterproofing system installation. The Contents of the submittals will also be reviewed during the meeting. This meeting will only be held after the Field Representative has inspected the prepared surface conditions and deemed the surfaces acceptable for placement of the waterproofing system. The Contractor shall complete all repairs to the bridge deck including cracks, spalls and concrete delaminations prior to the Field Representative's inspection.

The Field Representative shall instruct the Contractor and the Engineer on installation and inspection procedures.

For Type I and Type II membranes, the manufacturer's instructions shall include membrane thickness measurement procedures to be completed as soon as possible after the membrane is placed. The instructions shall also include procedures for applying additional layers of the

membrane if the thickness is deficient in a given location/area without damaging the in place membrane and applicable time constraints.

(d) **Scheduling**

When an asphalt overlay is to be removed from an existing concrete structure deck, the Contractor shall inform the Engineer, in writing, at least 7 days prior to his planned work start time and date. Within 24-hours of removal of existing asphalt and at least 14 days prior to waterproofing system installation, the Contractor shall inspect the deck for deterioration and immediately advise the Engineer of any deterioration. All deck deterioration, including cracks, spalls, and delamination, shall be repaired for in accordance with Section 412 prior to placing the membrane. Deck repairs will be measured and paid for in accordance with Section 412.

A waterproofing membrane system shall not be placed on new decks until at least 28 days after deck concrete placement unless otherwise directed by the Engineer.

The Contractor shall inform the Engineer, in writing, at least 48 hours prior to his planned waterproofing operations start time and date. The Field Representative shall confirm to the Engineer that the deck is in a suitable condition such that waterproofing operations can commence. Waterproofing shall not commence until authorized by the Engineer.

(e) **Application restrictions**

The Contractor shall not perform work under wet or damp conditions. The deck surface shall be thoroughly dry at the time of the application of the primer, liquid membrane or preformed membrane. Drying of concrete surfaces shall not be expedited by any means.

The Contractor shall not perform work when the deck and ambient air temperatures are below those or will drop below those recommended by the manufacturer. Temperatures shall also be above the dew point.

The Contractor shall complete each phase of the bridge deck construction, including placing the surface course overlay, before roadway traffic may be placed on that portion of the bridge structure. Placing membrane system will not be permitted until the adjacent roadway binder course has been completed and is under or ready for traffic. The Contractor shall maintain the condition of the membrane system until covered with the asphalt concrete surface course overlay.

The Contractor shall protect concrete parapet surfaces and railing, including joint seal armor plates, from splashing, overspray, or tracking of the primer or any component of membrane system. The Contractor shall clean any structure surfaces marred by primer or membrane component material to the satisfaction of the Engineer at no cost to the Department.

(f) **Deck surface preparation for asphalt concrete overlays**

New concrete bridge deck surface preparation: The Contractor shall thoroughly clean surfaces where the waterproofing membrane system is to be placed by shot blasting, removing dust, loose or other deleterious material with air jets, vacuum trucks, or other methods approved by the Engineer. Mechanical sweepers and hand brooms will not be permitted. Water shall not be used to clean the deck, except as permitted herein, unless authorized by the Engineer.

Deck surfaces shall be free of oil, grease, curing compounds, algae, moss, laitance, friable matter, and bituminous products. Any accumulations of oil or grease shall be cleaned in accordance with ASTM D4258 – Standard Practice for Surface Cleaning of Concrete for Coating using detergent water cleaning. Areas of minor surface deterioration or depressions of 0.5 inch and greater in depth shall be brought to grade with an approved patching mortar. Crack and joints shall be repaired in accordance with Section 412. The Contractor shall remove any sharp concrete protrusions on the deck surface prior to applying the membrane.

The Contractor shall air blast clean the surface of the concrete in accordance with ASTM D4259 – Standard Practice for Abrading Concrete and as recommended by the manufacturer of the waterproofing membrane. Cleaned areas shall be primed as soon as they are dry. The Contractor shall blow off dust and dirt with air jets immediately before applying primer.

Existing overlaid deck surface preparation: The Contractor shall remove all previous waterproofing membranes or bituminous products. All deck repairs shall be completed in accordance with Section 412 prior to surface preparation. All areas of the concrete deck shall have a flat surface with surface roughness no greater than 0.08 inches. Decks that have a grooved, tined or textured surface shall be bush hammered, ground down or scabbled to reduce the depth of micro texture to 0.08 inches or less prior to abrasive blast cleaning operations. Prior to waterproofing, the Contractor shall treat all concrete surfaces in accordance with new concrete bridge deck surface preparation requirements as described herein.

Existing deck joint assembly and deck drain modifications: Modifications to existing expansion joint assemblies and deck drains shall be performed and completed as specified on the Plans or elsewhere in the Contract prior to deck surface preparation and will be paid for accordingly.

(g) **Primer**

When instructed or recommended by the manufacturer, the Contractor shall apply a single coat of primer or sealer on all surfaces within 24 hours of the scheduled application of the waterproofing membrane. Any primed or seal coated areas not covered within 24 hours of applying the waterproofing membrane shall be primed or seal coated again at no additional cost to the Department.

The primer or seal coat shall be applied when the concrete is surface dry and clean, and the ambient temperature and dew point are above those recommended by the manufacturer.

The primer or seal coat shall terminate in the chase or, where there is no chase, be extended up the face of the curbs, barrier walls, expansion joints and deck drains to the level of the top of the proposed asphalt concrete overlay.

The minimum cure time shall be one hour or as recommended by the manufacturer. The manufacturer's field representative may extend the cure period based on ambient conditions for temperature and relative humidity or the tackiness of the primer or sealer. The primer or seal coat shall not be exposed to construction equipment and activity until it is fully cured and tack free.

(h) **Waterproofing membrane systems**

1. **Type I Membrane System**

Application - Application may proceed while air and substrate temperature are between 32°F and 104°F providing the substrate is above the dew point. Outside of these temperatures, the manufacturer shall be consulted. All components of the system shall be measured, mixed, and applied in accordance with the manufacturer's instructions.

Prior to the application of any materials, the primed or sealed surface must be clean and free from loose debris, moisture, oil, grease, or other contaminates. The Contractor shall spray apply the waterproofing membrane in two coats with manufacturer approved equipment. The minimum wet film thickness of each coat on any peak shall be in accordance with manufacturer's instructions. The membrane shall be cured between coats and before application of the asphalt tack coat.

Waterproofing membrane application shall be continuous once begun. Where the membrane is to be joined to existing cured material and application joints, waterproofing membrane shall be applied to overlap the existing material by at least 6 inches. Overlap area preparation shall be in accordance with the manufacturer's instructions. Where the existing materials are covered with a primer or seal coat the overlapped area shall be cleaned with solvent approved by the manufacturer before applying the waterproofing membrane.

The waterproofing membrane shall terminate in the chase or, where there is no chase, be extended up the face of curbs, barrier or parapet walls, expansion joints, and deck drains to the level of the top of the proposed asphalt concrete overlay.

2. **Type II Membrane Systems**

Mixing and application of the liquid membrane system shall be performed in accordance with the manufacturer's printed instructions and as directed by the Engineer.

The Contractor shall apply a surface conditioner evenly to all surfaces at a rate between one gallon per 600 square feet and one gallon per 300 square feet, depending on the condition of the concrete surface as directed by the manufacturer's Field Representative. The conditioner shall be allowed to dry before application of the membrane.

Cakes of membrane shall be melted on the job site in an approved double walled kettle boiler under continuous mechanical agitation until the material can be drawn from the kettle, free-flowing and lump-free, at a temperature within the range recommended by the manufacturer but not exceeding 425°F.

The Contractor shall apply the membrane to the deck surface within the temperature range recommended by the manufacturer. The membrane shall be evenly applied at approximately one pound per square foot to provide a continuous coating with an average thickness of 3/16-inch thick and a minimum thickness of 1/8-inch.

The waterproofing membrane shall terminate in the chase or, where there is no chase, be extended up the face of curbs, barrier or parapet walls, expansion joints, and deck drains to the level of the top of the proposed asphalt concrete overlay.

Waterproofing membrane application shall be continuous. Where the membrane is to be joined to existing cured material and application joints, waterproofing membrane shall be applied to overlap the existing material by at least 6 inches. Overlap area preparation shall be in accordance with the manufacturer's instructions. Where the existing materials

are covered with a primer or seal coat, the overlapped area shall be cleaned with solvent approved by the manufacturer before applying the waterproofing membrane.

a. Membrane Reinforcement

The Contractor shall place an 18 inch strip of membrane reinforcement centered over joints, construction joints, and wide width cracks and press the membrane reinforcement into the Type II membrane while it is still tacky. The Contractor shall then apply another 3/16 inch thick layer of waterproofing membrane overtop of the membrane reinforcement.

The membrane reinforcement shall terminate in the chase or, where there is no chase, be extended up the face of the curbs, barrier walls, expansion joints, and deck drains to the level of the top of the proposed asphalt concrete overlay.

b. Protection board

When recommended by the manufacturer, the Contractor shall lay protection boards over the entire waterproofing membrane immediately following application of the membrane and before vehicular or foot traffic is allowed on the membrane. The protection board shall be placed before the surface of the membrane cools and is still tacky. The Contractor shall not apply any material to the waterproofing membrane surface that will remove its tackiness prior to installation of the protection board.

Protection boards shall be placed transverse to the centerline of the deck with all edges overlapping 1-inch ± 1/4-inch. The protection board edge shall be laid within 1/4-inch of all curbs, vertical faces of drains, and vertical faces of expansion joints. Protection boards shall be placed such that the joints lap in the direction of traffic flow and be staggered a minimum of 6 inches.

All protective sheets shall be free of wrinkles, bubbles, fish mouths or other defects to achieve firm and uniform contact. The Contractor shall apply a continuous bead of hot membrane along the joints where the sheets terminate at the face of the curbs.

3. **Type III Membrane Systems**

The Contractor shall prime curb and bridge deck surfaces. Type III membrane shall be applied to the primed curb and deck surfaces by either hand methods or mechanical applicators. The Contractor shall double cover all corners such as at curbs by placing an initial 12-inch minimum width membrane strip along the axis of the corner. Finish inside corners with a fillet, and round outside corners. Double cover areas around drains or other protrusions with a minimum of 6 inches of membrane in each direction then liberally coat with a mastic as approved by the manufacturer.

The Contractor shall begin Type III membrane construction at the lowest point of the surface to be waterproofed and apply the membrane to the highest point both longitudinally and transversely. Overlap each membrane strip a minimum of 4 inches in a shingle fashion so that water will run over and not against any laps and will drain toward the curb and the drain pipes unless otherwise approved by the Engineer. The membrane shall extend to the edge of the joint openings.

The Contractor shall apply an adhesive or use a wide tipped torch, if necessary, to seal the membrane joints. The Contractor shall install Type III membranes without wrinkles, air bubbles, and other placement defects. Use hand rollers or other satisfactory pressure apparatus on the applied membrane to achieve firm and uniform contact with the primed concrete surfaces. The Contractor shall ensure that the membrane is uniformly and positively adhering to the concrete at the curb faces and drains by performing the work with a manufacturer's approved mastic according to the manufacturer's instructions. Steel rollers shall not be used unless recommended by the manufacturer.

The Contractor shall repair any torn or cut areas or narrow overlaps with the application of an adhesive and membrane patch extending at least 6 inches beyond the defect at no additional cost to the Department.

The Contractor shall pave over the membrane from higher to lower elevations.

4. **Sample areas**

When directed by the Engineer, the Contractor shall apply the membrane on a sample area of not less than 10 square feet. Once approved by the Engineer, the sample area shall serve as the standard of acceptance for all membrane work.

5. **Patching**

The Contractor shall repair untreated or damaged areas within the application area. The damaged area shall be cut back to sound material and wiped with a solvent approved by the membrane manufacturer up to a width of at least 6 inches on the periphery, removing primer or tack coat and any contaminants. The substrate shall then be primed, if necessary, followed by the application of membrane. A continuous layer of membrane shall be obtained over the substrate with a 6-inch overlap onto the existing membrane.

6. **Final Review**

The Engineer, the manufacturer's Field Representative, and the Contractor shall jointly review the deck area(s) where the completed system has been installed before surfacing or placing protection board. Any irregularities or other conditions which are not in accordance with these specifications or to the manufacturer's Representative's or Engineer's satisfaction shall be addressed before surfacing or placing protection board. Any deficiencies shall be repaired at the expense of the Contractor.

7. **Protection**

The Contractor shall protect the membrane from damage by construction operations during all stages of application.

(i) **Tack Coat**

The Contractor shall apply a tack coat directly to the waterproofing membrane prior to surfacing. The tack coat shall be supplied by and applied in accordance with the manufacturer's instructions.

(j) **Application of asphalt surface wearing course**

The Contractor shall place the asphalt concrete wearing surface course overlay as soon as possible after application of the membrane and no later than within 24 hours of the placement of the waterproofing membrane system. Placement shall be in accordance with Section 315, except as modified herein.

The asphalt concrete overlay course shall be as specified on the plans.

The paving operation shall be in the same direction as the end laps of the Type III membrane.

The mixing discharge temperature of the mixture shall not exceed 310 degrees F. The temperature of the mixture at the time of placement shall be not less than 275 degrees F. The mixture shall be dumped directly into the paver hopper. After filling the hopper, the truck shall pull forward and shall not be in contact with the paver while it is moving. The mixture shall not be dumped onto the deck ahead of the paver. The mixture shall be spread and rolled in such a manner that the Protection Board will not be damaged. The temperature of the mixture at the time of rolling and compacting shall be not less than 235 degrees F (200 degrees F for warm mix). Vibratory rollers shall be operated in static mode when used for compaction.

429.07—Quality Control and Quality Assurance and Acceptance of Waterproofing Membrane Thickness for Type I and Type II Membranes

The Contractor shall measure the thickness of membrane using equipment and methods according to the manufacturer's instructions. The Field Representative shall perform Quality Control thickness measurements of the membrane as the work progresses. The Engineer may directly monitor the Quality Control measurements or may complete independent Quality Assurance thickness measurements. If necessary, the Contractor shall adjust deck preparation, application, or installation operations in coordination with recommendations of the Field Representative to correct deficiencies.

The thickness measurement tools used by the Contractor for Quality Control measurements and Quality Assurance measurements shall be calibrated before applying the membrane. Quality Assurance measurements will govern over Quality Control measurements, and Quality Control measurements shall govern over the Contractor's measurements.

Quality Control measurements shall be obtained at a rate of one per each 10-foot by 10-foot section of the deck. Quality Control measurements at each location shall be completed as soon as possible after the membrane is placed and within 30 minutes after the application of the membrane at that location.

Whenever Quality Control or Quality Assurance measurements reveal that the membrane thickness is less than the minimum required thickness, the Contractor shall apply another layer of membrane within 60 minutes of the previous application of the membrane at that location. Additional layers of membrane shall be applied until Quality Control or Quality Assurance measurements demonstrate that the membrane thickness is equal to or greater than the minimum required thickness. No additional payment will be made for placement of additional layers of the membrane to achieve the required thickness.

The Contractor shall provide a daily Quality Control record to the Engineer promptly upon completion of the field measurements. The record shall include the following information:

- Date
- Time
- Weather conditions
- Temperature
- thicknesses and location of measurements, and
- Any adjustment to application methods, equipment, allowed components, etc. with explanation for adjustment
- Any reapplication thicknesses and location of measurements

429.08—Waterproofing Membrane Acceptance

During the waterproofing work, field samples of the membrane material shall be taken for testing and evaluation by the Engineer.

The Engineer, the Contractor, and the Field Representative shall jointly review the deck area(s) on which the completed system has been installed prior to installation of the asphalt overlay. Any irregularities or other non-permitted variations from these requirements shall be corrected to the satisfaction of the Engineer before acceptance of the work can be authorized.

(a) **Testing for Type I Membranes:** The Contractor shall perform random tensile bond strength tests on the bond between the substrate and the primed concrete surface using an Elcometer Adhesion Tester Model 106 or similar method (VTM 92, ASTM C1573) at a minimum frequency of three tests per 5,000 square feet. Smaller areas shall receive a minimum of three tests. Tensile bond strengths shall provide a tensile rupture strength of the bond interface greater than or equal to 100 psi, or a failure area at a depth of 1/4 inch or more into the base concrete, *greater than* 50 % of the test area and *greater than* 290 psi on steel. Additional surface preparation shall be performed as required to achieve passing test results.

(b) **Testing for Types I, II and III:** The Contractor shall determine the waterproofing effectiveness of the membrane pavement system after completion of the asphalt concrete overlay. The minimum electrical resistance shall be 500,000 ohms when tested in accordance with VTM-39. Areas having resistance readings lower than 500,000 ohms will be evaluated by the Department. Those areas determined by the Engineer to be detrimental to the effectiveness of the system shall be repaired by removing the asphalt concrete overlay, replacing or repairing the defective membrane, and replacing the asphalt concrete overlay in a manner that will yield a neat-appearing, smooth-riding pavement at the Contractor's expense. If more than 30 percent of the bridge deck area is shown defective by tests and is determined by the Engineer to be detrimental to the effectiveness of the system, the entire asphalt concrete pavement and membrane system shall be removed and the deck cleaned in a satisfactory manner. The entire membrane-pavement system shall then be replaced in accordance with these specifications at the Contractor's expense.

429.09—Measurement and Payment

Remove asphalt concrete overlay will be measured and paid for in accordance with Section 425.

Bridge deck waterproofing membrane (Type) will be measured in square yards and will be paid for at the contract unit price per square yard of completed surface as shown on the plans for the type specified. This price shall include preparing bridge deck, services of manufacturer's field representative, submittals, quality control and quality assurance, testing, and furnishing and placing primer, membrane, and

protection board. Allowance shall not be made in the measurement for the turn-up at vertical faces, for any overlap, or for a second application of waterproofing membrane over membrane reinforcement.

Membrane reinforcement will be measured in linear feet and will be paid for at the contract unit price per linear foot. Allowance will not be made in the measurement for the turn-up at vertical faces or for any overlap.

Payment will be made under:

Pay Item	Pay Unit
Bridge deck waterproofing membrane (Type)	Square yard
Membrane reinforcement	Linear Foot

SECTION 430—NBIS INSPECTION USING UNDER BRIDGE INSPECTION DEVICE

430.01—Description

This work shall consist of furnishing an OSHA compliant under bridge inspection device, including qualified operator, to facilitate the inspection of bridge structures by Department inspectors or designated consultant inspectors prior to opening such bridge structures or partial bridge structures, based on phase construction, to public traffic. The under bridge inspection device shall be of sufficient size, capacity, and reach to provide access to all areas of the specified bridge structure(s) or partial bridge structure(s) for inspection purposes. The Contractor shall provide VDOT inspectors full access to bridge structures for the National Bridge Inspection Standards (NBIS) bridge initial/inventory and/or final acceptance inspection before the bridge structure(s) or partial bridge structure(s) is opened to public traffic.

430.02—Notification Requirements

The Contractor shall notify the Engineer at least 1 month (30 days) in advance of his requested NBIS inspection date to arrange for NBIS inspection of the completed bridge structure(s) or completed partial bridge structures. If the Department is able to arrange to supply it's under bridge inspection device once the request for the NBIS inspection is received from the Contractor, the Contractor will be notified by the Engineer and payment for days/partial days not used will be deleted from the Contract. Advance notice and coordination by each party in scheduling mutually agreeable date(s) and time(s) for NBIS inspection is required due to bridge inspection device and personnel availability as well as associated costs.

430.03—Rescheduling Inspection

If the NBIS bridge inspection must be rescheduled, the Contractor's request for the NBIS inspection will be subject to the next available date of the bridge inspection team within 10 calendar days of the originally scheduled date of the NBIS inspection.

If either party must reschedule the inspection, they must furnish the other party at least 7 calendar days advance notice.

The under bridge inspection device and qualified operator shall also be available for any subsequent re-inspection(s) (including mobilization) for corrective measures identified in the NBIS bridge inspection, and will be subject to the next available date the bridge inspection team can perform the inspection. If necessary, only the first re-inspection will be paid for in accordance with the pay item herein. Re-inspections thereafter shall be at the Contractor's expense.

A delay in the NBIS bridge inspection attributable to the Contractor will not relieve the Contractor from his obligation to complete the work within the Contract time limit nor justify a time extension.

430.04—Traffic Control during Inspection

When the Contract has individual pay items to address maintenance of traffic operations, these items may be adjusted to accommodate traffic control necessary for the NBIS bridge initial/inventory and/or final acceptance inspection(s). In contracts where maintenance of traffic is specified for Lump Sum payment, the Contractor shall plan the work so that the cost for maintenance of traffic for the NBIS bridge inspection(s) is covered in the final percentage of the lump sum payment. Therefore, the final percentage of the lump sum amount bid will not be submitted for payment until after the NBIS inspection(s) has been satisfactorily completed.

430.05—Measurement and Payment

NBIS access, under bridge (Str. No.) will be measured in days or partial days and will be paid for at the contract unit price per day or partial days based on the actual working time required to conduct inspections for the bridge structure(s) specified. This price shall include furnishing an under bridge inspection device and qualified operator, mobilization/demobilization, development of a traffic control plan and furnishing traffic control for the NBIS inspection(s) required to perform and fully complete the inspection(s).

Time governing payment will commence once the under bridge inspection device and operator are at the inspection location based upon a mutually agreed schedule (date and time) between the Engineer and the Contractor and proper notification in accordance with the requirements herein has been made.

Payment will be made under:

Pay Item	Pay Unit
NBIS access, under bridge (Str. No.)	Day/Partial Day

SECTION 431—EPOXY BRIDGE DECK OVERLAYS

431.01—Description

This work shall consist of preparing the deck surface and furnishing and applying epoxy as an overlay over concrete bridge decks in accordance with this Specification, and within the specified tolerances for the lines, grades and details shown on the plans.

431.02—Materials

(a) **Fine aggregate** shall conform to Section 202.
(b) **Epoxy** shall be Type EP-7 conforming to Section 243.

431.03—Procedures

Personnel shall be thoroughly trained in the safe handling of materials in accordance with the manufacturer's recommendations and the MSDS included with the materials.

Epoxy shall be stored in accordance with Section 243. MSDS and other information pertaining to safe practices for storage, handling and disposal of the materials, and to their health hazards shall be obtained from the manufacturer and posted at storage areas. A copy of such information shall be provided to the Engineer.

Prior to placing the first course, the entire deck surface shall be cleaned by shot-blasting and other means, The Contractor shall determine the bridge deck cleaning method by preparing and testing trial patches in accordance with VTM-92 to obtain the size of shot, flow of shot, forward speed of shot-blast machine, and number of passes necessary to provide a tensile rupture strength of the bond interface greater than or equal to 250 psi or a failure area, at a depth of 1/4 inch or more into the base concrete, greater than 50 percent of the test area. A test result shall be the average of three tests on a test patch of at least 1.5 feet by 3 feet consisting of two courses. One passing test result must be obtained for each span or 300 square yards, whichever is the smaller area. Test patches shall be placed in wheel paths, the area between wheel paths, or in other areas that represent a worst surface condition as determined by the Engineer. Test patches shall be installed with the same materials, equipment, personnel, timing, sequence of operations, and curing period prior to opening to traffic that will be used for the installation of the overlay. The cleaning method, materials, and installation procedure will be approved if one passing test result is obtained from each test area.

If the cleaning method, materials, and installation procedure are not acceptable, the Contractor must remove the failed test patches and make the necessary adjustments, and then retest all test areas until test results are satisfactory at no additional cost to the Department.

The cleaning method shall remove asphaltic material, oils, dirt, rubber, curing compounds, paint carbonation, laitance, weak surface mortar and other potentially detrimental materials that may interfere with the bonding or curing of the overlay. Acceptable cleaning is usually recognized by a significant change in the color of the concrete and mortar, and the beginning exposure of coarse aggregate particles. Mortar that is sound and soundly bonded to the coarse aggregate must have open pores due to cleaning to be considered adequate for bond. Areas of asphalt larger than one inch in diameter, or smaller areas spaced less than six inches apart, shall be removed. Traffic paint lines shall be considered clean when the concrete has exposed aggregate showing through the paint stripe. Vacuum cleaning equipment shall be used to remove all dust and other loose material. Brooms shall not be used and will not be permitted.

If the Engineer determines that an approved cleaning method has changed prior to the completion of the job, the Contractor shall return to the approved cleaning methods and reclean the suspect areas or verify through tests that the altered method is acceptable at no additional cost to the Department.

Epoxy overlay shall not be placed on hydraulic cement concrete that is less than 28 days old. Patching and cleaning operations shall be inspected and approved prior to placing each layer of the overlay. Any

contamination of the deck or intermediate courses after initial cleaning shall be removed. Both courses shall be applied within 24 hours following the final cleaning and prior to opening the area to traffic.

There shall be no visible moisture present on the surface of the concrete at the time of application of the epoxy overlay. Oil-free compressed air may be used to dry the deck surface.

Mechanical application equipment shall consist of no less than an epoxy distribution system, fine aggregate spreader, application squeegee, vacuum trucks, and a lighting source if work will be performed at night. The distribution system or distributor shall accurately blend the epoxy resin and hardening agent in the proportions recommended by the manufacturer and shall uniformly and accurately apply the epoxy materials to the bridge deck at the specified application rate in a manner that covers 100 percent of the work area. The fine aggregate spreader shall uniformly and accurately apply the dry silica sand or basalt to cover 100 percent of the epoxy material. The vacuum truck shall be self-propelled.

Hand application equipment shall consist of calibrated containers, a paddle-type mixer, squeegees, rollers and brooms that are suitable for mixing the epoxy and applying the epoxy and aggregate in accordance with Section 243.

Handling and mixing of the epoxy resin and hardening agent shall be performed in a safe manner to achieve the desired results in accordance with Section 243 and the manufacturer's instructions as approved or directed by the Engineer. Epoxy overlay materials shall not be placed when weather or surface conditions inhibit proper handling, placing, spreading, and curing within the project limitations of operations.

The epoxy overlay shall be applied in 2 separate courses in accordance with the following rate of application, and the total of the 2 applications shall not be less than 7.5 gals. per 100 square feet.

Application Rates

Course	Epoxy gal./100 sq.ft.	Aggregate lbs./sq.yd.*
1	No less than 2.5	10+
2	No less than 5.0	14+

* Application of aggregate shall be of sufficient quantity to completely cover the epoxy.

After the epoxy mixture (resin+hardening agent) has been prepared for the epoxy overlay, it shall be immediately and uniformly applied to the surface of the bridge deck with a squeegee or paint roller. The temperature of the bridge deck surface and all epoxy and aggregate components shall be 60 degrees F or above at the time of application. Epoxy shall not be applied if the air temperature is expected to drop below 55 degrees F within 8 hours after application, or if the gel time is less than 10 minutes. The dry aggregate shall be applied in such a manner as to cover the freshly placed epoxy mixture completely within 5 minutes. First course applications that do not receive enough sand prior to gel, as determined by the Engineer, shall be removed and replaced. Insufficiently sanded second courses may be left in place, but require additional epoxy-sand applications to deficient areas before opening to traffic. Each course of epoxy overlay shall be cured until vacuuming or brooming can be performed without tearing or damaging the surface. Traffic or equipment shall not be permitted on the overlay surface during the curing period. After the curing period for Course 1, all loose aggregate shall be removed by vacuuming or brooming and the next overlay course applied.

The minimum curing periods shall be as follows:

Course	Average temperature of deck, epoxy and aggregate components in degrees F					
	60 to 64	65 to 69	70 to 74	75 to 79	80 to 84	85+
1	4 hrs.	3 hrs.	2.5 hrs.	2 hrs.	1.5 hrs.	1 hr.
2*	6.5 hrs.	5 hrs.	4 hrs.	3 hrs.	3 hrs.	3 hrs.

* Course 2 shall be cured for 8 hours if the air temperature drops below 60 degrees F during the curing period.

The Contractor shall plan and prosecute the work to provide the minimum curing periods as specified herein, or other longer minimum curing periods as prescribed by the manufacturer prior to opening to public or construction traffic, unless otherwise permitted. Course 1 applications shall not be opened to traffic.

Unless otherwise specified, the epoxy overlay courses shall be applied over the expansion joints of the bridge deck. The expansions joints shall be provided with a bond breaker. Within 12 hours of application and prior to opening to traffic, the overlay shall be removed over each joint by removal of the bond breakers, or by scoring the overlay prior to gelling or by saw-cutting after curing.

Unless otherwise specified, the epoxy overlay courses shall be applied to the area of the face of the curb or parapet for a distance of 6 inches from the face of the deck. Vertical and inclined surfaces on the face of the curb shall be cleaned by abrasive blast cleaning but do not require broadcast aggregate.

If the Contractor's operation damages or mars the epoxy overlay, the Contractor shall remove the damaged areas by saw-cutting the perimeter of the damaged areas in rectangular sections to the top of the concrete deck surface and replacing the various courses in accordance with this Specification at no additional cost to the Department. The method for removing the damaged sections of epoxy overlay shall be developed by the Contractor, and submitted to the Engineer for review.

The Contractor shall maintain and provide the Engineer with records for each batch provided including, but not limited to:

- Batch numbers and volumes
- Location of batches as placed on deck, referenced by stations
- Batch time
- Gel time (50 ml sample)
- Temperature of the air, deck surface, epoxy components, including aggregates
- Loose aggregate removal time
- Time open to traffic

431.04—Measurement and Payment

Epoxy overlay will be measured in square yards and will be paid for at the contract unit price per square yard. This price shall be include preparing deck and testing, furnishing and applying the overlay courses (epoxy and aggregate)removing and disposing of loose/excess aggregate, and saw-cutting joints.

Payment will be made under:

Pay Item	Pay Unit
Epoxy overlay	Square yard

Division V
INCIDENTAL CONSTRUCTION

SECTION 501—UNDERDRAINS, CROSSDRAINS, AND EDGEDRAINS

501.01—Description

This work shall consist of constructing underdrains, crossdrains, edgedrains, and prefabricated geocomposite pavement edgedrains (PGPE), including outlet pipe, (collectively, "underdrains") using pipe, aggregate, and geosynthetics, in accordance with these specifications, the VDOT Road and Bridge Standards, and in conformity to the lines and grades shown on the plans or as designated by the Engineer.

501.02—Materials

(a) **Pipe** for underdrains shall conform to Section 232.

(b) **Fine Aggregate material** used to level and fill depressions in the bottoms of underdrain, crossdrain, and outlet pipe trenches shall conform to Section 202.

(c) **Coarse Aggregate material** used to backfill underdrain, crossdrain, and outlet pipe trenches shall conform to Section 203 and be No. 57 aggregate, No. 8 aggregate, or crushed glass conforming to No. 8 aggregate material gradation requirements.

(d) **Geosynthetics,** including **geotextile drainage fabrics and prefabricated geocomposite pavement edge drains** shall conform to Section 245.

501.03—Procedures

(a) **Excavation:** The Contractor shall excavate trenches so that the walls and bottom are uniformly smooth and free of roots and unstable or jagged material. Fine aggregate shall be used to fill large depressions and level sharp contours and rises in the bottoms of underdrain, crossdrain and outlet pipe trenches. Excavated material shall be handled in a way that prevents contaminating clean aggregate material used to backfill the trench for the underdrain. Trench locations and grades shall be in accordance with the Plans, the Standard Drawings, and other Contract documents.

(b) **Placing Geosynthetics:** When geotextile drainage fabric or prefabricated geocomposite pavement edgedrain (PGPE) is required, these items shall be placed as shown on the plans and the VDOT Road and Bridge Standards. Torn or punctured fabric in either type of application shall be replaced at the Contractor's expense. The Contractor shall correct or repair misaligned installation of geotextile fabric or inadequate overlaps at pipe joints or other locations prior to placing aggregate.

Splices, when required for PGPE, shall be made using splice kits furnished by the manufacturer and installed in accordance with the manufacturer's written instructions. Spliced joints in PGPE shall not damage the panel or impede the open flow area of the panel, and shall maintain the vertical and horizontal alignment of the PGPE within 5 percent. The Contractor shall construct splices in such a manner as to prevent infiltration of the backfill or any fine material into the water flow channel. Inspection ports for PGPE shall be constructed in accordance with details shown in the Standard Drawings at locations as specified in the Contract.

(c) **Installing Pipe:** Perforated pipe shall be installed with the perforations facing downward on a bed of aggregate material. Pipe sections shall be joined with appropriate corresponding couplings, fittings, and plugs. Semi-round underdrain pipe shall be installed with the rounded section facing down.

The Contractor shall use concrete or other types of underdrain pipe having a minimum compressive strength of 100 psi wherever the depth of the trench is modified to a lesser depth than that shown on the VDOT Road and Bridge Standards. Pipe shall be placed with the bell end upgrade. Open joints shall be wrapped with the same geotextile drainage fabric used for lining the excavation. Geotextile drainage fabric shall extend at least 18 inches in each direction past the open joint.

Upgrade ends of underdrain pipe, except for crossdrains, shall be closed with suitable plugs. The Contractor shall construct a suitable secure watertight connection through the wall of the manhole or catch basin where an underdrain connects with a manhole or catch basin.

After the Engineer has approved the underdrain pipe installation, the Contractor shall place and compact the aggregate backfill material. The Contractor shall exercise caution to ensure both pipe and geotextile drainage fabric covering at open joint locations maintain their proper orientation and are not displaced during subsequent construction operations.

Outlet pipes shall be installed at the low points of sags in vertical alignment as detailed in the VDOT Road and Bridge Standards. Prior to video camera inspection, the underdrain system shall be filled with water to detect sags. The Contractor shall install outlet pipe in the trench with sections securely joined. The outlet pipe trench shall be backfilled with coarse aggregate material in layers not more than 6 inches in depth and thoroughly compacted by hand tamping, mechanical means or other Engineer-approved methods, but only after the Engineer has approved the outlet pipe installation.

Endwalls for outlet pipes shall be placed on a prepared surface that has been compacted to comply with Section 303.04. The Contractor shall make necessary repairs at the Contractor's expense if settlement of the outlet pipe or endwall occurs.

(d) **Post-Construction Inspection:** The Contractor shall conduct a post construction video inspection of the installed system in accordance with Virginia Test Method 108 prior to requesting final acceptance of the underdrain or crossdrain system. The Engineer must approve the video camera, and borescope camera (if used for PGPE), prior to use. Video camera inspection(s) on all underdrains shall be conducted at all outlet locations including mainline longitudinal connections after all potentially damaging construction operations over, near, or adjacent to the underdrain system have been completed. Pipe underdrains, including outlet pipes, shall be inspected in 200 foot segments in both directions from the outlet pipe. PGPE shall be inspected at all inspection ports, if provided. The Contractor shall provide a copy of the inspection report, including any digital recording/photographs, etc., to the Project Inspector, the Area Construction Engineer, and the District Materials Engineer within 2 business days of the completion of the inspection. The report shall be made part of the project records.

The Engineer will review the report and communicate the Engineer's findings to the Contractor within 5 business days of the date of receiving the report. If the report identifies areas requiring remediation efforts on the part of the Contractor, and the Engineer agrees with the proposed remediation measures submitted by the Contractor in the report, the Contractor

shall be notified of such agreement and authorized to begin such work at no cost to the Department. Where the Engineer disagrees with the proposed remediation measures or identifies additional deficiencies that require remedial action by the Contractor, the Contractor will be notified of The Engineer's findings and advised to submit an amended remediation plan for review.

The Contractor shall re-inspect the deficient locations upon completion of the authorized corrective measures and satisfy the same criteria for acceptability as was used in the initial inspection for the new underdrain system. The Contractor shall continue with corrective measures and inspections at the Contractor's expense until the Engineer accepts the underdrain system at that location.

The Contractor shall remediate all deficiencies identified by the Engineer by repairing or removal and replacement of such areas at no cost to the Department. Any pavement settlement above the underdrain installation shall be repaired in kind to the satisfaction of the Engineer at the Contractor's expense

The following deficiencies are examples of unacceptable underdrain installations that require corrective action by the Contractor:

1. Crushed or collapsed pipe (including couplings, connections, or other pipe fittings) in underdrain, crossdrain or outlet pipe applications that prevent passage of the 2-1/2 inch diameter inspection camera.

2. Pipe that is partially crushed, deformed, split or cracked for a length of 12 inches or greater, even if the deficiency allows the passage of the 2-1/2 inch diameter inspection camera.

3. Any blockage or sediment buildup caused by rodent nests, open connections, cracks, or splits in the pipe.

4. Sags in the longitudinal profile of the underdrain pipe as evidenced by ponding of water for continuous lengths of 10 feet or greater. The Contractor shall flush the pipe run with water prior to checking for sags.

5. Blocked, partially blocked, and/or flattened PGPE panels that will not allow the passage of a 3/8 inch diameter borescope camera.

6. Outlet pipes that are installed with less than a 2% uniform positive grade sloped toward the outlet end.

7. Freeboard of less than 12 inches from the outlet pipe invert to the bottom of the ditch.

8. Pipe that has been penetrated, crushed, misaligned or otherwise damaged by the installation of guardrail posts, sign posts, delineator posts, etc. or similar construction.

9. Cracked endwalls, reverse sloped installations, separation of outlet pipe from the back of the endwall, missing rodent screens, and missing or improperly installed outlet markers where required.

10. Cavities or undermining of the backfill at the endwall evidenced by or leading to the instability of the endwall or erosion at the endwall or on the slope.

11. Cavities, undermining or contamination of the bedding or backfill at joints or couplings as evidenced by instability or erosion in the vicinity of joints or couplings, lack of or displacement of geotextile fabric, etc.

501.04—Measurement and Payment

Underdrains and crossdrains will be measured in linear feet, complete-in-place, and will be paid for at the contract unit price per linear foot for the standard specified. The contract unit price for underdrains and crossdrains installed at depths greater than those shown in the VDOT Road and Bridge Standards will be increased 20 percent for each 1-foot increment of increased depth. No adjustment in the contract unit price will be made for an increment of depth of less than 6 inches. The contract unit price shall include removing and replacing pavement in kind when underdrains or crossdrains are to be installed under pavement that is not constructed under the Contract.

Prefabricated geocomposite edge drains will be measured in linear feet, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing edge drain including connections.

Outlet pipe for underdrain, crossdrain, and PGPE systems will be measured in linear feet, complete-in-place, and will be paid for at the contract unit price per linear foot.

These prices shall include furnishing and installing underdrain and outlet pipe (including couplings, fittings, and plugs), geotextile drainage fabric, aggregate materials, splice kits, inspection ports (if designated), and outlet markers (if used). These prices shall also include excavating or trenching, leveling or filling depressions, backfilling, compaction, disposing of surplus and unsuitable materials, and video inspection.

Payment will be made under:

Pay Item	Pay Unit
Underdrain (Standard)	Linear foot
Crossdrain (Standard)	Linear foot
PGPE (Standard)	Linear foot
Outlet pipe	Linear foot

SECTION 502—INCIDENTAL CONCRETE ITEMS

502.01—Description

This work shall consist of constructing concrete curbs and paved ditches and hydraulic cement concrete gutters, combination curbs and gutters, paved flumes, bridge drainage aprons and chutes, concrete median barriers, median strips, sign islands, and directional island curbs in accordance with these specifications and in conformity to the lines and grades shown on the plans or as established by the Engineer.

502.02—Materials

(a) **Hydraulic cement concrete** shall conform to Section 217. The design of the mixture may be modified, with the Engineer's approval, to accommodate the placement equipment to be used.

(b) **Asphalt concrete** shall conform to Section 211.

(c) **Preformed joint filler** shall conform to Section 212. Material shall be approximately 1/2 inch in thickness and shall have a width and depth equal to those of the incidental structure.

(d) **Curing materials** shall conform to Section 220.

(e) **Reinforcing steel** shall conform to Section 223, Grade 40 or 60.

(f) **Rubble stone** shall conform to Section 205.

(g) **Grout** shall conform to Section 218.

(h) **Foundation course** shall be aggregate No. 68 conforming to Section 203.

(i) **Dry filler** shall consist of aggregate conforming to Section 202 or 203, as applicable.

(j) **Seed** shall conform to Section 244.

(k) **Topsoil** shall conform to Section 244.

502.03—Procedures

The Contractor shall construct the foundation for the proposed item to the required elevation. Unsuitable material shall be removed and replaced as directed by the Engineer. The subgrade shall be thoroughly compacted and shaped to provide a uniformly smooth bearing surface. The foundation for hydraulic cement concrete items shall conform to the specified density of the course and shall be moist when concrete is placed.

Immediately following finishing operations, hydraulic cement concrete shall be cured and protected in accordance with Section 316.04.

(a) **Fixed Forms Requirements:** Fixed forms shall be straight, warp free, and of such construction that the Engineer will not experience any interference or obstruction with his inspection of grade and alignment. Forms shall be constructed to extend the entire depth of the item and shall be braced and secured so that no deflection from alignment or grade will occur during concrete placement. Radial forms shall be sufficiently flexible or otherwise designed to provide a smooth, uniform, curved surface of the required radius. Face forms shall be removed as soon as concrete has attained sufficient set for the curb to stand without slumping. The exposed surface shall then be smoothed by the use of a suitable finishing tool.

The Contractor shall provide transverse joints for crack control for fixed forms at the following locations:

1. at approximately 20-foot intervals

2. at the gutter where the curb and gutter tie to the gutter apron of drop inlets

3. when the time elapsing between consecutive concrete placements exceeds 45 minutes

4. where no section shall be less than 6 feet in length.

Crack control joints may be formed by using one of the following methods:

a. removable 1/8-inch-thick templates

b. scoring or sawing for a depth of not less than 3/4 inch when using curb machine

c. approved "leave-in" type insert

d. may be formed or created using other Department approved methods which will successfully induce and control the location and shape of the transverse cracks.

The joint at the gutter where the curb and gutter ties to the apron gutter of the drop inlet shall be formed by scoring or sawing.

The Contractor shall form expansion joints at intervals of approximately 100 feet, at all radii points at concrete entrances and curb returns, and at locations no less than 6 feet and no more than 10 feet from drop inlets.

Hydraulic cement concrete shall be sufficiently consolidated to produce a uniform, closed smooth surface. Edges shall be rounded to a 1/4-inch radius.

Exposed surfaces, except concrete median barrier immediately adjacent to the roadway, shall be given a light broom finish. Concrete median barrier shall be given a Class 1 finish in accordance with Section 404.07(a). Paved ditches and paved flumes shall be given a coarse or roughened texture. Other exposed surfaces shall be given a rough wood float finish. Mortar used in the correction of surface irregularities shall conform to Section 218.

(b) **Slipform Requirements:** The Engineer will allow the Contractor to slipform incidental concrete items provided the following conditions are met. Approval by the Engineer to allow the Contractor the option of slipforming concrete items is permissive only, and in no way relieves the Contractor from his responsibility to comply with the contract requirements and conditions.

Slipform equipment shall produce a product equal to or better than that produced by fixed form construction. Equipment for slipforming operations shall be designed or engineered to form the type of construction design for which its use is intended. Where equipment has been modified to such an extent that its use is questionable, the Contractor may be required at his expense to demonstrate to the Engineer's satisfaction that the equipment can consistently produce the desired type of construction.

The slipform equipment shall be self-propelled and shall be equipped to receive, consolidate, form, extrude, and finish the freshly placed concrete in such a manner that a minimum of hand finishing is required to produce a dense, consolidated, homogenous end product. Slipform equipment shall be controlled to line and grade by automatic sensing, guidance, and control devices such that the machine automatically senses and follows taut guidelines or other stable reference, performing any necessary corrective action to ensure the correct grade and alignment are achieved. The Contractor shall ensure the slipform operation is planned to result in the full cross section and grade of the desired design at the beginning and end of the placement. Slipform equipment shall operate with a continuous forward movement. The Contractor shall plan and stage the work to eliminate the need for the slipform machine to be stopped during placement operations. If for any reason it is absolutely necessary to stop the forward progress

of the machine, operation of the vibrating and tamping elements shall be stopped immediately. If the results of the slipform operation are unsatisfactory, the Engineer will not permit the continued use of the equipment.

Concrete for use in slipform operations may be manufactured with a slump as low as zero. The top of the slump range shall conform to the requirements for the class of concrete specified on the plans or special provisions in accordance with Section 217. The concrete shall have properties that consistently maintain workability and the cross section, line, and grade of the proposed design or product. Concrete shall be finished to a light broom finish. If water is held back to maintain the desired slump, it may be added in increments provided the maximum water per cubic yard has not been exceeded and a minimum of 30 revolutions at mixing speed is used for complete mixing.

Where reinforcing steel is incorporated into the proposed design, it shall be uncoated steel conforming to Section 223. Reinforcing steel shall be tied at 100 percent of the bar intersections and shall be sufficiently strengthened with braces, additional reinforcement, or chairs to make the reinforcement cage rigid so as to prevent any movement during concrete placement. The Engineer will suspend the work if the reinforcing steel exhibits any movement during concrete placement using slipforming methods, until the reinforcing steel has been sufficiently tied and stabilized to the Engineer's satisfaction. The reinforcing steel shall be continuous from fixed object to fixed object. All reinforcing steel shall have the appropriate amount of concrete cover for the particular design with a tolerance of – 0 or +½ inch. In no case shall the amount of cover be less than 1½ inches. Placing reinforcing steel in freshly placed concrete is not permitted.

Extrusions shall be of the full cross section of the designed item and multiple placements will be allowed based on the permissible construction joints as noted in the plans or standard drawings.

Where weep holes are part of the proposed median barrier design, the Contractor shall use 6-inch-diameter underdrain pipe in lieu of weep holes. The Contractor shall install underdrain pipe conforming to Section 232 at the grade at the bottom of the footing and shall terminate the underdrain pipe in catch basins or drop inlets.

Where naturally occurring vertical contraction cracking occurs and where there exists a grade separation on each side of the barrier, the Contractor shall install a waterproofing membrane conforming to Section 213, spanning 1½ feet on each side of the contraction crack at the back surface of the higher grade side of the barrier to prevent water from passing through the barrier.

The Contractor shall install expansion joint material 1½-inch thick adjacent to each fixed object. Expansion material shall be placed against each fixed object prior to placement of the slipformed concrete. The Engineer will not require the construction of contraction joints with slipformed operations provided the reinforcing steel is continuous from fixed object to fixed object.

(c) **Individual Item Requirements:**

1. **Hydraulic Cement Concrete Curbs, Gutters, Combination Curbs and Gutters, Paved Ditches, and Paved Flumes:** The Contractor shall modify adjacent curbs of standard entrance gutter and standard connection for streets to provide a mountable shape corresponding to the standard mountable shape where standard mountable curb or combination curb and gutter with mountable curb is specified on the plans.

The Contractor shall install the curb simultaneously with or immediately after placement of the slab where integral curb is specified. The time period between slab and curb placement shall be not more than 45 minutes except as specified hereinafter. The surface area of the slab on which the curb is to be placed shall be roughened, and the concrete shall be placed so as to form and ensure a bond between the slab and curb.

If authorized by the Engineer the Contractor may construct the integral curb by embedding 7 inch long, 5/8 inch diameter steel dowels, in the slab at 1-foot intervals. Dowels shall be located and placed so as to extend at least 2 inches into the curb. While the slab is still plastic, it shall be roughened to a depth of approximately ½ inch below the screeded surface for the full width of the curb.

The face and top of curbs (curbs only and the curb portions of curb and gutter) shall mirror the alignment and profile grade of the corresponding roadway as established in the plans and shall not deviate more than 3/8 inch between any two points 10 feet apart measured along the tangent or radial portion of the roadway. Vertical alignment shall be uniform and true to line and grade as to ensure complete drainage of the roadway.

Any curb, gutter, or combination curb and gutter, except those on structures, may be placed by the slipform method provided the finished product is true to line, cross section, and grade and the resultant concrete is dense and has the required surface texture. The concrete shall be of such quality and consistency that it will maintain the desired shape or cross section of the design without support.

Where concrete curb or curb and gutter is placed over existing pavement, it shall be anchored to the existing pavement either by placing steel dowels and reinforcing steel or by using a Department approved adhesive designed and manufactured for such use. Steel dowels shall be firmly mortared with 1:1 Portland cement and sand mortar in holes drilled in the pavement. If the Contractor uses an adhesive, the surface of the pavement shall be thoroughly cleaned according to the adhesive manufacturer's recommendations before the adhesive is applied. Adhesive shall be EP-4 epoxy resin, a two-component system conforming to Section 243. The surface area of the pavement shall be cleaned by either blast cleaning or wire brushing so that the prepared surface is free of dust, loose material, oil, or any other material that may prove deleterious to bonding.

The grade for the top of the extruded curb shall be indicated by an offset guideline set by the Contractor from survey information supplied by the Department or generated by the Contractor's survey information. The forming tube portion of the extrusion machine shall be readily adjustable vertically to accommodate, when necessary, a variable height of curb conforming to the predetermined curb grade line. A grade line gage or pointer shall be attached to the machine to monitor the elevation of the curb being placed against the established grade line so as to make corrective adjustments as necessary during placement. In lieu of a grade line gage or pointer, the extrusion machine may be operated on rails or forms set to produce the predetermined finished grade line for the curbing.

The Contractor shall ensure that concrete be continuously fed to the slipforming machine at a uniform rate. The machine shall be operated under sufficient uniform restraint of forward motion so as to produce a well-compacted homogenous mass of concrete free from surface pits larger than ¼ inch in diameter and requiring no further finishing other than light brushing with a broom. The Engineer will not permit finishing with a brush application of grout.

Expansion joints shall be constructed as specified for fixed formed curbing or shall be constructed by sawing through the curb section to its full depth. The width of the cut shall be such to allow the insertion of the joint filler with a snug fit. If sawing is performed before the concrete has hardened, the adjacent portions of the curb shall be supported firmly with close fitting shields. The operations of sawing and inserting the joint filler shall be completed before the start of concrete curing procedures.

If sawing is performed after the concrete has hardened, the joint filler shall be mortared in place with heavy trowel pressure. After sawing is performed, all exposed portions of the curb in the vicinity of the joint shall be covered with another application of curing compound. At the conclusion of the curing period, the filler in each sawn joint shall be checked for tightness of fit. Any loose filler shall be mortared in place again and cured.

Within 3 to 7 days after concrete placement, the Contractor shall carefully backfill curb, gutter, and combination curb and gutter to the required elevation with approved material. Backfill material shall be compacted with curbs and gutters remaining plumb, in their correct alignment and true to grade.

2. **Asphalt Concrete Curbs and Paved Ditches:** The Contractor shall install curb on a clean dry surface. The Contractor shall apply a tack coat of asphalt to the surface to receive the asphalt concrete curb at a rate between 0.05 and 0.15 gallon per square yard of surface area immediately prior to placement of the asphalt mixture. Asphalt tack coat shall be prevented from spreading outside the area to be occupied by the curb.

   Asphalt concrete curb shall be placed by a self-propelled automatic curb machine or a paver having curbing attachments to form a satisfactorily compacted curb of a uniform texture, shape, and density. The Engineer may permit construction of curbs by other means when short sections or sections with short radii are required. The resulting curbs shall conform in all respects to curbs produced by a curb machine to be considered acceptable.

   Sealing or painting shall be performed only on curbs that are clean, dry, and cooled to ambient temperature.

   Asphalt concrete paved ditches shall be placed and compacted so as to provide a ditch having a smooth, uniform, and dense texture of the required alignment and grade.

3. **Grouted Rubble Gutter:** The Contractor shall spread aggregate for the foundation course on the subgrade to a depth of at least 4 inches.

   Gutter stones shall be bedded in the foundation course perpendicular to the finished surface, flat side up, in straight rows, with the longest dimension perpendicular to the centerline of the gutter. Joints shall be broken in a satisfactory manner, and the width of interstices in the dry gutter shall be not more than 1 inch.

   Stones shall be rammed until the surface is firm and conforms to the finished grade and cross section. Joints shall then be filled with dry filler to within 4 inches of the top of stones, and the surface shall be rammed to ensure proper compaction of filler. After irregularities have been corrected, cement grout shall be poured and broomed into joints and over stones. Additional grout shall be applied and brooming shall be continued until finished grout remains flush with the top of stones.

4. **Concrete Median Barriers:** Concrete median barriers shall be constructed in accordance with the requirements specified herein and in Sections 512, 404, and 410 as applicable.

   Concrete median barriers shall be constructed within an allowable tolerance of ½ inch for overall depth and overall width, ¼ inch for the width of the upper portion of the barrier, and ¼ inch per 10 feet for horizontal alignment.

   The Contractor shall backfill concrete median barriers for roadways to the required elevation with approved material after the specified curing time has elapsed. Where crushed glass is used as porous backfill an 18-inch by 18-inch swatch of drainage fabric conforming to Section 245.03(c) shall be used to cover the #4 mesh at each weep hole opening exposed directly to crushed glass, or as approved by the Engineer. Crushed glass shall be capped with concrete in accordance with the details shown on the *VDOT Road and Bridge Standards,* or a minimum of 6 inches of approved soil or aggregate material. Crushed glass shall not be used as porous backfill directly beneath paved surfaces for barrier applications. Material shall be thoroughly tamped in layers not more than 6 inches in depth before compaction. Delineators shall be installed on median barriers in accordance with Section 702.03.

(d) **Saw Cut Hydraulic Cement Concrete Items:** This work shall consist of the Contractor saw cutting hydraulic cement concrete curb, sidewalk, and entrances to the length and depth as shown on the plans and as directed by the Engineer.

502.04—Measurement and Payment

Standard concrete curbs, radial curbs, standard combination curb and gutter, radial combination curb and gutter, and asphalt concrete curbs will be measured in linear feet along the face of the curb and will be paid for at the contract unit price per linear foot for the type and standard specified. The price shall include modifying curbs or curb and gutters to transition with standard entrance gutters, standard street connection pavement, and standard median strips. Where the curb or curb and gutter is adjacent to drop inlets, the contract unit price for the drop inlets shall include that part of the curb or curb and gutter within the limits of the structure.

Where there is no other excavation within the limits of the curb, gutter, combination curb and gutter, or median barrier other than that necessary for its construction, the contract unit price shall include excavating, backfilling, compacting, and disposing of surplus and unsuitable material. Where excavation is necessary for the roadway, the part of excavation within the limits of the curb, gutter, combination curb and gutter, or median barrier section will be paid for as regular excavation in accordance with Section 303.06.

Standard, radial, entrance, and grouted rubble gutters; paved ditches; paved flumes; street connection pavement; and bridge drainage aprons and chutes will be measured in square yards of surface area and will be paid for at the contract unit price per square yard for the type and\or Standard specified. The price for grouted rubble gutter shall include rubble stone, grout, foundation course, and filler. When pipe drain ditch liner is substituted for standard paved ditch at the Contractor's option, payment will be made at the contract unit price for the standard paved ditch specified on the plans. When pipe drain ditch liner is specified on the plans, payment will be made at the contract unit price per linear foot, complete-in-place.

The cost of excavation below the finished grade or below the slope surface of cut or fill sections that is necessary for installing and backfilling paved ditches and flumes shall be included in the contract unit

price for the paved ditch or flume. Undercut excavation below the neat lines of paved ditches in cut sections, including replacement backfill for undercut excavation and excavation above the upper lateral limits of paved ditches and paved flumes that are outside the normal plan earthwork limits, will be measured and paid for in accordance with Section 303.06 as applicable.

Cattle guards will be measured in units of each and will be paid for at the contract unit price per each.

Energy dissipators will be measured in units of each and will be paid for at the contract unit price per each.

Median barriers will be measured in linear feet along the centerline of barriers and will be paid for at the contract unit price per linear foot for the Standard specified. Unless otherwise specified, this price shall include furnishing and placing delineators, aggregate, excavation, backfill, weep hole covering material, concrete cap, dowels, and joint sealer.

Curb-cut ramps will not be measured for separate payment but will be measured in the units specified for the construction of their components.

Median strips will be measured in square yards or linear feet for the type specified and will be paid for at the contract unit price per square yard or linear foot.

Sign islands will be measured in units of each or square yards exclusive of posts and signs and will be paid for at the contract unit price per each or per square yard.

Directional island curbs will be measured in linear feet along the face of the curb and will be paid for at the contract unit price per linear foot.

Embankment material between curb lines will be measured and paid for in accordance with Section 303.06 except as follows.

When there is no excavation or construction other than that necessary for constructing median strips, sign islands, or directional island curbs, the contract unit price shall include excavating, removing existing pavement, disposing of surplus and unsuitable material, backfilling, and compacting. When excavation or demolition of pavement is necessary for the adjoining roadway, that portion within the limits of the median strip, sign island, or directional island curb will be paid for as regular excavation or demolition of pavement as appropriate in accordance with Sections 303.06 and 508.03, respectively.

These prices shall include furnishing and applying topsoil and seed to stabilize the area.

Ditch flume connector will be measured in units of each and will be paid for at the contract unit price per each. This price shall include excavation when required, dowels, welded wire fabric, reinforcing steel, anchor lugs, curtain walls, and concrete.

Saw cut hydraulic cement concrete items will be measured in linear feet and paid for at the contract unit price per linear foot to the depth specified. This price will be considered full compensation for saw cutting to the depth specified and protection of adjacent surfaces.

Payment will be made under:

Pay Item	Pay Unit
Curb (Type and standard)	Linear foot
Combination curb and gutter (Type and standard)	Linear foot

Pay Item	Pay Unit
Gutter (Type and standard)	Square yard
Paved ditch (Standard)	Square yard
Pipe drain ditch liner (Standard)	Linear foot
Paved flume (Standard)	Square yard
Energy dissipator (Standard)	Each
Entrance gutter (Standard)	Square yard
Street connection pavement (Standard)	Square yard
Median barrier (Standard)	Linear foot
Bridge drainage apron and chute (Standard)	Square yard
Median strip (Standard width)	Square yard or Linear foot
Sign island (Standard)	Each or Square yard
Directional island curb (Standard)	Linear foot
Cattle guard (Standard)	Each
Ditch flume connector (Standard)	Each
Saw cut hydraulic cement concrete items (Depth)	Linear foot

SECTION 503—CONTRACTOR BOUNDARY SURVEYING

503.01—Description

This work shall consist of the Contractor providing boundary surveying and right of way monumentation performed in accordance with Section 517, the VDOT Road and Bridge Standards, the VDOT Survey Manual, and this specification for property affected by this Contract. The Contractor shall ensure this work is performed by or under the direct responsibility, control and personal supervision of a Land Surveyor holding a valid license to practice surveying in the Commonwealth of Virginia. Boundary surveying will be performed by the Department when not specified in the Contract to be provided by the Contractor.

503.02—Materials

Right of way monuments shall conform to Section 219.

503.03—Procedures

(a) **Boundary surveying** shall include final locating of existing right of way monuments and boundary lines, final boundary stakeout, setting hub and tack for installing RM-1 right of way monuments, setting RM-2 right of way monuments and setting approved alternate monuments as detailed in this specification. Boundary surveying shall only apply to location, stakeout, and monumentation for property affected by this Contract. For the purpose of this specification "setting" shall include all surveying procedures necessary up to installing the actual right of way monument.

(b) **Right of way monuments:** Final right of way monumentation shall be provided by the Contractor in accordance with this specification and the following:

1. **RM-1:** The Contractor shall furnish and install RM-1 right of way monuments in accordance with the Standard Drawings.

2. **RM-2:** The Contractor shall furnish and install RM-2 right of way monuments and locator posts, in accordance with the Standard Drawings. The Department will furnish the required caps which the Contractor shall install.

3. **Alternate monumentation:** If the Contractor determines that RM-1 or RM-2 monuments are unsuitable for marking the right of way at various locations the Contractor shall request an alternative form of permanent monumentation from the Engineer. If the Engineer approves the request, the Contractor shall furnish and install such. If the Engineer determines RM-1 or RM-2 monuments are sufficient or specifies a different alternative form, the Contractor shall furnish and install the monument specified by the Engineer. The Contractor shall indicate this alternative monument usage on the final as-built plan in accordance with the Department Survey Manual.

4. **Monument excavation and backfill:** Monument excavation shall be kept to the minimum for installation so as minimize the disturbance of in-situ material and compaction and backfill efforts. Backfill shall be thoroughly compacted in a manner that will not displace the monument.

(c) **Surveying work and drawings:** Surveying work and drawings shall be in accordance with Sample Figure 4 in Chapter 8—Construction Surveys of the Survey Manual. Where required by the Department Survey Manual, all drawings, layouts, field notes, documentation, etc shall be signed and sealed by the licensed Land Surveyor. The certified record drawings, field notes, and computations shall be submitted to the Engineer.

(d) **Completion of the project:** The Contractor shall provide the Engineer with all original surveying drawings, field notes, layouts, computations, sketches and drawings in the format approved by the Engineer upon completion of the project. All electronic copies submitted shall be in a format fully compatible with the Departments' existing computer hardware and software.

503.04—Measurement and Payment

Boundary surveying will not be measured for separate payment. The cost thereof shall be included in the price for Construction surveying.

Right of way monuments will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each for the Standard specified. This price shall include furnishing, installing, excavating, backfilling and compaction of a Standard or an approved alternate monument. An approved alternate monument will be considered as an RM-2 monument for documentation and payment purposes.

Payment will be made under:

Pay Item	Pay Unit
Right of way monument (Standard)	Each

SECTION 504—SIDEWALKS, STEPS, AND HANDRAILS

504.01—Description

This work shall consist of constructing sidewalks, steps, handrails on steps or walls, and furnishing and installing detectable warning surfaces in accordance with the VDOT Road and Bridge Standards, these specifications and in conformity to the lines and grades shown on the plans or as established by the Engineer.

504.02—Materials

(a) **Concrete** shall be Class A3 conforming to Section 217.

(b) **Reinforcing steel** shall conform to Section 223.

(c) **Curing materials** shall conform to Section 220.

(d) **Preformed joint filler** shall conform to Section 212. Material shall be approximately 1/2 inch in thickness and shall have a width and depth equal to those of the structure.

(e) Asphalt concrete shall conform to Section 211.

(f) **Rails and posts** shall be galvanized steel pipe conforming to Section 232.02(c)4.b. Rails shall be of standard weight, and posts shall be extra strength pipe.

(g) **Geotextile drainage fabric** shall conform to Section 245.

(h) **Grounding materials** shall conform to Section 238.

(i) **CG-12 detectable warning surfaces** shall conform to the following:

1. The requirements of this section for hydraulic cement concrete sidewalk except as follows:

   Permanent, durable materials suitable for heavy traffic outdoor areas or concrete pavers approved by the Department may be used to construct the detectable warning surfaces where called for on the Plans or elsewhere in the Contract. Concrete paver units shall conform to ASTM C936 and the lines, grades, details and requirements shown in the plans. Other durable materials suitable for outdoor exposure shall be in accordance with Department approved manufacturer's design and specification requirements.

2. Products not on the VDOT Materials Division Approved Product List 72 shall be submitted to the VDOT Location and Design Division Standards & Special Design Section and the appropriate District Materials Engineer for Department review, evaluation and approval prior to use.

   All detectable warning surfaces shall meet the ADA Standards as set forth by the United States Access Board.

   The color of the detectable warning surface shall be "safety yellow" unless otherwise noted in the plans or directed by the Engineer.

When visual contrast other than "safety yellow" is specified in the Plans or Contract, the detectable warning surfaces shall contrast visually with adjacent walking surfaces either light-on-dark, or dark-on-light. The Engineer must verify and approve the visual contrast of the proposed warning surface prior to installation.

504.03—Procedures

(a) **Sidewalks:** The Contractor shall excavate, shape and compact the earthen foundation to a firm, even surface.

Unsuitable material shall be removed and replaced with Department approved material as directed by the Engineer.

When geotextile drainage fabric is required, the Contractor shall clear the designated area of debris prior to fabric installation. Large holes shall be filled with sandy, coarse material, and sharp contours and rises shall be leveled. Adjacent strips of geotextile drainage fabric shall be overlapped at least 12 inches. If fabric is torn or punctured, the Contractor shall repair it at the Contractor's expense with the same type of fabric by installing a patch having an overlap of at least 12 inches in all dimensions over the damaged area.

Forms shall be straight, free from warp, extend the full depth of the proposed concrete and of sufficient strength to resist the pressure of the newly placed concrete without dislodging or springing. Forms shall be braced and stacked so that they will remain in true horizontal and vertical alignment until their removal. Where practicable, the Contractor shall endeavor to place forms at least 100 feet in advance of concrete placement. Forms shall be cleaned of foreign matter, repaired if necessary and coated with a releasing agent such as a Department approved oil or form-coating material or thoroughly wetted with water immediately before concrete placement.

1. **Hydraulic cement concrete sidewalk:** The Contractor shall thoroughly moisten the foundation immediately prior to concrete placement. Concrete shall be placed in forms by methods that will prevent segregation of the mix. Concrete shall be spread full depth and width and brought to grade by screeding and straightedging. Concrete shall be spaded adjacent to forms to prevent a honeycomb appearance in the finished work. The surface shall be smoothed with a wooden float to produce a surface free from irregularities. The final finish shall be obtained with an approved hand float that will produce a uniform surface texture. The Contractor may use light metal marking rollers or light brooming to hide trowel marks. Outside edges of the sidewalk slab and joints shall be rounded with an edging tool having a radius of 1/4 inch.

   The Contractor shall construct transverse expansion joints at intervals of approximately 100 feet, except for closures. Slabs shall be at least 3 feet long. Slabs shall be separated by the installation of transverse preformed joint filler, 1/2 inch in thickness, which shall extend from the bottom of the slab to approximately 1/4 inch below the top surface of the sidewalk.

   The slab between expansion joints shall be divided into sections approximately 5 feet long by transverse control joints formed by a jointing tool, trowel, or another approved means. The Contractor shall also provide transverse control joints when the time period between consecutive concrete placements is more than 45 minutes. Control joints shall extend into

concrete at least 1/4 of the depth and shall be approximately 1/8 inch in width. Where slabs are more than 7 feet in width, control joints shall be formed longitudinally to obtain secure uniform blocks that are approximately square. Transverse control joints shall also be installed where the corners of drop inlets project into the sidewalk.

The Contractor shall form construction joints around appurtenances extending into and through the sidewalk. Preformed joint filler 1/4 inch thick shall be installed in these joints except that joint filler shall not be used adjacent to drop inlets. The Contractor shall form and fill the expansion joint with 1/4-inch preformed joint filler no less than 6 feet and no more than 10 feet from drop inlets. Preformed joint filler shall also be installed between concrete sidewalk and any adjacent fixed structure that is not tied to the sidewalk with steel dowels.

Where the sidewalk is constructed in conjunction with adjacent curb, expansion joints in the curb and sidewalk shall coincide. The expansion joint shall coincide where practicable where such construction is adjacent to existing curb.

Where existing or proposed structures are within the limits of the sidewalk area, concrete around them shall be scored in a block approximately 8 inches wider than the maximum dimension of the structure at the sidewalk elevation.

Preformed joint filler shall be securely fastened in place.

The Engineer may drill cores from the completed slab to take depth measurements. Sections showing a deficiency of more than 3/8 inch shall be removed and replaced at the Contractor's expense to the specified depth.

The Contractor shall cure and protect concrete in accordance with Section 316.04 immediately following finishing operations. Sidewalks shall not be opened to pedestrian traffic for the first 5 days. Vehicular traffic shall be excluded for the first 14 days or until the minimum design compressive strength is attained, whichever is the lesser time.

The Engineer will not permit the use of heavy concentrations of curing compound that will not properly set and that may be tracked into homes or businesses when liquid membrane-forming compound is used in curing operations.

2. **Asphalt concrete sidewalk:** When specified on the plans, the Contractor shall place bedding material consisting of approved aggregate conforming to the grading requirements of No. 8 aggregate in layers not more than 4 inches in depth, loose measurement, and thoroughly compacted.

   Asphalt concrete shall then be placed in forms in one or more courses to provide the specified depth once compacted. The Contractor shall compact the asphalt concrete by means of a hand-operated or power roller of a type and weight acceptable to the Engineer. The Engineer will allow tamping by hand in areas inaccessible to a roller. Regardless of the method, the means of compaction shall produce a smooth, dense, uniformly compacted sidewalk.

(b) **Hydraulic Cement Concrete Steps:** The Contractor shall construct hydraulic cement concrete steps in accordance with Sections 404 and 406. The tread portion of steps shall be given a lightly broomed texture. Finished concrete shall be cured and protected in accordance with Section 316.04.

(c) **Handrails:** The Contractor shall construct steel handrails using standard or special fittings as necessary, or joints may be welded. If joints are welded, exposed joints shall be finished by grinding or filing to give a neat smooth textural appearance. Handrails shall be bonded internally to maintain continuity. Handrails shall be electrically grounded according to Section 410.03(b).

Metal items, including rails, posts, and fittings, shall be galvanized in accordance with Section 233 except in the case of metal posts and rails fabricated from pregalvanized material whose ends and other exposed areas were satisfactorily repaired and protected with a material conforming to Section 233.

When rails are placed on a mortar rubble wall, the wall shall be securely capped with 12 inches of Class A3 concrete.

(d) **CG-12 Detectable Warning Surface:** The sidewalk ramp shall be constructed in accordance with Section 502, the provisions of this section for hydraulic cement concrete sidewalk and the details shown in the VDOT Road and Bridge Standard. Detectable warning/truncated domes and detectable warning surfaces shall be furnishing and installed in accordance with the details in this section, the manufacturer's recommendations where applicable, the VDOT Road and Bridge Standard and the plans.

All permanent installations of detectable warning surfaces shall be "wet set" in freshly placed concrete. Concrete pavers shall be wet set in concrete with a minimum depth of 4 inches of concrete underneath, unless otherwise shown on the plans or recommended by the manufacturer.

Surface mounted detectable warning surfaces are permitted only for temporary installations where the detectable warning will be in service 6 months or less.

The Contractor shall provide the Department with the manufacturer's installation instructions at least 48 hours in advance of the start of installation.

504.04—Measurement and Payment

Hydraulic cement concrete sidewalks will be measured in square yards of finished surface and will be paid for at the contract unit price per square yard for the depth specified. Each structure located within the limits of the sidewalk having an area greater than 1 square yard will be excluded in computing the square yards of sidewalk eligible for payment.

Asphalt concrete sidewalks will be measured in tons of asphalt mixture placed and finished and will be paid for at the contract unit price per ton.

The contract unit price for sidewalks shall include excavating, removing existing sidewalk, and disposing of surplus and unsuitable material if regular excavation is not shown in the sidewalk area. When the sidewalk area is located in the cross-sectional area for roadway excavation, excavation within the sidewalk area will be paid for at the contract unit price for regular excavation.

Bedding material will be measured in tons or cubic yards in accordance with Section 109 and will be paid for at the contract unit price per ton or cubic yard.

Concrete steps will be measured in cubic yards of concrete and pounds of reinforcing steel and will be paid for at the contract unit price per cubic yard of concrete and per pound of reinforcing steel.

Handrails will be measured in linear feet along the top rail and will be paid for at the contract unit price per linear foot. This price shall include grounding and concrete placed on mortar rubble walls for setting the handrail.

CG-12 Detectable Warning Surface will be measured in square yards and paid for at the contract unit price per square yard. This price shall be full compensation for furnishing and installing approved truncated dome finished materials including but not limited to concrete pavers, other Department approved materials, integral visual contrast, dowels or other anchorage devices.

Geotextile drainage fabric will be measured in square yards to the limits shown on the plans or as directed by the Engineer and will be paid for at the contract unit price per square yard. Overlaps, overwidths, and waste fabric will not be measured. This price shall include preparing the surface; furnishing and installing fabric, overlaps, and repair work; and excavating and backfilling toe-ins.

Payment will be made under:

Pay Item	Pay Unit
Hydraulic cement concrete sidewalk (Depth)	Square yard
Asphalt concrete sidewalk	Ton
Bedding material	Ton or Cubic yard
Concrete, Class A3, Miscellaneous	Cubic yard
Reinforcing steel	Pound
Handrail (Standard)	Linear foot
CG-12 Detectable Warning Surface	Square yard
Geotextile drainage fabric	Square yard

SECTION 505—GUARDRAIL AND W-BEAM MEDIAN BARRIERS

505.01—Description

This work shall consist of furnishing and constructing new guardrail and steel median barriers, installing reuseable guardrail in accordance with the plans and these specifications to the lines, grades, and tolerances shown on the plans or as designated by the Engineer.

505.02—Materials

(a) **Guardrail components** shall conform to Section 221.

(b) **W-beam median barriers and posts** shall conform to the contract requirements for the materials specified on the plans. Steel posts may be furnished with as many as six holes per flange so that posts for installation of standard guardrail and w-beam median barrier may be used interchangeably.

(c) **Concrete** shall be Class A3 conforming to Section 217 except that the Engineer will allow mixing by hand for installing guardrail terminal anchors.

(d) **Reinforcing steel** shall conform to Section 223.

(e) **Delineators** shall conform to Section 235.02(d).

505.03—Procedures

The Engineer will not permit the use of more than one type of post on the installation of a continuous line of guardrail.

The Contractor shall erect and align rail and elements in a manner that will result in a smooth, continuous, taut installation. Installation shall not result in the cross section of the rail or other elements being kinked or crimped. The Engineer will reject damaged rail or other elements. The Contractor shall replace rail and elements damaged prior to project acceptance at no additional cost to the Department.

Guardrail delineators shall be installed in accordance with Section 702.03.

The Contractor shall install spring cable end assemblies (compensating device) with a permanent match mark (hacksaw cut or file mark) on the bolt shaft or spring stop that shall be referenced to the outer assembly to denote the neutral position. Cable slack shall be eliminated by tightening the steel turnbuckle cable assembly at the end opposite the compensating device until the device is compressed 3-1/2 inches. Cables with a compensating device at each end shall be tightened such that neither end indicates less than the required tension. The assembly shall remain compressed for at least 2 weeks and then loosened, and each cable shall then be readjusted to the same required tension. The required tension shall be determined by tightening the turnbuckle at the end opposite the compensating device and displacing the match mark in accordance with the following:

Ambient Air Temperature (degrees F)	Match Mark Displacement (in)	Required Tension (lb)
0-19	3 1/2	1,575
20-39	3	1,350
40-59	2 1/2	1,125
60-79	2	900
80-99	1	675
100-120	1	450

Anchor assemblies shall be installed on firm earthen foundations, backfilled with suitable material in 4- to 6-inch layers, and thoroughly compacted by tamping or rodding. Stress loads shall not be placed on anchor assemblies until concrete has cured at least 28 days or has attained a compressive strength of at least 3,000 pounds per square inch as determined from testing corresponding field control cylinders in accordance with Section 404.03.

Nuts on anchor bolts shall be tightened to a snug tight fit as defined in Section 407.06 on beam guardrail anchors to ensure flush contact between the beam and concrete base throughout the length of the anchor assembly.

Postholes, cracks, and voids in the shoulder resulting from driving posts or removing guardrail and unused or abandoned guardrail postholes shall be backfilled to the ground line with Department approved backfill material conforming to Section 305 placed in layers not more than 4 inches in height before tamping. Postholes, cracks and voids in paved or surfaced treated shoulders shall also be sealed with a fine asphalt plant mix no larger than SM -9.5A conforming to Section 211. Each layer shall be compacted by tamping.

Wood posts shall be sawed to the dimensions shown on the plans within a tolerance of 2 percent for length and 1/4 inch scant.

The Contractor may install posts by driving provided the equipment used is capable of installing posts without damaging them. The Engineer will reject damaged posts. Posts that are damaged shall be replaced by the Contractor at no additional cost to the Department. Posts shall be set plumb. Posts shall not be set with a variation of more than 1/8 inch per foot from vertical.

If it is necessary to saw off the tops of wood posts to achieve a uniform and neat appearance, the amount sawed off shall be not more than 3 inches. Tops of sawed posts shall be brush coated with three heavy applications of the same type of preservative used in treating the posts. Each application of preservative shall be given sufficient time to penetrate the wood before the next application. Painting wood posts will not be required. Dirt and other foreign matter shall be removed after installation.

Galvanized items shall be handled and stored in accordance with Section 233. After erection, the threaded portion of fittings with fasteners and cut ends of bolts and galvanized surfaces that have been abraded or damaged shall be repaired according to Section 233.03.

The Contractor shall ensure that guardrail and barriers are kept clean during application of fertilizer, lime, tack coats, primer, or other material that cannot be readily cleaned from the guardrail or barrier after exposure.

The Contractor shall have a trained guardrail installer on the project during guardrail installation. For the purpose of this specification, a trained guardrail installer is a person who has a current certificate of training from a Department-approved guardrail installation training course.

Posts shall be spaced in accordance with the Standard Drawings. The Engineer will permit longitudinal deviation of 3/4 inch providing the bolt holes in the guardrail, offset blocks, and posts can be properly aligned without alteration or force. The height of the guardrail shall be as shown in the standard drawings.

On guardrail, nuts on bolts shall be tightened to a snug tight fit as defined in Section 407.06 to ensure full contact between the beam, offset block, and post.

The Contractor shall submit two copies of the manufacturers' recommended installation instructions and the FHWA NCHRP 350 or MASH approval letter to the Engineer at least 2 weeks prior to the start of installing guardrail end terminals for the type of new or salvaged guardrail end treatments being installed on the project. All end terminals shall be from manufacturers on the VDOT Approved Products List No. 12.

The Contractor shall field verify all materials and measurements required for installing Special Design Bridge Guardrail (BRGR) attachments prior to installation.

The Contractor shall perform Special Design Bridge Guardrail work in accordance with the Standard Drawings for "Recommended Method for Attaching Guardrail to Bridge Rails" (BR-GR). If the Contractor needs to modify the method of attachment due to field conditions, the Contractor shall submit a request, with detailed sketches, to modify the method of attachment to the Engineer for review and approval by the Responsible Charge Engineer.

The Engineer must preapprove all locations requiring drilling holes in concrete bridge railings and concrete fixed objects. Concrete spalls created by attachment of fixed object attachments (FOAs) or holes left by the removal of FOAs shall be repaired or filled with materials conforming to Section 218 to

conform to the shape and dimensions of the existing design, to the satisfaction of the Engineer. Concrete repair will not be measured for separate payment but the cost thereof shall be considered incidental to the work.

(a) **Existing Guardrail:** The Contractor shall request that the Engineer have VDOT underground assets marked a minimum seven (7) workdays prior to beginning the work in addition to contacting Miss Utility in accordance with Section 107.

The Contractor shall ensure all existing guardrail and end terminals to be left in place within the limits of construction are correctly installed, including verifying that all components are present, all bolts are properly torqued, all cables are taut and all end terminals are properly anchored according to the manufacturer's instructions. This confirmation work will not be measured for separate payment but the cost thereof shall be considered incidental to the work.

The Contractor shall replace all guardrail removed during the course of a work day that same work day, unless otherwise approved by the Engineer in writing. The Contractor shall not leave incomplete guardrail sections exposed to traffic over weekends or holidays, unless otherwise approved by the Engineer in writing.

Fixed objects, including but not limited to, bridge parapet walls, piers, blunt ends, and sign structures, shall not be left unprotected overnight. The Contractor shall use NCHRP 350 or MASH approved temporary guardrail terminal or impact attenuator service from VDOTs Approved Products List to protect traffic from the fixed object. Providing overnight protection will not be measured for separate payment but the cost thereof shall be considered incidental to the work.

Damage to pavement markings and rumble strips as a result of the Contractors operations, including but not limited to shoulder restoration, removing, salvaging and installing guardrail, shall be replaced or repaired by the Contractor. Repair or replacement will not be measured for separate payment but the cost thereof shall be considered incidental to the work.

(b) **Removing and salvaging existing guardrail:** All guardrail removal and salvage operations shall start at the run off end and proceed to the run on end terminal unless otherwise approved in writing by the Engineer.

Guardrail and guardrail end treatments designated for salvage shall be carefully removed so as not to damage the guardrail and guardrail end treatment components. The Contractor shall submit his proposed method for salvaging the guardrail or guardrail end treatments to the Engineer for his review and acceptance at least 1 week in advance of starting salvage operations.

Guardrail and guardrail terminal units designated for removal and disposal shall become the property of the Contractor. Removed materials not designated for salvage shall be disposed of at a licensed landfill, recycled, or be retained by the Contractor unless otherwise stated in the Contract. Disposal items shall include, but not be limited to, guardrail and guardrail end terminal, all hardware and unsuitable materials.

(c) **Installing new or salvaged guardrail:**

Guardrail installation shall start at the run on end terminal and proceed to the run off end, unless otherwise approved in writing by the Engineer.

The Contractor shall install salvaged guardrail and salvaged guardrail end terminal suitable for reuse in accordance with the plan details, the manufacturers' installation instructions and the current Standard Drawings. If existing posts and offset blocks are not in compliance with current Standards or Specifications, the Contractor shall furnish and install new posts or offset blocks where required and these will be measured and paid for under the appropriate pay item.

When the plans require an additional guardrail beam be nested to stiffen the guardrail, the additional guardrail beam will be measured and paid for as "Guardrail Beam" when new beam is used or "Install Salvaged Guardrail Beam" when a salvaged beam is used.

The Contractor shall review the locations where the need for longer posts is identified in the plans or schedule with the Engineer prior to installation. The Contractor notify the Engineer of locations where standard length guardrail posts may not be sufficient to meet the Standard Drawings installation criteria and NCHRP functionality requirements and request review of such locations prior to proceeding with the work. Guardrail installed with longer posts outside of those sites listed in the plans or replacement schedule or without the Engineer's written concurrence will be paid for at the contract unit price for standard guardrail. Upon written concurrence from the Engineer, the guardrail will be paid for as "Guardrail (Standard) (length) post".

When upgrading salvaged guardrail from GR-2 to GR-2A, additional posts and offset blocks necessary for the upgrade will be measured and paid for separately.

(d) **Adjusting existing guardrail:**

Adjusting existing guardrail beam shall consist of removing and disassembling the existing guardrail beam and offset blocks from the posts, drilling the post in accordance with the standard drawing, and reassembling the offset blocks and guardrail beam to the height required by current Standard Drawings or Specifications. Adjusting the existing guardrail beam shall be limited to 4 inches. Adjusting guardrail beam shall be limited to steel posts and shall be in accordance with the plan details and Road and Bridge Standards. Adjusting existing guardrail beam will not be permitted within the pay limits of end terminals. The terminal shall be completely removed and reinstalled or a new terminal installed in accordance with the Standard Drawings and the manufacturer's instructions.

Adjusting the height of the post will not be permitted unless the post is completely removed and the post hole backfilled and compacted as specified in 505.03. Posts shall meet the current standard length and shall be installed in accordance with 505.03 (c).

If field conditions do not allow the Contractor to adjust existing posts and offset blocks cannot be adjusted to bring the guardrail into compliance with the Standard Drawings or Specifications requirements, the guardrail and posts shall be removed and replaced. This work will be measured and paid for under the appropriate pay item.

505.04—Measurement and Payment

Guardrail will be measured in linear feet and will be paid for at the contract unit price per linear foot including hardware. Cable guardrail will be measured in linear feet from the point where the cable guardrail attaches to the run-on terminal treatment to the point where the cable guardrail attaches to the run-off terminal treatment, complete-in-place. Guardrail installed on a radius of 150 feet or less shall be

shop-curved; will be measured in linear feet and will be paid for at the contract unit price per linear foot of radial steel beam guardrail or radial steel median barrier.

W-beam median barriers will be measured in linear feet from center to center of end posts and will be paid for at the contract unit price per linear foot.

Intermediate anchorage assemblies will be measured in units of each and will be paid for at the contract unit price per each.

Terminal treatment for beam guardrail that terminates in back of the ditch line will be measured in linear feet along the regular guardrail section from center of end post (center of bolt group when guardrail is mounted flush to a structure) to the ditch line. The terminal section in back of the ditch line will be measured from the ditch line to center of end post.

Terminal treatment for beam guardrail, cable guardrail, and steel median barriers terminating on the roadway side of the ditch line will be measured in units of each and will be paid for at the contract unit price per each.

Fixed object attachments for guardrail will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing guardrail connectors, rubrail, and additional posts with offset blocks and providing holes to facilitate attachment.

Special design guardrail bridge attachments, BR-GR (Type) will be measured in units of each, for the type specified per attachment location and will be paid for at the contract unit price per each for the type specified. This price shall include, but not be limited to, furnishing and installing guardrail attachment type, posts, offset blocks, rub rail if required, delineators, and all hardware.

Guardrail beam bridge rail will be measured in linear feet for "x" dimension when guardrail is extended the length of structure as directed by the Engineer or in accordance with the Special Design Guardrail Bridge Attachment, BR-GR, detail and will be paid for at the contract unit price per linear foot.

Cable barricades will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing posts, cable, signs, and padlocks.

Guardrail beam will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing new guardrail beam, delineators and all hardware. This price includes disassembling and reassembling guardrail designated for stiffening. Guardrail beam installed on a radius of 150 feet or less shall be shop-curved, will be measured in linear feet, and will be paid for at the contract unit price per linear foot of radial guardrail beam.

Guardrail (Standard) (length) post will be measured in linear feet for the length of post for the guardrail standard specified and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing guardrail beam, posts, offset blocks and all hardware.

Guardrail offset block, wood or composite will be measured in units of each and will be paid for at the contract unit price per each. This price shall include disconnecting existing offset block, furnishing and installing new offset block and all hardware to connect guardrail beam to posts.

Guardrail post (length) will be measured in units of each for the length specified and will be paid for at the contract unit price per each. This price shall include furnishing and installing post and all hardware to guardrail beam and offset block.

Remove existing guardrail will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include removing and disposing of existing beam or cable, posts, offset blocks, hardware, connectors, end terminals, and fixed object attachments; furnishing backfill material; backfilling postholes; and repairing damage to shoulders, curbing, curb backup material or concrete.

Remove existing guardrail terminal will be measured in units of each and will be paid for at the contract price per each. This price shall include removing and disposing of existing guardrail terminals, including, but not limited to posts, offset blocks, hardware and the concrete anchor portion of terminals. This work shall also include furnishing backfill material, backfilling holes and repairing damage to shoulders, curbing, curb backup material or concrete and site restoration.

Salvage existing guardrail will be measured in linear feet and will be paid for at the contract unit price of linear foot. This price shall include carefully removing, salvaging, transporting and storing existing guardrail beam, post, offset blocks, fixed object attachments and end terminals; disposing of existing hardware; furnishing backfill material; backfilling existing postholes; and repairing damage to shoulders, curbing, curb backup material or concrete.

Salvage existing guardrail terminal will be measured in units of linear feet or each for the standard and type specified and will be paid for at the contract unit price per linear foot or each. This price shall include removing guardrail beam, posts, offset blocks, connectors, and end terminals; temporary storage; furnishing backfill material and backfilling holes; and repairing damage to shoulders, curbing, curb backup material or concrete and site restoration. This price shall also include removing and disposing of hardware and the concrete anchor portion of the terminals.

Thrie beam guardrail will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing thrie beam, posts, offset blocks, transition section delineators and all hardware.

Install salvaged guardrail will be measured in linear feet for the standard specified and will be paid for at the contract unit price per linear foot. This price shall include transporting and installing salvaged guardrail posts, offset blocks, guardrail beam, and fixed object attachments; and furnishing and installing new delineators and new hardware. Salvaged guardrail installed on a radius of 150 feet or less shall be shop-curved; will be measured in linear feet and will be paid for at the contract unit price per linear foot of install salvaged guardrail.

Install salvaged guardrail terminal (Standard) will be measured in units of linear foot or each for the standard and type specified and will be paid for at the contract unit price per linear foot or each. This price shall include transporting salvaged guardrail beam, post, offset blocks, installing salvaged guardrail beam, guardrail post, end terminals and offset blocks; and furnishing and installing reflective sheeting, delineators, concrete, and all hardware.

Install salvaged guardrail beam will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include disassembling and reassembling guardrail designated for stiffening, storing and transporting salvaged guardrail beam, furnishing and installing delineators and all hardware. Salvaged guardrail beam installed on a radius of 150 feet or less shall be shop-curved; will be measured in linear feet and will be paid for at the contract unit price per linear foot of installed salvaged guardrail beam.

Adjust existing guardrail beam will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include disassembling and removing guardrail beam and offset

block(s) from the existing posts; drilling the existing posts and offset blocks; and reinstalling the offset blocks, guardrail beam, end terminals and associated hardware to the required height.

When specified as a separate bid item, **rub rail** will be measured in linear feet for the type specified and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing the type of the rub rail specified, rub rail offset blocks, and all hardware.

When specified as a separate bid item, **guardrail terminal site preparation** will be measured in units of each per site and will be paid for at the contract unit price per each site.

The price for guardrail terminal site preparation shall also include clearing and grubbing; supplying, hauling, and placing fill material; benching existing slopes; and restoration of site including fertilizing and seeding.

These prices shall also include excavating; backfilling holes; installing delineators; repairing damaged surfaces; furnishing, galvanizing, and erecting units; furnishing concrete anchor assemblies; and drilling or preboring.

Bull nose barrier will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and placing foundation soil tubes, concrete, polystyrene sheeting, welded wire fabric, posts, radial guardrail, offset blocks, hardware, and delineators.

Payment will be made under:

Pay Item	Pay Unit
Guardrail (Standard)	Linear foot
Radial guardrail (Standard)	Linear foot
Guardrail terminal (Standard and type)	Linear foot or Each
Intermediate anchorage assembly	Each
Median barrier (Standard)	Linear foot
Radial median barrier (Standard)	Linear foot
Median barrier terminal (Standard and type)	Each
Cable barricade (Standard)	Each
Fixed object attachment (Standard)	Each
Special design guardrail bridge attachment BR-GR) (Type.)	Each
Guardrail beam	Linear foot
Guardrail (Standard) (length) post	Linear foot
Guardrail offset block, (Wood or composite)	Each
Guardrail post (length)	Each
Remove existing guardrail	Linear foot
Remove existing guardrail terminal	Each
Salvage existing guardrail	Linear foot
Salvage existing guardrail terminal (Standard)	Linear foot or each
Thrie beam guardrail	Linear foot
Install salvaged guardrail (Standard)	Linear foot
Install salvaged guardrail terminal (Standard)	Linear foot or each
Install Salvaged guardrail beam	Linear foot
Adjust existing guardrail beam	Linear foot
Rub rail	Linear foot
Guardrail terminal site preparation (Standard)	Each
Bull nose barrier	Each

SECTION 506—RETAINING WALLS

506.01—Description

This work shall consist of constructing rubble and hydraulic cement concrete retaining walls in accordance with the plans and these specifications and in conformity to the lines and grades shown on the plans or as established by the Engineer.

506.02—Materials

(a) **Dry rubble and mortar rubble retaining walls** shall be constructed of stone conforming Section 204 and mortar conforming to Section 218.

(b) **Hydraulic cement concrete retaining walls** shall be constructed of concrete conforming to Section 217.

(c) **Reinforced concrete crib walls** shall be constructed of precast concrete units. Concrete shall conform to Section 217 except that No. 7 aggregate may be used in lieu of No. 57 aggregate. Crib units shall be free from cracks, depressions, spalls, patched or plastered surfaces or edges, and any other defects that might impair their strength or durability.

(d) **Drain pipe** shall conform to Section 232.02.

(e) **Reinforcing steel** shall conform to Section 223, Grade 40 or 60.

(f) **Porous backfill** shall conform to Section 204.02(c).

(g) **Granular backfill within crib walls** shall be any material available within the project limits consisting of sand, sandy loam, gravel, rock, or a combination thereof. Materials containing a high percentage of fines, such as clay and silt soils, shall not be used.

(h) **Piles** shall conform to Section 403.

506.03—Procedures

The Contractor shall perform excavation, backfill, and foundation exploration according to Section 401.

The Contractor shall perform concrete construction of retaining walls in accordance with Section 404. Immediately following finishing operations, concrete shall be cured and protected according to Section 404.03.

(a) **Dry Rubble and Mortar Rubble Retaining Walls:** The Contractor shall not place stones in freezing weather or when stone contains frost.

Each stone shall have a thickness of at least 8 inches; a width of at least 1 1/2 times the thickness; and, except for headers, a length at least equal to 1 1/2 times the width. The thickness of courses, if varied, shall diminish from the bottom to the top of the wall.

Header stones in the heart of the wall shall be the same size as in the face and shall extend at least 12 inches into the core or backing. They shall occupy at least 1/5 of the face area of the wall and shall be evenly distributed. Header stones in walls 2 feet or less in thickness shall extend entirely through the wall.

Stones shall be roughly squared on joints, beds, and faces. The Contractor shall use selected stone, roughly squared and pitched to line, at angles and the ends of walls.

Stones shall be placed to line and in courses roughly leveled. Bottom or foundation courses shall be composed of large, selected stones. Courses shall be placed with bearing beds parallel to the natural bed of the material.

The Contractor shall perform any shaping or dressing of stone before stone is placed in the wall. The Engineer will not allow any dressing or hammering that will loosen the stone after placement.

1. **Dry rubble retaining walls:** Face joints shall be not more than 1 inch in width.

   Each stone shall have a firm bearing on the underlying course at no fewer than three points of contact. Open joints, both front and rear, shall be chinked with spalls fitted to take firm bearing on their top and bottom surfaces so as to result in a firm bearing throughout the length of the stone.

2. **Mortar rubble retaining walls:** The Contractor shall clean and thoroughly wet each stone with water before it is placed. The bed that is to receive the stone shall also be cleaned and moistened. Stones shall be bedded in freshly prepared mortar. Mortar joints shall be full, and stones shall be carefully settled into place before the mortar has set. The Engineer will not permit the use of spalls in beds. Joints and beds shall not have an average thickness of more than 1 inch.

   Whenever possible, face joints shall be properly pointed before mortar has set. Joints that cannot be pointed shall be prepared for pointing by raking them out to a depth of 2 inches before mortar has set. Face surfaces of stones shall not be smeared with mortar forced out of joints.

   Vertical joints in each course shall offset joints of adjoining courses by at least 6 inches. The Contractor shall not locate a vertical joint directly above or below a header.

   If a stone is moved or a joint is broken after it has been set, the Contractor shall remove the stone, the mortar shall be thoroughly cleaned from the bed and joints, and the stone shall be reset in fresh mortar.

   Joints that are not pointed at the time stone is placed shall be thoroughly wetted with clean water and filled with mortar. Mortar shall be forced into joints and finished with an approved pointing tool. The wall shall be kept wet while pointing is being done. In hot or dry weather, freshly pointed masonry shall be protected from the sun and kept wet by saturated burlap for at least 3 days after completion.

   After pointing is completed and mortar has set, the Contractor shall thoroughly clean the wall and leave it in a neat, orderly condition.

(b) **Concrete Retaining Walls:** Concrete retaining walls shall be constructed according to Sections 403, 404, and 406 as appropriate.

(c) **Reinforced Concrete Crib Walls:** Crib units that are damaged during storage or erection shall be removed and replaced at the Contractor's expense.

Granular backfill shall be used inside and approximately 2 feet in back of and beyond each end of a crib. Backfilling for the crib wall shall follow closely the erection of successive tiers of units. The wall shall not be placed higher than 3 feet above the backfilled portion. Backfill shall be placed carefully to avoid distorting the crib wall.

506.04—Measurement and Payment

Standard retaining walls will be measured in cubic yards within the limiting dimensions shown on the plans, and will be paid for at the contract unit price per cubic yard. This price shall include rubble stone, concrete, joint material, and weep holes.

Concrete and reinforcing steel for special design retaining walls will be measured and paid for according to Sections 404.08 and 406.04, respectively.

Reinforced concrete crib walls will be measured in cubic feet of the net volume of concrete in crib units and will be paid for at the contract unit price per cubic foot. This price shall include concrete and reinforcing steel.

Granular backfill will be measured and paid for as regular excavation in accordance with Section 303.06.

Porous backfill for retaining walls will be measured and paid for in accordance with Section 401.04.

Piles for retaining walls will be measured and paid for in accordance with Section 403.08.

Excavation for retaining walls will be measured in accordance with Section 401.04 and will be paid for at the contract unit price per cubic yard. This price shall include excavation, foundation exploration, sheeting and shoring, placing and compacting backfill and disposal of surplus material, and porous backfill when not specified as a separate pay item.

Payment will be made under:

Pay Item	Pay Unit
Retaining wall (Standard)	Cubic yard
Concrete crib (Standard)	Cubic foot
Retaining wall excavation	Cubic yard

SECTION 507—FENCES

507.01—Description

This work shall consist of constructing and grounding new fence in accordance with these specifications and in conformity to the lines and grades shown on the plans or as established by the Engineer.

507.02—Materials

(a) **Materials for fences** shall conform to Section 242.

(b) **Staples** shall be 9-gage galvanized strand wire and shall be at least 1 1/2 inches in length for soft wood posts and at least 1 inch in length for hardwood posts.

(c) **Grounding materials** shall conform to Section 238.

507.03—Procedures

The Contractor shall remove old fences that are not to be salvaged, trees, stumps, logs, and other debris that will interfere with new fence construction, and dispose of these according to Section 106.04 or as directed by the Engineer.

If rock is encountered before the specified post depth is reached, the Contractor shall install posts to approximately 3 feet in depth or 18 inches into rock, whichever is less. The diameter of holes prepared for setting posts in rock shall be at least 3 inches greater than the larger cross-sectional dimension of the post. If rock is encountered during installation of gates, corners, or brace posts, posts shall be placed in concrete.

Post and braced post anchor devices may be used in lieu of placing post and braces in concrete, except where rock is encountered. Anchor devices shall be fabricated of steel having a yield strength of at least 30,000 pounds per square inch or of other metal approved by the Engineer; shall have a thickness of not less than that specified for the post or 1/8 inch, whichever is greater; and shall be galvanized in accordance with Section 233.

Post and braced post anchor devices, together with the post, shall develop at least 80 percent of the resistance to horizontal and rotational displacement of individual post and braced post assemblies set in concrete when the load is gradually applied to the fence fabric at midheight. The Contractor shall demonstrate that the performance and stability of post and braced post anchor devices will be comparable to that of concrete when such devices are proposed for use in lieu of concrete. The use of post and braced post anchor devices in lieu of concrete and the demonstration of comparable performance and stability shall be at the Contractor's expense and to the satisfaction of the Engineer.

(a) **Standard Chain Link Fences:** The Contractor shall install metal posts for chain link fences in Class A3 concrete footings. Posts set in concrete footings shall not be disturbed for at least 7 days following the initial set of concrete and for at least 14 days when the average air temperature for the week following placement is below 50 degrees F.

Each span shall be attached independently at pull and corner posts. Ends of fabric rolls and other sections to be spliced shall be joined by weaving a single strand of the fabric wire into ends of the fabric to create a continuous pattern of mesh. Fabric shall be stretched taut and securely fastened to each post and rail. Fastenings at ends, gates, corners, and pull posts shall be with stretcher bars and metal bands.

(b) **Standard Fences:** The Contractor shall install wooden posts with the larger end down. Backfill around wood posts shall be thoroughly compacted in layers approximately 6 inches in thickness. The Contractor may install wooden posts by driving provided they are not damaged. Damaged posts shall be removed and replaced at the Contractor's expense.

Metal posts shall be driven into insitu soils.

Wire shall be stretched taut and securely fastened to each post. The Engineer will only permit splicing at post locations unless a splice can be provided that will develop a strength comparable to the strength of the wire. Each horizontal strand of wire shall be wrapped around the end of the gatepost and securely fastened by winding it about the wire leading to the post.

A new fence shall be joined to an existing fence at the beginning and end of the new fence and at points where cross fences intersect the new fence.

Wood fence posts shall be installed so that the tops form a regular grade line. Tops or bottoms of posts that are sawed in the field shall be brush coated with three heavy applications of 2 percent copper naphthenate from the VDOT Materials Division Approved Products List No. 51. Each application shall be given sufficient time to penetrate the wood.

Gates shall be erected at locations shown on the plans or where designated by the Engineer. If preferred by the property owner and with the Engineer's approval, gates and fences similar in type to those that exist may be substituted for the gates and fences shown on the *VDOT Road and Bridge Standards.*

The Contractor shall remove surplus excavated material and other debris resulting from erecting fences and leave the site in a neat, orderly condition.

The Contractor shall be responsible for damage caused to or by livestock straying through areas where the Contractor has removed an old fence that is to be replaced with a new fence.

(c) **Pedestrian Fences for Bridges:** The frame for pedestrian fences for bridges shall be bonded internally to maintain continuity. Electrical grounding shall conform to Section 410.03(b).

(d) **High Visibility Fences:** The Contractor shall furnish and install high visibility fence at required locations or as directed by the Engineer. The fence shall be no less than 4 feet high and be a bright orange polyethylene web design conforming to Section 242.02(a)12.

The high visibility fence shall be installed on metal "T" or "U" post spaced on 6-foot centers and driven to a minimum depth of 18 inches.

The Contractor shall maintain the high visibility fence and remove it when no longer required or directed to by the Engineer.

507.04—Measurement and Payment

Fences will be measured in linear feet of fence fabric along the top of the fence from outside to outside of end posts for each continuous run of fence, exclusive of gates, and will be paid for at the contract unit price per linear foot of fence fabric. This price shall include clearing, leveling, and preparing terrain at the fence level; furnishing and installing line posts; attaching to posts; grounding; and disposing of surplus and unsuitable material.

Line and corner braces will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing posts, braces, concrete, and dowels.

Water gates, Types I and II, will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing end posts, gate and fittings.

Water gate, Type III, will be measured in linear feet of gate between inside edges of end posts and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing end posts and anchor block assemblies.

Pedestrian fences will be measured along the top of the wall and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing posts, fabric, braces, ties, and grounding.

High visibility fence will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing the fence, metal post, maintenance, and removal.

Payment will be made under:

Pay Item	Pay Unit
Fence (Standard)	Linear foot
Corner brace unit (Standard)	Each
Line brace unit (Standard)	Each
Pedestrian fence (Height)	Linear foot
Gate (Standard and length)	Each
Water gate (Standard)	Each or Linear foot
High visibility fence, 4 feet	Linear foot

SECTION 508—DEMOLITION OF PAVEMENT AND OBSCURING ROADWAY

508.01—Description

This work shall consist of demolishing existing pavement and obscuring roadway to restore areas that are no longer needed for highway use in accordance with these specifications and in conformity to the lines and contours shown on the plans or as established by the Engineer.

508.02—Procedures

(a) **Demolition of Pavement Structures:**

1. **Hydraulic cement concrete pavement:** The Contractor shall demolish such pavement according to the following:

   a. Pavement shall be broken into pieces and either used in fill areas as rock embankment in accordance with Section 303 or disposed of at locations selected by the Contractor and approved by the Engineer.

   b. Material within the proposed roadway prism and more than 3 feet below the subgrade may be broken into pieces not more than 18 inches in any dimension, sufficiently displaced to allow for adequate drainage, and left in the roadway prism.

2. **Asphalt concrete pavement:** The Contractor shall remove asphalt concrete pavement that does not overlay or underlie hydraulic cement concrete pavement as follows:

a. Pavement shall be removed and used in the work as designated on the plans or as directed by the Engineer.

b. When approved by the Engineer, pavement shall be removed and disposed of at locations selected by the Contractor.

3. **Cement-stabilized courses underlying pavement designated for demolition** shall be disposed of in accordance with (a)1.a. or (a)1.b. herein.

4. **Aggregate underlying pavement designated for demolition** except hydraulic cement concrete pavement disposed of in accordance with (a)1.b. herein shall be salvaged and used for maintenance of traffic or, when approved by the Engineer, disposed of in accordance with (a)2.a. herein.

(b) **Obscuring Roadway:** The Contractor shall obscure existing roadways in accordance with the following procedures:

1. **Areas outside construction limits consisting of asphalt concrete or hydraulic cement concrete pavement demolished in accordance with (a) herein** shall be conditioned in accordance with the following:

a. Tops of slopes that do not contain rock shall be rounded for a distance of not more than 10 but not less than 5 feet (where sufficient right of way exists) beyond the point of intersection of the existing slope and the natural ground surface. The depth of the rounding shall be not more than 2 feet below the original surface of slopes.

b. The Contractor shall scarify or plow, harrow and shape disturbed areas that are to receive vegetation.

c. The Contractor shall clear and grub such areas in accordance with Section 301.

2. **Areas outside construction limits consisting of pavement structures, other than asphalt concrete or hydraulic cement concrete, that are designated for obscuring roadway** shall be conditioned in accordance with (b)1. herein. The Contractor shall remove pavement structures in accordance with the applicable requirements of (a) herein prior to beginning obscuring activities.

508.03—Measurement and Payment

Demolition of hydraulic cement concrete pavement and shoulder structure courses or a combination thereof will be measured as demolition of pavement (rigid) in square yards and will be paid for at the contract unit price per square yard based on the width of the widest course of this pavement type as designated. This price shall include performing all demolition, removing and disposing of pavement, base, subbase and stabilized subgrade materials.

Demolition of asphalt concrete pavement and shoulder structure courses or a combination thereof will be measured as demolition of pavement (flexible) in square yards and will be paid for at the contract unit price per square yard based on the width of the widest course of this pavement type as designated. This price shall include performing all demolition, removing and disposing of pavement, base, subbase and stabilized subgrade materials.

Demolition of a combination of hydraulic cement concrete pavement and asphalt concrete pavement and shoulder structure courses or a combination thereof will be measured as demolition of pavement (combination) in square yards and will be paid for at the contract unit price per square yard based on the width of the widest course of this pavement type as designated. This price shall include performing all demolition, removing and disposing of pavement, base, subbase and stabilized subgrade materials.

Obscuring roadway will be measured in units of 1,000 square feet computed to the nearest 1/10 unit and will be paid for at the contract unit price per unit. The area measured will be entirely outside the construction limits of the new roadway, as evidenced by slope stakes. Areas disturbed by the operations, including tops of slopes to be rounded, will be included in the measurement. Removing pavement structures other than hydraulic cement–stabilized, hydraulic cement concrete, and asphalt concrete pavement structures in accordance with (b) 2. herein will be measured as regular excavation in accordance with Section 303 or as lump sum grading on minimum plan and no plan projects. Clearing and grubbing will be paid for in accordance with Section 301.

Payment will be made under:

Pay Item	Pay Unit
Demolition of pavement (Type)	Square yard
Obscuring roadway	Unit

SECTION 509—FLOWABLE BACKFILL PLACEMENT

509.01—Description

This work shall consist of furnishing and placing flowable fill for use as backfill material in pipe installations or in other uses at locations as designated on the plans or as designated by the Engineer, and as backfill material for plugging designated abandoned pipes and culverts.

509.02—Materials

Flowable backfill shall conform to Section 249.

509.03—Procedures

The Contractor shall mix and transport flowable backfill in accordance with Sections 217 and 249 or by other methods approved by the Engineer.

Temperature of flowable backfill shall be at least 50 degrees F at the time of placement. The Contractor shall protect the material from freezing for 24 hours after placement.

When used as backfill for pipe installation floatation or misalignment of the pipe may occur while the material is in its plastic state. The Contractor shall maintain correct alignment of the pipe by means of straps, soil anchors or other approved means of restraint.

When flowable backfill is used to fill the voids in abandoned pipes and culverts, the pipes and culverts shall be plugged and then backfilled in accordance with the plan details, the VDOT Road and Bridge Standards, or as directed by the Engineer. The flowable backfill materials shall be installed in the abandoned pipe or culvert in such a manner as not to create voids. When deemed necessary by the Engineer, the Contractor shall submit a plan of operations for the Engineer's acceptance showing how the flowable backfill will be placed without voids. The opening for culvert flowable backfill installation shall be sealed with Class A3 concrete conforming to Section 217 or masonry conforming to Sections 204, 218, and 222 as applicable at the completion of backfilling.

509.04—Measurement and Payment

Flowable Backfill will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. When used as backfill material in pipe installations or in other uses at locations as designated on the plans or by the Engineer, this price shall include furnishing and placing flowable backfill, securing the pipe alignment, and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

When used as backfill material for plugging designated abandoned pipes and culverts, this price shall include furnishing and placing of backfill material and furnishing and installing plugs.

Payment will be made under:

Pay Item	Pay Unit
Flowable Backfill	Cubic yard

SECTION 510—RELOCATING OR MODIFYING EXISTING MISCELLANEOUS ITEMS

510.01—Description

This work shall consist of removing, salvaging, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating existing items or items furnished by the Department or others, including, but not limited to, right-of-way monuments, guardrail, riprap, drainage structures, traffic control devices, water or sanitary sewer facilities, or other items designated on the Plans or elsewhere in the Contract.

510.02—Materials

The principal materials to be used in this work shall be salvaged items or materials from current or previous construction.

Items shall be constructed, adjusted, modified, or reconstructed with the same type of material as was used in the original construction.

The suitability of existing material for salvage, modification, or reuse will be as designated in the Contract or determined by the Engineer.

New, salvaged, or refurbished materials necessary for resetting, relaying, adjusting, modifying, or relocating the item specified shall conform to the applicable specifications for items of the same character and type. Salvaged or refurbished materials shall be in good working and useable condition. Preparation for use shall include cleaning, repainting, and refinishing to the approximate original condition.

510.03—Procedures

Materials designated for salvage shall be carefully removed, dismantled, cleaned, and stockpiled in areas where they will not be damaged or shall be delivered to a storage area designated in the contract or by the Engineer. Material that is not designated for salvage shall be disposed of in an approved disposal area. Items designated for relocation, relaying, adjustment, modification, or installation shall be installed in accordance with the applicable specifications or as directed by the Engineer.

510.04—Measurement and Payment

Removing, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating designated items will be measured by the unit specified in the Contract in accordance with the plans and the applicable sections of these specifications and will be paid for at the contract unit price for the specified item and action designated. This price shall include salvaging by dismantling, loading, transporting, and unloading furnished materials; cleaning, repainting, and refinishing or refurbishing salvaged items; removing, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating designated items; salvaging or disposing of surplus and unsuitable material; excavating; trenching; backfilling; preparing foundation; reconnecting components for electrical and electronic items; revising wiring diagrams or schematics; and restoring disturbed areas.

Payment will be made under:

Pay Item	Pay Unit
Remove, reset, relay, adjust, install, modify, reconstruct, relocate existing (Item or standard)	Each, Linear foot, Square yard, Cubic yard, or Lump sum

SECTION 511—ALLAYING DUST

511.01—Description

This work shall consist of applying either water, calcium chloride, or both on areas designated by the Engineer for the purpose of controlling or allaying the release of nuisance dust from construction operations.

511.02—Materials

Calcium chloride shall conform to Section 239.

Water to control dust shall be potable or with the Engineer's approval may be from other sources provided it is clear, clean, and free from oil, acid, salt, alkali, organic matter, or other deleterious substances.

511.03—Procedures

The Contractor shall furnish a truck(s) equipped with a water tank having a capacity of at least 1,000 gallons and pumps for furnishing, loading, and applying water to the roadway.

Equipment and operators shall be available at all times.

The Contractor shall apply calcium chloride at the rate specified on the plans or directed by the Engineer.

The Contractor shall plan and prosecute the work so as to expedite completion of the pavement structure or other dust generating activities as soon as is practicable.

511.04—Measurement and Payment

Allaying dust will be measured in hours or tons and will be paid for at the contract unit price per hour based on the time the truck is in actual service on this work or at the contract unit price per ton of calcium chloride actually applied in the work. Loading time for water allowed for payment shall be not more than 30 minutes per 1,000 gallons of water. Truck hours shall be evidenced by daily time reports submitted by the Contractor and approved by the Engineer. The price shall apply to and include furnishing and applying water and calcium chloride.

When in-place base material is used as a riding surface to maintain traffic or as a haul route, truck hours or tons of calcium chloride used for allaying dust will be paid for in accordance with the provisions herein.

Payment will be made under:

Pay Item	Pay Unit
Allaying dust	Hour or Ton

SECTION 512—MAINTAINING TRAFFIC

512.01—Description

This work shall consist of maintaining traffic and protecting workers through temporary work areas, maintaining public and private entrances and mailbox turnouts, constructing and obliterating temporary traffic Diversions, providing positive guidance to the traveling public within the limits of the work area and over approved traffic Detours. All work shall be in accordance with the *Virginia Work Area Protection Manual (VWAPM), the Virginia Supplement to the MUTCD,* the *MUTCD,* the Standard Drawings, and the Contract, as directed by the Engineer.

512.02—Materials

(a) **Materials** salvaged from the roadway shall be used in the maintenance of traffic insofar as possible. Material shall conform to the applicable specifications for the intended work or use.

(b) **Signalization, barricades, channelizing devices, safety devices, and pavement markings** shall conform to the applicable specification requirements in Division VII of the Specifications

and the VWAPM except where otherwise indicated. Retroreflective surfaces shall conform to Sections 235, 238, 247, and 702 as applicable.

(c) **Temporary pavement markers** shall conform to Section 235.

(d) **Flexible temporary pavement markers (FTPMs)** shall consist of products from the Materials Division Approved Products List 22. All FTPMs shall be new. FTPMs are suitable for use one year after the date of receipt when stored in accordance with the manufacturer's recommendations.

(e) **Temporary (Construction) pavement markings** shall conform to Section 246.

(f) **Temporary (Construction) signs** for traffic control during construction, maintenance, permits, utility, and incident management activities shall conform to Section 247, Section 701, and with the provisions herein.

Sign substrates for rigid temporary (construction) signs mounted on posts and temporary (construction) sign panels for overlays shall be either fabricated of aluminum at least 0.080-inch thick, which shall be smooth, flat, and free of metal burrs and splinters; 0.4-inch-thick corrugated polypropylene; 0.4-inch-thick corrugated polyethylene plastic; or 0.079-inch-thick aluminum/plastic laminate.

Sign substrate materials for signs mounted on drums, Type 3 barricades, and portable sign stands shall be as specified below and shall be the same material that was used when the device was tested and found to be in compliance with *National Cooperative Highway Research Program (NCHRP) Report 350,* Test Level 3, or of other materials allowed in the FHWA acceptance letter.

Sign Substrates for Type 3 Barricades and Portable Sign Stands
Rollup sign 0.4 inch thick corrugated polypropylene or polyethylene plastic 0.079 inch thick aluminum/plastic laminate

Sign Substrates for Drums
0.4 inch thick corrugated polypropylene or polyethylene plastic

512.03—Procedures

Traffic shall be maintained and protected in accordance with Section 105.14. The Contractor shall schedule and perform the Work in a manner that provides minimum interference and maximum protection for public traffic. The Contractor's personnel, equipment, machinery, tools, and supplies shall be kept outside the clear zone (VWAPM Appendix A) and clear of active traffic lanes and active pedestrian and bicycle facilities except as necessary for progressively prosecuting active work. The Contractor shall build stabilized construction entrances in work areas where there is a potential for work vehicles to track material from the work site onto a paved surface. Material that is spilled or tracked onto the traveled pavement during prosecution of the work shall be promptly removed.

The Contractor shall maintain traffic control devices throughout construction requiring their use, which shall include but not be limited to, repositioning displaced devices including traffic barrier service, replacing due to inadequate structural integrity including traffic barrier service, replacing due to loss of reflectivity, repairing defaced sheeting and legend, replacing broken supports, repositioning leaning signs so they are plumb and the sign face is perpendicular to the pavement edge, cleaning dirty devices, replacing and repositioning due to weather related conditions, and replacing stolen, vandalized or damaged devices. Safety and protective devices furnished by the Contractor shall remain the property of the Contractor and shall be removed from the project site upon completion of the work or as directed by the Engineer.

The Contractor shall inspect all temporary traffic control devices, barriers, and other safety devices daily and periodically throughout the day. Traffic switches/changes, repairs or adjustments to temporary traffic control devices shall be documented on the Work Zone Safety Checklist form. Nighttime reviews shall be conducted twice monthly on long-term stationary projects and documented on the Work Zone Safety Checklist form and a copy submitted to the Engineer.

Replacement and correction of ineffective work zone traffic control devices shall be accomplished in accordance with the *American Traffic Safety Service Association's (ATSSA) Quality Standards for Work Zone Traffic Control Devices* with the following additions and exceptions:

1. Replacing and correcting temporary (construction) pavement markings and markers shall conform to the requirements herein.

2. The categories for "Arrow Board (Flashing Arrow and Double Arrow Mode)" are replaced by the following:

   Acceptable: No required lamps out in stem and arrow heads, and dimming properly.

   Marginal: No more than 1 required lamp out in the stem, no lamps out in the heads, and dimming properly.

   Unacceptable: Any lamp out in the heads, more than 1 required lamp out in the stem, or arrow board not dimming properly.

3. "Arrow Board (Chevron Mode)" is replaced by the following:

   EVALUATION GUIDE - ARROW BOARD (Chevron Mode)

   Acceptable: No lamps out in any chevron segment and dimming properly.

   Marginal: Not more than 1 lamp out in a maximum of 1 chevron segment and dimming properly.

   Unacceptable: 2 or more lamps out in any one chevron segment or 1 lamp out on 2 or more chevron segments or not dimming properly.

4. "Arrow Board (Caution Mode - Corners)" is replaced by the following:

   EVALUATION GUIDE - ARROW BOARD (CAUTION MODE - CORNERS)

   Acceptable: No lamps out and dimming properly.

   Unacceptable: Any lamp out or arrow board not dimming properly.

Any operating lamp in an arrow board display that is misaligned and does not meet minimum visibility requirements will be considered nonfunctioning and out.

The Contractor shall correct "Unacceptable" arrow board conditions immediately.

The color of Automated Flagger Assistance Device trailers, arrow board trailers, portable traffic control signal trailers, ITS trailer equipment, and portable changeable message sign trailers and sign frames shall be either Virginia highway orange (DuPont Color No. LF74279 AT or color equivalent) or federal yellow. The back traffic facing trailer frame, where the signal and brake lights are located, shall be fully covered with 2 inch high retroreflective sheeting conforming to Section 247.02(c). The sheeting shall have alternating 11 inch wide vertical red stripes and 7 inch wide vertical white stripes.

Stationary Automated Flagger Assistance Devices, portable traffic control signal trailers, ITS equipment trailers, portable changeable message sign trailers and arrow board trailers located within the clear zone shall be delineated with a minimum of four (4) Group 2 Drums, installed in advance of the device and spaced appropriately for the posted speed limit. Four Group 1 Cones may be substituted for Group 2 Drums in advance of arrow board trailers in short-term stationary and short duration applications.

(a) **Temporary (Construction) Signs:** The Contractor shall furnish, install, remove, relocate, and maintain temporary (construction) signs and/or sign panels necessary for prosecution of the work which shall include but not be limited to, maintenance of traffic, off project detour signs and begin and end of road work for construction, maintenance, permit, utility, and incident management activities. The Contractor shall also furnish and install those signs not listed in the *VWAPM, the Virginia Supplement to the MUTCD,* the *MUTCD,* or the Contract (such as "Turn Lane Open with arrow" and "Grooved Pavement Ahead") that may be required by the Engineer.

The Contractor shall fabricate or obtain signs which meet the design standards of the *Virginia Supplement to the MUTCD, VWAPM, Virginia Standard Highway Sign book,* the *MUTCD, and the Standard Highway Signs and Markings* book and it's *Supplement.* The Contractor shall submit shop drawings for any regulatory or warning signs not found in these manuals to the State Traffic Engineer for approval prior fabrication or installation. The shop drawing shall include sign size, legend, font, legend dimensions, radius, border, margins, sheeting type, and colors.

The Contractor shall relocate, cover, uncover, remove, and/or reinstall existing signs that conflict with the signs needed for maintenance of traffic. Covering existing signs shall be accomplished in accordance with Section 701.03(d).

The Contractor shall also ensure an unrestricted view of sign messages. The Contractor shall furnish and install flags for temporary (construction) signs, as directed by the Engineer; however, flags will not be required for use on portable sign supports.

Signs and their placement shall conform to the *VWAPM, the Virginia Supplement to the MUTCD,* the *MUTCD,* the Contract, and as directed by the Engineer. When the sign layout is not provided in the plans, either by illustration or reference to a typical traffic control figure in the VWAPM, the Contractor shall submit a sketch of his proposed temporary (construction) sign layout to the Engineer for approval before installation. The Contractor shall furnish sign supports, i.e., wood posts, square tube posts, or alternate posts, barrier and wall attachments, and hardware for use with the temporary (construction) signs. Signs shall be installed and attached to wooden supports or square tube sign post in accordance with Standard WSP-1 of the Standard Drawings with the exception of the top of the sign post, which may extend no more

than two feet above the top of the sign. The size and number of supports shall be in accordance with the details in the Standards.

Retroreflective rollup sign base materials conforming to Section 247 may be used for both daytime and nighttime operations up to a maximum of three consecutive days (72 continuous hours).

The Contractor shall furnish portable sign stands for mounting temporary (construction) signs in accordance with the following:

1. Portable sign stands for sign installations, their placement, and the allowed time of use in lieu of post installation, shall conform to the *VWAPM, the Virginia Supplement to the MUTCD,* the *MUTCD,* the Contract, and as directed by the Engineer.

2. Portable sign stands shall be used with signs having a substrate material of the type required in Section 512.02(f) and that were tested and found to be in compliance with NCHRP Report 350, Test Level 3, Manual for Assessing Hardware (MASH), or otherwise accepted in an FHWA acceptance letter for the specific sign stand.

Portable sign stands shall conform to NCHRP Report 350, Test Level 3, and/or MASH, and shall be selected from those shown on the *VDOT NCHRP-350 Approved List.* The Contractor shall submit a certification letter stating the brands and models of portable sign stands to be used along with a copy of the FHWA acceptance letter indicating compliance with NCHRP Report 350, Test Level 3, or MASH. Portable sign stands shall be self-erecting and shall accommodate signs of the shape planned for use on the project. Portable sign stands shall support a 20 square foot sign in sustained winds of 50 miles per hour or wind gusts of passing vehicles without tipping over, walking, or rotating more than ±5 degrees about its vertical axis. Additional weight consisting of no more than one sandbag weighing approximately 25 pounds placed on each leg or no more than two drum collar weights positioned on the center of the sign stand and around the mast may be used to comply with this requirement. When used on uneven surfaces, the portable sign stand shall be capable of adjusting to such surfaces to allow the signs to be placed approximately plumb to their position ±15 degrees. Portable sign stands shall include decals, stenciling, or some other durable marking system that indicates the manufacturer and model number of the stands. Such marking shall be of sufficient size so it is clearly legible to a person in a standing position.

When a portable sign stand is used to mount a temporary STOP (R1-1) sign, YIELD (R1-2) sign, EXIT OPEN (E5-2) sign, EXIT CLOSED (E5-2a) sign, EXIT (E5-V1) sign and TURN LANE (M4-V8L) sign, the sign shall be mounted at least 7 feet from the pavement surface to the bottom of the sign on intermediate-term, stationary operations or work operations of less work durations. For long term stationary projects, these signs shall be post mounted.

The Contractor shall erect, maintain, move, and be responsible for the security of sign panels and shall ensure an unrestricted view of sign messages for the safety of traffic.

The Contractor shall cover the entire sign face with opaque material approved by the Engineer when temporary (construction) signs are required to be covered to prevent the display of the sign message. Plywood shall only be used to cover post mounted temporary (construction) signs. Sign covering material attachment methods shall be a durable construction that will prevent the unintentional detachment of the material from the sign. At no time shall a

temporary (construction) sign on post or portable sign support be rotated to prevent the display of the message. The Contractor shall mount two ED-3 Type II delineators vertically on the posts of covered signs below the signs at a height of 4 feet to the top of the uppermost delineator. The bottom delineator shall be mounted 6 inches below the top delineator. The color of the delineator shall match the color of the pavement marking edge line. If no edge lines exist, the delineator shall be white.

(b) **Flagger Service:** The Contractor shall provide flagger service in accordance with Section 105.14.

(c) **Automatic Flagger Assistance Device (AFAD):** An AFAD system consists of two or more paired AFAD devices of the same make and model, allowing the paired system to be operated remotely by one or more operators. The trailers or carts and all mounted equipment shall be structurally adequate for unlimited normal operation in wind velocities up to 80 mph.

AFAD use shall conform to Sections 6E.04 and 6E.05 or 6E.06 of the VWAPM and this specification.

AFADs purchased prior to the effective date of these Specifications shall meet the requirements of the VWAPM. The Contractor shall submit proof of purchase and a letter certifying that their AFAD meets the requirements of the VWAPM.

All operators shall exclusively operate their AFAD in the AFAD system. The operating remote shall be capable of working the STOP/SLOW Sign AFAD and its flashing beacons or the CIRCULAR RED/YELLOW Lens AFAD and their intrusion alarm. The minimum communication range between the AFADs shall be one mile. The AFAD unit shall be equipped with a manual override system in case the remote fails.

The gate arm shall be made of a lightweight rigid material that deflects if an errant vehicle strikes the gate arm. The gate arm shall deflect and return to a functional position after the errant vehicle clears the gate arm. The height of the bottom of gate arm to the crown of the roadway shall be a minimum of 3.5 feet to a maximum of 4.5 feet.

Transition between STOP and SLOW Conditions - The gate arm shall begin descent to the down position no less than 2 seconds or more than 4 seconds after the AFAD unit displays the STOP face or Red Lens for approaching traffic to stop. The gate arm shall begin ascent to the upright position not less than 1 second or more than 2 seconds prior to display of the SLOW face or the Yellow Lens that allows stopped traffic to proceed.

STOP/SLOW AFAD Transition between STOP and SLOW Conditions:

Slow to Stop: The RED lens beacon shall enter a “flashing mode” at least 5 seconds before transitioning from the SLOW face to the STOP face. Immediately upon completion of the transition to display of the STOP face, the “flashing mode” of the RED lens beacon shall transition to a steadily illuminated condition.

Stop to Slow: The gate arm shall begin its ascent to the upright position not less than 1 second prior to the initiation of the transition from the STOP face to the SLOW face. The RED lens beacon shall cease to illuminate and the flashing YELLOW lens beacon shall begin to illuminate immediately upon completion of the transition of the STOP face to the SLOW face and the ascent of the gate arm to its completed upright position.

RED/YELLOW lens AFAD Transition between RED and YELLOW Conditions:

Yellow to Red: A flashing CIRCULAR YELLOW lens shall enter a steady illumination phase for a minimum of 5 seconds prior to transitioning to the steady illuminated Circular RED indication. The gate arm shall remain in the upright position during the display of the illuminated CIRCULAR YELLOW change interval.

Red to Yellow: The gate arm shall complete its ascent to the upright position within 1 to 2 seconds prior to flashing Circular YELLOW lens illumination. The illuminated Circular RED lens shall transition to the flashing Circular YELLOW lens. A change interval shall not be provided between the display of the CIRCULAR RED indication and the display of the flashing CIRCULAR YELLOW indication.

When approved by the Engineer, AFADs that are not specified on the plans but are installed by the Contractor for the Contractor's convenience to maintain traffic will be measured and paid for as Flagger Service and shall conform to the requirements above. AFADs shall not be used as Portable Temporary Signals.

(d) **Pilot Vehicles:** Where necessary and approved by the Engineer, the Contractor shall provide pilot vehicles in conjunction with flagger service to maintain two-way traffic. Each vehicle shall be equipped with at least one roof mounted vehicle warning light and shall display required signs conforming to Chapter 6F of the VWAPM while in service.

(e) **Electronic Arrows:** Electronic arrows shall be electronic flashing amber arrow or sequential chevron amber arrow or flashing amber four corner caution having dimmer controls and shall be mounted on suitable trucks or trailers. The Contractor shall maintain, deploy, and move electronic arrows as needed for traffic control.

(f) **Warning Lights:**

1. **Type A flashing lights** shall be used for advance warning signs and may be placed at hazardous locations on Group 2 channelizing devices according to FHWA acceptance letter WZ-54, and shall be in operation during hours of darkness and low visibility.

2. **Type B flashing lights** shall be used when specified on the plans for advanced warning signs and extremely hazardous locations. A Type B flashing light shall be installed on traffic barrier service at the beginning of the barrier run and at the breakpoint where the barrier becomes parallel to the roadway. A Type B flashing light shall also be used to delineate the breakpoints of a pull-off area. On two-way roadways where one lane is closed to traffic with traffic barrier service, the Type B flashing lights shall face the barrier transition (flare rate) for both barrier breakpoint directions. Type B flashing lights shall be in operation at all times except when used by Contractors to notify motorists of increased fines in a work zone when workers are present.

3. **Type C steady burn lights** shall be used when specified on the plans for channeling traffic and may be placed on Group 2 channelizing devices in accordance with FHWA acceptance letter WZ-54. Type C steady burn lights shall be placed at intervals of 80 feet along tangent sections and 40 feet along bridges, transitions, and curves greater than 6 degrees.

4. **Type D 360 degree steady burn lights** shall be used when specified on the plans for channeling traffic and may be placed on Group 2 channelizing devices.

Type A, Type C and Type D warning lights shall be in operation from 30 minutes before sunset until 30 minutes after sunrise, on heavy overcast days, in fog, and during periods of darkness or low visibility, or as directed by the Engineer.

When Type A or C warning lights are used on Group 2 channelizing devices, they shall comply with FHWA acceptance letter WZ-54. Otherwise, a FHWA issued acceptance letter indicating compliance with NCHRP Report 350, Test Level 3, or MASH as required in (f) herein shall be submitted to the Engineer before being authorized for use on the project.

When Type D warning lights are used on Group 2 channelizing devices, the channelizing devices shall have been crash tested with the warning light and a FHWA issued acceptance letter indicating compliance with NCHRP Report 350, Test Level 3, or MASH as required in (f) herein shall be submitted to the Engineer being authorized for use on the project.

(g) **Channelizing Devices:** Channelizing devices shall conform to NCHRP Report 350, Test Level 3, or MASH. All retroreflective sheeting for channelizing devices shall conform to Section 247. The Contractor shall provide catalog cuts/brochures of each brand and model and a certification letter stating the brands and models of channelizing devices conform to the specification and comply with the following before their use on the project.

1. **Channelizing devices except drums/cones with an auxiliary device attached and portable vertical panel assemblies:** The Contractor shall provide the Engineer a copy of a letter from the manufacturer certifying that the specific channelizing device is crashworthy, i.e., that it will comply with the evaluation criteria specified in NCHRP Report 350 or MASH. This certification may be a one page affidavit signed by the manufacturer.

2. **Drums/cones with an auxiliary device attached, and portable vertical panel assemblies with or without an auxiliary device attached:** The Contractor shall provide the Engineer a copy of the FHWA acceptance letter indicating compliance with NCHRP Report 350, Test Level 3, and or MASH.

   Spacing of all listed and non-listed channelizing devices shall be in accordance with the VWAPM.

   a. **Group 1 devices** shall consist of tubular markers and cones ranging from 36 inches to 42 inches in height conforming to the VWAPM. They shall be used as temporary channelizing devices. Tubular markers and cones shall be provided with retroreflective collars or sleeves conforming to Section 247 when used during hours of darkness.

   b. **Group 2 devices** shall be drums, vertical panels, directional indicator barriers, longitudinal channelizing devices or pedestrian channelizing devices.

      1) **Drums** shall be round or partially round; made from plastic; have a minimum height of 36 inches; have a cross-sectional width no less than 18 inches in any direction; have a closed top; and shall conform to the VWAPM. Drums shall be designed to allow for separation of ballast and drum upon vehicular impact but not from wind and vacuum created by passing vehicles. The base of the unit height shall not exceed 5 inches. Two-piece drums may have a flared drum foundation, a collar not exceeding 5 inches in height and be of suitable shape and weight to provide stable support. One-piece drums that comply with these requirements may be used.

Drum retroreflective sheeting shall be selected from the Materials Division's Approved Products List 46 and conform to the VWAPM.

Drums shall be used in all unmanned work zone locations and shall also be used to delineate the locations of all non-crashworthy trailer mounted devices such as but not limited to intelligent transportation systems (ITS), Portable Changeable Message Sign, Highway Advisory Radio, Speed Trailers, CB Wizards, ITS cameras, Portable Traffic Control Signals, AFAD units, etc. as well as light towers. Drums shall be used to delineate merging tapers on limited access highways during nighttime operations and the location of Electronic Arrow Boards.

The Contractor shall furnish and install signs (Stop, Chevron, Keep Right, etc.) for drums as directed by the Engineer. Signs used on drums shall be tested for conformance with NCHRP 350, Test Level 3, and/or MASH requirements and shall be made of the same material used in the test. The Contractor may use other materials allowed by the FHWA acceptance letter when approved by the Engineer.

2) **Vertical panels** shall be selected from those shown on the *VDOT NCHRP 350 Approved List.*

3) **Direction indicator barricades** shall consist of a One Direction Large Arrow sign mounted above a diagonal striped, horizontally aligned, retroreflective rail. The One Direction Large Arrow shall be black on orange. The rail shall have alternating diagonal orange and white 4 inch stripes sloping downward at a 45 degree angle in the direction vehicular traffic is to pass. The sign and bottom rail shall have a length of 24 inches and a height of 12 inches.

4) **Longitudinal channelizing devices** shall be at least 36 inches in height and interlocked. If used at night, longitudinal channelizing devices shall be supplemented with retroreflective material for delineation.

5) **Pedestrian barricade devices** shall be at least 36 inches in height. Pedestrian barricade devices shall be interlocked and, if used at night, supplemented with retroreflective material or delineation. Pedestrian barricade devices shall have a continuous detectable edge at least 6 inches above the walkway surface and be of a contrasting color to the walkway surface. A maximum 2 inch gap above the ground surface may be used to facilitate drainage.

All longitudinal channelizing and pedestrian barricade devices used to guide pedestrians shall be interlocked barricades without gaps that allow pedestrians to stray from the channelized path; be free of sharp, splintered or rough edges with all fasteners installed below the surface and capped.

(h) **Traffic Barrier Service:** Barrier service shall be of sufficient length to provide anchorage and protection of traffic and personnel in work areas.

The Contractor shall begin continuous progressive prosecution of the work protected by the barrier once the barrier is in place until its completion. If the Contractor ceases to continuously prosecute such work, the Engineer may cause the Contractor to discontinue operations in other areas on the project and concentrate work efforts behind the traffic barrier service

until that work is completed. The Contractor shall remove the traffic barrier service when the Engineer determines work is completed to the extent that traffic barrier service is no longer required. While performing work activities, workers and equipment shall remain behind the protection of the traffic barrier service except as approved by the Engineer. Work outside traffic barrier service protection shall only proceed under the protection and direction of approved traffic control devices or flagger service to safeguard workers and traffic in advance of and at the point the traffic barrier service is opened for ingress or egress adjacent to the travel lane. The Engineer will not permit any equipment extending into an open travel lane. Barrier openings for access to the work area may be provided only along tangent sections or along curved sections on the inside of traffic and shall be limited to the minimum length required for equipment access. The Contractor shall delineate and maintain normal pavement alignment at the barrier opening with Type D pavement marking. At ingress openings, the exposed end of the barrier service shall be provided with a temporary impact attenuator approved by the Engineer. At egress openings, the exposed end shall be transitioned at a rate that complies with the *Virginia Work Area Protection Manual.* For speeds below 30 miles per hour, the transition flare rate shall be the same as that indicated for 30 miles per hour. An impact attenuator will not be required at the exposed end of egress openings in barrier service provided the deflection angle between the pavement edge and ends of the barrier service openings is 20 degrees or more.

Repairs to traffic barrier service shall match existing barrier so that positive connections can be maintained.

Delineators from the Materials Division's Approved Products List 27 shall be designed and installed on traffic barrier service in accordance with the VWAPM. Barrier panels shall be installed on top of the concrete barrier service. Retroreflectorized sheeting shall comply with Section 247 and be on the Materials Division's Approved Products List 46.

The Contractor shall maintain the structural integrity of the barrier and its alignment while it is in use and shall maintain any associated warning lights, barrier delineators, barrier panels, and other devices in functional, clean and visible conditions at all times.

1. **Guardrail barrier service and terminal treatments** shall be installed in accordance with Section 505 except that the offset distance shall be as specified by the Engineer. The Contractor may be permitted to reuse guardrail and/or its hardware used for traffic barrier service guardrail for permanent installation provided the guardrail material is acceptable to the Engineer and conforms to Section 505 and the Standard Drawings for such guardrail. Marred galvanized surfaces shall be repaired in accordance with Section 233. Terminal treatments (St'd GR-7 and St'd GR-9) shall be permanently identified with a device specific Manufacturers' identification number by stamping or marking with a durable weather resistant material in accordance with Section 33.274.1 of the Code.

2. **Traffic barrier service** shall be installed in accordance with the plans and standard drawings or as directed by the Engineer, who will design according to Appendix A of the VWAPM. When traffic barrier ends at guardrail, fixed object attachment methods for construction zone shall be used to connect the barrier to the guardrail. Installation shall include additional guardrail posts and attachments as required. The traffic barrier, at a minimum, shall be tapered with the end of the barrier located behind the adjacent guardrail post in accordance to the VWAPM. Barrier connections shall be snug to prevent motion between sections.

Traffic barrier service used as a parapet shall be anchored as shown on the plans. Anchor holes in bridge decks shall be drilled with a rotary impact drill or other approved equipment that will limit damage to the deck. Anchor holes shall be located to avoid cutting reinforcing steel. Upon removal of the parapet, anchor holes shall be cleaned and filled with Type EP-4 or EP-5 epoxy mortar conforming to Section 243.

The Department will not permit the use of concrete traffic barrier service for permanent installations on bridge structures.

Traffic barrier service shall be selected from those shown on the *VDOT NCHRP 350 Approved List* or those approved by the Engineer and shall be interlocking barrier of the same design or type.

The Contractor shall visually inspect all traffic barrier service shipped to a project before placing it in use. Concrete barrier sections shall be structurally sound with no concrete missing along the top, bottom, sides, or end sections of the barrier; no through cracks; and no exposed rebar. The Contractor shall promptly remove any traffic barrier service found by the Contractor or Engineer to be unacceptable due to inadequate structural integrity or functionality and replace the concrete barrier service at no cost to the Department.

Concrete barrier service shall be cleaned or coated sufficiently to afford good visibility and uniformity of appearance.

All metal traffic barrier service shall meet NCHRP 350 or MASH and be on the *VDOT NCHRP 350 Approved List.* The Engineer will review and must approve the layout and anchorage method for job specific applications before the barrier is authorized for installation. Traffic barriers service not shown on the plans may be used at the request of the Contractor at the Contractor's expense.

(i) **Impact Attenuator Service:** The Contractor shall install impact attenuator service at locations shown on the plans or designated by the Engineer. An object marker for temporary impact attenuator shall be installed on the attenuator according to the details shown in the standard drawings. The object marker for impact attenuator service shall have reflective sheeting conforming to Section 247 featuring alternating diagonal black and orange 3 inch stripes sloping downward at an angle of 45 degrees in the direction vehicular traffic is to pass. Reflective sheeting shall be on the Materials Division's Approved Products List 46. Impact attenuators shall be permanently identified with a device specific Manufacturers' identification number by stamping or marking with a durable weather resistant material in accordance with § 33.2-274.1 of the Code of Virginia.

Only Type 1 re-directive impact attenuators shall be used on Limited Access highways with posted speed limits greater than 50 mph.

Impact Attenuator Service not shown on the plans may be used at the request of the Contractor for the Contractor's convenience at the Contractor's expense.

All impact attenuator service shall be reviewed and approved by the Location and Design Division Standards/Special Design Section before installation.

(j) **Traffic Signals:** The Contractor shall furnish, install, maintain, relocate, and remove existing, temporary, and/or proposed traffic signal equipment and all necessary hardware as needed

and as many times as necessary throughout the duration of construction to maintain operations at traffic signals. The Contractor shall revise the signal equipment, signal phasing, signal sequencing and signal timing as many times as deemed necessary or as directed by the Engineer.

Modify Signal or a Temporary Traffic Control Signal for maintenance of traffic shall be in accordance with the Contract or the Contractor's approved modifications for maintenance of traffic.

Modify Signal and Temporary Traffic Control Signal, when specified in the contract, shall be used as follows:

Modify Signal: The Contractor shall modify and maintain equipment and traffic operations at each existing traffic signal within the project limits, or a traffic signal at any other location specified in the contract, at all times or as specified in the contract. Existing signal equipment on the site, signal equipment brought to the site, revised signal equipment, proposed equipment, or any combination thereof shall be used.

Temporary Traffic Control Signal: The Contractor shall install a temporary traffic control signal at a location shown on the plans that is not currently signalized. The Contractor shall keep this temporary traffic signal operational at all times specified in the contract by using temporary signal equipment brought to the site.

A portable traffic control signal is a traffic control signal assembly, inclusive of signals and supports, which is designed to be easily transported and reused at different locations. Typically, a portable trailer is used with Portable Traffic Control signals. When indicated in the contract or approved by the Engineer, the Contractor may use a Portable Traffic Control Signal during signal modification or as a Temporary Traffic Control Signal.

Unless otherwise specified, when the Contractor is required to supply documentation and/or plans to the Engineer as specified below, a copy of the required documentation and/or accepted plans shall be maintained in a watertight enclosure within the signal cabinet.

The Contractor shall maintain communications with existing signals unless otherwise noted in the contract and provide communications to temporary traffic signals when noted in the contract so that the Department has online access to the signal controller and any other signal equipment specified in the contract.

1. **Plans:**

   a. **Signal layout plans:** When the Contractor proposes an alternate traffic control signal method or traffic control signal layout from that presented in the Contract, or when a Contractor prepared signal layout is specified in the Contract, the Contractor shall submit to the Engineer a plan depicting the Contractor's design for maintaining traffic flows.

      This plan shall be submitted for approval at least 30 days before implementation. A separate plan shall be submitted before each construction phase change that necessitates revision to the location of any signal supports, signal heads, cabinets, and/or controllers as well as revisions to signal phasing or phase sequencing.

The Contractor's design shall conform to the *MUTCD,* the *Virginia Supplement to the MUTCD,* the *Virginia Work Area Protection Manual* and Division VII. This plan shall depict:

- Intersection configuration, including the locations of lanes, curbs, sidewalks, pavement areas, stop line(s), and other geometric features
- The location of traffic signal supports, including trailers for portable traffic control signals
- Vehicular and/or pedestrian signal heads
- Controllers and/or cabinets
- Detection areas including type of detection
- Signal phasing and phase sequencing

b. **Signal timing plans:** When specified in the Contract, the Contractor shall submit a timing plan to the Engineer for each location where signal modification and/or Temporary Traffic Control Signal is specified. The timing plan shall include the applicable timing data specified in the Contract. A timing plan shall be submitted for approval at least 30 days before activation of a signal modification or a temporary traffic control signal and before each construction phase change that necessitates revisions to signal phasing, phase sequencing, removal/addition of lanes, intersection widths, and/or pedestrian crossing widths.

When the Contractor proposes to revise the clearance (yellow) and/or change (red) interval durations from the existing durations upon initiation of signal modification or those shown in the Contract, the Contractor shall submit the proposed modifications to the Engineer for approval.

All clearance (yellow) interval and change (red) interval calculations shall be determined in accordance with Traffic Engineering Memorandum 306.1 (or any document that supersedes Traffic Engineering Memorandum 306.1).

c. Professional engineer signing and sealing: Signal layout plans and Change and Clearance Interval calculations shall be prepared by or prepared directly under the supervision of a Professional Engineer licensed to practice engineering in the Commonwealth of Virginia.

2. **Equipment:** Existing traffic control signal equipment on the project site may be used during signal modifications and/or for Temporary Traffic Control Signals.

New, salvaged, or refurbished traffic control signal equipment brought to the project site for use during existing signal modifications and/or at temporary traffic control signals shall conform to the Specifications for new installations except that the controller, accessory, auxiliary, and conflict monitoring equipment may conform to NEMA TS-1 (Functional Standards), or as approved by the Engineer.

The Contractor may use new signal equipment for existing signal modifications or for signal modifications that will remain in place upon completion of the work. Such signal equipment shall meet the Specifications for new traffic control devices at the time of testing and acceptance of the permanent signal installation.

All Contractor supplied signal equipment or appurtenances that will remain the Contractor's property shall be included in the contract Lump Sum price for these items.

Furnishing and final installation of permanent signal equipment or appurtenances will not be paid for under this item. Relocation of any permanent signal equipment or appurtenances from the temporary location(s) to the permanent location shall be included in the cost of these items.

Portable traffic control signals shall conform to the following:

a. phase sequencing, timings, and conflict monitoring complying with NEMA TS-1 (Functional Standards).

b. 5 programmable day programs within a 24 hour period.

c. 12 inch aluminum or polycarbonate traffic signal head sections with backplates mounted in the vertical display arrangement. Aluminum backplates shall be used with aluminum signal heads. Plastic backplates shall be used with polycarbonate signal heads. Signal head sections may be mounted in the horizontal display arrangement when approved by the Engineer. Signal head sections and backplates shall conform to Section 238.

d. be equipped with vehicular detection that will detect all vehicles unless otherwise indicated in the Contract.

e. adequate safeguards to prevent unauthorized entry to the control equipment.

f. be a trailer mounted type with at least one of the two traffic signal heads positioned over the travelway with a minimum 16 feet of clearance from the pavement to the lowest point of the signal head assembly.

g. operate from its own self-contained power supply with the capability of connecting to an external 110 VAC electrical power supply. When operating from a self-contained solar power supply, the battery backup shall be capable of operating for 18 continuous days at 77 degrees F without solar array assistance.

h. be designed to comply in the operating mode with wind loading conditions associated with wind gusts of 80 miles per hour as specified in *AASHTO's 1994 Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.*

3. **Procedures:** The Contractor shall maintain existing traffic control signals in accordance with the Contract or the approved Plans in accordance with Section 512.03(i)1.

Installation of signal heads, span wire, tether wire, and rigging shall conform to Section 703.03 as applicable unless otherwise approved by the Engineer. Installation of cables, conduit, electrical service, grounding systems, and signal structures shall conform to Section 700.04 unless otherwise approved by the Engineer.

Temporary and portable traffic control signals that are not specified on the plans but are installed by the Contractor to support his operations shall be installed at the Contractor's expense and approved by the Engineer prior to use.

a. **Signal maintenance and operational responsibility:**

The Contractor shall maintain and operate Temporary Traffic Control Signals from initial activation until the Temporary Traffic Control Signal is removed or until the permanent signal installed at the location of the Temporary Traffic Control Signal is accepted by the Department in accordance with Section 703.

When an existing signalized intersection is used during construction, the existing intersection with all accepted modifications shall become the sole responsibility of the Department upon successful completion of the Local Intersection Acceptance Test in accordance with Section 703.

The Contractor shall maintain and operate existing traffic signals upon any signal modification until the signals are no longer required and are removed or the until permanent signal equipment installed at the location and/or final signal equipment modifications are accepted by the Department in accordance with Section 703. Before modifying signals, the Contractor shall inspect the existing traffic signal installation and verify its working condition in the presence of the Engineer. Upon completion of the inspection and verification that the signal is functioning properly, the Engineer will provide the Contractor written notice that maintenance responsibility for the signal has been transferred to the Contractor. The Contractors' responsibility for signal maintenance and operation shall begin at the date and time indicated on the written notice.

b. Traffic signal outages, malfunctions and emergencies: The Contractor shall be responsible for responding to, assessing and correcting all traffic signal outages, malfunctions, and emergency situations identified by the Engineer at locations for which the Contractor has assumed maintenance and operational responsibility. The Contractor shall furnish the Engineer with the emergency contact information of the supervisory employee of his company who shall be responsible for repair calls during all hours, including weekends, holidays, and any other times the Contractor is not on site at the intersection. The emergency contact information shall include the employee's name, phone number, email address and mobile number.

The following procedure shall be used when the Contractor is required to respond to an outage, malfunction, or other issue at a signal for which he has maintenance responsibility:

1) The Engineer will notify the Contractor of the location of the outage, malfunction, or other issue. Notifications may be by phone, email, or other communications methods.

2) The Contractor shall acknowledge receipt of the Engineer's notification within thirty (30) minutes after being notified. The Contractor shall respond via the same means as the original notification or by other approved method.

3) The Contractor shall arrive to the site within ninety (90) minutes of the Engineer's initial notification. The Contractor shall notify the Engineer upon arrival at the site.

4) The Contractor shall assess the situation and provide a diagnostic report to the Engineer within one hour of arrival onsite. The diagnostic report shall include details of the issue, the work necessary to complete the repair, and the estimated duration to make the repair.

5) The Engineer will direct the Contractor to immediately make the repair or to take other action relative to the issue. If the Contractor does not acknowledge receipt of the Engineer's notification as indicated in 2) above or does not arrive at the site within 90 minutes as indicated in 3) above, the Department may mobilize to the site, assess the situation, and take whatever action or make such repairs as it deems necessary in accordance with Section 105.14, and assess a per hour, per location nonresponse fee of the amount specified in the contract for each hour, or portion thereof, starting at either the time of initial notification by the Engineer. The assessment of this fee shall terminate either: when the Department leaves the site (if the Department has arrived on the site) or when the Contractor receives direction from the Engineer (if the Department has not arrived on the site). This shall in no way relieve the Contractor of his responsibility for maintaining and operating the signal and completing the work.

At the time of notification or at any time while the Contractor is in route to the site, the Contractor may request additional time to respond to the site due to inclement weather or circumstances beyond the Contractor's control. Approval of additional response time will be determined by the Engineer.

c. **Electrical Service:** The Contractor shall make arrangements with the local utility company for electrical service for Temporary Traffic Control Signals or for new service required during signal modifications, which shall include the cost of connection, disconnection, and energy. If electrical service is not available, the Contractor shall provide a generator capable of continuously operating the temporary and portable traffic control signals for at least 24 hours unassisted. All temporary traffic control signals used to control alternating one-way traffic shall be equipped with an Uninterruptable Power Supply system in accordance with Section 703. When generator power is used, all generator power shall be conditioned through an Uninterruptable Power Supply system in accordance with Section 703.

(k) **Temporary (Construction) Pavement Markings:** Temporary (construction) pavement markings shall be installed at locations shown on the plans, in the *Virginia Work Area Protection Manual,* and at other locations as directed by the Engineer. Temporary (construction) pavement markings shall conform to Section 704 and be selected from the Materials Division's Approved Products Lists 17 and 48. Temporary (construction) pavement markings are classified as Type A or B (temporary (construction) markings), Type D, Classes II and III (removable tape), and Type E (non-reflective black removable tape).Temporary (construction) pavement markings shall be used as follows:

1. **Type A or B pavement markings** shall be used where the roadway is to be resurfaced before changes in the traffic pattern or where pavement is to be demolished and traffic patterns will not change before demolition.

2. **Type D, Class II or III pavement markings** shall be used on final roadway surfaces or in areas where traffic patterns are subject to change before pavement is resurfaced. Type D, Class III pavement markings shall be used on Limited Access highway projects, or other locations as shown on the plans. Type D, Class II pavement markings may be used on all other roadways except Limited Access highways when specified on the plans. Type D, Class III pavement markings may be used in place of Type D, Class II pavement markings at the contract price for Type D, Class II pavement markings.

The Contractor may install Type A or B pavement markings when the surface temperature of the pavement is below the manufacturer's minimum application temperature for a Type D, Class II or III pavement marking, except on final pavement surfaces. In such cases, the Contractor shall select a Type A or B product known to perform the best under those temperature conditions. When a Type A or B pavement marking is used instead of a Type D pavement marking due to the surface temperature being below the manufacturer's minimum application temperature, the Contractor will be paid the contract price for Type D, Class II or Class III pavement marking, which shall include the Type A or B markings and any necessary eradication of the Type A or B pavement markings.

3. **Type E pavement markings** shall be used to cover existing markings in accordance with (l) herein.

   The Contractor shall install temporary (construction) pavement markings in accordance with the manufacturer's recommendations. Application thickness and bead application shall comply with the manufacturer's recommendations except as follows. If the manufacturer's recommendation for material thickness and quantity of beads is less than that used when the material was tested by the National Transportation Product Evaluation Program (NTPEP), the minimum product application rates shall conform to the NTPEP approved test rates for the specific marking. The Contractor shall furnish a copy of the manufacturer's installation recommendations including the NTPEP data for product thickness and glass bead quantities to the Engineer.

   The Contractor shall maintain the temporary (construction) pavement markings and shall correct any deficient markings by reapplying markings as directed or needed. The Department considers deficient temporary (construction) pavement markings as any markings that do not provide adequate guidance to motorists due to inadequate retroreflectivity, color qualities, or adherence to the pavement. The Engineer will make a visual nighttime inspection of all temporary (construction) pavement markings to identify areas of markings that have inadequate retroreflectivity qualities. Other deficient qualities may be identified by visual inspection at any time.

   Those markings that no longer adhere to the pavement which will cause guidance problems for motorists or that are inadequately retroreflective as determined by the Engineer shall be replaced by the Contractor with the following exceptions:

   a. Reapplication of skip line temporary (construction) pavement markings is not required unless the pavement marking does not adhere or inadequate retroreflectivity qualities are present for at least two consecutive skip lines.

   b. Reapplication of centerline (except skip lines) or edge line temporary (construction) pavement markings is not required unless the pavement marking does not adhere or inadequate retroreflectivity qualities are present for a continuous section of at least seventy (70) feet.

   c. Reapplication of transverse markings is not required unless the pavement marking does not adhere or inadequate retroreflectivity qualities are present for a continuous section of at least three (3) feet.

All Type A or B pavement markings that no longer adhere to the roadway that may cause guidance problems for motorists shall be removed and replaced by the Contractor.

The Contractor may take retroflectivity readings to counter visual observations by the Engineer as the basis for replacement of temporary (construction) pavement markings. These measurements shall be taken within forty eight (48) hours after the Contractor has been notified of the visual determination by the Engineer of deficient markings. The Engineer will grant additional time to the Contractor when inclement weather prevents accurate measurement of the temporary (construction) pavement markings.

The Contractor shall brush any form of debris from the marking before taking the retroflectivity readings. Retroflectivity measurements shall be taken in the presence of the Engineer using Contractor furnished equipment conforming to ASTM E 1710. A copy of the operating instructions for the reflectometer shall be furnished to the Engineer prior to taking the measurements. The Contractor shall operate the equipment in accordance with the manufacturer's instructions. The photometric quantity to be measured is the coefficient of retroreflected luminance (RL), which shall be expressed as millicandelas per square foot per footcandle. Measurements shall be taken at three (3) random locations within each area of markings that are suspected of being inadequately retroreflective. When the length of the questionable visually inspected area is greater than one (1) mile, the Contractor shall take measurements at three locations per mile segment or portion thereof. Measurements for all lines shall be taken in the middle of the line horizontally. Measurements for skip lines shall be taken in the middle of their length. Measurements for transverse lines shall be taken outside of the wheel path locations. The Engineer will designate the locations along the line segments where the measurements shall be taken. The Contractor shall make a log of the measurements and their locations and provide a copy to the Engineer. When the average of the three (3) readings for an area is below 100 millicandelas per square foot per footcandle, the Contractor shall reapply the markings as indicated.

Removable Type D temporary (construction) pavement markings shall be replaced within the time frames recommended by the markings manufacturer to prevent the need for eradication. The Contractor shall furnish the Engineer a copy of the manufacturer's recommendations.

Temporary (construction) pavement markings found in need of reapplication in accordance with these requirements shall be reapplied by the Contractor at no additional cost to the Department with the following exceptions:

- Type D markings that have been under traffic for more than ninety (90) days will be paid for at the contract unit price when reapplied unless the manufacturer's warranty coverage is still applicable.

- Markings damaged by the Department's snow removal or other maintenance and construction operations will be paid for at the contract unit price.

Temporary (construction) pavement markings shall be replaced in accordance with the time requirements of Section 704.

Eradication for reapplication of Type A or B pavement markings is not required if allowed by the marking manufacturer, provided the existing marking is well adhered and the total thickness of the existing and reapplied marking combined will not exceed 40 mils. If not well adhered, 90 percent of the existing markings shall be removed before reinstallation of the markings.

Temporary pavement markers shall be installed with temporary (construction) pavement markings in accordance with paragraph (m) herein.

(l) **Eradicating Pavement Markings:** Markings that may conflict with desired traffic movement, as determined by the Engineer, shall be eradicated as soon as practicable: either immediately before the shifting of traffic or immediately thereafter and before the conclusion of the workday during which the traffic shift is made.

The Contractor shall perform eradication by grinding, blasting, or a combination thereof. Grinding shall be limited to removal of material above the pavement surface except when removing thermoplastic and preformed tape markings, which may be removed by grinding alone. Blasting shall be used on both asphalt concrete and hydraulic cement concrete pavements to remove all other types of pavement markings.

The Department will not permit obscuring existing pavement markings with black paint or asphalt as a substitute for removal or obliteration.

The Contractor may submit other methods for eradication for the Engineer's approval. The Contractor shall minimize roadway surface damage when performing the eradication. The Contractor shall repair the pavement as directed by the Engineer, if eradication of pavement markings results in damage to or deterioration of the roadway presenting unsafe conditions for road users including, but not limited to, motorcyclists and bicyclists.

The Contractor shall ensure workers are protected in conformance with *Occupational Safety and Health Administration's (OSHA)* standards as detailed in 29 CFR 1910 or 1926, whichever is the most stringent, when eradicating pavement markings. The Contractor shall collect the eradication residue during or immediately after the eradication operation; however, dust shall be collected during the entire operation. Eradication residue from the removal of any pavement markings is considered to be a nonhazardous waste material and shall be disposed of in a properly permitted waste disposal facility in accordance with applicable state and federal laws and regulations. The Department does not require Contractor testing of the eradication residue for the eight Resource Conservation Recovery Act metals.

When markings are removed for lane shifts, transitions, or other areas or conditions required in the VWAPM, 100 percent of the pavement marking shall be removed.

Non-reflective removable black temporary (construction) pavement marking (Type E) may be used to cover existing markings instead of eradication on asphalt concrete surfaces when its use will not be required for more than 120 days or when specified as a pay item. The Contractor shall use this material to cover markings as indicated in the plans or as directed by the Engineer. Non-reflective removable black temporary (construction) pavement marking shall be applied in accordance with the manufacturer's recommendations.

(m) **Temporary Pavement Markers:** Temporary pavement markers shall be installed with temporary (construction) pavement markings in merging (lane drop) or shifting (lane shift) tapers of work zones that will encroach upon the traveled roadway for more than three (3) days and in other areas as required by the Engineer. Temporary pavement markers shall not be required on Type E removable markings or Type D, Class III removable markings.

Temporary pavement markers shall installed on 20 foot centers in merging and shifting tapers in accordance with the VWAPM. When temporary pavement markers are required in other areas, they shall be installed on 40 foot centers unless otherwise required by the Engineer. Temporary (construction) pavement markers shall be located between and in alignment with broken lines and beside solid line pavement markings opposite traffic. Where double line

pavement markings separating traffic are installed, two-way markers shall be installed between the lines. The Contractor may install two one-way markers instead of each two-way marker at no additional cost to the Department.

Temporary pavement markers shall be installed with a hot applied bitumen adhesive, except epoxy may be used on hydraulic cement concrete roadways and non-final surfaces of asphalt concrete roadways. Pavement damage caused by removing markers shall be repaired in kind by the Contractor at no additional cost to the Department.

The Contractor shall replace damaged, ineffective, or missing temporary pavement markers upon notification by the Engineer at no additional cost to the Department except those markers damaged by the Department's snow removal operations or other maintenance and construction operations which will be paid for at the contract unit price.

(n) **Diversions:** Where temporary structures are necessary to maintain traffic, such structures shall be of sufficient strength, width, and design to accommodate the volume and character of traffic using the highway, be designed by an Engineer licensed to practice engineering in the Commonwealth of Virginia, and provided by the Contractor. Temporary structures crossing waterways shall provide necessary hydraulic openings to accommodate the flow of the waterway. Temporary structure designs shall be submitted to the Engineer for review and approval prior to installation.

When a Diversion is no longer required, as determined by the Engineer, it shall be promptly removed, and the materials shall be disposed of as approved or directed by the Engineer. The Contractor shall design and provide temporary drainage facilities of adequate size to carry the normal flow of the existing drainage or waterway.

(o) **Aggregate Material:** Aggregate material shall be placed at crossovers, private entrances, mailbox turnouts and where specified by the Engineer.

(p) **Construction (Temporary) Pavement Message and Symbol Markings:** Message markings shall be the color required by the *MUTCD,* the plans for the specific location, or as specified by the Engineer. The Contractor shall install message and symbol markings in accordance with MUTCD, Section 704, Virginia Supplement of the MUTCD, VWAPM and Standard PM-10 of the *VDOT Road and Bridge Standards.*

Temporary pavement message and symbol markings shall be installed using Type A or Type D material as specified on the plans.

Pavement messages and symbols markings shall be installed at locations shown on the plans or at locations designated by the Engineer. The pavement message or symbol shall have clean and well-defined edges without running, bleeding or deformation, and shall be uniform in appearance throughout.

Temporary pavement message marking material including maintenance of the markings shall comply with the requirements for temporary pavement markings. Retroreflective measurements shall be taken out of the wheel path locations and each separate entity of a pavement message marking shall be replaced when the average of the three readings for the entity is below 100 millicandelas per square foot per footcandle.

Work performed in conjunction with paragraphs (k), (l), (m), and (p) herein shall be performed in accordance with Section 704 except as noted herein.

(q) **Type 3 Barricades:** Type 3 barricades shall conform to NCHRP Report 350, Test Level 3, or MASH, and be at least 4 feet wide with each barricade rail approximately 8 inches to 12 inches wide. Type 3 barricades shall be selected from those shown on the *VDOT NCHRP 350 Approved Products List.* The Contractor shall provide a certification letter stating the brands and models of Type III barricades from the list that will be used on the project. Instead of using Type 3 barricades on that listing, the Contractor may use other brands and/or models provided that he submits a copy of the FHWA acceptance letter indicating their compliance with NCHRP Report 350, Test Level 3, or MASH before their use.

The Contractor may provide additional weight to provide the required ballast by placing one sandbag weighing no more than approximately 50 pound on each leg of the frame of the Type 3 Barricade as flat to the ground as possible.

(r) **Truck-mounted or trailer-mounted attenuators:** Truck-mounted and trailer-mounted attenuators shall conform to NCHRP Report 350, Test Level 3, or MASH.

The Contractor shall submit catalog cuts/brochures of the Truck/Trailer-mounted attenuator and a copy of the FHWA's acceptance letter documenting acceptance of the specific Truck/Trailer-mounted attenuator before their use on the project. Truck-mounted and trailer-mounted attenuators shall be permanently identified with a device specific Manufacturers' identification number by stamping or marking with a durable weather resistant material in accordance with Section 33.274.1 of the Code.

The weight of the support vehicle shall be as recommended by the manufacturer of the Truck/Trailer-mounted attenuator. The Contractor shall provide a copy of the manufacturer's recommendations to the Engineer, a copy of the original weigh ticket for the support vehicle and a self-certification letter stating the support vehicle has not been altered since the original weight ticket was issued. The weigh ticket shall contain adequate information to associate the ticket with the applicable support vehicle. A copy of the self-certification and weigh ticket shall be available in the support vehicle at all times.

Additional weight may be added to the support vehicle to achieve the range recommended by the manufacturer of the Truck/Trailer-mounted attenuator provided the total weight is properly balanced without overloading any one axle and is within the Gross Vehicle Weight Recommendation of the support vehicle. The added weight shall be securely attached to the support vehicle to prevent movement during an impact or movement of the vehicle. The additional weight and attachment method shall be self-certified by the Contractor and a copy of the self-certification letter shall be with the support vehicle at all times or a final stage manufacturer's certification sticker may be placed on the inside door of the altered vehicle.

The Truck/Trailer-mounted attenuator shall be no less than 72 inches wide and no more than 96 inches wide.

The rear panel shall have alternate 6 to 8 inch wide orange and black or yellow and black chevron (inverted V) stripes. Stripes shall be sloped at a 45 degree angle downward in both directions from the upper center of the rear panel. Stripes shall be fabricated from fluorescent orange or yellow prismatic lens reflective sheeting conforming to Section 247.

The support vehicle shall have at least one rotating amber or one high intensity amber flashing vehicle warning light (visible for 360 degrees) functioning while in operation in accordance with the VWAPM. When allowed by the VWAPM, an electronic arrow operated in the caution

mode may be used with the vehicle warning light. When installing and removing lane closures on a multilane roadway as well as when performing mobile operations, the support vehicle shall be equipped with a vehicle warning light and an arrow board.

The support vehicle shall be operated and parked in accordance with the manufacturer's recommendations.

Limitations: Traffic control devices shall not be installed from or removed to the Truck/Trailer-mounted attenuator support vehicle. When the Truck/Trailer-mounted attenuator is deployed there shall be no unsecured material in the bed of the support vehicle except the additional secured weight or truck-mounted devices such as an arrow board, a changeable message sign, or truck mounted signs. There shall also be no additional devices such as signs, lights, and flag holders attached to the Truck/Trailer-mounted attenuator except those that were tested on the Truck/Trailer-mounted attenuator and provided by the manufacturer of the Truck/Trailer-mounted attenuator.

If the Truck/Trailer-mounted attenuator is impacted, resulting in damage that causes the unit to be ineffective, all work requiring the use of the Truck/Trailer-mounted attenuator shall cease until such time that repairs can be made or the Contractor provides another acceptable unit.

(s) **Portable Changeable Message Sign (PCMS):** Units shall be self-contained, including message board and power supply, whether trailer or vehicle mounted. The controller head shall have a backup system to prevent loss of memory.

The sign shall be capable of sequentially displaying at least 2 phases of 3 lines of text each with appropriate controls for selection of messages and variable off-on times. The message board text shall be formed of characters at least 18 inches high for trailer mounted PCMS or at least 10 inches for vehicle mounted PCMS or they should consist of a full matrix display. Each line shall be composed of at least eight characters and each character module shall at a minimum use a five wide by seven high pixel matrix. The message shall be composed from keyboard entries. The message shall be legible in any lighting condition. Motorists should be able to read the entire PCMS message twice while traveling at the posted speed.

The sign panel support shall provide for an acceptable roadway viewing height that shall be at least 7 feet from bottom of sign to crown of road.

The Contractor shall determine from its plan of operations or work schedule the most efficient and effective use of the PCMS units based on its plan of operations, maintenance of traffic sequencing, or traffic control operations. PCMS signs shall be periodically checked by the Contractor for compliance with manufacturer's requirements for operation and functions, and shall be ready for immediate use once deployed to the project.

During emergency situations the Contractor shall make every effort to deploy units it has assigned to the project. However, if the number of units shown on the plans are already in operation and cannot be reassigned to handle the emergency situation, the Contractor shall immediately contact the Engineer. The Engineer will then make a determination as to the most expeditious manner in which to deploy units for emergency use, whether by using Department supplied units, directing the Contractor to reassign those units he has committed to the project, or having the Contractor supply additional units as needed. In these circumstances, the cost for such additional units that are authorized by the Engineer shall be paid for in accordance with Section 109.05.

If the Engineer determines the use of additional units beyond the number of those identified in the plans is required due to reasons attributable to the Contractor or his manner of operations, and no units are available, the Contractor shall furnish such additional units to the project within two hours of the Engineer's request or the Department will move to provide such units as necessary and deduct the cost from any monies due the Contractor. This action by the Engineer, if necessary, shall in no way relieve the Contractor of the responsibility for controlling, maintaining, and completing the work.

The number of PCMS units estimated by the Department to be used for the project will be as shown on the plans. The number of units and hours of use estimated by the Department is based on the suggested maintenance of traffic shown in the plans and may be different from the Contractor's plan of operation.

(t) **Temporary Curb Ramps:** Temporary curb ramps shall conform to the minimum requirements of the 2*010 ADA Standards for Accessible Design.*

(u) **Temporary Detectable Warning Surface:** Temporary detectable warning surface shall conform to the minimum requirements of the *2010 ADA Standards for Accessible Design.*

(v) **Temporary Detectable Warning Strips:** Temporary detectable warning strips shall conform to the minimum requirements of the *2010 ADA Standards for Accessible Design.*

(w) **Portable Temporary Rumble Strip (PTRS):** Portable Temporary Rumble Strip (PTRS) is a transverse rumble strip that consists of intermittent, narrow, transverse areas of rough-textured or slightly raised or depressed surface that extends across the travel lane to alert drivers to unusual vehicular traffic conditions.

A PTRS may be made of rubber or recycled rubber and the color shall be orange or black. It shall have a recessed, raised or grooved design to prevent movement and hydroplaning.

A PTRS shall consist of interlocking or hinged segments of equal length that prevent separation when in use. The combined overall usable length of the PTRS shall be between 10 9 and 11 feet. The width of the PTRS shall be 12 to 13 inches. The maximum height of the PTRS shall be 1 inch; and the minimum height shall be 5/8 inch. The weight of each roadway strip shall be a minimum of 100 lbs. to a maximum of 120 lbs. The leading and departing edge taper shall be between 12 and 15 degrees.

The PTRS shall be installed without the use of adhesives or fasteners. Each roadway length of the PTRS shall have either a minimum of one cutout handle in the end of the rumble strip, or an interlocking segment which can be used as a handle for easy deployment or removal.

The manufacturer of the PTRS shall provide a signed affidavit that states the PTRS is able to withstand being run over by an 80,000 pound vehicle and retain its original placement with minor incidental movement of 6 inches or less during an 8 hour deployment. Incidental movement of the PTRS shall be parallel with other rumble strips in an array but shall not move so that its placement compromises the performance and safety of the other rumble strips, workers or the traveling public.

The PTRS shall be used in arrays of three rumble strips spaced 5 to 8 feet center to center, placed transverse across the travel lane. Only one set of PTRS should be used in the work zone's advance warning area per direction.

(x) **Work Zone Traffic Control:** The Contractor shall provide individuals trained in Work Zone Traffic Control in accordance with Section 105.14.

512.04—Measurement and Payment

Flagger service will be measured in hours of operation as authorized or approved by the Engineer. Authorized flagger service shall be according to the VWAPM and will be paid for at the contract unit price per hour. This price shall include paddles and safety equipment.

Automated flagger assistance device (AFAD) will be measured in hours of operation per each AFAD as authorized or approved by the Engineer. When the contract requires the use of the AFAD, it will be paid for at the contract unit price per hour for each device used. This price shall include furnishing or mobilizing the AFAD to the project, services of trained AFAD operator(s), channelizing devices, safety equipment, fuel, necessary warning devices and maintenance. Separate payment for the certified flagger operating the AFAD will not be made.

When an AFAD is used for the Contractor's convenience, each AFAD will be paid for as Flagger Service and will be measured in hours as authorized or approved by the Engineer.

Pilot vehicles will be measured in hours of actual use, as required by the Engineer, and will be paid for at the contract unit price per hour. This price shall include vehicles, drivers, necessary warning devices, fuel, and maintenance.

Electronic arrow boards will be measured in hours of actual use, as required by the Engineer, except when used as an alternative to rotating amber light or alternating high intensity amber flashing light. In such cases, payment will not be made for electronic arrows. Electronic arrows will be paid for at the contract unit price per hour. This price shall include arrow board, fuel, maintenance, and a truck or trailer having flashing amber warning lights.

Warning lights used on signs will be measured in days of actual use for the type specified and will be paid for at the contract unit price per day. This price shall include maintaining, relocating, and removing warning lights as needed. Warning lights installed on traffic barrier service will not be measured for separate payment, but the cost thereof shall be included in the contract linear foot price for traffic barrier service.

Group 1 channelizing devices will not be measured for separate payment. The cost thereof shall be included in the price for other appropriate pay items.

Group 2 channelizing devices, as required by the Engineer, will be measured in days and will be paid for at the contract unit price per day. This price shall include maintaining and removing devices when no longer required, and signs. When Group 2 channelizing devices are moved to a new location or are removed and reinstalled at the same location, they will be measured for separate payment. However, when the Group 2 channelizing devices are moved from one lane to another by simply moving the devices across the lane edge line without a planned or authorized removal from the roadway, no additional payment will be made.

Group 2 longitudinal channelizing devices will be measured in linear feet and will be paid for at the contract unit price per linear foot per location. This price shall include maintaining and removing when no longer required. When a Group 2 longitudinal channelizing device is moved to a new location as directed or approved by the Engineer, the relocated longitudinal channelizing device will be measured for separate payment.

Pedestrian barricade devices will be measured in linear feet and will be paid for at the contract unit price per foot per location. This price shall include maintaining, sand bag ballast, and removing when no longer required. When pedestrian barricade is moved to a new location as directed or approved by the Engineer, the relocated barricade will be measured for separate payment.

Traffic barrier service will be measured in linear feet and will be paid for at the contract unit price per foot per location. This price shall include maintaining Type B warning lights, barrier delineators, barrier panels, fixed object attachments; patching restraint holes, and removing when no longer required. When fixed object attachments are used on traffic barrier service in locations where existing guardrail is in place, this price shall also include restoring existing guardrail to its original condition. When traffic barrier service is moved to a new location as directed or approved by the Engineer, the relocated barrier will be measured for separate payment. Payment for traffic barrier service will not be made until the work behind the barrier is actively pursued.

Traffic barrier service guardrail terminal will be measured and paid for in units of each or linear feet, as applicable. This price shall include guardrail terminal, barrier delineators and removing the traffic barriers surface guardrail terminal when no longer needed. When traffic barrier service guardrail terminal is moved to a new location, as directed or approved by the Engineer, the relocated terminal will be measured for separate payment.

Impact attenuator service will be measured in units of each and will be paid for at the contract unit price per each. This price shall include impact attenuator and object marker. Impact attenuators used with barrier openings for equipment access will not be measured for separate payment but the cost thereof shall be included with other appropriate items. When impact attenuator service is moved to a new location, as directed or approved by the Engineer, the relocated terminal will be measured for separate payment.

Temporary traffic control signal will be paid for at the contract lump sum price for the location specified in the Contract. This price shall include, but not be limited to, supports; span wire; tether wire; conduit; conductor cable; traffic signal heads; backplates; hanger assemblies; necessary control items; vehicle detection; uninterruptable power supply; and, when approved, portable traffic control signal equipment. The price shall also include installing, maintaining, adjusting, and aligning signal equipment; when required plan development, inclusive of signal layout, signal timing, phasing, and/or sequencing; providing electrical service; utility company costs; and removing temporary signal equipment when no longer required.

Modify signal (Location) will be paid for at the contract lump sum price for the location specified in the Contract. This price shall include, but not be limited to, supports; span wire; tether wire; conduit; conductor cable; traffic signal heads; backplates; hanger assemblies; necessary control items; vehicle detection; uninterruptable power supply; and modifying existing or proposed signals as necessary to support temporary traffic alignments in various phases of project construction or, when approved, furnishing and installing portable traffic control signal equipment. The price shall also include supplying and installing supplemental signal equipment when necessary; maintaining, adjusting, and aligning signal equipment; plan development, inclusive of signal layout, signal timing, phasing, and sequencing; providing electrical service; utility company costs; and removing temporary equipment when no longer required.

Temporary (Construction) pavement markings will be measured in linear feet and will be paid for at the contract unit price per linear foot for the type, class and width specified. This price shall include marking materials, glass beads, adhesive, preparing the surface, maintaining, removing removable markings when no longer required, inspections, and testing.

Temporary (Construction) pavement message markings will be measured in units of each and will be paid for at the contract unit price per each. This price shall include marking materials, preparing the surface, adhesive, maintaining, removing removable markings when no longer required, inspections, and testing.

Temporary pavement markers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include temporary markers, surface preparation, adhesive, maintaining and replacing lost or damaged markers, and removing the pavement markers and adhesive when no longer required.

Eradication of existing pavement markings will be measured in linear feet of a 6 inch width or portion thereof as specified herein. Widths that exceed a 6 inch increment by more than 1/2 inch will be measured as the next 6 inch increment. Measurement and payment for eradication of existing pavement markings specified herein shall be limited to linear pavement line markings. Eradication of existing pavement markings will be paid for at the contract unit price per linear foot. This price shall include removing linear pavement line markings, cleanup, and disposing of residue.

Eradication of existing nonlinear pavement markings will be measured in square feet based on a theoretical box defined by the outermost limits of the nonlinear pavement markings as defined in Standard PM-10 of the VDOT Road and Bridge Standards. Nonlinear pavement markings shall include but not be limited to, arrows, images, symbols, and messages. Eradication of existing nonlinear pavement markings will be paid for at the contract unit price per square foot. This price shall include removing nonlinear pavement markings, cleanup, and disposing of residue.

Temporary Diversions will be measured in linear feet along the centerline of the Diversion or by individual components with the quantities shown on the plans as maintenance of traffic items, in which case the components will be measured in accordance with the applicable specifications. When listed as a single pay item, temporary Diversions will be paid for at the contract unit price per linear foot. This price shall include excavating, grading, aggregate materials, drainage items, asphalt, maintaining and removing the Diversion, disposing of surplus and unsuitable material, and restoring property.

Aggregate material will be measured in tons and will be paid for at the contract price per ton for the type specified. This price shall include preparing the grade and furnishing, placing, maintaining, and removing material as required.

Type 3 barricades will be measured in units of each and will be paid for at the contract unit price per each for the width specified. Multiple 4 foot wide Type 3 barricades may be used together to obtain the width specified in the pay item. This price shall include barricades with retroreflective sheeting; sandbags; appropriate warning signs; and maintaining, relocating to new locations, and removing the barricades when no longer required. When Type 3 barricades are moved to a new location, as directed or approved by the Engineer, the relocated barricade will be measured for separate payment.

Temporary (Construction) **signs** installed for long term stationary temporary traffic control zone as defined by the VWAPM, will be measured in square feet and will be paid for at the contract unit price per square foot. This price shall include furnishing, installing, maintaining; covering, uncovering, relocating and removing temporary signs, temporary sign panels, sign panel bracing, sign supports, hardware, delineators, and flags. Payment based on square footage shall be compensation for the sign(s) for the duration of the project; multiple payments for the same sign used more than once will not be allowed. Temporary signs, portable sign supports and weights, and vehicle mounted signs, their supports and mounting hardware used for intermediate term, short -term, short duration and mobile work operations, as defined in the VWAPM will not be measured for payment; all costs for providing such signs shall be included with other items of work.

Truck-mounted attenuator will be measured in hours of actual use and will be paid for at the contract unit price per hour. This price shall include the truck-mounted attenuator, support vehicle, vehicle warning lights, vehicle mounted signs, electronic arrow boards used in lieu of vehicle warning lights, and maintenance. Electronic arrow boards required on truck-mounted attenuator support vehicles in moving or mobile operations will be measured and paid for separately.

Portable changeable message sign will be measured in hours of actual use and will be paid for at the contract unit price per hour. This price shall include mobilizing the units to the project, maintenance, operation, and repositioning the units.

Temporary curb ramp will be measured in units of each and will be paid for at the contract unit price per each. This price shall include detectable edging, landings, maintaining, and removing when no longer required. When the temporary curb ramp is moved to a new location as directed or approved by the Engineer, the relocated temporary curb ramp will be measured for separate payment.

Temporary detectable warning surface will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include ADA compliant truncated domes, maintaining, and removing when no longer required

Portable Temporary rumble strip (PTRS) will be measured in units of each and will be paid for at the contract unit price per each array consisting of three rumble strips. This price shall include installing, maintaining, removing and relocating throughout the life of the project.

Temporary detectable warning strip will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include ADA compliant truncated domes, maintaining, and removing when no longer required.

Basic Work Zone Traffic Control: Separate payment will not be made for providing a person in accordance with Section 105.14. The cost thereof shall be included in the price of other appropriate pay items.

Intermediate Work Zone Traffic Control: Separate payment will not be made for providing a person in accordance with Section 105.14. The cost thereof shall be included in the price of other appropriate pay items.

Payment will be made under:

Pay Item	Pay Unit
Flagger service	Hour
Automated Flagger Assistance Device	Hour
Pilot vehicle	Hour
Electronic arrow board	Hour
Warning light (Type)	Day
Group 2 channelizing device	Day
Group 2 longitudinal channelizing device	Linear foot
Pedestrian barricade device	Linear foot
Traffic barrier service (Type and/or Standard)	Linear foot
Traffic barrier service Guardrail terminal (Standard)	Each or Linear foot
Impact attenuator service (Type)	Each
Temporary traffic control signal (Location)	Lump sum
Modify Signal (Location)	Lump sum
Temporary pavement marking (Type and width)	Linear foot
Temporary pavement message marking (Type and message)	Each
Eradication of existing pavement marking	Linear foot

Pay Item	Pay Unit
Eradication of existing nonlinear pavement marking	Square foot
Temporary pavement marker ([ ]-way)	Each
Temporary Diversion (Standard and type)	Linear foot
Aggregate material (No.)	Ton
Type 3 barricade (Width)	Each
Temporary sign	Square foot
Truck-mounted attenuator	Hour
Portable traffic control signal	Lump sum
Portable changeable message sign	Hour
Temporary curb ramp (Type)	Each
Temporary detectable warning surface (width)	Linear Foot
Temporary detectable warning strip	Linear Foot
Portable temporary rumble strip	Each

SECTION 513—MOBILIZATION

513.01—Description

This work shall consist of performing preliminary operations, including moving personnel and equipment to the project site; paying bonds and insurance premiums; and establishing the Contractor's offices, buildings, and other facilities necessary to allow work to begin on a substantial phase of the Contract.

513.02—Measurement and Payment

Mobilization will be paid for at the contract lump sum price. This price shall include demobilization.

Payment for mobilization up to the limitations specified hereinafter will be made in two separate installments. The first installment of 50 percent of the contract lump sum price will be made on the first progress estimate following partial mobilization and initiation of construction work. The second installment will be made on the next progress estimate following completion of substantial mobilization, including erection of the Contractor's offices and buildings. Completion of erection of processing plants, if any, will not be required as a condition for the release of the second installment.

If the original contract lump sum price exceeds the limit stated hereinafter, the excess will be included on the semifinal estimate as follows:

More Than	To and Including	Limit
$0	$200,000	10% of total contract amount
200,000	1,000,000	$20,000 plus 7.5% (of total contract amount minus $200,000)
1,000,000	More	$80,000 plus 5% (of total contract amount minus $1,000,000)

No additional payment will be made for demobilization and remobilization because of shutdowns, suspensions of work, or other mobilization activities.

When not shown as a pay item, the cost of mobilization shall be included in the price bid for other appropriate items of work.

Payment will be made under:

Pay Item	Pay Unit
Mobilization	Lump sum

SECTION 514 – FIELD OFFICE

514.01—Description

This work shall consist of furnishing, erecting, equipping, maintaining and removing upon completion a field office of the type specified for the exclusive use of Department Engineers and Inspectors at a location on the project approved by the Engineer.

514.02—Procedures

The field office and equipment required herein shall remain the property of the Contractor. The Contractor supplied Department field office shall be separated from buildings and trailers used by the Contractor and shall be erected and made functional as an initial operation of the work. The Contractor's failure to have the field office functional when work first begins on the project will result in the Engineer withholding payment of the Contractor's monthly progress estimate, except that the estimate will not be withheld if the Contractor has shown that the failure is not due to negligence on his part or for reasons beyond his control. The field office shall be operational throughout the duration of the project and shall be removed from the project site upon completion and final acceptance of the project. Furnishings and equipment specified herein shall be maintained in sound and functional condition throughout the duration of the project.

The field office shall be weatherproof, tightly floored and roofed, constructed with an air space above the ceiling for ventilation, supported above the ground and anchored against movement. The width of the field office shall be at least 8 feet, and the floor-to-floor ceiling height shall be at least 7 feet 6 inches. If a trailer is provided for the field office, its width shall be at least 7 feet 6 inches and the floor-to-ceiling height shall be at least 6 feet 6 inches. The inside walls and ceilings shall be constructed of Masonite, gypsum board, or other similarly suitable materials as permitted by national and\or local fire and building codes. The exterior walls, ceiling and floor shall be insulated. Field office shall be provided and outfitted as follows according to the type specified.

Type I Field Offices shall have an enclosed floor space of at least 500 square feet with 100 square feet of counter space and 120 square feet of overhead shelving. The field offices shall be equipped with the following:

Quantity	Item
4	Double–pedestal desks, keyed, (approximately 60 inches by 34 inches or at least 2,000 square inches)
1	Plan and drafting table (approximately 30 inches by 96 inches) with an adjustable stool
2	Computer tables - 29 inch height (approximately 48 inches by 30 inches surface area)

3	4-Drawer metal fire protection file cabinets, 15-inch drawer width, minimum UL rating of Class 350
2	2-Drawer fire protection file cabinets, 15 inch drawer width, minimum UL rating of Class 350
2	Rolling Plan racks for 24 by 36 inch drawings with 6 plan clamps
2	Bookcases, 36 inches by 42 inches with four shelves
1	Dry erase board – wall mounted, minimum 15 square feet, with eraser and markers
1	Small frost free refrigerator
1	Small microwave
2	Printing calculators
6	Office Chairs, 2 with casters
3	Wastebaskets
3	Folding conference tables – minimum 36 inches by 72 inches
4	Folding chairs
1	Pencil sharpener
1	Answering Machine
1	Facsimile machine with optional memory and service contract for preventative maintenance, including replacement print cartridges
1	Copy machine with the following features: - Capability of copying 8-1/2” x 11”, 8-1/2 x 14” and 11” x 17” sized originals - Bin sorter - Automatic Feed - Automatic paper size selection - Size magnification/reduction from 200% to 50% of original image size - Service contract with preventive maintenance, including drum replacement and toner supply
1	First Aid kit containing eyes and skin protection for emergencies
2	Smoke detectors with batteries

Type II Field Offices shall have an enclosed floor space of at least 400 square feet and shall be equipped with the following:

Quantity	Item
1	Double–pedestal desk, keyed (approximately 60 inches by 34 inches or at least 2,000 square inches)
1	Plan and drafting table (approximately 30 inches by 96 inches) with an adjustable stool
1	Computer table - 29 inch height (approximately 48 inches by 30 inches surface area)
1	4-Drawer metal fire protection file cabinet, 15 inch drawer width, minimum UL rating of Class 350
2	2-Drawer fire protection file cabinets, 15 inch drawer width, minimum UL rating of Class 350
1	Rolling Plan rack for 24 by 36 inch drawings with 6 plan clamps
1	Bookcase, 36 inches by 42 inches with four shelves
1	Dry erase board – wall mounted, minimum 15 square feet, with eraser and markers
1	Small frost free refrigerator
1	Small microwave
1	Printing calculator
4	Office chairs, 2 with casters
4	Folding chairs
4	Wastebaskets
1	Folding conference table – minimum 36 inches by 72 inches

1	Pencil sharpener
1	Answering Machine
1	Copy machine capable of copying 8-1/2” x 11”, 8-1/2” x 14” and 11” x 17” sized originals
1	First Aid kit containing eye and skin protection for emergencies
2	Smoke detectors with batteries

Type III Field Office shall have an enclosed floor space of at least 200 square feet and shall be equipped with the following:

Quantity	Item
1	Double–pedestal desk, keyed (approximately 42 inches by 30 inches) at least 1,250 square inches
1	Plan and drafting table (approximately 30 inches by 72 inches) with an adjustable stool
1	Computer table - 29 inch height (approximately 48 inches by 30 inches)
1	4-drawer metal fire protection file cabinet, 15 inch drawer width, minimum UL rating of Class 350
2	2-Drawer fire protection file cabinets, 15 inch drawer width, minimum UL rating of Class 350
1	Rolling Plan rack for 24 by 36 inch drawings with 6 plan clamps
1	Dry erase board – wall mounted, minimum 15 square feet, with eraser and markers
1	Small frost free refrigerator
1	Small microwave
1	Printing calculator
3	Office chairs, 2 with casters
4	Folding chairs
2	Wastebaskets
1	Folding conference table, minimum 36 inches by 72 inches
1	Pencil sharpener
1	Answering machine
1	First Aid kit containing eye and skin protection for emergencies
1	Smoke detector with batteries

(a) **Windows and Doors:** The field office shall have at least three windows with removable screens and appropriately sized blinds or shades. Each window shall have an area of at least 540 square inches, capable of being easily opened and secured from the inside. All field office types shall have at least two exterior passage doors. Doors shall be at least 30 inches in width and 78 inches in height. Exterior passage doors shall be equipped with locks and at least two keys per door shall be furnished to the Engineer or Project Inspector.

In addition, each exterior door shall be equipped with a steel security bar that is installed horizontally and fabricated to lock with a 3/8” diameter padlock shank. The Department will furnish the padlocks for the security bars.

(b) **Steps:** Steps shall conform to the State Building Code and shall be maintained free from obstructions.

(c) **Storage Facility for Nuclear Gage(s):** The field office shall be furnished with an outside storage facility for the Department’s nuclear gages. The storage facility shall not be located within 10 feet of any structure. This facility shall be provided with electrical power and shall be

equipped for an interior switched light and one single-phase, 120V, 15 amps, grounded, weatherproof, duplex receptacle for recharging the nuclear gages. The storage facility for the nuclear gages shall be weatherproof, tightly floored and roofed, and shall have a tamper resistant key operated lock with two keys furnished to the Engineer or Project Inspector.

(d) **Storage Facility for Test Equipment:** The field office shall be provided with a storage facility, separate from the office for storage of test equipment, other than the nuclear gage. The storage facility shall have a minimum floor space of 64 square feet and include four shelves at least 11 inches deep mounted along the length of one wall. The storage facility for test equipment shall be weatherproof, tightly floored and roofed, and shall have a tamper resistant key operated lock with two keys furnished to the Engineer or Project Inspector.

(e) **Lighting, Heating, and Air Conditioning:** The field office shall have satisfactory functional lighting, electrical outlets, heating equipment, an exhaust fan, and air conditioner connected to an operational power source. At least one of the light fixtures shall be a fluorescent light situated over the plan and drafting table. There shall also be at least one 100 watt incandescent or equivalent compact fluorescent lamps (CFL) or light emitting diode (LED) exterior light fixture at each exterior doorway. Electrical power and fuel for heating equipment shall be furnished by the Contractor.

(f) **Fire Extinguishers:** The Contractor shall furnish and maintain one fire extinguisher for each required exterior passage door. Fire extinguisher(s) may be chemical or dry powder, UL Classification 10B:C (minimum), suitable for Type A:B:C fires and shall be mounted and maintained in accordance with OSHA Safety and Health Standards.

(g) **Toilets:** Toilets shall conform to the state and local boards of health or other bodies or courts having jurisdiction in the area. Toilet facilities may be located either inside the Field Office or be portable toilet facilities.

If the Contractor provides toilet facilities inside the Field Office, the toilet facilities shall have a continuous supply of water at a flow rate of not less than five gallons per minute. The toilet facilities shall be connected to either a sewer line or a permitted sewage holding tank with sewage pumping at a frequency that prevents overflow and back ups. The toilet facilities shall have a positive functional lock on the inside of the doors.

If the Contractor provides portable toilet facilities, then there shall be separate facilities for both male and female personnel with appropriate signs for "Men's Rest Room" and "Women's Rest Room" having lettering at least 2 inches in height. Both men's and women's portable toilet facilities shall have an adequate positive locking system provided on the inside of the doors. The facility labeled "Women's Rest Room" shall also have a positive, uniquely-keyed, exterior locking device, and the Contractor shall provide two keys to the Engineer or Project Inspector.

The Contractor shall also provide washing facilities in accordance with VOSH regulations.

(h) **Drinking Water:** The Contractor may provide either potable water inside the Field Office or bottled drinking water service that includes a dispenser capable of providing both hot and cold water, and disposable cups. The Contractor shall cause the bottled drinking water service to replenish both bottled water and disposable cups no less frequently than twice per month.

(i) **Utilities:** Except for telephone services and high speed Internet service, the Contractor shall make arrangements for necessary utility connections, maintain utilities, pay utilities service

fees and bills, and make arrangements for final disconnection of utilities. The Contractor shall also furnish two touch tone telephones in each field office and permit the work necessary to install them.

(j) **Miscellaneous Items:** The field office shall also include the following:

1. A certification that the office is free of asbestos and other hazardous material.

2. A broom, dust pan, mop, mop bucket, general cleaning supplies, and trash bags.

3. An all weather parking area for either twelve vehicles (for a Type I office) or six vehicles (for either a Type II or a Type III office), and all weather graveled access to the public roadway. The Contractor shall maintain the parking area and graveled access such that it is passable with a compact sedan without causing vehicular damage. The parking lot shall be sufficiently lighted to illuminate all areas of the lot.

4. Security measures for the Field Office during other than normal working hours shall be equivalent to that used by the Contractor for his job site and office facilities.

514.03—Measurement and Payment

Field office will be measured in months of actual use by the Engineer and Inspectors and will be paid for at the contract unit price per month. This price shall include furnishing, erecting, maintaining, and removing the field office when no longer required, and providing the facilities, furnishings, equipment, utilities and services as described herein. Payment for periods less than one month shall be based on the pro-rata days during the month that the field office was used by the Engineer and Inspectors, however, payment will not be made for any time in excess of the time limit established in the Contract as extended in accordance with Section 108.04.

Installation and service fees for the telephone(s) and high speed Internet service will be paid for by the Department.

Payment will be made under:

Pay Item	Pay Unit
Field Office (Type)	Month

SECTION 515—PLANING OR MILLING PAVEMENT

515.01—Description

This work shall consist of mechanically planing rigid or flexible pavement to the designated depth specified in the Contract in preparation for pavement repair or pavement overlay and disposing of milled cuttings in accordance with Section 106.04 or using such cuttings in the work if permitted in the Contract or directed by the Engineer. Rigid pavement will mean hydraulic cement concrete pavement or hydraulic cement concrete surfaced pavements and flexible pavement will mean asphalt concrete or asphalt concrete surfaced pavements herein. Planing as used in this section may also be referred to as milling or grinding.

515.02—Equipment

The Contractor shall perform planing with a pavement planing or pavement grinding machine of a capacity and type that has operated successfully on work comparable to that specified in the Contract. Milling or cold planing equipment shall be capable of accurately cutting to the depth, width, length, and typical section specified in the Contract in flexible pavement or rigid pavement while leaving a uniformly cut or ground roadway surface capable of safely handling traffic prior to pavement repair or overlay placement. The milling equipment shall not damage the underlying pavement surface or structure. The milling machine shall be equipped with an automatic grade control system that will control the longitudinal profile and cross slope of the milled pavement surface as the milling operation proceeds. The ground speed of the machine and the cutting equipment shall operate independently. The machine shall have a self-contained water system for the control of dust and fine particles. The width of the machine shall allow for the safe passage of controlled public traffic while in use. The machine shall have a dust collection system or have a system capable of minimizing the dust created by the planing operation escaping into the atmosphere.

The Contractor shall continuously monitor the cutting or grinding head of the machine so as to produce and maintain the creation of a uniformly textured milled surface. Equipment and vehicles in use under traffic shall be equipped according to the VWAPM.

515.03—Procedures

Limitations of operations for planing operations shall be in accordance with Section 108.02 and as specified in the Contract.

The Contractor may perform either regular planing or performance planing at his option unless otherwise stated in the Contract. The finished surface for regular pavement planing and performance planing shall have a tolerance of plus or minus 1/4 inch per foot between any two contacts of the resultant surface and the testing edge of a 10-foot straightedge unless the Engineer directs otherwise.

No application of pavement overlay shall decrease the vertical clearance under a bridge. In situations where the existing pavement under the overpass cannot be planed in direct proportion to the proposed overlay, the Contractor shall tie down the new pavement to the existing pavement under the overpass no less than 75 feet from the outer edges of the overpass in accordance with Std. AC-1 Standard Drawings for Asphalt Concrete Overlay Transition.

The finished surface macrotexture for performance planing shall have a pavement macrotexture MTD (mean texture depth) of less than 2.0 millimeters. Testing for performance pavement planing shall be as described hereinafter.

Irregularities and high spots of existing pavement shall be eliminated. The pavement surface shall be planed, milled or ground to the designated grade or gradient specified on the plans, or when not specified as a grade, shall parallel that of the existing roadway. Transversely, the cross slopes of tangent sections shall be planed to approximately 1/4 inch per foot or as directed by the Engineer. Superelevated curves shall be planed as directed by the Engineer. Where the pavement is to be resurfaced by means of the application of an overlay on curb and gutter roadways, a 1-inch shoulder shall be cut along the gutter line to eliminate the necessity of feathering the edge of the new surface. Payment for providing the 1-inch shoulder shall be based on the total square yards of removed material regardless of the variable depth of the pass.

The finished planed surface shall be true to grade, free from gouges, grooves, ridges, fractures, soot, oil film, and other imperfections and shall have a uniformly textured appearance suitable for use as a temporary riding surface.

Humps and depressions that exceed the specified tolerances and require additional planing or grinding shall be subject to correction or replacement as directed by the Engineer at no additional cost to the Department.

The Contractor shall ensure positive drainage is provided for all planed surfaces in accordance with Section 315.05(c). The Contractor shall endeavor to work with existing drainage and grades to maintain positive flow when planing in curb and gutter sections. The Engineer may require the Contractor to erect signage to warn motorists, sweep the roadway to vacate the water, or in extreme cases, close the lane to traffic until proper drainage of the planed surface can be restored in the event of significant buildup of standing water.

The Contractor shall construct temporary transverse pavement-wedge tie-ins where planed existing pavement is to remain temporarily without overlay to the extent allowed or required herein, in Section 315, elsewhere in the Contract, or by the Engineer. Each tie-in shall be constructed no less than 3 feet in length for every inch of depth of pavement planing performed and shall consist of a mix that is suitable as a riding surface to provide a smooth transition between planed existing pavement and undisturbed existing pavement or bridge decks. The Contractor shall construct such tie-ins prior to the planed surface being opened to traffic.

When planing to a depth of 2 inches or less at a bridge, the planed surface at the bridge may be left unpaved for up to 10 days.

Additional or other limitations and conditions to planing operations will be as specified and applicable to the Contract.

515.04—Performance Pavement Planing Testing

The Contractor shall perform mean texture depth (MTD) testing of the macrotexture surface on performance planed pavement in accordance with ASTM E965. Testing shall be accomplished by using a volumetric technique after planing operations have been completed and prior to opening a section of performance planed pavement to public traffic on roadways with posted speed limits of 55 mph or greater. The Contractor shall randomly select 10 locations at each section. Each location shall be tested and the average MTD of the 10 locations per section determined. The average MTD of the performance planed site shall be less than 2.0 millimeters and the upper limit for any one MTD measurement shall not exceed 3.10 millimeters in order for that section to be exposed to traffic.

515.05—Measurement and Payment

Flexible pavement planing will be measured in square yards of pavement surface area removed to the depths specified in the Contract of the designated pavement type. The Engineer may direct the depth to be adjusted during the initial pass ± 1/2 inch due to field conditions at no additional cost, except in cases where such adjustment constitutes a “changed condition.” If the Engineer’s authorized adjustment of up to an additional 1/2 inch requires the Contractor to “square up” the planed

area (depth of planed area now in excess of 2 inches), this will be considered a "changed condition" to the Contract according to Section 104.02, and the additional 1/2 inch area will be measured for payment.

The planed area is defined as the area resulting from actual length and width of the planed pavement surface visually verified and approved by the Engineer for payment.

If scabbing or laminations still exist and the Contractor has uniformly planed the pavement to the maximum potential depth of the initial pass as defined by the pay item (depth +1/2 inch), the Engineer may direct the Contractor to perform additional passes to increase the depth to eliminate the scabbing or delamination. The area of additional passes or increased depth beyond the maximum potential depth of the initial pass will also be measured and paid for in square yards as authorized by the Engineer. Such additional passes (beyond the maximum potential depth of the original pass) will not be adjusted, as in averaging or as a percentage of the original depth or considered as the maximum potential depth of the initial pass, to achieve final measurement or payment.

Flexible pavement tie-in planing used to tie into existing structures such as curbs, combination curb and gutters, and bridge terminal walls will be measured in square yards of surface area removed within the variable depth range designated. Measurement will be based on the full surface area (the actual length and width of the planed pavement surface visually verified and accepted by the Engineer for payment) within the range of depth specified in the Contract. The Engineer may direct the depth to be adjusted during the initial pass up to and including an additional ½ inch of the maximum depth stated in the pay item due to field conditions such as scabbing or delamination at no additional cost, except where such adjustment constitutes a "changed condition."

If scabbing or laminations still exist after the Contractor has uniformly planed the pavement to the maximum potential depth of the initial variable pass as defined by the pay item (variable depth +1/2 inch), the Engineer may direct the Contractor to perform additional pass(es) to increase the depth to eliminate the scabbing or delamination. The area of additional pass(es) of increased depth beyond the maximum potential depth (+1/2 inch) of the initial variable depth pass will also be measured and paid for in square yards as authorized by the Engineer. Such additional pass(es) beyond the maximum potential depth of the original pass will not be adjusted, as in averaging, or as a percentage of the original depth, or considered as the maximum potential depth of the initial pass, to achieve final measurement or payment.

Rigid pavement planing will be measured in square yards of pavement surface area removed to the uniform depth specified in the contract and will be paid for at the contract unit price per square yard for the range of depth designated.

Rigid pavement tie-in planning will be measured in square yards of pavement surface area removed to the variable depth specified in the contract and will be paid for at the contract unit price per square yard for the range of depth designated.

Planing performed to tie-in overlaid pavement to existing pavement or bridge decks that is determined by the Engineer to be a part of the mainline planing operations will not be measured for separate payment, the cost of which shall be included in the price bid for the appropriate depth range of flexible or rigid pavement planing.

Pavement planing will be paid for at the contract unit price of the specified pavement type and depth or range of depths designated.

These prices shall include removing and disposing of existing pavement.

Payment will be made under:

Pay Item	Pay Unit
Flexible pavement planing (0-2” depth)	Square yard
Flexible pavement planing (Above 2”-4” depth)	Square yard
Flexible pavement planing (Above 4” depth)	Square yard
Flexible pavement tie-in planing (0-2” depth)	Square yard
Flexible pavement tie-in planing (Above 2”-4” depth)	Square yard
Flexible pavement planing (over 4” depth)	Square yard
Rigid pavement planing (0-2” depth)	Square yard
Rigid pavement tie-in planing (0-2” depth)	Square yard

SECTION 516—DEMOLITION OF BUILDINGS AND CLEARING PARCELS

516.01—Description

This work shall consist of disconnecting utilities, closing wells, demolishing building(s), removing materials from the right of way, and removing improvements and material unsuitable for use in roadway embankments from vacant parcels and other areas within the right of way.

516.02—Procedures

(a) **Utilities:** The Contractor shall make necessary arrangements and perform necessary work, in accordance with local ordinances, involved with disconnecting or interrupting public utilities or services. These services shall include, but not be limited to: gas, water, sewer, electrical power, cable\internet and telephone.

(b) **Closing Wells:** The Contractor shall close all wells prior to any demolition and clearing of parcels in accordance with State Board of Health Private Well Regulations, State Water Control Board, and local jurisdiction regulations. The Contractor shall execute and file abandonment document with the Virginia Department of Health in accordance with Section 107.01.

(c) **Refrigerant-Containing Appliances:** The Contractor shall disconnect all chemical refrigerant-containing equipment including air conditioners, heat pumps, and refrigerators in accordance with state and federal laws and regulations. Any disconnections shall be made by certified individuals.

(d) **Demolition:** The Department will issue written notification to the Contractor when buildings are ready for demolition. Demolition shall include removing and disposing of materials from buildings and appurtenances down to the ground lines or below the ground lines in the case of basements or similar existing below-ground structures.

The Contractor may use buildings designated for demolition for project-related office space or storage or as a field office for Department personnel only after receiving the Engineer’s written approval prior to occupancy.

The Contractor shall remove all regulated asbestos-containing materials (RACM) in accordance with the Special Provision for Asbestos Removal for Road Construction Demolition Projects, included in Contracts where such work is required or available upon request from the Department's jurisdictional district environmental office, prior to demolition or occupancy. Any structures that contain non-regulated asbestos-containing materials shall be demolished in accordance with the Special Provision for Demolition of Structures Containing Non-Friable Asbestos-Containing Materials included in Contracts where such work is required, also available upon request.

The Contractor shall assume all personal and property liability associated with the use of or salvaging of materials from such buildings and shall protect and save the state harmless from any and all damages and claims associated with such buildings. Salvage operations shall not be performed in advance of the Department's asbestos inspection, and if asbestos-containing materials are identified, prior to asbestos abatement activities. The Contractor is advised that the Department's asbestos inspection procedures are intended to support whole structure demolition and, as such, may not be sufficient to support worker protection for salvage operations. Any additional testing, abatement, notification, and/or worker protection activities required to salvage materials, and related costs, shall be the determination and sole obligation of the Contractor.

Buildings, materials resulting from their removal, and improvements on the property shall become the property of the Contractor at the time of their removal and shall be disposed of outside and away from the project site. Nothing herein shall be construed as giving the Contractor any rights in and to the buildings in the Contract except for their demolition or for the purposes permitted herein. The Contractor shall have no right to sell or lease the buildings. The Department does not warrant or guarantee the existence or continued existence of any materials that are a part of the demolition item(s) included in the Contract, and the Department will not be responsible in any way thereof to the Contractor.

(e) **Clearing Parcels:** Parcels shall not be cleared until buildings have been demolished or removed.

Clearing parcels shall include disposing of materials from noncombustible foundations down to and including floor slabs, basement slabs, and any improvement or appurtenance designated for removal but not listed as a pay item. Combustible debris and rubble, including fences, posts, or pillars shall be removed from the right of way or from within the limits of easements obtained for removing buildings that may be partially outside the right of way.

The Contractor shall limit the cutting or removing of trees and shrubs to those necessary for completion of the work as approved by the Engineer. Trees or shrubs that are cut down shall be removed from the right of way. The Contractor shall not enter or encroach on any parcel that is not included in the Contract.

Materials contained in cisterns, septic tanks, and other openings, including basements, shall be removed and properly disposed of in accordance with Section 107.01. Underground tanks shall be closed and removed; cisterns, septic tanks, and other openings, including basements shall be demolished; and the area shall be backfilled with materials suitable for use in roadway embankment according to Section 303.

516.03—Measurement and Payment

Demolition of buildings will be paid for at the contract lump sum price for the parcel and structure specified. This price shall include coordinating and performing utility work, disposing of materials, and

cleaning up. The Contractor shall also take into consideration the salvage value of any material removed and shall include the same in the lump sum price.

Clearing parcels will be paid for at the contract lump sum price for the specified parcel. This price shall include clearing, removing and disposing of materials, backfilling, and cleaning up. The limits of payment shall be from the construction limits to the right-of-way or easement line.

Closing wells will be measured in units of each and will be paid for at the contract unit price per each. This price shall include chlorinating, furnishing and installing cement grout or bentonite grout, or other material as applicable; backfilling; and filing of abandonment documents.

Payment will be made under:

Pay Item	Pay Unit
Demolition of building (Parcel no.) (D no.)	Lump sum
Clearing parcel (Parcel no.)	Lump sum
Closing well	Each

SECTION 517—CONTRACTOR CONSTRUCTION SURVEYING

517.01—Description

This work shall consist of the Contractor providing surveying and stakeout as detailed herein for the successful prosecution of work as indicated on the plans and as directed by the Engineer. Stakeout work shall be in accordance with the Department's Survey Manual and this specification.

517.02—General Requirements

The Contractor shall ensure the following surveying work shall be performed by or under the direct responsibility, control and personal supervision of a Land Surveyor holding a valid license to practice surveying in the Commonwealth of Virginia and who is experienced in highway construction stakeout work including the following:

- horizontal and vertical control for bridges,
- horizontal and vertical control for box culverts and single and multiple line pipe culverts as specified herein,
- horizontal and vertical control for additional centerlines or baselines for roadways, ramps, loops and connections and
- fine grade or other grade stakes as necessary for construction.
- when specified in the Contract, boundary surveying in accordance with Section 503.

All other surveying work shall be performed by or under the direct supervision and control of the Contractor who is experienced in highway construction stakeout.

The Contractor shall preserve Department furnished centerline or baseline control, references and location benchmarks. The Contractor shall provide all construction benchmarks and reference stakes he develops as detailed herein. All alignment established by the Contractor shall be referenced, with a copy of the references furnished to the Engineer.

For Construction or Minimum Plan projects, the Contractor shall provide the Engineer with a record copy of certified plats, survey drawings, field notes and computations prior to the use of said stakeout information for construction. Survey record drawings shall be prepared and certified in accordance with this specification and the sample figure drawings as shown in the Department's Survey Manual. Electronic data files may be submitted along with paper sketches and drawings, subject to the prior approval of the Engineer. All electronic copies submitted shall be in a format fully compatible with the Department's existing computer hardware and software.

For No Plan projects, the Contractor will not be required to reference alignment he creates; provide construction benchmarks and reference stakes he develops; provide record copy of certified plats, survey drawings, field notes, computations, survey record drawings, and electronic data files.

517.03—Contractor Responsibility for Examination of Data

For Construction or Minimum Plan projects, it shall be the responsibility of the Contractor to examine all surveying work provided by the Department for accuracy. Should a disagreement involving the accuracy of stakeout or survey work arise during construction, the Contractor shall provide written notice to the Engineer within 24 hours, precisely describing and documenting the discrepancy. The Engineer will determine the validity of the Contractor's assertion in the notice, respond to the Contractor within 3 working days of receipt of the Contractor's notice, and provide direction on how to proceed. The Engineer will give consideration to an extension of time in accordance with Section 108.04 or provide additional compensation as deemed appropriate after documentation and evidence to the Engineer's satisfaction if both of the following occurs:

- There are delays to the project as a result of inaccurate stakeout information provided by the Department where such delays adversely impact the critical path of the work or where extra expense is encountered by the Contractor to correct elements of defective survey work by the Department.

- Where written notice is provided by the Contractor within the timeframe specified. Failure to furnish written notice of such a discrepancy within the timeframe specified will invalidate any later claim for time impact or costs by the Contractor unless specifically waived by the Engineer.

Examination of Data as specified above will not be required of the Contractor for No Plan projects.

517.04—Construction (C) projects

The following specific requirements shall apply:

(a) **Digital Terrain Model (DTM) and Construction Cross-sections:** Original location Digital Terrain Model (DTM) will be provided by the Department and will serve as a basis of payment for earthwork. The Contractor shall be responsible for taking construction DTMs or cross-sections of areas that, in their determination, do not agree with the Department furnished original location DTMs. The Contractor shall submit the disputed DTM information to the Engineer for verification prior to any excavation by the Contractor in these alleged areas of change. The DTM information furnished by the Department and submitted by the Contractor shall be compatible to the Department's current DTM format.

(b) **Borrow Pits:** All borrow pit DTMs or cross-sections, originals and finals, will be secured by the Engineer through the Department Survey party. The Contractor should also secure DTMs or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained and submitted by the Contractor to substantiate their claim.

(c) **Temporary Benchmarks:** The Contractor shall provide and protect temporary construction benchmarks within the construction limits. Temporary construction benchmarks shall be located not farther than 500 feet apart for the total length of the project or as indicated on the plans. Temporary construction benchmarks that are disturbed by the Contractor's activities during construction operations shall be reestablished by the Contractor at no additional cost to the Department.

(d) **Horizontal and vertical control for bridges:** The Contractor shall stake all bridges. These stakeouts shall require certified plats. Certified plats, field notes, coordinates and computations shall be furnished by the Contractor to the Engineer in accordance with Sample Figures 2 and 3 as shown in the Deaprtment's Survey Manual prior to the Contractor beginning work on these structures.

(e) **Horizontal and vertical control for all box culverts, all pipe culvert installations (including single and multiple line installations) with a total hydraulic opening equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size:** These stakeouts are deemed critical and require certified plats. The Contractor's surveyor shall stake all such installations. Certified Plats for these stakeouts shall be furnished in accordance with Sample Figure 1 as shown in the Department's Survey Manual and shall be submitted to the Engineer prior to the Contractor beginning installation work on these culvert structures. The notes, coordinates, or computations used to support the platted information shall be provided to the Engineer with the certified plat. For the purposes of identifying those pipe culvert installations refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes shall apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

(f) **Horizontal and vertical control for pipe culvert installations (including single and multiple line installations) having a total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Contractor shall stake horizontal and vertical controls for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. These stakeouts require sketches, but not certified plats and shall be furnished to the Engineer prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes shall apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

(g) **Horizontal and vertical control for additional centerlines or baselines for roadways, ramps, loops and connections:** The Contractor shall provide horizontal and vertical controls for additional centerlines or baselines for roadways, ramps, loops and connections.

(h) **Grading and paving construction:** The Contractor shall provide fine grade or other grade stakes required for the construction of the project as the work progresses except as otherwise stated herein.

Fine grade stakes shall be set on all projects on which the plans show a definite grade line. Fine grade hubs shall be set on at least one side with distances and grades referenced to the finished centerline grade. Typically, on curves, the Contractor shall provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be required by the Engineer. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes shall be provided by the Contractor only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches shall be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections shall be staked by the Contractor.

Generally, slope stakes shall be set by the Contractor as an initial part of the construction operations on the project.

(i) **Right of way and boundary stakeout affecting property ownership:** Right of way stakes shall be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes shall be marked with both the station and offset back to centerline.

When specified in the Contract, the Contractor shall provide all final boundary stakeout in accordance with Section 503.

(j) **Locating and setting right-of-way monuments:** When specified in the Contract, the Contractor shall provide all location and final right of way monumentation in accordance with Section 503.

517.05—Minimum Plan (M) projects

Roadway centerlines shall be in accordance with the centerline shown on the plans or established by the Engineer. The grade shall generally follow that shown on the plans. In the absence of a grade line on the plans, the proposed grade shall generally follow the existing grade as directed by the Engineer. The approximate depth of centerline cuts and fills shall be obtained from the plans with the exception of certain locations at the discretion of the Engineer. At those locations, only a minimum number of centerline grade stakes may be furnished by the Department from which the approximate depth of centerline cuts and fills shall be obtained. Slope tolerances specified in the Specifications will not be required.

The following specific requirements shall apply:

(a) **Digital Terrain Model (DTM) and construction cross-sections:** “M” projects are based on plan quantities; therefore DTM and construction cross-sections are not required.

Should the Engineer determine at any time that an actual measurement is warranted, the Department will make the necessary measurement in the field.

(b) **Borrow Pits:** All borrow pit DTM's, originals and finals, will be secured by the Department. The Contractor should also secure DTMs or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained and submitted by the Contractor to substantiate the claim.

(c) **Horizontal and vertical control for bridges:** These stakeouts require certified plats. Certified plats, field notes, coordinates and computations shall be furnished to the Engineer by the Contractor in accordance with Sample Figures 2 and 3 as shown in the Department's Survey Manual prior to the Contractor beginning work on these structures.

(d) **Horizontal and vertical controls for all box culverts, all pipe culvert installations (including single and multiple line installations) with a total hydraulic opening equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size:** These stakeouts are deemed critical and require certified plats. Exceptions may be granted by the Engineer for simple closed systems by requiring stake out sketches. The Contractor shall stake all such installations. Certified Plats for these stakeouts shall be in accordance with Sample Figure 1 as shown in the Department's Survey Manual and shall be submitted to the Engineer prior to the Contractor beginning work on these culvert structures. The notes, coordinates, or computations used to support the platted information shall be provided by the Contractor to the Engineer with the certified plat.

(e) **Horizontal and vertical control for pipe culvert installations (including single and multiple line installations) having a total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Contractor shall stake horizontal and vertical controls for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. These stakeouts require sketches, but not certified plats and shall be furnished to the Engineer prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standard to determine areas of total hydraulic opening.

(f) **Temporary Benchmarks:** The Contractor shall provide and protect temporary construction benchmarks within the construction limits. Temporary construction benchmarks shall be located not farther than 500 feet apart for the total length of the project or as indicated on the plans. Temporary construction benchmarks that are disturbed by the Contractor's activities during construction operations shall be reestablished by the Contractor at no additional cost to the Department.

(g) **Grading and paving construction:** The Contractor shall provide fine grade or other grade stakes required for the construction of all projects except as stated herein as the work progresses. Slope stakes are not required on "M" projects.

Fine grade stakes shall be set on all projects on which the plans show a definite grade line. Fine grade hubs shall be set on at least one side with distances and grades referenced to the finished centerline grade. Typically, on curves, the Contractor shall provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be required by the Engineer. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes shall be provided by the Contractor only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches shall be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections shall be staked by the Contractor.

(h) **Right of way and boundary stakeout affecting property ownership:** Right of way stakes shall be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes shall be marked with both the station and offset back to centerline.

When specified in the Contract, the Contractor shall provide all final boundary stakeout in accordance with Section 503.

(i) **Setting right-of-way monuments:** When specified in the Contract, the Contractor shall provide final right of way monumentation.

517.06—No Plan (N) projects

Roadway centerlines shall be in accordance with the centerline shown on the plans or established by the Engineer. The grade shall generally follow that shown on the plans. In the absence of a grade line on the plans, the proposed grade shall generally follow the existing grade as directed by the Engineer. The approximate depth of centerline cuts and fills will be obtained from the plans with the exception of certain locations at the discretion of the Engineer. At those locations, only a minimum number of centerline grade stakes may be furnished by the Department from which the approximate depth of centerline cuts and fills may be obtained. Slope tolerances specified in the Specifications will not be required.

517.07—Measurement and Payment

Construction surveying will be paid for at the contract lump sum price for the type of project specified, Construction or Minimum Plan. This price shall be full compensation for performing the work prescribed herein.

Payment for construction surveying will be made upon written request by the Contractor. Such request shall be submitted to the Engineer no earlier than five days, and no later than two days prior to the progress estimate date. Payment may be made in increments selected by the Contractor. However, payments will not exceed 60 percent of the contract unit price bid until the Contractor provides the Engineer with surveying field notes, layouts, computations, certified plats, sketches and drawings in the format approved by the Engineer.

The cost of **No Plan project construction surveyin**g shall be included in the price bid for other appropriate items which shall be full compensation for performing the work prescribed herein.

Payment will be made under:

Pay Item	Pay Unit
Construction surveying (Type)	Lump sum

SECTION 518—TRAINEES ON CONSTRUCTION PROJECTS

518.01—Description

This work shall consist of providing the training specified herein as part of the Contractor's EEO Affirmative Action Program. This specification implements the provisions and requirements of 23 CFR, Part 230, Subpart A, Appendix B.

518.02—Procedures

The Contractor shall provide each trainee with a copy of the specific training program and a certificate showing the type and duration of training satisfactorily completed upon completion of the training program. The Contractor shall maintain records and furnish periodic reports to the Engineer documenting compliance with the requirements herein.

(a) **Number of Trainees:** The number of trainees for each contract shall be as specified in the Contract. The number of trainees is determined by the District Civil Rights Manager (DCRM). If the Contractor sublets a portion of the Contract, the Contractor shall determine how many trainees are to be trained by the subcontractor. The Contractor shall retain the primary responsibility for conforming to the training requirements imposed by this specification. The Contractor shall ensure that these same training requirements are included and made applicable to the subcontract. Where feasible, 25 percent of apprentices or trainees in each occupation shall be in their first year of apprenticeship or training.

(b) **Distribution of Trainees:** The number of trainees shall be distributed among the work classifications on the basis of the Contractor's needs and the availability of journeymen in the various classifications within a reasonable area of recruitment. The Contractor will be credited for each trainee employed by the Contractor or approved subcontractors under the Contract who is currently enrolled or becomes enrolled in an approved program.

The enrollment of minorities, women, and other disadvantaged persons is approved and monitored by the DCRM. Trainees will be enrolled and approved by the DCRM on Form C-65 prior to the start of training.

(c) **Minorities and Women:** Training and upgrading of minorities and women toward journeymen status are primary objectives under this program. The Contractor shall make every effort to enroll minority and women trainees by conducting systematic and direct recruitment through public and private sources likely to yield minority and women trainees to the extent such persons are available within a reasonable area of recruitment. The Contractor shall demonstrate the steps taken in pursuit thereof prior to a determination as to whether or not the Contractor is in compliance with the requirements herein. This training commitment shall not be used to discriminate against any applicant for training, whether a member of a minority group or not.

(d) **Use of Journeymen:** No employee shall be employed as a trainee in any classification in which the person has successfully completed a training course leading to journeyman status or has been employed as a journeyman. The Contractor shall satisfy this requirement by including appropriate questions on the employee application or by other suitable means. The Contractor's records shall document the findings in each case.

(e) **Length and Type of Training:** The minimum length and type of training for each classification shall be established in the training program selected by the Contractor and approved by the DCRM. The DCRM will approve a program if it is reasonably calculated and designed to meet the EEO obligations of the Contractor and qualify the average trainee for journeymen status in the indicated classification by the end of the training period. Apprenticeship programs registered with the U.S. Department of Labor, Bureau of Apprenticeship and Training, or with a state apprenticeship program (Virginia Department of Labor & Industry) recognized by the U.S. Department of Labor, Bureau of Apprenticeship and Training, will also be considered acceptable in meeting the trainee contract goal provided they are being administered in a manner consistent with the EEO obligations of the Contract. Approval of a training program shall be obtained from the DCRM prior to the commencement of work in the classification covered by the program.

Training shall be provided in the construction trade classifications indicated in the *On the Job Training (OJT) Manual for Standard Pre-Approved Job Classifications.* The Contractor shall provide all training on state or federally funded projects of the Department.

(f) **Commencement of Training:** It is normally expected that a trainee will begin training on the project as soon as is feasible after the start of the work that requires the skill involved and will remain on the project as long as training opportunities exist in the work classification or until the trainee has completed the training program. It is not required that all trainees be on board for the entire duration of the contract. The number trained will be determined on the basis of the total number enrolled under the contract for the entire contract period.

(g) **Payment to Trainees:** Trainees shall be paid at least 60 percent of the appropriate prevailing minimum journeyman's rate for the first half of the training period, 75 percent for the third quarter of the training period, and 90 percent for the last quarter of the training period unless apprentices in an approved existing program are enrolled as trainees on the project. In such cases, the appropriate rates approved by the DCRM in connection with the existing program shall apply to all trainees being trained for the same classification who are covered by these requirements.

(h) **Failure to Provide Required Training:** The Contractor's failure to provide the required training damages the effectiveness and integrity of this Affirmative Action Program and circumvents the Department's federal mandate to bring women and minorities into the highway construction industry. Therefore, if the Contractor has failed by the end of the project to meet the required trainee contract goal, the Contractor shall submit written good faith documentation indicating the reasons the trainee goal was not attained. This documentation shall be submitted to the DCRM, and should it be determined insufficient, the lack of commitment to this Affirmative Action Program will be relayed to the Engineer for inclusion in the Contractor's Performance Evaluation Report for the project.

Efforts taken by a Contractor that result in the OJT contract goal being exceeded will be recognized for the Contractor's support of the Department's commitment to assuring skill improvement opportunities for minorities and women in highway construction. To exceed an OJT goal is to enroll and graduate more trainees than the number specified in the contract.

518.03—Measurement and Payment

The Contractor will be paid $3.00 per hour for each employee who is trained in accordance with the approved training program, except as otherwise noted hereinafter. The DCRM can request approval by the Engineer that

a Contractor be paid for training persons in excess of the trainee contract goal specified or for trainees enrolled on a contract without a trainee goal. If approved, this payment will be made even though the Contractor received additional training program funds from other sources provided such other sources do not specifically prohibit the Contractor from receiving other payments. The Department will pay the Contractor stipend $3.00 per training hour for training occurring on state or federally funded Department projects.

The Contractor will be credited for each apprentice/trainee employed on the project and will be reimbursed on the basis of hours worked listed on certified payrolls and the weekly submittal of trainee Form C-67. This form will serve as a record of trainee hours completed under the Contract.

If, in the judgment of the Contractor, Engineer, and DCRM, a trainee becomes proficient enough to qualify as a journeyman before the end of the prescribed training program and the Contractor so employs the trainee, full credit will be given toward the attainment of the trainee goal; however, the Contractor will be paid only for the actual trainee hours completed. The Department will pay the Contractor for only those training hours completed if the trainee does not complete training due to lay-off, termination, or resignation.

No payment will be made to the Contractor should the required training not be provided or the trainee is not hired as a journeyman and there is evidence of a lack of good faith on the part of the Contractor in complying with the requirements specified herein.

SECTION 519—SOUND BARRIER WALLS

519.01—Description

This work shall consist of furnishing and constructing sound barrier walls in accordance with these specifications and approved working drawings furnished by the Contractor and within the specified tolerances for the lines, grades, and details shown on the plans or as established by the Engineer.

(a) **Acoustic performance standards:**

1. Sound barrier walls shall provide a transmission loss of at least 23 dB(A) when tested in accordance with ASTM E90 using the typical truck noise spectrum and shall have vibration-free connections, joints and fittings.

2. Absorptive sound barrier walls shall be designed so that the absorptive portion on the highway side has a minimum noise reduction coefficient of 0.70 when measured in accordance with ASTM C423.

3. Sound barrier walls shall be designed to minimize or eliminate gaps or openings to prevent transmission of sound through the barrier.

(b) **Design Standards:**

1. Structural design loadings for sound barrier walls shall be based on a design life of not less than 50 years. Sound barrier walls shall be designed in accordance with the current AASHTO Guide Specification for Structural Design of Sound Barriers except as modified herein. References in the AASHTO sound barrier specification to “an industry recognized

specification" shall not apply. All concrete, steel, and aluminum members shall be proportioned with reference to the service load design methods (allowable or working stress design) of the current AASHTO Standard Specifications for Highway Bridges. Fatigue and traffic impact shall be considered in the design of these structures. Sound barrier walls subject to lateral earth pressure shall have those portions so loaded, designed in accordance with the aforementioned AASHTO specifications. In all cases, settlement shall also be considered.

2. Unless specified otherwise, this paragraph governs the selection of wind pressure coefficients in Virginia. Any sound barrier wall (structure or ground mounted) to be constructed within one half mile of the shore of the Chesapeake Bay or the Atlantic Ocean shall be designed for exposure category D. All other ground-mounted sound barrier walls shall be designed for exposure category B2, and all other structure-mounted sound barrier walls shall be designed for exposure category C. The wind pressure to be applied to the full height of the wall shall be based on the height to the centroid of the loaded area. For structure-mounted walls, this height shall be measured from the surface of the feature over which the bridge or structure crosses (e.g. mean sea level of the Chesapeake Bay, normal water level at stream crossings, roadway surface on the low shoulder at highway intersections) or in the case of sound barrier walls mounted on retaining walls, measured from the prevailing ground elevation in the vicinity of the sound barrier wall.

3. Unless specified otherwise, this paragraph governs the selection of wind speeds for design purposes (50-year mean recurrence interval) in Virginia. Sound barrier walls in Hampton Roads District shall be designed for a wind speed of not less than 100 mph. Walls in Fredericksburg, Northern Virginia and Richmond Districts shall be designed for a wind speed of not less than 90 mph. Walls in Bristol, Culpeper, Lynchburg, Salem and Staunton Districts shall be designed for a wind speed of not less than 80 mph. Any continuous wall crossing district boundaries may use the lower of the two adjacent wind speeds.

4 The vertical posts shall be proportioned to have a maximum deflection of no more than h/240 due to wind load, where "h" is the cantilever height of the post from the top of foundation to the top of the sound barrier wall. The unbraced length of the post for design shall not be less than "h" unless both flanges are sufficiently braced to allow a reduction of the unbraced length of the section. Post design shall account for the presence of all holes needed for connections. Wall panels and other supporting members shall be proportioned to have a maximum deflection of no more than l/240 due to wind load, where "l" is the length of the panel or member.

5. Structure-mounted sound barrier panels shall not weigh more than 7.5 psf and the structure-mounted sound barrier system shall not weigh more than 15 psf. Posts for structure-mounted sound barrier wall panels shall not be spaced more than 8 feet on center. Posts shall only be mounted on the outside of parapets. The Contractor and wall manufacturer shall be responsible for the anchorage of the sound barrier wall to the structure including the location of anchor rods, pattern or layout of rods, size, length of embedment, base plate for attachment, posts, etc. Structure elements designed to accommodate sound barrier walls shall not be slip formed.

   Posts for ground-mounted sound barrier panels shall not be spaced more than 24 feet on center.

6. Anchor rod performance shall be evaluated against the net area of the anchor rod after reduction to account for threads. Anchor rods shall be checked against the effect of

combined stresses in accordance with the following formula (found in the 2013 *AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*):

$$\left(\frac{f_v}{F_v}\right)^2 + \left(\frac{f_t}{F_t}\right)^2 \leq 1.0$$

Where:

F_t is the allowable normal stress on the rod, 0.5 x F_y

f_t is the predicted normal stress on the rod due to direct compression or tension and bending:

$f_t = f_a + f_b$ where:

f_a is the predicted stress on the rod due to direct compression or tension

f_b is the predicted stress on the rod due to bending about the rod's neutral axis

f_b shall be included in the computation of f_t whenever the clearance between the bottom of the leveling nuts and the top of the concrete foundation is greater than or equal to the diameter of the rod

F_v is the allowable stress on the rod due to direct shear, 0.3 x F_y

f_v is the predicted stress on the rod due to direct shear

Note: All stresses are based on the applied load acting on the net area after consideration for the reduction due to the presence of the threads.

e.g. $\text{Net Area} = 0.7854\left(D - \frac{0.9743}{n}\right)^2$ and $S_x = 0.0982\left(D - \frac{0.9743}{n}\right)^3$

where "D" is the diameter of the rod in inches and "n" is the number of threads per inch.

No mortar, grout or concrete shall be placed between the bottom of the base plate and the top of the concrete.

7. Soil friction angle and strength of soils shall be used when designing foundations. Foundations shall be designed in accordance with the current AASHTO Standard Specifications for Highway Bridges. Foundation designs may require pilings, caissons, or special designs as indicated by subsurface investigations (soil reports and boring logs) to establish bearing capacity.

8. When caissons are used, the soil at the surface to a depth equal to the required diameter of the caisson, but not less than two (2) feet or as required by the conditions, shall not be considered effective when calculating the required embedment of the caisson. The ground surface slope shall be taken into account when determining caisson embedment.

   An unfactored wind load shall be used in the analysis. Deflections and factors of safety for caissons shall be determined using actual wind loads not factored loadings.

   For axial capacity, the caisson tip elevation shall provide a length of caisson such that at least two thirds of the total predicted resistance is provided by shaft resistance. Total vertical deflection of the caisson head, from settlement and elastic shorting of the caisson, is limited to one (1) inch under service axial design loads.

The minimum area of longitudinal reinforcement for caisson type foundations shall be one percent of the gross area of the foundation section. In caissons where the wall post/beam is embedded to the bottom of the caisson, no reinforcement is required.

The required allowable stresses for steel and concrete in the caisson may be modified by the allowable overstress permitted in the wind load condition.

9. The Brom's method may be used for the design of laterally loaded caissons less than twenty (20) feet in length. For Group II and Group IV, where wind is a contributing load, a minimum safety factor of 2.25 shall be used if soil parameters are based on the results of standard penetration tests. When parameters are based on the results of subsurface exploration and laboratory testing programs as detailed in the current *AASHTO Standard Specifications for Highway Bridges,* or are set by the Department, a safety factor of 2.0 may be used.

   The preferred method of analyses for the design of laterally loaded caissons is the "p-y curve" method for the design and analysis of caissons under lateral loads, using public domain computer program such as COM624P or commercially available software. The caisson embedment shall provide a length where the second point of zero deflection is reached. The second point of zero deflection may be assumed to be the point on the deflection curve where the deflection is decreasing and becomes less than 0.02 inch. The total horizontal deflection at the head of the caisson is limited to 0.5 inch.

   Temporary casing may be used to stabilize a drill hole; however, the Contractor shall remove the temporary casing immediately prior to or while placing the concrete. If the drill hole can not be maintained, the Contractor shall employ other methods of stabilizing the excavation such as wet hole construction with slurry.

   If, at the time of placing concrete, water in the hole exceeds five (5) feet or 20% of the caisson length, whichever is greater, the Contractor shall install the concrete by pump or tremie.

10. For walls on spread footings, the Contractor shall furnish the Engineer, for the Engineer's consideration and acceptance, a bearing capacity analysis as part of the design calculations. The safety factor against bearing failure shall be taken as 2.25 for Group II and Group IV where wind is a contributing load. The ground surface slope shall be taken into account when determining bearing capacity of the soil. The depth of the embedment of footings shall be in accordance with the aforementioned current *AASHTO Standard Specifications for Highway Bridges.*

11. For walls on piles, foundation design shall be in accordance with current *AASHTO Standard Specifications for Highway Bridges.* The factor of safety shall be on the level of construction control as required in Subsection 4.4.6.2. The required factors of safety may be modified by the allowable overstress permitted in the wind load condition.

12. Where new sound barrier walls tie into existing barriers, existing sound barrier walls and other structures shall be analyzed to determine if they are adequately stable for the addition of new loads, if the Contractor chooses to use them for support. The Contractor shall make any field measurements and observations necessary to analyze the existing structures and detail all connections. Alternatively, the new wall may be designed to be independent of existing structures with details for closing gaps.

13. The Contractor shall submit nine (9) copies of the working drawings and supporting calculations in accordance with Section 105.10 to:

    Virginia Department of Transportation
    Location and Design Division
    Engineering Services
    1401 E. Broad Street
    Richmond, Virginia 23219

    Working drawings shall contain all specific details and dimensions (such as post spacings, post sizes, foundation details, and panel fabrication and attachment details) necessary for the complete review, construction and inspection of the work. The working drawings for sound barrier walls shall also reflect coordination with the working drawings for retaining walls, bridges or other mounting structures or adjacent construction items where applicable. Working drawings and the accompanying calculations shall be sealed by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia. Calculations using computer programs or spreadsheets shall include a description of the design methodology necessary to validate the results of the computer output.

    Any changes to the working drawings by the Contractor after the initial submittal shall be clearly identified on subsequent revisions. Changes shall be identified on the working drawings, denoted in a narrative (e.g. cover letter) and dated after making all requested changes. This format shall be followed until all Department requested responses are addressed and changes are completed to the satisfaction of the Engineer. Approval of these working drawings shall not relieve the Contractor of the responsibility for accuracy of the drawings or conformity with contract and site requirements. Approval by the Department will not indicate a check on dimensions.

519.02—Materials

The Contractor may furnish plastic, metal, concrete or, in specific applications, wooden sound barrier walls. Walls shall conform to the Contract, AASHTO material specifications and the following applicable specifications. Acceptable wall system designs shall have been pre-approved by the Department for use. Requirements for evaluation and approval of sound barrier wall may be obtained from the Air, Noise, and Energy section of the Environmental Quality Division.

(a) **Concrete** shall conform to Section 217 and Section 404 or 405 as applicable. Concrete for reflective sound barrier panels and concrete posts shall be Class A5. Concrete for footings or leveling pads shall be Class A3. All other concrete shall be Class A5 or Class A4. Sound absorptive concrete shall be considered a sound coating subject to other provisions in the specifications; the manufacturer's cited standards or proprietary materials and the Contract. The use of systems employing such sound absorptive concrete materials shall require pre-approval by the Department.

(b) **Reinforcing steel** shall conform to Section 223. Reinforcing steel requiring welding shall be ASTM A706, Grade 60, and shall be welded in accordance with the current AWS D1.4. All other reinforcing steel shall be ASTM A615, Grade 60, or ASTM A706, Grade 60. Threads on reinforcing steel bars shall be UNC (coarse) Series, Class 2A as specified in ANSI B1.1. Welded wire fabric used to reinforce sound barrier panels shall conform to Section 223.

(c) **Aluminum** shall conform to Section 229 for the use and shape specified. Welding of aluminum shall be performed in accordance with current AWS D1.2.

(d) **Steel piles** shall conform to Section 228. Steel piles that shall be used as posts will be galvanized in accordance with Section 233 for their full length above the finished grade and to a point 2 feet below the finished grade.

(e) **Structural Steel** shall conform to Sections 226 and 407, and shall be galvanized in accordance with Section 233. Painting of structural steel shall be in accordance with Section 411.

(f) **Structural tubing** shall conform to ASTM A500 and Sections 226 and 407; and shall be galvanized in accordance with Section 233. Structural tubing serving as posts is subject to Charpy V-Notch Impact test requirements in accordance with Section 226.

(g) **Miscellaneous steel** shall conform to Sections 226 and 407, and shall be galvanized in accordance with Section 233.

(h) **Asphalt mastic** shall conform to and be applied in accordance with AASHTO M243.

(i) **Miscellaneous hardware** shall conform to the following: Anchor rods shall conform to Section 226.02(c), and shall be galvanized in accordance with Section 233. One nut and one washer shall be provided above and below the base plate at the connection to the anchor rods. The nut against the base plate shall be installed in such a way as to tension the anchor rod and create adequate friction between the nut and the base plate. There shall be no play or slack in the connection of the anchor rods to the base plate after the nuts have been tightened. The distance from the underside of the base plate to the top of the concrete shall be no more than the diameter of the anchor bolt plus one inch.

Bolts, nuts, and washers shall be high strength steel conforming to Section 226.02(h) and shall be galvanized in accordance with Section 233. Self-drilling screws shall be Class 410 stainless steel conforming to FS QQ-S-763 and shall be cadmium coated in accordance with ASTM B766.

(j) **Caulking sealant** shall conform to FS TT-S-00230, TT-S-001543, or TT-S-001657. Exposed caulking shall be color-pigmented so as to match or be similar to the color of finished panels or shall be as approved by the Engineer.

(k) **Steel flashings and caps** shall be of the same material and thickness as metal panels. Protective coating requirements shall be the same as those for panels.

(l) **Elastomeric pads** shall conform to ASTM D1056, Grade 1B3 C1, 1B4 C1, or 1B5 C1. Adhesives shall conform to the manufacturer's recommendations.

(m) **Interlocking metal panels** shall conform to the following: Metal panels shall be of a cold-formed, trapezoidal-faced configuration. The covering width of the panel face shall be at least 12 inches. Each panel shall have a male and female rib providing a friction interlock connection with adjacent panels. The friction interlock connection shall provide sufficient connection when two connected panels are held in the same vertical and horizontal positions.

(n) **Panel** finish of metal or plastic barrier shall be embossed or otherwise designed or treated to minimize light reflectance under wet conditions.

(o) **Protective color coating** for metal panels shall be System No. 1 or System No. 2 as specified on the plans and detailed herein. When the system is not specified, System No. 1 shall be furnished. The coating system shall be flat in accordance with the Federal Standard Number(s) specified on the plans or approved by the Engineer.

1. **System No. 1** shall be either a polyvinyl fluoride (PVF1) plastic film or urethane coating. System No. 1 coatings shall have an abrasion index of at least 16 liters per mil in accordance with ASTM D968, shall be resistant to permanent graffiti markings, and shall produce an impervious finish free from cracks and crazings.

   a. **PVF_1** shall have a thickness of at least 1.5 mils per coated side and shall be applied at the factory to thoroughly cleaned and pretreated galvanized steel in accordance with ASTM D2092, Method F. The PVF_1 film shall be pigmented to obtain optimum color performance and shall be laminated to the steel with heat and adhesive to produce a uniform, durable coating.

   b. **Urethane coating** shall be acrylic or polyester material with a chromate-bearing epoxy prime coat having a thickness of at least 1.2 mils per coated side and shall be applied at the factory to thoroughly cleaned, pretreated, and galvanized steel sheets. The urethane coating shall be inorganically pigmented to obtain optimum color performance and oven cured under quality controlled conditions to produce a uniform and durable coating.

2. **System No. 2** shall be a polyvinyl fluoride (at least 70 percent resin) enamel (PVF_2) with a dry film thickness of at least 1 mil per coated side that shall be applied at the factory to thoroughly cleaned and pretreated galvanized steel in accordance with ASTM D2092, Method F. The PVF_2 enamel shall be pigmented to obtain optimum color performance and oven baked under quality controlled conditions to produce a uniform, durable coating free from cracks and crazings.

(p) **Protective color coating** for concrete panels shall be a semi opaque toner containing methyl methacrylate-ethyl acrylate copolymer resins with toning pigments suspended in solution at all times by a chemical suspension agent and solvent. Color toning pigments shall consist of laminar silicates, titanium dioxide, and inorganic oxides. There shall be no settling or color variation. Vegetable or marine oils, paraffin materials, stearates, or organic pigments shall not be used in the coating formulation.

Physical properties of the coating shall be as follows:

Weight per gallon	8.3 pounds (min.)
Solids by weight	30 percent (min.)
Solids by volume	21 percent (min.)
Drying time	30 minutes (max.) at 700F and 50 percent humidity

Coating material shall not oxidize and shall show no appreciable change in color after 1000 hours when tested in accordance with ASTM D822; shall have excellent resistance to acids, alkalies, gasoline, and mineral spirits when tested in accordance with ASTM D543; shall allow moisture vapor from the concrete interior to pass through when tested in accordance with ASTM E398 or D1653; and shall reduce the absorption rate of exterior moisture into the pores of the concrete surface when tested in accordance with Federal Specification TT-C-555 B.

Surface preparation, application rates, and application procedures shall be as specified by the coating manufacturer for use with airless spray equipment having a minimum capacity of 1,000 psi and 1/2 gallon per minute. Coating shall not be applied when the air temperature is below 50ºF, or to damp surfaces or when the air is misty or otherwise unsatisfactory for this work as determined by the Engineer.

The sound wall color coating shall be from the Materials Division Approved Products List 19 for Absorptive Sound wall Color Coatings.

(q) **Wood** used for sound barrier walls shall conform to Section 236 and shall be CCA preservative pressure treated with a minimum net retention of 0.60 pcf in accordance with American Wood Preservers Association UC4B. Panel design shall result in a sound transmission class of 38 or better when tested in accordance with ASTM E90 or ASTM E413. Wood sound barrier walls shall be from the Materials Division Approved Products List 65. The use of wood sound barrier systems shall be limited to those applications specifically identified in the Contract.

(r) **Plastics** used in sound wall designs shall be of high density, high impact resistant materials such as, but not limited to; acrylic, fiberglass, polyethylene, polyvinylchloride, or polyurethane with antioxidant additives and UV stabilizers; and shall be capable of being produced with integral color pigmentation where such color is specified on the plans or elsewhere in the Contract. Plastic sound barrier systems shall be from the Materials Division Approved Products List 65.

519.03—Procedures

The Contractor shall design the wall so that the finished profile of the top panels shall be as uniform in height as possible when the wall is traversing a grade. The top face of the sound barrier wall shall be aligned to maintain a continuous appearance and shall not deviate from true alignment by more than 1/2 inch in 10 feet.

(a) **Foundations**

Existing ground line elevations shall be established and verified by the Contractor prior to submitting working drawings. The Contractor shall remove and dispose of all above ground obstructions such as trees, debris, brush, etc. and other clearing and grubbing items that will interfere with erection unless otherwise directed by the Engineer.

The Contractor shall adjust foundations during design and while erecting sound barrier walls to avoid conflicts with pipes or utilities. Wall panel lengths may be shortened or lengthened so that foundation locations may be adjusted to avoid conflicts and clear existing pipes, utilities, and other underground obstructions. When a conflict cannot be avoided using this method, the Contractor shall submit the Contractor's alternative design for the Department's written approval. The Contractor shall modify the design of wall foundations where foundations may conflict with the limits of proposed or existing rights-of-way or where foundation designs and existing topography may leave a portion of the foundation exposed above the finished ground line. The Contractor shall review such conflicts and proposed modifications with the Engineer prior to installation. Where sound barrier walls are self-supporting, they shall be designed to prevent pipe or utility damage caused by excessive loading when placed over pipes, utilities, or other underground obstructions.

(b) **Piles and Posts**

The Contractor shall drive piles according to Section 403 except that the tolerance for the position of a single steel H-pile shall be ±1/2 inch.

The portion of posts from the finished grade to the bottom end and the portion of the H-pile lapped with posts shall be painted with asphalt mastic after splicing. Voids between posts and piles created by the use of shims for plumbing posts shall be caulked prior to the application of asphalt mastic.

The Contractor may furnish the galvanized post and girts with the protective color-coating system specified for panels, thereby eliminating the related flashing covering, provided the posts and girts conceal threads of bolts and screws.

Structure-mounted sound walls shall have metal posts.

(c) **Panels**

1. **General Requirements**

Panels shall not be patched without the written approval of the Engineer. Panel patching shall be performed in accordance with the manufacturer's recommendations if the Engineer allows it. Cut, marred, or scratched surfaces shall be repaired in accordance with the manufacturer's recommendations. Panels having deficiencies such as cracking, crazing, scaling, efflorescence, segregation, mottling of the color coating or stains on the finish shall be rejected. Irregularities at panel edges that appear broken, ragged, chipped or dented to the extent that a gap appears once they are stacked will be cause for rejection.

Sound absorptive coating shall be permanently bonded or attached to the panel's core material and have the same service life as the core materials.

The absorptive finish of concrete panels shall meet the requirements of ASTM C666, Procedure B, for 300 cycles.

Where sound barrier panels do not occupy the full width between the flanges of the sound barrier posts, panel attachment details shall be furnished with the working drawings. Such details shall also include material descriptions of the attachment hardware. Post flanges and panels shall overlap at least 1-1/2 inch after installation. The face of the panel on the roadway side of the barrier shall fit tightly against the post flange for the full height of the panel after installation. Spacer blocks or wedges shall not be used.

Joints and connections shall be secured so as to be structurally sound with no visible openings for sound transmission and shall not be a secondary source of noise attributable to vibration.

All lifting devices cast into panels shall be galvanized and flush with the panel.

2. **Structure-Mounted Barriers**

All structure-mounted sound barrier panels shall be metal or other pre-approved lightweight material. The bottom portion of the panels within 6 inches of the top of the parapet

to which the wall is to be mounted shall not have an absorptive finish. The Contractor shall orient panels on structure-mounted sound barrier walls either vertically or horizontally to match any adjacent ground mounted sound barrier walls. Installed panel orientation shall be such that panels are free draining to prevent moisture buildup and possible corrosion. Structure-mounted sound barrier walls shall aesthetically match adjacent ground mounted barriers as to color unless stated otherwise in the contract. Anchor rods (bolts) for structure-mounted walls shall be integrally cast into parapets. Concrete parapets or retaining walls shall not be slip formed when used as mounting structures for structure-mounted sound barrier walls. Connections between the panel and the posts and the sound barrier panel and the bridge shall account for the movement of the bridge as well as the expansion and contraction of the panels.

3. **Ground-Mounted Barrier**

Base panels shall be a minimum height of 2 feet and shall be embedded in the ground a minimum of 6 inches to prevent sound leaks. A non absorptive durable finish or construction is required on that portion of the base panels below ground and 6 inches above the ground line.

The Contractor shall align horizontal joints to create continuous horizontal lines where panels must be stacked for erection; however, foundations and/or ground contact panels may be adjusted within the limits established herein to provide for the continuous horizontal alignment of joints. Horizontal joints formed where panels mate together and false or dummy joints, if present, must match in appearance and alignment. The Contractor shall install panels so that the edges of stacked panels are neat and sides that mate together are straight and true.

Reflective concrete sound barrier panels shall have all edges chamfered 3/4 inch or rounded to 1/2 inch radius. Vee-shaped control joints, 3/8 – 1/2 inch deep, shall be scored into one side of panels less than 8 inches thick and both sides of panels 8 inches or more in thickness to control temperature and shrinkage cracking. These joints shall be no more than 8 feet on center.

The Contractor shall coat all panel connection hardware and portions of metal base panels to be embedded in the ground with asphalt mastic.

4. **Sample Section**

The Contractor shall erect a sample section of the ground-mounted wall at the job site prior to receiving final written approval to proceed with panel fabrication from the jurisdictional District office. The sample section shall be three bays of panels with corresponding posts to show how panels shall be secured to the posts with the attachment hardware. Sample panels shall show the attachment area formed in the panel. Sample panels shall show color and finishes of both sides of the wall.

(d) **Drainage Requirements**

The Contractor shall ensure onsite ground surface drainage and other drainage considerations are accounted for in the design of the sound barrier walls. Sound barrier walls shall be designed to deter impoundment and trapping of water. Disturbed areas shall be graded in front and behind the sound barrier wall to control and dispose of roadway and slope drainage using a

graded ditch or similarly functional drainage. The ground-mounted sound barrier posts and bottom sound barrier wall panel shall be designed with consideration for additional load created by the ditch slope where it rests against the wall.

Weep holes shall be provided in panels, where necessary, to facilitate proper drainage. Drainage design shall not create sound leaks.

The Contractor shall seed, fertilize, and lime disturbed areas in front and behind of sound barrier walls in accordance with Section 603.

(e) **Other Detail Requirements**

1. **Concrete clear cover** over reinforcing steel, except precast concrete panels, shall not be less than 3 inches for primary reinforcement and 2-1/2 inches for ties and stirrups. Concrete clear cover shall not be less than 1-1/2 inches for precast concrete panels. Concrete clear cover excludes any sound absorptive concrete finish.

2. **Steel reinforcement** shall be designed to resist in-service loads as described in Section 519.01(b) and handling loads resulting from manufacture, transport, storage, and installation. All concrete elements shall have at least enough reinforcement to satisfy the requirements in article 8.20, "Shrinkage and Temperature Reinforcement," of the aforementioned AASHTO specifications. Mechanical butt spliced connections shall develop at least 125% of the tensile yield strength of the bar. If welds are necessary, they shall be detailed on the working drawings.

3. **Anchor rods** shall be embedded into concrete a distance equal to or greater than the development length of an equivalent reinforcing steel bar in accordance with the article 8.25, "Development of Deformed Bars and Deformed Wire in Tension," AASHTO Standard Specifications for Highway Bridges. Hooked anchor rods shall not be used to reduce the embedment length. Anchor rods shall be enclosed in reinforcing steel ties over their full embedded length. These ties shall not be spaced more than 12 inches on center and shall not be less than #3 bar in size. A minimum of four anchor rods shall be used per post if the anchor rods have adequate capacity to resist 150% of the design loads; otherwise a minimum of six anchor rods shall be used per post. Anchor rods shall not be heated or bent in the field to accommodate misalignment of anchor rods without the prior approval of the Engineer. Anchor rods, washers and nuts of ground mounted sound barrier walls shall be coated with asphalt mastic above and below base plates after installation.

4. **Epoxy or adhesive anchors, expansive anchors, split washers, and lock nuts** shall not be used. Multiple washers shall not be used as spacers on bolted connections or anchor rods.

5. **Base panel leveling pads** (support blocks), where needed, shall be cast-in-place reinforced concrete with steel dowels embedded in the concrete foundation.

6. **Precast concrete members,** including panels, shall not be lifted from casting beds until their design compressive strength is sufficient to prevent damage. Concrete shall have attained the minimum 28-day design compressive strength before members are shipped to the project site. During storage, the Contractor shall separate stacked members from each other by the use of wood spacing blocks. Curing, storing, transporting, and handling of precast members shall be done in such a manner as to avoid excessive bending stresses and to prevent cracking, spalling, chipping, or other damage. Units damaged by improper

storage or handling shall be replaced at the Contractor's expense. Acceptable lifting and support points and directions of reactions shall be shown on the working drawings. The Contractor shall be responsible for the design and safety of the lifting devices used. Embedded lifting inserts and devices shall be steel and galvanized in accordance with Section 233. Computations accompanying the working drawings shall demonstrate that stresses in the member are within the allowable range during shipping, handling, storage, and installation using appropriate impact factors.

Precast units conforming to the requirements herein will only be accepted under the VDOT Precast Concrete Products Quality Assurance Program. The Contractor shall have the producer perform quality control functions in accordance with a Department approved QC plan. Each piece manufactured under the Quality Assurance program in addition to the date and other required markings, shall be stamped with the letters (QC), as evidence that the required QC procedures have been performed. Each shipping document shall be affixed with the following:

> We certify that these materials have been tested and conform to VDOT Precast Concrete Products Quality Assurance Program
>
> _____
>
> Signature and Title

519.04—Measurement and Payment

Sound barrier walls will be measured in square feet of surface area from the finished grade to the sound attenuation line shown on the plans and from end to end of the wall, complete-in-place, and will be paid for at the contract unit price per square foot for the type listed (reflective or sound absorptive). The six inch minimum embedment in the ground of all base panels of ground mounted sound barrier walls will be considered incidental and will not be measured for separate payment. Sound barrier walls will be considered to refer to ground mounted barrier.

Structure-mounted sound barrier walls will be measured in square feet of surface area from the top of the parapet or mounting structure to the sound attenuation (noise abatement) line shown in the plans, complete-in-place, and will be paid for at the contract unit price per square foot for the type listed (reflective or sound absorptive).

These prices shall include designing, furnishing; installing; providing modifications to avoid utility, right-of-way, foundation exposure, and tie-back conflicts; grading; seeding; disposing of surplus and unsuitable material; restoring property; and construction outside the grade or sound attenuation line. Excavation of tree roots, existing limited access fence, and other clearing and grubbing items such as those identified in Section 301 required for the placement of walls shall be included in the square foot price of the sound barrier walls. The cost of foundation designs and supplemental geotechnical investigation and foundations shall be considered incidental and will not be measured for separate payment but shall be included in the square foot price of sound barrier wall. Costs for ultrasonic and radiographic testing and all other quality control measures required by the specifications shall be included in the square foot price of sound barrier wall.

After the second submittal of working drawings, costs for further review shall be in accordance with Section 105.10.

Payment for sound barrier walls shall be made incrementally as construction progresses in accordance with the following percentages: 20 percent of the contract unit square foot price after completion of wall design and submission acceptance, 20 percent of contract unit square foot price after construction and installation of foundations and posts including posts caps, and geotechnical\subsurface investigation, testing where specified and if applicable, 45 percent of contract unit square foot price after installation of panels, and 15 percent of contract unit price after completion of sound barrier wall and color coating, if specified.

Where multiple walls are specified in the contract, incremental payments will not apply to individual walls but to all walls specific to the individual pay items listed.

Sound wall color coating will be measured in square yards and will be paid for at the contract unit price per square yard. This price shall include preparing surface and furnishing and applying the sound wall color coating.

Payment will be made under:

Pay Item	Pay Unit
Sound barrier wall (Type)	Square foot
Structure-mounted sound barrier wall, (Type)	Square foot
Sound wall color coating	Square yard

SECTION 520—WATER AND SANITARY SEWER FACILITIES

520.01—Description

This work shall consist of furnishing and installing necessary materials for water distribution systems and sanitary systems in accordance with these specifications and in conformity to the dimensions, lines, and grades shown on the plans or as established by the Engineer.

520.02—Materials

(a) **Pipe, fittings, and flanges** shall conform to Section 232.

(b) **Gaskets and joint materials** shall conform to Section 212.

(c) **Casing pipe** shall be 14-gage corrugated metal half-circle pipe conforming to Section 232 except as modified for securing interlocked or nested connections.

(d) **Concrete blocks** shall conform to Section 222.

(e) **Bricks** shall conform to Section 222.

(f) **Hydraulic cement mortar** shall conform to Section 218.

(g) **Concrete** shall conform to Section 217 and shall be Class A3.

(h) **Reinforcing steel** shall conform to Section 223.

(i) **Curing material for concrete** shall conform to Section 220.

(j) **Timber skids** shall conform to Section 236, and the preservative and treatment shall conform to Section 236.

(k) **Valves** shall conform to AWWA C500, C504, C506, C507, C508, or C509 for the types and features specified.

(l) **Fire hydrants** shall conform to AWWA C502 or C503 with the various features specified.

(m) **Water meters** shall conform to AWWA C700, C701, C702, C703, C704, C706, C707, C708, or C710 for the type and features specified. Each meter shall be furnished with a meter box.

(n) **Corporation stops** shall be made of bronze or red brass conforming to ASTM B62. The fitting design and thread dimension shall conform to AWWA C800. The working pressure of the corporation stop shall be equal to that of the water main to which it is attached.

(o) **Castings** shall conform to Section 224.

(p) **Nonshrink waterproof grout** shall conform to Section 218.

(q) **Aggregate** shall conform to Section 203. Aggregate for drain fields shall be No. 5.

520.03—Procedures

The Contractor shall be responsible for anticipating and locating underground utilities and obstructions in accordance with Section 105.08.

When construction appears to be in close proximity to existing utilities, the Contractor shall unearth trench(es) a sufficient distance ahead of the work or shall excavate test pits to verify the exact locations and inverts of the utility to allow for changes in line or grade as may be necessary.

Connections to existing lines shall be made only after the proposed line is completed and approved by the Engineer. Connections shall be made in the minimum time possible with minimum interruption of service. Work and interruptions in existing service shall be scheduled with the utility owner.

The Contractor shall abandon existing water and sewer lines and appurtenances and manholes not required in the completed system as directed by the Engineer. Abandoned materials shall become the property of the Contractor, unless otherwise noted on the plans, upon satisfactory replacement with the new installation. The Contractor shall clean abandoned pipe that is not removed of debris and plug it with Class A3 concrete at open ends.

The Contractor shall remove existing manholes that are not required in the completed system to at least 2 feet below the proposed subgrade or natural ground line and fill the rest of the manhole with approved backfill in accordance with Section 302.03 (a)2.g.

The Contractor shall restore disturbed property prior to final acceptance. Restoration shall include, but not be limited to, replacing shrubbery, sod, or topsoil, including lime, fertilizer, seed, and mulch; replacing paved or finished surfaces with similar materials; and performing other work in accordance with Section 107.08.

Sidewalks and streets shall be kept open for passage. The Contractor shall provide and maintain adequate and safe passage over excavations to accommodate pedestrians or vehicles as directed by the Engineer until no longer required.

(a) **Protecting Water Supplies:** During the course of construction, the Contractor shall protect water supply facilities within the construction limits from contamination by sewage. The Contractor shall use the following criteria to govern the installation of water and sewer facilities in proximity of each other:

1. **Parallel separation:** Except as specified hereinafter, water lines shall be placed at least 10 feet horizontally from existing or proposed sanitary sewer lines, combination sewer lines, and sanitary sewer manholes. Sanitary sewer lines shall be placed at least 10 feet horizontally from existing and proposed water lines. This distance shall be measured from edge to edge. If local conditions prevent a lateral separation of 10 feet, a water line may be placed closer than 10 feet to a sewer, or a sewer line may be placed closer than 10 feet to a water line if the top of the sewer pipe is at least 18 inches below the bottom of the water line. Where the vertical separation cannot be obtained, the sewer shall be constructed of mechanical joint water pipe. Gravity sewers shall be pressure tested, in place, to 50 pounds per square inch without leakage prior to backfilling. Force main sanitary sewer shall be pressure tested in accordance with Section 520.04(c).

2. **Crossings:** Water and sewer lines that cross shall be placed to provide a separation of at least 18 inches between the bottom of the water line and the top of the sewer line. Where this vertical separation cannot be obtained, the sewer shall be constructed of mechanical joint or other approved water pipe for at least 10 feet on each side of the crossing.

   Sanitary sewers and combined sewers crossing over a water line shall have a vertical separation of at least 18 inches between the bottom of the sewer and the top of the water line. The support shall be adequate to prevent excessive deflection of joints and the settling on and breaking of the water line. The water or sewer line shall be centered at the point of the crossing so that joints will be equidistant and as far from each other as practicable.

   Water lines shall not pass through or come in contact with any part of a sanitary sewer, combined sewer, or sanitary sewer manhole.

   The Contractor shall immediately notify the Engineer if he becomes aware that the work will result in the violation of these criteria. Upon such notification, the Engineer will issue instructions concerning remedial measures to allow the work to proceed.

(b) **Excavation:** The Contractor shall perform excavation, backfill, and compaction in accordance with Section 302 except that stone larger than 1 inch in diameter shall not be used in backfill until the pipe has a cover of at least 1 foot. The remainder of backfill to the original ground or to within 12 inches of the finished subgrade shall not include stone larger than 10 inches in its greatest dimension. Pipelines installed outside the roadway shall be backfilled in 8-inch layers and compacted to approximately 85 percent of the theoretical maximum density.

The Contractor shall generally excavate trenches for pipelines along straight lines with the bottoms uniformly graded as required. Bedding material shall be placed in accordance with the plans. Where the trench bottom is in rock, it shall be excavated to at least 8 inches below the bottom of the pipe and backfilled with Engineer approved local or commercial bedding material. The Contractor shall ensure installed pipe shall have a uniform bearing on a solid

foundation for its entire length. Where pipe foundations are yielding, pipe shall be bedded on at least 8 inches of approved local or commercial bedding material. Bell holes, where applicable, shall be of sufficient size to provide proper joints.

Trenches below the grade line of the pipe shall be dewatered during installation of pipelines.

When work is not in progress for any reason, lines shall be securely closed.

Where adjacent pavements are to be retained, pavement removed for pipeline trenches shall be replaced in kind with equal or better material or as otherwise specified or directed by the Engineer. The Contractor shall maintain a smooth riding surface until pavement repairs are completed after backfilling.

(c) **Inspecting Pipe and Fittings:** The Contractor shall inspect pipe and fittings for cracks and defects before they are lowered into the trench. Faulty pipe and fittings shall be removed from the site.

(d) **Placing Pipe:** Water mains shall have a cover of at least 36 inches, and water service lines shall have a cover of at least 24 inches. Pipe, fittings, valves, hydrants, and accessories shall be carefully lowered into the trench to prevent damage to materials, protective coatings, and linings. The Contractor shall not drop or dump materials into the trench.

If pipe, fittings, valves, hydrants, or accessories are damaged during handling, the Contractor shall immediately bring such damage to the Engineer's attention. The Contractor shall then submit a method for repairing the damaged item, if the item is repairable, to the Engineer for approval or replace the item at the Contractor's expense if it is not repairable. Damaged items shall be repaired as approved by the Engineer or shall be removed from the project.

The Contractor shall remove lumps, blisters, and excess coating from ends of pipes that are to be joined. The inside of the bell and the outside of the spigot shall be wire brushed, wiped clean, dry, and free from oil and grease before installing the pipe. Foreign material shall be kept from entering pipe during placement.

The spigot end shall be centered in the bell and the pipe forced home and brought to the correct line and grade as each length of pipe is placed in the trench. Pipe shall be secured in place with approved backfill material tamped under it except at bells. The Contractor shall take precautions to prevent dirt from entering the joint space. If it becomes necessary to deflect water main pipe during construction, the amount of deflection shall not exceed the manufacturer's recommendation.

(e) **Cutting Pipe:** The Contractor shall cut pipe for fittings or closure pieces in a neat and orderly manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. The lining of the pipe shall not be damaged. The Engineer will not permit flame cutting of ductile iron or cast iron pipe with an oxyacetylene torch.

(f) **Joining of Pipe:** Gasket and joint lubricant for water facilities shall be a nontoxic, tasteless, and odorless substance that will not support bacteria. Gasket end joint lubricant for sewer facilities shall be as recommended by the manufacturer or as approved by the Engineer. Pipe that is not furnished with a depth mark shall be marked before assembly to ensure that the spigot end is inserted to the full depth of the joint. Field-cut pipe lengths shall be filed or ground to resemble the spigot end of such pipe as manufactured.

1. **Ductile iron pipe** shall be joined in accordance with AWWA C-111 and AWWA C-600.

2. **Steel pipe** shall be joined by field welding unless otherwise specified on the plans or directed by the Engineer. Pipe ends shall comply with AWWA C-206 for the type of field joint specified. Field-welded joints shall comply with AWWA-206; flanged joints shall comply with AWWA C-207, and rubber gasket joints shall comply with AWWA M11.

3. **Galvanized steel pipe** shall be joined by fittings in accordance with the manufacturer's recommendation.

4. **Copper pipe or tubing** shall be joined by fittings in accordance with the manufacturer's recommendation.

5. **PVC pipe** shall be joined by gasketed bell and socket joints in accordance with AWWA C-900.

6. **Concrete pipe** for water facilities shall have joints of the round rubber gasket type, unless otherwise specified, using either a bell and spigot joint or a double spigot and sleeve joint. The gasket will be confined within a groove or by shoulders on the bell and spigot when the pipe is laid and the joint completed. The Contractor shall handle the pipe during installation so that the contact surface in the joint does not cause cutting of the rubber gasket.

   The Contractor shall join concrete pipe for sewer facilities by using rubber gaskets. The gasket shall be continuous and fit snugly into the annular space between the overlapping surfaces of the assembled pipe joint to form a flexible watertight seal. The annular space between the gasket bearing surface of the assembled and centered joint shall be more than 75 percent of the uncompressed thickness of the applied gasket including the manufacturer's tolerances of the joint and gasket.

7. **Vitrified clay pipe** shall be joined with compression joints in accordance with ASTM C-12 and manufacturer's recommendation.

8. **PE pipe** shall be joined in accordance with AWWA C-901 and the manufacturer's recommendation.

9. **ABS pipe** shall be joined with a solvent cement joint in which pipe solvent cements into a coupling socket to form the joint. Priming solvent for cement joints shall be methylethyl ketone (MEK), and the cement shall be MEK containing a minimum of 20 percent by weight of dissolved ABS. Type OR joint is a mechanical-seal joint in which a gasket shall be compressed between the pipe and the bell coupling to form the joint closure.

(g) **Plugs, Caps, Tees, and Bends:** The Contractor shall anchor plugs, caps, tees, and bends with reaction backing. Backing shall be concrete reaction blocks, metal reaction harnesses, or a combination thereof. Concrete shall be placed in accordance with Section 404 and cured in accordance with Section 316.04(j). Metal harness tie rods and clamps shall be of adequate strength to prevent movement and shall be galvanized or rustproofed by a means approved by the Engineer.

(h) **Encasement Pipe:** Encasement pipe shall be installed in accordance with Section 302.

(i) **Casing Pipe and Concrete:** Casing pipe and concrete shall be constructed in accordance with plan details and the applicable requirements of Sections 302, 303, 316, and 406, with the half-circle sections of casing pipe nested or interlocked to obtain a satisfactory union of the two sections of pipe. The Contractor shall clean and remove foreign matter from existing pipe to be encased prior to installation.

(j) **Valves, Valve Boxes, and Manholes:** Valve boxes shall not transmit shock or stress to the valve and shall be centered and plumbed over the wrench nut of the valve with the box cover flush with the surface of the finished pavement. Manholes shall be constructed to permit minor valve repairs and protect the valve and pipe from impact where they pass through the walls of the manhole.

(k) **Fire Hydrants:** Wherever a hydrant is to be set in pervious soil, drainage shall be provided at the base of the hydrant by placing coarse gravel or crushed stone mixed with coarse sand from the bottom of the trench to at least 6 inches above the waste opening in the hydrant and to a distance of 1 foot around the elbow.

Wherever a hydrant is set in clay or other impervious soil, the Contractor shall excavate a drainage pit 2 feet in diameter and 3 feet in depth below each hydrant. The pit shall be filled compactly with coarse gravel or crushed stone mixed with coarse sand under and around the elbow of the hydrant to a level 6 inches above the waste opening. The drainage pit shall not be connected to a sewer.

(l) **Installing Corporation Stops:** Corporation stops shall be installed while the main is under pressure and at a 45-degree angle to the horizontal plane.

(m) **Concrete Encasement:** Concrete encasement shall be constructed in accordance with Sections 302, 303, 316.04(j), 404, and 406 as applicable.

(n) **Water Meters and Yokes:** Meter boxes shall not transmit shock or stress to the meter and shall be centered and plumb over the meter. The top of the box shall be flush with the surrounding surface.

(o) **Jacked Encasement Pipe:** Jacked encasement pipe shall be installed in accordance with Section 302.03(a)1.

(p) **Sanitary Service Lateral Connection:** Connection shall be performed by approved methods prior to installation using wyes, bends, adapters, cleanouts, and necessary pipe. Existing service laterals shall mate with the new fitting, adapter, or pipe to produce a watertight joint.

(q) **Sanitary Manholes and Manhole Frames and Covers:** These items shall be constructed in accordance with Section 302.03(c). A secure bond between the pipe and manhole wall shall be obtained. Flexible insert gaskets shall be used to obtain a watertight joint. The gasket style and composition shall be subject to the approval of the Engineer. Precast wall sections shall be seated with flexible joint sealant for their full circumference. Lift holes, defects, joints between sections, and frames and covers shall be sealed with nonshrink waterproof grout.

(r) **Sanitary Drop Connections:** Connections shall be constructed in accordance with Sections 302, 303, 404, and 406 as applicable.

(s) **Sewer Cleanouts:** Cleanouts shall be constructed in accordance with Sections 302, 303, 404, and 406 as applicable.

(t) **Conveying Sewage:** When it is necessary to contain or pump sewage during the adjustment of or connection to existing sewers, sewage shall be carried by a watertight conveyor to sewers or manholes approved by the Engineer or shall be disposed of in accordance with local and state health codes and regulations. The Contractor shall not permit sewage to flow onto or over any open surface.

(u) **Manhole Frame and Covers, Valve Boxes, and Other Castings located within the Paved Roadway, Shoulder, or Sidewalk:** These items shall be constructed within a tolerance of ±0.05 foot of the finished grade.

(v) **Reconstruct Existing Sanitary Manhole:** Reconstruction shall consist of removing the existing manhole to the point indicated on the plans or directed by the Engineer. The Contractor shall reconstruct by using existing units and pavement rings or new units and adjustment rings to attain the proposed finished grade.

520.04—Testing

The Contractor shall test water and sewer mains, appurtenances, and materials for leakage after installation. Testing shall be performed in the presence of the Engineer. The Contractor shall provide water, plugs, equipment, tools, labor, materials, and incidentals necessary to perform the testing. If any section of a main or manhole under test shows leakage in excess of that specified, the Contractor shall make necessary repairs or replacements at his own expense. Testing shall be repeated until satisfactory results are obtained. Visible leaks shall be repaired regardless of the amount of allowable leakage.

(a) **Water Mains and Appurtenances:** New water mains and appurtenances shall be tested for leakage using the hydrostatic pressure test method in accordance with Section 4 of AWWA C600 and the following:

1. The duration of each test shall be at least 2 hours. Sections of main with concrete reaction backing shall not be tested until at least 5 days after the backing is placed. If the backing is constructed with high-early-strength concrete, the test may be performed 2 days after backing is placed.

2. Testing of tie-ins with existing mains shall be performed under the normal working pressure of the main involved. The Engineer will not allow visible leakage at these points during a period of at least 2 hours.

3. The hydrostatic test pressure shall be 100 pounds per square inch or 1.5 times the working pressure, whichever is greater, based on the elevation of the lowest point in the line or section under test and shall be corrected to the elevation of the test gage. The Contractor shall ascertain the specific working pressure of the water main from the utility owner. Leakage loss shall not exceed the allowable leakage (L) as determined by the following formula:

$$L = \frac{ND\sqrt{P}}{7{,}400}$$

Where:
L = the allowable leakage in gallons per hour;
N = the number of joints in the length of pipe line tested;
D = the nominal inside diameter of the pipe in inches; and
P = the average test pressure during the leakage test in pounds per square inch.

(b) **Gravity Sanitary Sewers:** Leakage shall be not more than 200 gallons per inch of pipe diameter per mile per day (24 hours) for pipe up to and including 24 inches in diameter and not more than 4,800 gallons per mile per day for pipe more than 24 inches in diameter for any section of the system, including manholes, when subjected to at least 4 feet of head above the line crown at the upstream manhole of the section being tested.

1. **Infiltration test:** When, in the opinion of the Engineer, the trench or excavation is sufficiently saturated as a result of natural ground water, tests may be made on the basis of infiltration. The Contractor shall measure the flow of water at the nearest downgrade manhole. Three series of measurements shall be made at not less than 1-hour intervals, and the results shall be reduced to an average. The average for a 24-hour period shall then be computed. If the pipeline or manholes fail to meet the test requirements, the Contractor shall repair leaks and defective pipe and replace manholes at the Contractor's expense. The Contractor shall then repeat the test until satisfactory results are obtained.

2. **Exfiltration test:** The Contractor shall perform an exfiltration test when the trench or excavation is dry and infiltration will not occur. The test shall be conducted as follows: The pipe shall be plugged at the lower manhole. The line and manhole shall be filled with water to a 4-foot level or to the top of the straight section if the manhole is less than 4 feet in height. The water shall stand until the pipe has reached maximum absorption and until trapped air has escaped (at least 4 hours). After maximum absorption has been reached, the manhole shall be filled to the original level. After 1 hour has elapsed, the Contractor shall record the difference in the level in terms of gallons. The 24-hour loss shall then be computed. If the pipe line system and manholes fail to meet test requirements, the Contractor shall repair leaks at the Contractor's expense. The test shall then be repeated until satisfactory results are obtained.

3. **Air test:** In lieu of the infiltration or exfiltration test for leakage, the Contractor may test the sewers by using low air pressures. The Contractor shall perform the low air pressure test in accordance with the following:

   a. The Contractor shall eliminate discernable water leaks and remove debris after backfilling and prior to air testing. Tests shall be conducted from manhole to manhole or from manhole to terminus. No personnel shall be allowed in manholes once testing has begun.

   b. The Contractor shall provide securely braced test plugs at each manhole and a suitable means of determining the depth of the ground water level above the inverts immediately before testing.

   c. The Contractor shall slowly add air to the portion of the pipe being tested until the internal air pressure is at a test pressure of 4 pounds per square inch above the invert or ground water table, whichever is greater, or until the pressure is equal to the hydraulic gradient, whichever is greater. If the test plug shows leakage, as determined by the Engineer, the Contractor shall relieve the pressure for at least 2 minutes. The Contractor shall then disconnect the hose and compressor. If the pressure decreases to 3.55 pounds per square inch, the Contractor shall record the amount of time required for the pressure to drop from 3.5 to 2.5 pounds per square inch. The minimum allowable holding times will be as specified herein. The Engineer will not accept pipes that fail to maintain minimum holding times. Any repairs, replacement, and retesting as specified by the Engineer shall be performed at the Contractor's expense.

The minimum allowable holding time for an 8-inch sanitary sewer pipe that is required for the pressure to drop from 3.5 to 2.5 pounds per square inch is:

Line Length	Time (sec)
50	35
75	53
100	70
125	88
150	106
175	123
200	141
225	158
250	176
275	194
300	211
350	227
400	227

The minimum allowable holding time for a 12-inch sanitary sewer pipe that is required for the pressure to drop from 3.5 to 2.5 pounds per square inch is:

Line Length	Time (sec)
25	40
50	79
75	119
100	158
125	198
150	238
175	277
200	317
225	340
250	340
275	340
300	340
350	340
400	340

If low air pressure tests are used, the manholes shall be tested by exfiltration. Inflatable stoppers shall be used to plug all lines into and out of the manhole being tested. The stoppers shall be positioned in the lines far enough from the manhole to ensure testing of those portions of the lines not air tested. The manhole shall then be filled with water to the top and a 12-hour soaking period shall be allowed prior to test measurement. The manhole shall be refilled to a mark, and at the end of 1 hour, the amount of leakage shall be measured. Leakage shall not exceed 1/2 gallon per hour. If the manhole fails to comply with the test requirements, the Contractor shall repair leaks at the Contractor's expense. The test shall then be repeated until satisfactory results are obtained.

(c) **Force Main Sanitary Sewers:** Leakage shall not exceed the allowable leakage (L) as determined by the following formula:

$$L = \frac{ND\sqrt{P}}{1{,}850}$$

Where:
L = the allowable leakage in gallons per hour;
N = the number of joints in the length of pipe line tested;
D = the nominal inside diameter of the pipe in inches; and
P =the average test pressure during the leakage test in pounds per square inch.

The Contractor shall maintain the hydrostatic test pressure for at least 30 minutes at 100 pounds per square inch or 1.5 times the working pressure, whichever is greater, based on the elevation of the lowest point in the line or section under test and shall be corrected to the elevation of the test gage. The Contractor shall ascertain the specific working pressure of the force main from the utility owner. Visible leaks shall be satisfactorily repaired regardless of the amount of allowable leakage.

(d) **Offsets of Existing Pipe:** Offsets will not be subjected to hydrostatic pressure testing unless specified on the plans. After installation and connection to the existing mains, the offset shall be placed in service and left uncovered for visual inspection by the Engineer for at least 2 hours. Visible leaks shall be repaired to the satisfaction of the Engineer prior to acceptance of the offset. The Contractor shall disinfect offset of existing pipe for water mains in accordance with AWWA C-651, Section 9.

520.05—Disinfecting Water Mains

The Contractor shall disinfect new, relocated, and modified water mains and accessories prior to tie-ins in accordance with AWWA C651.

If the initial disinfection fails to yield satisfactory samples after testing, disinfection shall be repeated until satisfactory samples have been obtained. The Contractor shall submit a written report to the Engineer that states the results of the tests after each group of samples is taken.

520.06—Measurement and Payment

Excavation and replacement of pavement removed for pipe trenches will not be measured for separate payment unless otherwise specified. However, minor structure excavation will be measured and paid for in accordance with Section 303.06. When excavation is required below the proposed trench bottom as directed or confirmed by the Engineer, necessitating additional bedding material, the bedding will be measured and paid for in accordance with Section 302.04.

Water mains, water service lines, sanitary sewer pipe, and sanitary sewer force mains will be measured in linear feet of pipe through all valves and fittings, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include excavating when not a specific pay item for the utility in question; testing; disinfecting; backfilling; compacting; dewatering; disposing of surplus and unsuitable material; sheeting and shoring; furnishing and installing bedding material; furnishing and installing pipe; connecting to existing lines or manholes; fittings less than 16 inches in diameter; reaction blocking; concrete anchor block; watertight welds; restrained joints; abandoning or removing lines, manholes, and other appurtenances; and restoring property. Pipe of one size, except for cast iron and ductile iron pipe, shall be combined into one contract item for the respective size of water main and

sanitary sewer pipe. The salvage value of abandoned materials shall accrue to the Contractor and shall be reflected in the contract unit bid price for the respective replacement facility.

Encasement pipe and casing pipe and concrete will be measured in linear feet, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include excavating, dewatering, sheeting and shoring, blocking, furnishing and installing pipe, grouting, concrete encasement, reinforcing steel, masonry blocks, watertight bulkheads, backfilling, compacting, disposing of surplus and unsuitable material, and restoring property.

Jacked encasement pipe will be measured and paid for in accordance with Section 302.04. This price shall include furnishing and installing pipe; excavating, backfilling, disposing of surplus and unsuitable material, sheeting and shoring, blocking, bulkheads, and jacking.

Concrete encasement will be measured in linear feet of encased pipe or cubic yard of concrete and will be paid for at the contract unit price per linear foot or cubic yard. This price shall include excavating, sheeting and shoring, furnishing and installing concrete, reinforcing steel, backfilling, compacting, and disposing of surplus and unsuitable material.

Sanitary service lateral connections will be measured in linear feet from the center line of the sewer main to the point of connection of sanitary service lateral and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing pipe and fittings, excavating, backfilling, compacting, disposing of surplus and unsuitable material, sheeting and shoring, connecting to existing service lateral, and restoring property.

Sanitary drop connections will be measured in linear feet, vertical measure, from the invert of the upper inlet pipe to the invert of the lower inlet pipe and will be paid for at the contract unit price per linear foot. This price shall include pipe and fittings, concrete, reinforcing steel, connections to sewer lines and manholes, excavating, bedding material, backfilling, compacting, disposing of surplus and unsuitable material, and restoring property.

Sanitary sewer manholes, frames and covers, and watertight frames and covers will be measured and paid for in accordance with Section 302.04.

Sewer cleanouts (main or lateral) will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing fittings; riser pipe, frame, cover, and box; excavating; backfilling; compacting; disposing of surplus and unsuitable material; and restoring property.

Reconstruct existing sanitary manhole will be measured in linear feet, vertical measure, from the point of the removed section to the top of masonry on which the frame and cover is placed and will be paid for at the contract unit price per linear foot. This price shall include removing, salvaging and resetting frame and cover, reconstruction of manhole, new materials, excavation, backfilling, compaction, disposal of surplus of unsuitable material and restoring property.

Fire hydrants will be measured in units of each and will be paid for at the contract unit price per each. This price shall include excavating, dewatering, backfilling, compacting, connections, concrete blocking, pipe straps, crushed stone drain, disposing of surplus and unsuitable material, restoring property, and testing.

Water meters and boxes; water meter boxes and yokes; valves and boxes or manholes; and tapping sleeves, valves, and boxes or manholes will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include furnishing and installing utility fitting, excavating, backfilling, and restoring property.

Bends, plugs or caps, reducers, and branches (tees, wyes, and crosses) will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing pipe fittings, restrained joints, excavating, reaction blocking, testing, backfilling, sheeting and shoring, watertight welds, abandoning or removing existing lines as noted on the plans, and restoring property.

Offsetting existing pipe will be measured in linear feet of pipe parallel to the flow line between tie-in points, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing fittings, couplings, restrained joints, excavating, testing, disinfecting, backfilling, compacting, dewatering, disposing of surplus or unsuitable material, sheeting and shoring, bedding material, installing pipe, connecting existing lines as noted on the plans, reaction blocking, watertight welds, abandoning or removing existing lines as noted on the plans, and restoring property.

Leak detectors will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing pipe, return bends, bird screens, clamps, excavating, backfilling, and restoring property.

These prices shall include containing or pumping sewage during adjusting or connecting existing sewers and providing and maintaining adequate and safe passage over excavations to accommodate pedestrians or vehicles as directed by the Engineer.

Payment will be made under:

Pay Item	Pay Unit
Water main (Size and type)	Linear foot
Water service line (Size)	Linear foot
Encasement pipe (Size and type)	Linear foot
Casing pipe and concrete (Size)	Linear foot
Leak detector (Standard)	Each
Bend (Size)	Each
Reducer (Size)	Each
Plug or cap (Size)	Each
Branch (Size)	Each
Offset existing pipe (Size)	Linear foot
Valve and (box or manhole) (Size and type)	Each
Tapping sleeve, valve, and (Box or manhole)	Each
Fire hydrant (Standard and type)	Each
Water meter and box (Size)	Each
Water meter box and yoke (Size)	Each
Jacked encasement pipe (Size and type)	Linear foot
Sanitary sewer pipe (Size and type)	Linear foot
Sanitary service lateral connection (Size)	Linear foot
Sanitary sewer force main (Size)	Linear foot
Bend-force main (Size)	Each
Reducer-force main (Size)	Each
Plug or cap-force main (Size)	Each
Branch-force main (Size)	Each
Offset existing pipe-force main (Size)	Linear foot
Sanitary sewer manhole (Standard)	Linear foot
Manhole frame and cover (Standard)	Each
Sanitary drop connection	Linear foot
Valve and (box or manhole) (Size and type)-force main	Each

Pay Item	Pay Unit
Tapping sleeve, valve, and (box or manhole) (Size)-force main	Each
Concrete encasement (Standard)	Linear foot or Cubic yard
Reconstruct existing sanitary manhole	Linear foot
Watertight manhole frame and cover (Standard)	Each

SECTION 521—MAILBOX POST

521.01—Description

This work shall consist of replacing existing mailbox posts shown on the plans or designated as hazardous objects by the Engineer.

521.02—Materials

Post and mounting hardware shall conform to Standard RFD-1. Replacement mailboxes, if required, shall also conform to Standard RFD-1.

521.03—Procedures

The Contractor shall be responsible for damage to mailboxes and their posts through negligence on the part of the Contractor incurred during their removal, at their temporary location, and during resetting in accordance with Section 105.15. Where the Contractor has properly preserved the existing mail boxes, these may be remounted with new posts and hardware; or the property owner may elect to furnish a new mailbox in lieu of remounting the existing mailbox, in which case the installation of the new mailbox shall be at no additional cost to the Department or property owner.

The placement and installation of the mailbox and post to be replaced shall be in accordance with Standard RFD-1 and the Maintenance Division's *Best Practices Manual.*

Mailbox post types shall be single, double, or multiple corresponding with existing installations or as directed by the Engineer.

521.04—Measurement and Payment

Mailbox posts will be measured in units of each and will be paid for at the contract unit price per each for the type specified. This price bid shall include removing the existing mailbox(s) and post(s); temporary relocation; installing existing mailbox, including new post and hardware; furnishing new mailbox, post and hardware; mounting new homeowner furnished mailbox(s) and providing new post and hardware, and disposal of existing post(s) damaged mailbox and debris.

Payment will be made under:

Pay Item	Pay Unit
Mailbox post (Type)	Each

Division VI
ROADSIDE DEVELOPMENT

SECTION 601—SELECTIVE TREE REMOVAL, TRIMMING, AND CLEANUP

601.01—Description

This work shall consist of selectively removing, trimming, and disposing of trees, shrubs, and vegetation to improve sight distance, create open vistas, or improve the appearance and condition of trees as shown on the plans, described elsewhere in the Contract, or as directed by the Engineer. This work shall be accomplished by removing and disposing of rubbish and fallen or undesirable trees and shrubs; selective pruning of desirable trees and shrubs; and spraying the stumps of removed trees with an approved herbicide to prevent sprouting.

601.02—Materials

Herbicide shall conform to Section 244.02(a).

601.03—Procedures

The Contractor shall cut trees and stumps so that remaining stumps are not higher than 4 inches above the ground. Loose roots more than 1 inch in diameter and more than 1 foot in length shall be removed. The Contractor shall only remove those living trees and shrubs the Engineer selects for removal. Trees to be removed shall be felled in a manner that will not damage the trees and shrubs to be preserved.

Debris shall be disposed of by burning, chipping, or in accordance with Section 106.04. Burning, if permitted, shall be performed in accordance with Section 107.16. Fires shall be located and supervised so that they will not spread or damage vegetation. If the Contractor elects to chip debris, the Contractor shall use a mechanical chipper and spread the resulting chips thinly and uniformly within the immediate area or dispose of them as directed by the Engineer.

(a) **Treating Stumps:** Stumps of living trees and shrubs shall be coated with an approved herbicide solution within 48 hours after they are cut. The exposed surface of stumps and exposed live roots shall be saturated with herbicide to the point of runoff.

(b) **Trimming:** Branches and limbs that affect sight distance, viewing of the open vista and dead or diseased branches and limbs more than 2 inches in diameter that will hinder the healthy normal growth of trees shall be removed as designated by the Engineer. Cuts shall be made flush at the collar of the supporting trunk or limb.

The Contractor's operations and equipment used to perform selective trimming shall not damage trees and shrubs that are to remain. The Contractor shall not use climbing spurs or spikes to access trees for trimming. If the Contractor's operations cause damage to the bark, limbs, and roots of trees and shrubs that are to remain these shall be repaired, if repairable, or replaced in kind in a manner acceptable to the Engineer. The Contractor shall bear the cost for such repairs and the replacement in kind of those that cannot be satisfactorily repaired.

601.04—Measurement and Payment

Selective tree removal, trimming, and cleanup will be measured in acres of surface area computed to the nearest 0.1 acre and will be paid for at the contract unit price per acre.

Payment will be made under:

Pay Item	Pay Unit
Selective tree removal, trimming, and cleanup	Acre

SECTION 602—TOPSOIL

602.01—Description

This work shall consist of applying topsoil in accordance with these specifications and in conformity with the depths and limits shown on the plans or as established by the Engineer. In the case of Class B topsoil this work shall also involve furnishing topsoil to the project site.

602.02—Materials

(a) **Class A topsoil** shall conform to Section 244.02(b)1.

(b) **Class B topsoil** shall conform to Section 244.02(b)2.

602.03—Procedures

(a) **Submittals:** When is specified, the Contractor shall submit soil test reports to the Engineer in accordance with Section 244.02 (b).

(b) **Preparing Areas to Receive Topsoil:** The Contractor shall grade and shape areas designated to receive topsoil and then scarify by disking, harrowing, or other approved methods to a depth of approximately 2 inches unless otherwise designated on the plans or directed by the Engineer. Topsoil shall only be applied when the subsoil is in a loose, friable condition. Subsoil on slopes that have been horizontally grooved in accordance with the plans shall not be loosened.

(c) **Applying Topsoil:** The loose depth of topsoil shall be sufficient to allow the area to conform to the elevations shown on the plans after topsoil settles. If not applying screeded material, the Contractor shall remove large clods, hard lumps, stones larger than 3 inches in diameter, brush, roots, stumps, litter, and foreign material from the area after topsoil has been applied. Where residential or commercial yards exist adjacent to the work, the size of the large clods, hard lumps, and stones shall not exceed 3/4 inch in diameter. The Contractor shall hand rake residential or commercial yards to provide a smooth mowing surface. The topsoiled area shall be ready to receive seed, sod, or plants without further soil preparation when the topsoiling operation is complete. Topsoiled areas shall be seeded within 7 calendar days after application of topsoil is completed.

602.04—Measurement and Payment

Topsoil will be measured in acres of surface area computed to the nearest 0.1 acre and will be paid for at the contract unit price per acre for the class and depth specified. For smaller areas, and those areas

designated on the plans to receive topsoil by the cubic yard, topsoil will be measured in cubic yards and will be paid for at the contract unit price per cubic yard for the class and depth specified. This price shall include furnishing, loading, transporting, and applying topsoil; soil testing and providing test reports; preparing areas to receive topsoil; finishing such areas; and restoring damaged areas.

Payment will be made under:

Pay Item	Pay Unit
Topsoil (Class and depth)	Acre or Cubic Yard

SECTION 603—SEEDING

603.01—Description

This work shall consist of furnishing and applying fertilizer, lime, mulch, and seed in the quantities specified to stabilize areas designated on the plans or selected by the Engineer.

603.02—Materials

(a) **Seed** shall conform to Section 244.02(c).

(b) **Fertilizer** shall conform to Section 244.02(d).

(c) **Lime** shall conform to Section 244.02(e).

(d) **Mulches and Hydraulic Erosion Control Products** shall conform to Section 244.02(g).

(e) **Fast Acting Lime** shall conform to Section 244.02(e)2.

(f) **Biological Growth Stimulants** shall conform to Section 244.02(n).

(g) **Sediment Retention Products** shall conform to Section 244.02(o).

603.03—Procedures

The Contractor shall perform seeding operations at the times designated in Sections 303.03(b) and 602.03(c) unless otherwise specified. The Contractor shall not perform seeding operations when the ground is frozen or when soil or weather conditions will prevent proper soil preparation and subsequent operations. When hydroseeding is performed, nozzles or sprays shall not be directed toward the ground in a manner that will cause erosion or runoff. The Contractor shall notify the Engineer at least 48 hours prior to beginning seeding operations.

(a) **Preparing Soil**

- **Slopes 3H:1V or flatter** shall be loosened to a depth of approximately 3 inches by disking, harrowing, or other methods approved by the Engineer.

- **Excavated slopes steeper than 3H:1V:** Loosening of soil will not be required except to eliminate hard or crusted surfaces.

- **Shoulders and embankment slopes steeper than 3H:1V** shall be loosened to a depth of approximately 1 inch.

- **Clods, loose stones, and other foreign material larger than 3 inches in any dimension** shall be removed and disposed of in accordance with Section 106.04 or as directed by the Engineer.

- **Gullies, washes, and disturbed areas** that develop subsequent to final grading shall be repaired before they are seeded. Soil preparation for overseeding shall include the repair of gullies, washes, and disturbed areas that develop prior to final overseeding and project acceptance.

- **Topsoil,** when specified, shall be applied in accordance with Section 602.

(b) **Applying Lime**

1. **Agricultural Lime:** The Contractor shall uniformly apply lime to areas to be seeded at the rates specified on the Roadside Development plan sheet. Lime shall be uniformly incorporated into the prepared soil prior to seeding. Lime may also be applied through a hydraulic seeder. The method of application for all lime products shall be approved by the Engineer prior to applying the lime. Lime applied by a hydraulic seeder shall be constantly agitated during application.

2. **Applying Fast Acting Lime:** Fast acting lime may be applied in either liquid or dry form to provide an immediate pH adjustment. Apply liquid fast acting lime at the rate of 5 gallons per acre or as recommended by the manufacturer's instructions. Apply dry fast acting lime at the rate of 100 pounds per acre or as recommended by the manufacturer's instructions.

(c) **Applying Fertilizer:** The Contractor shall apply fertilizer for temporary, permanent, and overseeding applications in accordance with the requirements herein and at the rates and timeframes specified on the Roadside Development plan sheet.

The Contractor may apply all slow release and slowly soluble fertilizer through a hydraulic seeder except for Sulfur Coated Urea (SCU). The method of application for all fertilizer products shall be approved by the Engineer prior to applying the fertilizer. Fertilizer applied in liquid form or mixed with water shall provide the same value of nutrients per acre as specified for dry fertilizer. Fertilizer applied in liquid form shall be constantly agitated during application.

(d) **Applying Seed**

Applying regular seed shall consist of preparing the seed bed and uniformly applying seed, fertilizer, lime, fast acting lime, and biological growth stimulants over the area designated to be seeded in the Contract.

The Contractor shall ensure that all biological growth stimulant applications strictly follow the manufacturer's rates and recommendations to avoid damage to or burning of the seedbed. Use approved hydraulic methods to apply biological growth stimulants.

Where temporary seeding is employed as a means of soil stabilization of unfinished areas it shall consist of applying seed, fertilizer, and mulch in accordance with the rates specified in the plans or in this section to stabilize areas on which grading operations are anticipated to be suspended for durations greater than 14 days. Where temporary seeding is required or directed by the Engineer, the cost for removal of vegetation once grading operations resume shall be included in the price of seeding.

For hydroseeding, seed shall be put in the mixture slowly to result in a uniform mixture before application. Hydroseeding mixtures shall be constantly agitated from the time of mixing until application on the seed bed and shall be applied within 8 hours from the beginning of mixing operations.

Overseeding shall generally consist of applying reduced quantities seed and fertilizer on prepared areas as directed by the Engineer.

Leguminous seeds shall be inoculated or treated with approved cultures as specified by the manufacturer or directed by the Engineer before they are applied or mixed with other seeds to be applied. Leguminous seed shall be applied within 24 hours after treatment. When the hydroseeding method is used to accomplish seeding, leguminous seeds shall be treated with 5 times the amount of inoculant recommended by the manufacturer.

(e) **Applying mulch or hydraulic erosion control products (HECP) for seeding or erosion control:** The Contractor shall apply mulch or HECP within 48 hours after completion of the seeding operation.

Selection of the appropriate seeding mulch or HECP for seeding shall be based on the following table. Mulch will not be required for overseeded areas.

HECP Selection	Maximum Slope
HECP, Type 1	≤ 4 to 1
HECP, Type 2	≤ 3 to 1
HECP, Type 3	≤ 2 to 1
HECP, Type 4	≤ 1 to 1

HECP shall be applied at the following amounts per type:

1. **HECP, Type 1** at the rate of 2,000 Pounds per acre. In lieu of applying Type I the Contractor may substitute one of the following for the HECP Type 1 with the approval of the Engineer.

    a. **Straw and hay** at the rate of approximately 2 tons per acre. Straw and hay shall be applied to a uniform thickness in such a manner that not more than 10 percent of the soil surface will be exposed once installed. Wet straw or wet hay shall not be used. Straw or hay shall be anchored to the seeded surface by spraying with a HECP, Type 1 at the rate of 750 pounds per acre; or using other materials or methods approved by the Engineer. Straw or hay should not be used on medians of shoulders that are directly adjacent to roadways that are open to traffic.

    b. HECP, Type 1 at a rate of 1,000 pounds per acre along with the installation of Rolled Erosion Control Products (RECP) EC-2, Type 1.

2. **HECP Type 2** at a rate of 2,500 pounds per acre. In lieu of installing at the previous rate, the Contractor may substitute HECP, Type 2 at a rate of 1,000 pounds per acre along with the installation of RECP, EC 2 Type 1.

3. **HECP Type 3** at a rate of 3,000 pounds per acre. In lieu of installing HECP, Type 3 at the previous rate the Contractor may substitute one of the following with the approval of the Engineer.

   a. HECP, Type 3 at a rate of 1,000 pounds per acre along with the installation of RECP, EC-2, Type 3 or,

   b. A compost blanket at the rate of 806 cubic yards per acre (average depth of 2 inches).

4. **HECP, Type 4** at a rate of 3,500 pounds per acre. In lieu of installing HECP, Type 3 at the previous rate the Contractor may substitute HECP, Type 4 at a rate of 1,000 pounds per acre along with the installation of Rolled Erosion Control Product EC 2, Type 4 with the approval of the Engineer.

(f) **Installing Sediment Retention Rolls as Slope Interrupters**

The Contractor shall install sediment retention roll for use in conjunction with HECP applications prior to the HECP installation. The Contractor shall excavate a trench along (parallel to) the contour of the slope to a depth that is 1/3 the diameter of the sediment retention roll. Place the excavated soil on the up-slope side of the trench. Place the tube into the trench so it contours to the soil surface, ensuring that no gaps exist beneath the tube. Compact the excavated soil against the tube on the up-slope side. Ensure the installation of the tube does not damage the prepared seedbed.

Where sediment retention rolls are installed with RECP applications, install them on top of the RECP after the RECP installation is completed. Tube trenching is not required for RECP applications. Ensure the installation of the roll does not damage the installed RECP.

Sediment retention rolls used as slope interrupters shall be installed in accordance with the incremental seeding requirements in 303.03(b). Sediment retention rolls used as slope interrupters shall be 18, 20, or 24 inches in diameter in accordance with the manufacturer's instructions and site conditions or as directed by the Engineer.

603.04—Measurement and Payment

Lime will be measured in tons and will be paid for at the contract unit price per ton.

Fertilizer will be measured in pounds and will be paid for at the contract unit price for the quantity of each of the three fertilizer components of the nitrogen-phosphoric acid-potash (N-P-K) ratio. Weights are determined by manufacturer certification of the N-P-K ratio and weight ticket from a certified scale in the case of bulk delivery. For a bagged product, the N-P-K ratio and weight on the bag shall be used.

Regular Seed will be measured in pounds of seed applied and will be paid for at the contract unit price per pound.

Temporary Seed will be measured in pounds of seed applied and will be paid for at the contract unit price per pound.

Legume Seed will be measured in pounds of seed applied and will be paid for at the contract unit price per pound. This price shall include applying the inoculant during the seeding process.

Overseeding will be in pounds of seed applied and will be paid for at the contract unit price per pound. This price shall include the repairing gullies, washes, and disturbed areas that develop subsequent to seeding and furnishing and applying seed and additional fertilizer and lime.

Prices for seed shall include preparing seed beds; furnishing and applying seed, fast acting lime, biological growth stimulant, fertilizer, and lime; and maintaining seeded areas until final acceptance. When bags of seed are transferred from project to project, certified scales shall be used for weighing the seed. The Engineer will not accept open bags for use.

Hydraulic Erosion Control Products will be measured in square yards and will be paid for at the contract unit price per square yard for the type specified. This price shall include preparing seed beds, furnishing and installing, and preparing slopes or channels as required.

Sediment Retention Products will be measured in linear feet and will be paid for at the contract unit price per linear foot.

Payment will be made under:

Pay Item	Pay Unit
(Type) seed	Pound
Overseeding	Pound
Fertilizer (Component)	Pound
Lime	Ton
Hydraulic Erosion Control Product (Type)	Square yard
Sediment Retention Roll (Size)	Linear foot

SECTION 604—SODDING

604.01—Description

This work shall consist of preparing sod beds; furnishing and placing sod; and furnishing and applying lime, fertilizer, topsoil, and water at locations designated on the plans or by the Engineer.

604.02—Materials

(a) **Sod** shall conform to Section 244.02(h).

(b) **Fertilizer** shall conform to Section 244.02(d).

(c) **Lime** shall conform to Section 244.02(e).

(d) **Topsoil** shall conform to Section 244.02(b).

604.03—Procedures

(a) **Preparing Sod Beds:** The Contractor shall shape soil on which sod is to be placed to an even surface and grade to such an elevation that sod and adjacent surfaces will have a smooth contour.

The Contractor shall uniformly apply lime to areas designated to receive sod at the rate of approximately 2 tons per acre.

The Contractor shall uniformly apply fertilizer to areas designated to receive sod at the rate of 16 1/2 pounds of 15-30-15 fertilizer, or an equivalent quantity of 1-2-1 ratio fertilizer and 10 pounds of ureaformaldehyde per 1,000 square feet. Fertilizer shall have a guaranteed nitrogen, phosphorous, and potassium (N-P-K) analysis as detailed in the plans, with a minimum 30 percent of the nitrogen from a slow release or slowly soluble source. Following application of lime and fertilizer, the Contractor shall thoroughly cultivate the soil to a depth of 2 to 3 inches and sprinkle the cultivated area with sufficient water to moisten the cultivated soil.

(b) **Placing Sod:** The Contractor shall not place sod between June 1 and September 1 or at any time the ambient temperature is below 32 degrees F. The Contractor shall not install frozen sod or place sod on frozen soil. Sod shall be placed by hand and joints shall tightly abut without overlapping. Open joints and gaps in sodded areas shall be plugged with sod that has been cut to the size and shape of the opening.

The Contractor shall place sod on sloping areas beginning at the bottom of the slope. Sod shall be placed in horizontal strips with the long edges of rectangular pads parallel to the contour. When practicable, horizontal joints shall be reasonably straight and vertical joints shall be staggered. In areas where sod mats may be displaced by foot traffic during sodding operations, ladders or treaded planks shall be used.

The Contractor shall anchor sod placed on slopes steeper than 2H:1V with wood stakes driven into the slope and flush with the top of the sod. Stakes shall be at least 8 inches in length with a cross sectional area of approximately 1 square inch. The number and spacing of stakes shall be adequate to hold sod securely in place. The Contractor shall give special attention and care to anchoring sod placed in drainage ditches, channels, and swales.

After sod has been placed, any joints and gaps that were too small to be effectively plugged with sod shall be filled with loamy topsoil.

The Contractor shall thoroughly water, roll, or tamp sodded areas after installation to press the root system of the sod into full contact with the underlying prepared sod bed.

Sodded areas shall be kept watered to promote growth and maintain the life of the sod until final acceptance.

604.04—Measurement and Payment

Sod will be measured in square yards of surface area and will be paid for at the contract unit price per square yard of installed surface area. This price shall include preparing sod beds; furnishing and applying lime, fertilizer, sod, and water; and maintaining sodded areas until final acceptance.

Payment will be made under:

Pay Item	Pay Unit
Sod	Square yard

SECTION 605 – PLANTING

605.01—Description

This work shall consist of furnishing and planting trees, shrubs, vines, perennials, and other plants of the kinds, sizes, qualities, and quantities specified on the plans or by the Engineer and maintaining and replacing plants as specified herein. The fulfillment of the work is divided into two phases, the Installation Phase and the Establishment Period. The Installation Phase will begin with the start of landscaping operations by the Contractor after the Planting Operations Coordination Meeting and will terminate with Installation Phase Acceptance by the Department. The Establishment Period will begin once all plantings are accepted by the Department in accordance with Section 605.07

The Engineer will consult with the VDOT Landscape Architect (VLA) or the representative designated by the VLA on all plant identifications, phase inspections, discretionary actions, approvals, and acceptance or rejection decisions. For purposes of this Section, references to the Engineer shall include the VLA as a "duly authorized representative" as specified in the definitions in Section 101.02. The VLA is granted the authority of the Engineer specified in Section 105.03(a) in administering this specification. The representative designated by the VLA is granted the authority of the Inspector specified in Section 105.03(b) in administering this specification. The authority of the VLA and VLA representative to reject or suspend work is limited to safety issues and work covered by this specification.

605.02—Materials

(a) **Herbicide** shall conform to Section 244.02(a).

(b) **Topsoil** shall conform to Section 244.02(b).

(c) **Seed** shall conform to Section 244.02(c).

(d) **Fertilizer** shall conform to Section 244.02(d).

(e) **Lime and Iron Sulfate** shall conform to Section 244.02(e).

(f) **Mulch** shall conform to Section 244.02(g).

(g) **Trees, Shrubs, Vines, Perennials, and Other Plants** shall conform to Section 244.02(i).

(h) **Compost** shall conform to Section 244.02(j).

(i) **Horticultural Grade Perlite** shall conform to Section 244.02(k).

(j) **All other Misc. Planting Materials** shall conform to Section 244.02(k).

605.03—Qualifications of Personnel

(a) **Contractor and Equipment Qualifications:** The Contractor shall be personally experienced or arrange to furnish a subcontractor who is personally experienced in all aspects of landscape preparation, planting operations, arboriculture, and landscape maintenance operations as required by the work described in the Contract, including these Specifications. Workers and equipment shall conform to Section 105.05. The Contractor shall submit documentation of equipment proposed for use on the project to the Engineer. On independent landscape projects, the Contractor is also required to have or to furnish personnel possessing appropriate Traffic Control and Erosion and Siltation Control certifications to control the work according to Sections 105.14, 107.16 and Section 512 as appropriate.

(b) **Landscape Operations Crew and Crew Manager Qualifications:** The Contractor shall furnish the following personnel to supervise landscape field operations:

1. **Work Crew** - The majority of crew personnel must have at least two years continuous experience working on a commercial landscaping crew.

2. **The Crew Manager** - Crew Manager must have at least three years continuous experience working as a Virginia Nursery and Landscape Association (VNLA) Certified Horticulturalist, or approved equivalent from a neighboring state. This individual shall be proficient in areas of worker safety, environmental regulations, and efficient landscape management in conformance with accepted horticultural practice and methodologies.

(c) **Herbicide/Pesticide Applicators** must be Virginia Department of Agriculture and Consumer Services (VDACS) certified or a registered technician to perform all applications of pesticides, herbicides, or fungicides as required herein. Certified applicators shall have at least 5 years continuous experience in the commercial application of pesticides and herbicides required for the establishment and maintenance of trees, plant materials, and grasses specified in this Section and on the Plans.

(d) **Pruning** shall be performed by personnel certified by the International Society of Arboriculture.

Copies of current certifications shall be furnished to the Engineer prior to the start of work requiring the specific certifications. The Contractor will not be allowed to begin the specific work until the Engineer receives such certifications.

605.04—Procedures

(a) **Confirmed Order Documentation:** The Contractor shall submit documentation to the Engineer of a confirmed order of all plant materials required for the contract at least 30 days in advance of the start of the proposed planting operations. This documentation shall list the source(s) of supply, all species by common and botanical name, specific variety, and cultivar in the sizes, and quantities reserved. When special requirements are listed on the planting summary sheet, such as “Specimen Quality,” or “Specimen Street Tree”, etc., the documentation shall certify that the species reserved meets those specific requirements. The Engineer may require sample photographs of materials to be supplied and/or to inspect and approve the selection of plant materials at the source of supply prior to delivery, once the documentation of confirmed order is received. If specific plant materials are not available, the Contractor shall submit a request for substitutions in accordance with paragraph (g) herein.

(b) **Contractor's Installation Plan:** The Contractor shall follow the Contract phasing plan (if applicable) or submit to the Engineer a plan for executing the planting operations for the project at least one week prior to the date of the Planting Operations Coordination Meeting (paragraph (c) herein). The plan shall be submitted in an 11x17 inch format with color coding for each phase of the installation planting plan. The plan shall include, but not be limited to, the anticipated date of delivery of specific planting materials per phase, staging of materials (as necessary), phasing of site preparation and the phased installation of plant materials that can be completed in three to five days of continuous work, barring any delays due to weather or other unforeseen circumstances. Very large planting operations, such as those entailing interchange plantings, may be staged by selected quadrants (areas) as necessary.

(c) **Planting Operations Coordination Meeting:** At least 2 weeks prior to the beginning of any landscaping operations, the Contractor shall arrange for a meeting between the Contractor, the Contractor's Landscape Operations Advanced Crew Managers, the Engineer, the VDOT Traffic Operations Engineer (as necessary), and the VLA. This meeting shall be for the purpose of reviewing the proposed phasing of various operations detailed in the Contractor's Installation Plan, to review proper planting and landscaping procedures, to review and discuss general and project specific requirements, and to ensure proper safety measures and traffic control are employed while prosecuting the work. This meeting shall also serve as a forum to answer any questions that the Contractor or VDOT may have prior to the start of landscaping operations.

(d) **Planting:** The Contractor shall adhere to the following seasonal schedule for planting unless the Engineer, with the written approval of the Landscape Architect, directs otherwise.

PLANTING SEASON SCHEDULE

		DECIDUOUS MATERIAL			**EVERGREEN MATERIAL**		
REGION		Balled and Burlapped and Bare Root	Container Grown	Seedling Stock	Balled and Burlapped	Container Grown	Seedling Stock
	Season	**Dates**	**Dates**	**Dates**	**Dates**	**Dates**	**Dates**
Bristol, Culpepper	Spring	3/1-4/30	3/1-6/15	3/15-4/15	3/15-4/30	3/15-6/15	3/15-4/15
NOVA, Salem, Staunton, Lynchburg	Fall	10/15-12/15	8/15-12/15		9/1-11/15	8/15-11/15	10/1-10/31
Fredericksburg, Richmond, Hampton Roads	Spring	2/15-4/15	2/15-4/15	2/15-4/15	2/15-4/15	2/15-4/15	2/15-4/15
	Fall/ Winter	10/15-1/31	10/15-1/31		10/15-1/31	10/15-1/31	10/1-1/31

REGION		CONTAINER/FIELD GROWN PERENNIALS AND ORNAMENTAL GRASSES	BULBS
	Season	Dates	Dates
Bristol, Culpepper NOVA, Salem	Spring	4/14-6/30	
Staunton, Lynchburg	Fall	9/1-10/30	10/1-11/30
Fredericksburg, Richmond,	Spring	3/15-5/15	
Hampton Roads	Fall/ Winter	10/15-12/15	10/1-11/30

(e) **Sources of Supply:** All plants shall be obtained from a nursery certified by the VDACS with a "Certificate of Registration", or certified by a comparable agency responsible for nursery inspection and issuance of a "Certificate of Registration" from the State of origin. The Contractor shall supply the Engineer with a copy of this certification with each separate delivery of plant materials to the project site. Failure to supply this certification will result in rejection of the plant delivery.

(f) **Inspecting and Identifying Plants:** Plants will be inspected and identified by the Engineer in accordance with the Standardized Plant Names prepared by the Editorial Committee of the American Joint Committee on Horticultural Nomenclature. The Engineer may inspect plants at any time and place. Plants will be inspected immediately prior to being planted. If plants are installed prior to inspection and found to be noncompliant, they shall be replaced with Department approved plants at the Contractor's expense.

(g) **Substitutions:** The Engineer will not allow any changes in the quantity, size, kind, or quality of plants from those specified in the Contract unless otherwise authorized in writing by the VLA or VLA representative. When requesting permission to substitute, the Contractor shall submit to the Engineer written evidence in accordance with paragraph (a) herein of the Contractor contacting at least 3 certified nurseries in search of specified plants, verifying their unavailability, and provide the Engineer with the nursery contact information including date, time, and contact name and title. The Engineer may direct the Contractor to contact additional nurseries to confirm that the specified plants are unavailable from those sources as well. After ascertaining that the specified plants are not available the Contractor shall suggest substitute plants that best conform to the Contract. If the Engineer approves the substitution, the Contractor shall indicate the reduced cost, if any, that will accrue to the Department as a result of the substitution. Substitute plant materials shall conform to the same requirements as plant materials originally designated in the Contract. As an option, the Engineer may also delete plants from the Contract in lieu of approving substitutions.

(h) **Plant Acclimation:** The Contractor shall ensure that container grown plants are acclimated to prevailing weather conditions before their installation. Any plants originating from greenhouse storage shall be acclimated prior to shipping. Generally, acclimation can be satisfied by placing plants outdoors for a period of at least 1 week prior to shipment. Install bare root plants while dormant when soil and air temperatures are above freezing.

(i) **Delivery:** The Contractor shall notify the Engineer at least 48 hours in advance of the anticipated delivery date for plants. The Contractor shall submit a legible copy of the invoice show-

ing the sources of supply, all species by common and botanical name, specific variety, and cultivar in the sizes amount, and quality (if applicable) reserved in each shipment to the Engineer. A copy of the current Certificate of Nursery Inspection from the State of origin must accompany each shipment of plants for acceptance.

(j) **Labeling:** Plant material delivered to the project shall be legibly identified with a waterproof label as to the genus, species (common and botanical name), cultivar, quality (where applicable), and size of the plants. When plants are in bales, bundles, boxes, or other containers, a legible label indicating the genus, species (common and botanical name), size, and quantity of the plants shall be attached to each container. A minimum of 10 percent of each species in each shipment shall be so labeled. The Engineer will reject plants that do not comply with this identification labeling requirement.

(k) **Transporting and Protecting:** Plants transported to the project in open vehicles shall be covered with suitable covers securely fastened to the body of the vehicle for protection. Closed vehicles shall be adequately ventilated to prevent overheating or dehydration of plants. Plants shall be kept moist, fresh, and protected at all times.

(l) **Storing:** When plants are to be stored prior to installation, they shall be stored at a location approved by the Engineer. The Engineer will reject any plants stored for more than 30 days. Unless the Engineer approves other methods of storage, bare-root plants that are not planted within 24 hours after delivery shall be heeled-in in a moist trench dug in the ground. Bundled plants shall be opened, and the plants shall be carefully separated and placed singularly in the trench with the roots spread in a natural position. Roots of each layer of plants shall be immediately covered with moist, pulverized soil; moist sawdust; or other approved material in a manner satisfactory to the Engineer. The Contractor shall ensure root-covering materials are kept moist at all times. The Contractor shall provide shade for plants when and as directed by the Engineer. Balled material, container-grown plants, and plants in plantable pots that are not installed within 48 hours of delivery shall be grouped together according to the method of containment they are delivered in, and shall have their root zones protected by covering their root balls or containers with wet sawdust, mulch or other approved material. Plants rejected by the Engineer and the VLA for non-compliance to these requirements shall be removed from the storage area within 24 hours of rejection or, with the written approval of the Engineer, may be marked with yellow paint or otherwise made readily identifiable for later disposal. If the Contractor has not removed rejected plants or acceptably marked such material within 24 hours of rejection, the Engineer will not permit the use of other plants from the storage area until the rejected plants have been removed or properly identified as "Rejected" by marking.

(m) **Preparation:** The Contractor shall inspect all areas designated on the plans for planting to ensure that final grade has been met. Planting operations shall not proceed in any area that has not reached final grade. Plantings that have been installed prior to establishment of final grade shall be reinstalled at the Contractor's expense or are subject to rejection upon review by the Engineer and the VLA.

(n) **Marking Underground and Aboveground Conditions:** The Contractor shall arrange for the marking of the location of all underground utilities with Ticket Information Exchange (TIE) or Miss Utility and all other applicable underground utility providers such as sewer and water service, and VDOT Regional Traffic Control Centers (for Intelligent Transportation System assets, traffic signal cable, or other facilities) prior to digging. The Contractor shall locate and work around aboveground utilities. If underground obstructions or any other unforeseen subsurface or aboveground conditions are encountered that could interfere with a utility, prohibit

plant installation, or be detrimental to acceptable plant installation or sustainable growth, the Engineer may require the Contractor to enlarge or relocate the plant pits or to delete the plants from the contract.

(o) **Layout:** The Contractor shall stake or mark plant locations and outlines of plant bed areas designated to receive plants. The Engineer will inspect and approve plant locations and planting beds prior to the start of plant installation. The Contractor shall notify the Engineer a minimum of 48 hours prior to scheduling the layout inspection. Planting will not be permitted until the Engineer has approved the staking layout. Unforeseen or unintended conditions such as the location of traffic signs, utilities, and drainage items, etc. may necessitate adjustments in proposed plant locations; however, such adjustments will only be permitted when approved by the Engineer.

(p) **Pruning:**

1. **Limbs:** The Engineer will reject any plants that have been freshly pruned before delivery. If necessary, plants shall be pruned either immediately before or within 48 hours after they are planted. In the case of trees, while laying tree on its side, inspect the tree crown, and make clean pruning cuts as necessary to remove co-dominant leaders, dead or broken branches, and basal suckers. Pruning of trees and shrubs shall consist of removing dead, diseased, broken, or other branches and removing sprouts and sucker growth deemed injurious to the health of the plant. Care shall be taken to preserve the natural character of the plant. Pruning shall be performed with tools and equipment in excellent working and sharpened condition that are specifically designed for the appropriate work. All pruning shall be performed in accordance with the current ANSI A300 and as directed by the Engineer. The Contractor shall remove and dispose of all debris from the pruning operations in accordance with Section 106.04. All above ground pruning shall be made just outside the branch collar and all basal suckers shall be pruned back to the point of origin, even if from the root system. Trees having co-dominate leaders within the lower two-thirds of the crown will be rejected. Reduction pruning of co-dominate leaders shall be limited to limbs less than 1.5” inches in diameter.

2. **Roots:** The Contractor shall inspect root zones for potential stem girdling roots (SGRs), “J” roots, or any roots starting to encircle the trunk, stem or root system and prune away dead, detrimental, or defective roots back to live tissue.

(q) **Planting**

1. **Slopes Steeper than 3H:1V:** When designated in the Planting Summary General Notes to test for pit drainage on slopes, the Contractor shall determine drainage requirements for trees or shrubs on slopes steeper than 3H:1V by percolation tests, with no more than 3 tests per slope, at specific locations as determined by the Engineer. Slopes requiring this test are determined by the Department from cut and fill slopes shown on the cross sections. Percolation testing shall consist of the following: The Contractor shall auger holes that are 12 inches in diameter and 24 inches in depth. Three holes shall be distributed across the slopes vertically and horizontally. The Contractor shall fill the holes with water and allow them to drain. If soil is extremely dry, the Contractor shall fill holes twice and allow them to drain. The holes shall be filled again and the rate measured at which water percolates into the soil. Water in holes should recede at the rate of 2 inches per hour (minimum). If not, the Engineer will require the Contractor to perform planting pit modification to improve drainage quality.

2. **Preparing Planting Pits for Trees and Shrubs:** Planting pits shall be excavated to at least meet the minimum requirements of the planting details of the Standard Drawings unless otherwise indicated on the plans by specific detailed drawings. The Contractor shall scarify the sides of pits that are plastered or glazed. Surplus excavation and unsuitable material shall not be piled on top of the root ball or used to make tree rings but shall be disposed of in accordance with Section 106.04. Existing soil excavated from individual planting pits shall be used as standard backfill material for planting except as otherwise indicated in the planting plan details and notes. The Contractor shall take care in reviewing all plan details and notes that may include a specific backfill soil mix, oversize planting pits, linear planting pits, etc.

3. **Oversize Planting Pits:** The Contractor shall prepare oversize planting pits according to the plan details at the locations indicated on the plans. Backfill shall consist of two-thirds part native soil excavated from the planting pit, and one-third part compost unless otherwise indicated in the Contract or approved by the Engineer. The Contractor shall add additional soil mix at the direction of the Engineer if settlement occurs prior to planting. The planting pit shall be neatly edged in a 4 foot diameter around the tree after planting and the remaining disturbed soil shall be reseeded in accordance with requirements listed on the Roadside Development Sheet except when the planting pit falls within a larger planting bed area.

4. **Linear Planting Pits:** The Contractor shall excavate areas labeled on the plans and details as "Linear Planting Pit" to the horizontal and vertical dimensions indicated to receive soil mixture. The soil mixture shall consist of 1 part compost, 1 part horticultural grade perlite, and 1 part topsoil unless otherwise indicated in the Contract or approved by the Engineer. Construction of linear planting pits shall also include any necessary excavation required for installation of plant underdrain systems, if indicated. The inclusion of plant underdrain systems, as applicable, will be indicated on the plans.

   Soil mix for linear planting pits shall be installed in 6 inch lifts, lightly compacted by foot or other approved methods, and moistened prior to proceeding with the next lift. If settlement occurs prior to planting, the Contractor shall furnish and install additional soil mix as directed by the Engineer.

   Following installation of the linear planting pit, remaining disturbed soil that falls outside of tree rings shall be reseeded in accordance with the Roadside Development Sheet except when the linear planting pit falls within a larger planting bed area. If the linear planting pit is used as a plant bed, the Contractor shall till the linear planting pit to a depth of 4 inches prior to planting and shall hand rake the area and adjust the grade adjacent to curb, sidewalk or "V" cut edge as necessary to receive 3 inches of mulch.

5. **Preparing Plant Beds:** The Contractor shall prepare plant beds in accordance with the following:

   a. The Engineer will only require plant bed preparation on 3H:1V or flatter slopes. Where grass and weeds are present, the Contractor shall treat the designated bed areas with a broad spectrum grass and weed killing herbicide at least 14 days prior to beginning plant bed preparation, or shall physically remove all turf and weeds immediately before bed preparation. Apply non-selective herbicide in water with wetting agent and dye as follows:

NON-SELECTIVE HERBICIDE APPLICATION

MATERIAL	RATE PER ACRE
Glyphosate Herbicide	5 lbs. of active ingredient
Marking Dye	6 to 15 oz.
Water	40 to 50 gal

Following removal or elimination of grass and weeds, the entire area of the plant bed shall be cultivated to a depth of 4 inches by a rotary cultivator or other method approved by the Engineer. The Contractor shall then apply compost to a depth of three inches over the entire plant bed and re-till the area to form a homogenous soil medium. Soil shall be cultivated so that there are no clods larger than 2 inches in diameter.

b. The Contractor shall remove any remaining grass, sod, and weeds from the bed. Rocks over 3 inches in diameter, clods, roots, and other objectionable material remaining on the surface shall be removed and disposed of in accordance with Section 106.04 or as approved in writing by the Engineer. Individual planting pits within the bed shall not be dug until after the bed is prepared to the satisfaction of the Engineer.

c. Upon completion of planting, the bed shall be hand raked to an even surface and neatly edged with a "V" cut edge located a minimum of 12 inches from the root ball of any plants located along the outer edge of the bed. The Contractor shall then apply mulch to the entire bed area. On certain projects where mulched beds around large quantities of plant materials are used to control weed growth and are not intended as a prepared soil medium or are located on slopes steeper than 3H:1V, tilling and application of compost throughout the plant bed may not be necessary. The addition of compost to individual plant pits within beds in such cases will be required when designated on plan details or in accompanying plan notes.

6. I**nstalling Trees and Shrubs:** Balled and burlapped and containerized plant materials shall be installed in plant pits in accordance with the details and requirements of the Standard Drawings unless otherwise indicated on the plans. Bare roots of plants shall be spread out in a natural position. Broken, dead, or bruised roots shall be carefully pruned. The Contractor shall cut and remove root ball wrapping materials and cages from the planting pits after positioning plants in the planting pit and prior to backfilling. All other wrapping or identifying materials such as tags, twine and colored marking ribbon shall be removed from the plant unless otherwise directed by the Engineer. The soil mixture shall then be filled in around the roots and lightly tamped. Light tamping around root balls shall be performed using a method approved by the Engineer. The Engineer will allow foot tamping in the bottom of pits before plants are installed, around root balls when there is ample room to accommodate the foot without damage to the root ball, and in the planting of bare-root plants after roots have been covered with the soil. The Engineer will not permit the use of saturated or frozen backfill material.

Backfill material in pits shall be saturated with water. The amount of water applied and method of application shall be approved by the Engineer. Failure to water properly at the time each plant is installed will be cause for rejection of the plant. The Contractor shall be responsible for continuing to water as frequently as is necessary to maintain an adequate supply of moisture within the root zone of all plantings at all times and especially whenever there is less than 1 inch of rainfall in a seven day period until the start of the Establishment Period.

Potted plants shall not be removed from their container until immediately before planting. Plants in containers shall be removed by Department approved methods that will not damage roots or loosen soil balls. The sides of containerized plants shall be scarified prior to planting.

When planted, watered, and fully settled, plants shall be vertical and shall stand at a height flush with the height they were growing prior to installation.

7. **Handling Plants during Planting:** Roots of bare-root plants shall be kept covered with moist burlap, moist soil, moist sawdust, or other approved material prior to planting. Forest tree seedlings and forest tree transplants shall be carried in a container filled with sufficient mud to puddle roots. When seedling roots have been coated with a protective material, the seedlings shall be protected in accordance with the U.S. Forest Service's recommendations relative to treatment of seedling roots while seedlings are being planted. The Engineer will reject any plants if their roots are exposed to drying conditions at any time prior to planting.

8. **Fertilizer:** The Contractor shall top dress each planting pit and all plant beds with a granular, slow release fertilizer at the manufacturer's specified rate per square foot of surface area, prior to mulching.

9. **Mulch** shall be applied uniformly to a 3-inch depth over the entire area of the plant pit or plant bed within 48 hours after completion of all planting. The Contractor shall apply mulch at the terminus of the Establishment Period at a depth of 1-1/2 inches. Mulch shall be anchored in a manner satisfactory to the Engineer. Mulch shall not be required for wetland trees and shrubs except as stated herein or upland forest tree seedlings unless specified on the plans. Mulch shall be applied to wetland trees and shrubs on slopes and upland areas adjacent to the wetland.

10. **Staking, Guying, Anchoring:** Each tree shall be staked with two or three stakes, guyed or secured with below ground tree anchors the same day trees are planted. Staking and guying of trees shall be performed as detailed herein and in the Standard Drawings. The Contractor shall use below ground tree anchors when specified on detailed drawings in the plans. The Contractor shall stake deciduous trees 3" in caliper and greater, and evergreen trees 8' or taller, with three stakes. When two or three stakes are used, install two stakes parallel to traffic. Drive stakes vertically to a depth of 10 inches minimum below the bottom of the tree pit and at least 6 inches from the root ball or container.

11. **Pre-emergent Herbicide Application:** 14 days after mulching, the Contractor shall top dress each planting pit and all plant beds with a granular, pre-emergent herbicide at the manufacturer's specified rate per square foot of surface area. Thoroughly water in herbicide according to the manufacturer's recommendations.

(r) **Pit Drains:** Pit drains or plant underdrain systems shall be installed according to the manufacturer's recommendations and as shown on the Plans.

(s) **Tree Tubes:** Tree tubes shall be installed on all seedling trees in accordance with the manufacturer's instructions, the Plans, and product details and specifications.

605.05—Completion of Installation Phase

(a) **Installation Phase Plant Replacements:** Between the beginning and ending dates of the Installation Phase, plants that are dead, defective, or otherwise not in a healthy growing

condition as determined by the Engineer shall be removed immediately and replaced as soon as viably feasible within the appropriate planting season at the Contractor's expense. Plant replacements shall be made once in the spring, if required, and once in the fall, if required (See Planting Season), as necessary to replace unacceptable plant materials as directed by the Engineer.

The following criteria will be used to identify plants that are unacceptable that the Contractor shall replace at the spring or fall planting times indicated above. Replacement plants shall be true to species, cultivar, size, root condition, and quality as specified in the Contract unless a request for substitution has been approved, in which case, the replacement may be the substitution or if now available, the originally specified plant as directed by the Engineer.

CRITERIA OF UNACCEPTABLE PLANTS

Item	Plant Name	Condition	Unacceptable
1	Tree, Shrub, Vine, Perennial, Grass	Death or Absence	Any dead or missing plant, any cause.
2	Tree, Shrub, Vine, Perennial, Grass	Defoliation	More than 25% of leaf area dead, lost, or dropped
3	Tree, Shrub, Vine	Bark Wound or Exfoliation	More than 15% of bark circumference or 2 in. length, whichever is less
4	Shrub or Vine	Height Die-back	More than 25% of the shrub or vine height.
5	Tree	Leader Die-back/missing	More than 10% of tree height or central leader dead or missing
6	Tree	Branch Die-back	More than 6 in. on 50% of branches
7	Tree	Vertical Rotation	Tree is bending over (bowed) more than 3' off center from trunk base
8	Shrub, Perennial, Grass	Weed infestation	Root Ball or Container infested with weeds across the surface

(b) **Installation Phase Inspection:** The Contractor shall request an Installation Phase Acceptance inspection be performed by the Engineer to confirm completion of all planting operations in accordance with this Section and the Contract, and to verify all plants are living, healthy and in a viable growing condition. The Installation Phase Acceptance Inspection will be performed on a mutually agreeable date following completion of the appropriate planting season (spring or fall), but in no case, less than 14 days before the end date of the appropriate planting season. Plants that are replaced in order to meet the initial specification requirements to begin the Establishment Period are not considered as "plant replacements" and, therefore, are to be replaced at the Contractor's expense.

The Engineer will schedule the Installation Phase Acceptance Inspection with the Contractor, the VLA (or VLA representative) and any other affected parties at a mutually agreeable time and place on the project site.

(c) **Installation Phase Punch List:** The Engineer, in consultation with the Contractor, will develop an Installation Phase Punch List of unfulfilled requirements to be met and any deficiencies, including a list of plants to be replaced prior to acceptance of this phase of the planting operation. The Contractor shall complete the Punch List requirements and replace plants as indicated. The criteria for plants that are unacceptable and are to be replaced shall be as indicated in paragraph (a) herein.

(d) **Installation Phase Acceptance:** The Engineer will perform re-inspection with the Contractor as needed until the Installation Phase planting is accepted. The Engineer will approve and issue Installation Phase Acceptance when all items on the Installation Phase Punch List are completed, replacement plants are properly installed, and all Installation Phase requirements for Acceptance listed below have been met.

REQUIREMENTS FOR INSTALLATION PHASE ACCEPTANCE

Item	Requirement
1	Source of Supply and Submittals are accepted and Inspections are completed
2	All species are correct for the variety, cultivar, size and root condition specified
3	Damaging pests are controlled
4	Layouts are inspected and approved.
5	Oversize and Linear Planting pits are the correct size.
6	Planting pits and planting beds are weed free.
7	Trees and shrubs are pruned
8	Trees are installed vertically and at the proper elevation.
9	Planting pits and beds are neatly edged with a 3 inch “V” cut edge
10	Mulch is uniformly spread to the specified depth
11	Washouts in planting pits and beds are repaired
12	Plants are watered and fertilized
13	Clean up is completed, plant tags and ribbons and other debris are removed
14	Unacceptable plants are replaced.
15	Shrubs and Herbaceous Plants are properly installed
16	Tree Rings and beds have been top dressed with Pre-emergent herbicide
17	Establishment Phase Schedule is accepted.
18	Damage repairs and Installation Punch List is completed.

605.06—Plant Care and Maintenance

Plant care and maintenance shall begin immediately after each plant is satisfactorily installed and shall continue until the end of the Establishment Period. Care and maintenance shall include, but not be limited to, replacing displaced mulch, repairing and reshaping water rings or saucers, maintaining stakes and guys as originally installed, watering when needed as required by the specifications or as directed by the Engineer, pruning as needed, applications of pesticides, herbicides or fungicides as required, and performing any other work required to keep plants in a healthy growing condition. Dead, defective, or rejected plants shall be immediately removed and replaced in accordance with of Section 605.05(a).

605.07—Establishment Period

The Contractor shall submit an Establishment Period Phased Maintenance Schedule to the Engineer for review and approval at least one week prior to the start of the Establishment Period. The Establishment

Period shall begin on a date, determined by the Engineer, following completion of the appropriate planting season (spring or fall) and acceptance of the Installation Phase by the Department. The Establishment Period shall continue through a minimum of one calendar year (or for the time period established in the Contract), and shall terminate on the date determined in writing by the Engineer in accordance with Section 605.08. In order to satisfy the Establishment Period requirements and provide for Final Acceptance of the Contract in accordance with Section 108.09(c), the Contractor shall provide the Department a minimum one year (or as necessary to cover the Establishment Period duration) separate performance bond in the full amount of the Landscaping section of the contract applicable for the duration of the Establishment Period. The Contractor shall do all work necessary to keep the plants in a healthy growing condition, including, but not limited to the following:

(a) **Watering:** The Contractor's watering schedule shall be in accordance with the frequency listed on the project's summary sheet general notes and in accordance with the Contractor's approved Establishment Period Phased Maintenance Schedule. That schedule withstanding, the Contractor shall be responsible for watering as frequently as is necessary to maintain an adequate supply of moisture within the root zone of all plantings at all times and especially whenever there is less than 1 inch of rainfall in a seven day period during the months of April through September. Water shall not be applied at a force that displaces soil or mulch. Quantities and frequency of watering shown on the plans are the minimum for estimating purposes only.

1. The Engineer may require the use of watering needles or other approved watering methods to prevent displacement of soil, mulch and the runoff of water. The Engineer may make periodic inspections to ascertain the adequacy of the Contractor's watering efforts and the moisture content of the soil in the root zone of plantings. If it is determined from the Department's inspection the Contractor's watering efforts are not adequate to continuously maintain moisture in the root zone of plantings the Contractor will be notified that additional watering is required and shall respond as detailed herein.

2. The quantity of water supplied shall not be in excess of that normally required to ensure optimum growing conditions. Watering shall not commence until methods and equipment have been approved by the Engineer. The Engineer may require or suspend watering at any time.

Notification and Scheduling: When notified by the Engineer that additional watering is required (in addition to watering scheduled in the Contractor's approved Establishment Period Phased Maintenance Schedule), the Contractor shall begin watering within 48 hours of such notification with sufficient water, labor, materials, and equipment as required and shall continue to water daily where and as directed, without delays or interruptions, to ensure that the root zones of plantings do not become dry at any time. If the Contractor fails to begin watering operations within 48 hours after notification, the Engineer may proceed with adequate water, forces, equipment, and materials to perform the needed watering and the entire cost of the Department's watering operations will be deducted from monies due the Contractor.

(b) **All Establishment Period maintenance work** shall begin within 7 working days after the Engineer notifies the Contractor that the Establishment Period has begun.

Establishment Period Plant Replacements: Between the beginning and ending dates of the Establishment Period, plants that are dead, defective, or otherwise not in a healthy growing condition as determined by the Engineer shall be removed immediately and replaced as soon as viably feasible within the appropriate growing season at the monetary replacement amounts

listed below. Plant replacements shall be made once in the spring, if required (Between March 1 and April 15), and once in the fall, if required (Between October 15 and December 31), as necessary to replace dead, damaged, or defective plant materials unless otherwise directed by the Engineer.

For each plant replaced, the first replacement shall be at the Contractor's expense. The second replacement, if required, will be paid at 35 percent of the original contract unit price for each plant replaced. The criteria used to identify plants that are unacceptable during the Installation Phase and which shall be replaced at the spring or fall times as indicated in Section 605.05 (a) above shall be used to determine acceptability during the Establishment Phase. Replacement plants shall be true to species, cultivar, size, root condition, and quality as specified in the Contract unless a request for substitution is submitted and approved by the Engineer, in which cases substitutions shall conform to Section 605.04 (g).

(c) **Stakes, and Guys, and/or Below Ground Tree Anchors** shall be repaired or replaced immediately as needed. Replacements shall take place when units are no longer functional as intended for use. Stakes and Guys shall be removed when no longer required as directed by the Engineer. Below ground tree anchors shall remain in place.

(d) **Mulch** shall be redressed as needed and/or as directed by the Engineer throughout the Establishment Period. Beds shall be re-edged as necessary.

(e) **Re-mulching:** When established as a separate pay item, remulching shall be applied to all individual plants and plant beds prior to the end of the Establishment Period at a rate of approximately 1-1/2 inch depth uniformly over all individual plant pits and plant beds, or as directed by the Engineer.

(f) **Vegetation Control** shall consist of the control and removal of weeds, grasses (except ornamental varieties identified in the Contract) and root growth from plant beds and mulched areas around individual plants. The Contractor shall perform such weeding once in the months of May, June, July, August, and September for a total of five weeding operations over the duration of the Establishment Period (unless a different schedule is specified in the Planting Summary Sheet and Notes) in accordance with the Contractor's approved Establishment Period Phased Maintenance Schedule.

1. **Removal of weeds, grass and root growth** shall be performed by the application of broad spectrum and selective "post emergent" herbicides as approved by the Engineer. All herbicide applications shall be performed or supervised by certified pesticide applicators in accordance with the requirements herein and Section 607. Selective hand weeding may be performed where weeds and vines are growing through plants or where selective herbicide treatment has not proven effective or successful. The Contractor shall be responsible for replacing plants that are damaged or that die due to the application of herbicide, pesticide, or fungicide treatments.

   When beds and plantings therein become inundated with weeds due to a lack of weed control, the Contractor shall remove all plants in the bed (except for trees) within the area of weed infestation as determined by the Engineer. Plants whose root systems are inundated with weeds to the point that plant viability is threatened in the opinion of the VLA shall be replaced at the Contractor's expense. Salvageable plants from the plant beds shall be stored on site in accordance with Section 605.04 (l). The Contractor shall then protect the removed plants root zones from drying out, physically remove all weed growth from the affected

areas, replace any excavated soil mix, reinstall plants, fertilize, re-mulch, water, and reapply pre-emergent herbicide in accordance with these provision, all at the Contractor's expense.

2. When herbicides are used for post emergent weed control, the weeds shall be cut to a height of 6 inches or as recommended by the herbicide manufacturer, if necessary, prior to applying the herbicide. The Engineer reserves the right to change the frequency or delete specific areas scheduled for weed control. Other pesticides, adjuvants and plant growth regulators may be used when approved by the Engineer.

3. Vegetation Control shall also include turf management and maintenance, which includes mowing grass and other vegetation to a height of 3 inches around individual plant pits, between groups of plant pits that are 15 feet on center or less, and around the perimeter of plant beds. For each individual plant pit, group of plant pits, and plant beds, a perimeter extending 2-1/2 feet in width shall be maintained around the outermost plant pits and 5 feet around the perimeter of beds where grass and other vegetation is present, and where such areas exist within the right-of-way or construction easement. The Contractor shall perform mowing once each month from May and to September, inclusive. Additional mowing may be required when requested by the Engineer. If requested and authorized by the Engineer additional mowing will be paid for as shown in the contract. The Engineer may delete individual mowing cycles when deemed appropriate.

(g) **Additional Plant Maintenance:** The Contractor shall also perform plant maintenance operations including pruning of dead, broken, or diseased branches, and seasonal spraying with approved insecticides and fungicides as approved or directed by the Engineer to ensure plant health and survival.

605.08—Termination of Establishment Period

(a) **Establishment Period Final Inspection:** The Engineer will schedule the Establishment Period Final Inspection with the Contractor, VLA (or VLA representative), and any other affected parties on a mutually agreeable date at least one year, or as otherwise required by the duration of the Establishment Period stated in the Contract, following the start date of the Establishment Period. During this inspection an Establishment Phase Terminal Punch List will be developed, if necessary, to address deficiencies, repairs, replacements, and other work as specified in the Contract.

The Establishment Period Final Inspection will be performed on a mutually agreeable date at least one year following the start date of the Establishment Period and 1 year completion of the appropriate planting season (spring or fall) but in no case less than 14 days before the end date of the appropriate planting season.

Any dead, missing, or defective plants shall be replaced as directed by the Engineer prior to the termination of the Establishment Period.

(b) **Establishment Period Final Inspection Punch List:** The Engineer will develop an Establishment Period Punch List based on the requirements listed below of any unfulfilled requirements or deficiencies, including a list of plants to be replaced prior to acceptance of this phase of the planting operations. The Contractor shall perform repairs, replacements and other work as required to finalize conformance to Punch List items and any other unfulfilled requirements specified in the Contract.

(c) **Final Acceptance of the Establishment Period** shall end on a date established by the Engineer, when the Contractor receives written notification from the Engineer that confirms all the requirements of this Section have been satisfactorily completed and the following list of key Establishment Period requirements have been satisfied:

ESTABLISHMENT PERIOD FINAL INSPECTION & ACCEPTANCE

Item	Requirement
1	Water sprouts (suckers) are manually pruned and removed up to the height of the first branch
2	Trees are vertical in position
3	Staking and guying are removed (except for trees replaced to terminate the Establishment Period)
4	Washouts in planting pits and beds are repaired
5	Tree rings and plant beds are remulched and neatly edged
6	Any abandoned planting pits are filled, leveled, and seeded.
7	Accepted plants are successfully established for 12 months
8	Damaging pests are controlled.
9	Planting pits and planting beds are weed and trash free.
10	Unacceptable plants are replaced with replacement stock in the correct position and in accordance with these Specifications
11	Annual foliage dieback of perennials and grasses is cut and removed.
12	Plants are fertilized again
13	All ribbons, flags, labels, tags, containers, cages, burlap and other waste materials are removed and sidewalks and paved medians are clean swept
14	Damaged or dead limbs/branches are pruned from accepted trees and shrubs
15	Damage repairs and Establishment Punch List are completed.

605.09—Guarantee

The Contractor shall provide the Department a minimum one-year separate performance bond in the full amount of the Landscaping section of the contract applicable for the duration of the Establishment Period. The 1 year landscape performance bond shall begin on the start date of the Establishment Period as described in Section 605.07.

The Contractor's separate performance bond for the landscaping portion of the Contract as specified in Section 605.07 shall provide for necessary maintenance during the Establishment Period. Among other things this bond shall ensure plant replacements in kind (or with a substitute acceptable to the Engineer) for plants that are not in a healthy growing condition or that have died back to the crown or beyond the normal pruning limit and for all associated maintenance as required by these specifications and the Contractor's approved Establishment Period Phased Maintenance Schedule.

605.10—Measurement and Payment

Plants will be measured in units of each, on an actual count of living plants in a healthy growing condition, and will be paid for at the contract unit price per each as described in the Contract for the size (and, if specified, quality) designated. Plants that the Engineer deleted from the Contract will not be measured for payment. This price shall include furnishing and installing plants and miscellaneous planting materials;

preparing planting pits, except when established as a separate pay item; initial watering when planting; watering during the Installation Phase and the Establishment Period; furnishing and applying fertilizer; backfilling with approved soil mixture, except when linear or oversize planting pits are established as a separate pay item; staking; guying; anchoring; pruning; applying mulch, except to areas designated on the plans as plant beds; applying pre-emergent herbicide to beds and individual plant pits; pest management; controlling weeds in plant beds and tree rings (vegetation control) throughout the Establishment Period; replacing dead or damaged plants; repairing, replacing and removing stakes and guys when no longer needed; and maintaining plants in a healthy growing condition until final acceptance.

(a) Trees or shrubs planted on a slope steeper than 3H:1V with pit modification as indicated in the Standard Drawings, Section 1201.06 will be paid for at 125 percent of the contract unit price. Such price shall also include the cost of pit modification, stone, and geotextile filter fabric. Percolation tests shall be included in the contract unit price of these plants.

(b) Replacements for plants lost during the Establishment Period due to damage or destruction caused by non-Contract personnel or equipment, or damage or destruction caused by wild or domestic animals will be paid for at the rate of 35 percent the contract unit price per each. If the Engineer determines the cause of damage, destruction, or loss to be theft, vandalism, or public vehicular damage, the rate will be 50 percent of the contract unit price per each. This price shall include all costs associated with furnishing and installing the replacement plant. Replacements for plants that die due to other reasons shall be replaced and paid for in accordance with Section 605.07 (l).

(c) Tree, shrub, vine, ornamental grass, perennial or aquatic plant installation and establishment will be paid for in monthly pro-rated payments based upon the approved list of these items and their contract unit prices. Payment will be made according to the following schedule of project inspections when construction requirements are met (adjustments to this schedule will be made, when required, as approved by the Engineer.

PLANT PAYMENT SCHEDULE

	PERCENTAGE OF TOTAL CONTRACT PRICE		**PRORATED MONTHLY FOR COMPLETED WORK**
PHASE COMPLETION	Part of Roadway Contract	Stand Alone Landscaping Contract	Subject to adjustment based on site conditions and duration of Installation Phase
Installation Phase		50	65
Establishment Phase Care & Maintenance in growing	3	4	April Inspection***
	7 {10}	5 {7}	May Inspection
	10	5 {7)	June Inspection
	7	5	July Inspection
	7	3	August Inspection
	6	3	September Inspection
Establishment Phase Removal & Replacement and Final	10	10	At Final Acceptance
Total Payment	100	100	

*** April Inspections for projects planted the previous fall. For projects planted in the spring, inspections will begin in May with the percentage of payment indicated in brackets beginning in May.

(d) The Contractor shall notify the Engineer within 48 hours if vegetation control for a specific month is changed from the Contractor's approved Establishment Period Phased Maintenance Schedule. Following maintenance operations for that month, the VLA (representative, consultant, or VDOT inspector) will make an inspection of the project and report to the Engineer for approving work or will submit a "punch list" for additional work to be completed prior to approval and payment being made.

(e) Watering during the Installation Period shall be applied at the rates and frequencies designated on the Plans and, during the Establishment Period, in accordance with the Contractor's approved Establishment Period Phased Maintenance Schedule.

(f) Vegetation Control for weeding and turf maintenance shall include removing and disposing of unwanted vegetation, applying pesticides, herbicides, and mowing around and in between individual plant pits in accordance with the Contractor's approved Establishment Period Phased Maintenance Schedule.

(g) Forfeiture: failure to complete operations required or directed in conformance with the Plant Payment Schedule will result in delay of that percentage of payment based upon the list of Contract Prices until the work is completed or, in the absence of completion, forfeiture of that percentage.

Bed Preparation will be measured in units of 100 square feet of surface area and will be paid for at the contract unit price per unit. This price shall include herbicide spraying of areas to be prepared for planting or physically removing turf and weeds, restoring low areas to original grade with topsoil (as applicable) as directed by the Engineer, tilling soil, furnishing, delivering, and applying composted yard waste to the specified depth, tilling in composted yard waste, hand raking, neatly edging bed, and all incidentals necessary to prepare a healthy growing medium for planting.

Pit drains, when detailed and established as a separate pay item on the plans, will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include furnishing and installing drainage stone, pipe, pipe grate, prefabricated drainage core, drainage and aeration cloth, and geotextile drainage fabric as designated on the Plans.

Linear Planting Pit will be measured in cubic yards of excavated material required to achieve the horizontal and vertical dimensions indicated on the plans to receive soil mixture and will be paid for at the contract unit price per square yard. This price shall include furnishing, and storing soil mixture materials to be used, and the disposing of surplus or unsuitable excavated materials. This price shall also include mixing and installing of all components of the soil mix (horticultural grade perlite and compost), preparing bed, hand raking and adjusting planting pit surface to receive mulch, and furnishing and installing underdrain systems if indicated on the plans, including drainage stone, drainage and aeration cloth, prefabricated drainage core, geotextile drainage fabric, pipe, and pipe grate in accordance with the Plans and detailed drawings, and all necessary incidentals, complete-in-place.

Oversize Planting Pit will be measured in units of each and will be paid for at the contract unit price per each. This price shall include excavating and disposing of unsuitable or surplus material, furnishing and installing pit drain materials if shown as part of the plan details, furnishing, installation, and mixing of approved backfill material and composted yard waste. Surplus material may be disposed of onsite if approved by the Engineer.

Mulching for plant beds at the time of initial installation will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. This price shall include furnishing, and applying mulch.

No separate payment will be made for initial application or maintenance of mulch around plants that are not in continuous mulched plant beds, the cost thereof shall be included in the price for the plant.

Remulching, when established as a separate pay item, will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. This price shall include furnishing, and applying mulch to plant beds and to plants in individual saucer rings prior to the end of the Establishment Period. Remulching does not include regular maintenance of individually mulched plants or plant beds for the duration of the Establishment Period.

Tree Tubes will be measured and paid for at the contract unit price per each which shall include furnishing and installing the tube and all incidentals necessary to complete the work. This price shall also include removing and disposing of the tree tube at the end of the Establishment Period.

Payment will be made under:

Pay Item	Pay Unit
(Name of) Plant (Size)	Each
Bed Preparation	Unit (100 square feet)
Pit Drain	Each
Linear Planting Pit	Cubic Yard
Oversize Planting Pit	Each
Mulching	Cubic Yard
Re-mulching	Cubic Yard
Tree Tube	Each

SECTION 606—ROLLED EROSION CONTROL PRODUCTS (RECP)

606.01—Description

This work shall consist of furnishing and placing Rolled Erosion Control Products (RECP) (Standard EC-2 or EC-3 protective coverings) on construction slopes, in drainage channels or concentrated flow areas to facilitate vegetation establishment according to these Specifications and in conformity to the dimensions, lines, and grades shown on the Plans or as established by the Engineer.

606.02—Materials

Materials shall conform to Section 244.02(l). Determination of the type of RECP will be as designated in the Contract and installation shall be at the locations shown on the Plans in accordance with the usage criteria shown in Section 244 and Section 603.

606.03—Procedures

(a) **Drainage Channel Installation**

1. **Preparing Areas:** Drainage channels shall be shaped in accordance with the cross sections shown on the Plans and then rolled or tamped to compact soil in place before final shaping.

During shaping operations, the Contractor shall prepare a seedbed approximately 3/4 inch in depth over the areas to be covered by the RECP. Stones, roots, and other objects that will prevent the protective covering from making consistently firm contact with the seedbed shall be removed before covering is installed.

2. **Applying Seed:** Seed, lime, fertilizer and Hydraulic Erosion Control Product (HECP), type 3 shall be applied at a rate of 1000 pounds per acre (23 pounds per 1000 square feet) in accordance with Section 603 prior to installation of RECP.

   Seeded areas adjacent to the channel or ditch that are disturbed during installation of covering shall be uniformly reshaped, reseeded, and mulched for seeding at the Contractor's expense.

3. **Installing RECP:** RECP shall be installed in accordance with the Standard Drawings and the manufacturer's instructions. A copy of the manufacturer's installation instructions shall be furnished to the Engineer prior to the start of installation.

4. **Watering:** After coverings are installed, seeded areas shall be watered sufficiently to saturate the seedbed. Water shall be applied in a spray, after which no additional watering will be required.

(b) **Slope Installation**

RECP on slopes shall be installed at the locations shown on the Plans in accordance with the manufacturer's instructions, Standard Drawings, and the Roadside Development Sheets in the Plans and the following:

1. **Preparing Areas:** Seed bed shall be prepared in accordance with Section 603.

2. **Applying Seed:** Seed, lime, fertilizer and HECP at a rate of 1000 pounds per acre (23 pounds per 1000 square feet) shall be applied in accordance with Section 603 and shall be applied prior to installation of RECP.

3. **Installing RECP:** RECP shall be installed in accordance with the Standard Drawings and manufacturer's instructions.

4. **Sediment Retention Roll:** Sediment Retention Rolls used as slope interrupters shall be installed in accordance with Section 603.

606.04—Measurement and Payment

Rolled Erosion Control Product (Type) installed in drainage channels will be measured in square yards of area covered, complete-in-place, in accordance with the nominal plan dimensions and will be paid for at the contract unit price per square yard for the type specified. Overlaps, overwidths, and cut slots will not be measured for payment. This price shall include furnishing, installing, smoothing, and shaping ditch channels and waterways; preparing seed beds; and furnishing and applying lime, seed, fertilizer, mulch for seeding, and water.

Rolled Erosion Control Product (Type) installed on slopes will be measured in square yards of area covered, complete-in-place, in accordance with the nominal plan dimensions and will be paid for at the

contract unit price per square yard for the type specified. Overlaps, overwidths, and cut slots will not be measured for separate payment. This price shall include furnishing, installing, preparing seed beds; and furnishing and applying lime, seed, fertilizer, mulch for seeding and watering.

The cost of RECP installed at the Contractor's option as a HECP component in accordance with Section 603.03 (f) shall be included in the HECP contract unit price.

Sediment Retention Rolls will be measured and paid for in accordance with Section 603.

Payment will be made under:

Pay Item	Pay Unit
Rolled Erosion Control Product, EC-2 (Type)	Square yard
Rolled Erosion Control Product, EC-3 (Type)	Square yard

SECTION 607—HERBICIDE SPRAYING

607.01—Description

This work shall consist of applying an approved herbicide for the control of weeds in turfed areas as indicated on the Plans or as designated by the Engineer.

607.02—Materials

Herbicide shall conform to Section 244.02.

607.03—Procedures

Herbicide shall be applied in accordance with the manufacturer's recommendations by a Virginia Department of Agriculture and Consumer Services (VDACS) certified applicator or registered technician. Herbicide shall not be applied when the ambient temperature is above 85°F or below 60°F. The spray pressure shall be at least 20 but not more than 30 pounds per square inch. Spraying shall not be performed when the vegetation is wet, when it appears that rain is imminent within 6 hours, or when the wind is blowing enough to scatter paper or trash or when drifting of spray onto non designated areas seems likely.

607.04—Measurement and Payment

Herbicide spraying will be measured in units of 1,000 gallons of mixture and will be paid for at the contract price per unit. This price shall include furnishing and applying herbicide.

Payment will be made under:

Pay Item	Pay Unit
Herbicide spraying	Unit (1,000 gallons)

SECTION 608—MOWING

608.01—Description

This work shall consist of mowing designated areas to a height of not less than 4 inches when and as directed by the Engineer until final acceptance.

608.02—Equipment

Equipment used for mowing operations shall be mechanical with a cutting width of at least 5 feet unless otherwise restricted by access limitations. Mowing equipment operators shall carefully and diligently load, unload, temporarily store, and safely operate equipment according to Section 512, the VWAPM and MUCTD guidelines.

608.03—Measurement and Payment

Mowing, when a pay item, will be measured in hours of operation and will be paid for at the contract unit price per hour. This price shall include furnishing equipment, operators, fuel, lubricants, and any required traffic control including signs and warning devices.

Maintenance of traffic costs will be considered incidental to mowing operations.

Payment will be made under:

Pay Item	Pay Unit
Mowing	Hour

SECTION 609—TREE WELLS AND TREE WALLS

609.01—Description

This work shall consist of constructing wells and walls to protect the root system of trees, shrubs, or other woody plants at the locations shown on the Plans or as designated by the Engineer. Tree wells and Tree walls shall conform to the details shown in the Standard Drawings or as otherwise shown in the Plans.

609.02—Materials

(a) **Aggregate** shall conform to Section 203.

(b) **Polyvinyl chloride (PVC) pipe** shall conform to Section 232(g).

(c) **Geotextile fabric** shall conform to Section 245.

(d) **Stone for rubble masonry** shall conform to Section 204.

(e) **Masonry block and masonry brick** shall conform to Section 222 or be as indicated in the plans.

609.03—Procedures

The Contractor shall perform excavation incidental to and necessary for constructing tree wells and tree walls in a manner that will not damage the root system of the tree. Ends and damaged sections of roots shall be cleanly cut. Roots with a diameter of more than 3 inches shall not be cut.

Before any earthen fill that will exceed 12 inches in thickness is spread over the feeding root system of trees or shrubs to be protected by tree wells, an aeration layer of coarse gravel or stone, ranging from 1/2 to 5 inches in size, shall be spread over the entire area to a depth of at least 6 inches or at the rate of 3 inches for every 12 inches of earthen fill where such fills will be more than 2 feet in depth. The layer of aggregate shall be capped with sufficient fine screenings to choke the top of the porous fill. Aggregate shall not be placed inside the tree well.

609.04—Measurement and Payment

Tree wells and tree walls will be measured in cubic yards of masonry and will be paid for at the contract unit price per cubic yard for the standard specified. This price shall include excavating, and furnishing and installing stone, masonry block or block faced brick, drain pipe, geotextile fabric and backfill, including aggregate.

Payment will be made under:

Pay Item	Pay Unit
Tree well (Standard)	Cubic yard
Tree wall (Standard)	Cubic yard

SECTION 610—GABIONS

610.01—Description

This work shall consist of furnishing, assembling, and installing gabions in accordance with these Specifications and in conformity to the lines, dimensions, and grades shown on the Plans or as established by the Engineer.

610.02—Materials

(a) **Gabions** shall have a uniform horizontal width of at least 36 inches. Their dimensions shall be within ±3 percent of the manufacturer's stated sizes.

(b) **Wire mesh** shall conform to Section 223.02(a).

(c) **Selvedge (or perimeter) wire** shall be at least 0.148 inch in diameter (9 gage) and shall conform to Section 223.02(a) for wire mesh.

(d) **Tie and connection wire** shall conform to the requirements for the wire used in the mesh except that it shall be not more than two gages smaller.

(e) **Gabion stone** shall conform to Section 204.

610.03—Procedures

Gabions shall be fabricated in such a manner that the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular wire mesh baskets. Gabions shall be of single unit construction whereby the base, lid, ends, and sides are woven into a single unit or whereby one edge of these units is connected to the base section of the gabion. The strength and flexibility at the point of connection shall be at least equal to those of the wire mesh.

If the length of the gabion exceeds its horizontal width, the gabion shall be equally divided into cells by diaphragms of the same mesh and gage as the body of the gabion. The length of each cell shall not exceed its width. The gabion shall be furnished with the necessary diaphragms securely tied in their proper positions on the base so that no additional tying at the junction will be necessary.

Perimeter edges of the mesh forming the gabion shall be securely clip bound or selvedged in such a manner that the joints formed by tying the selvedges will have at least the same strength, durability, and integrity as the body of the mesh.

The Contractor shall supply tie and connection wire in sufficient quantity to securely fasten all edges of the gabion and diaphragms. At least two cross connecting wires shall be in each cell whose height is one-third or one-half the width of the gabion. At least four cross-connecting wires shall be in each cell whose height equals the width of the gabion. The wire shall be secured through two open loops of the cage.

The Contractor shall perform excavating and backfilling operations for the installation of gabions according to Section 303. Gabions shall be placed on a smooth foundation, and the final line and grade shall be approved by the Engineer.

Each gabion unit shall be assembled by binding the vertical edges with wire ties at approximately 6 inch intervals or by stitching a continuous piece of connecting wire around the vertical edges with a coil approximately every 4 inches. Wire ties or connecting wire shall be used to join units in the same manner as described for assembling. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure.

The Contractor may use a standard fence stretcher, chain fall, or iron rod to stretch wire baskets and hold the installation alignment.

The Contractor shall fill gabions with stone so that the finished basket maintains alignment, has a minimum of voids, and avoid bulges. Rock and connection wires shall be alternately placed until the gabion is filled. After the gabion is filled, the lid shall be bent over until it meets the sides and edges of the gabion. The Contractor shall then secure the lid to the sides, ends, and diaphragms with wire ties or connecting wire in the manner described hereinbefore.

610.04—Measurement and Payment

Gabions will be measured in cubic yards and will be paid for at the Contract unit price per cubic yard. This price shall include furnishing, assembling, excavating, installing and backfilling with suitable material, compacting, and disposing of surplus or unsuitable material.

610.04

Minor structure excavation for gabions, when specified on the Plans, will be measured and paid for in accordance with Section 303.

Payment will be made under:

Pay Item	Pay Unit
Gabion	Cubic yard

Division VII
TRAFFIC CONTROL DEVICES

SECTION 700—GENERAL

700.01—Description

These specifications cover general construction items, methods, and procedures common to the furnishing and installing traffic control devices, Intelligent Transportation Systems (ITS), and associated systems. Installation of materials shall be accomplished in accordance with the manufacturer's instructions except when otherwise indicated. All electrical work shall be in accordance with the applicable National Electrical Code (NEC) unless otherwise specified herein. Refer to the latest applicable edition of the National Fire Protection Association (NFPA)/NEC for electrical technical definitions, acronyms and abbreviations.

700.02—Materials

(a) **Concrete** shall be Class A3 conforming to Section 217 unless otherwise specified.

(b) **Reinforcing steel** shall conform to Section 223.

(c) **Dissimilar metals** - The contact surfaces between dissimilar metals shall be isolated with an approved durable nylon washer, gasket, or other approved isolation material to prevent corrosion, except that isolation material shall not be used between an aluminum signal or sign hanger and steel sign pole.

(d) **Galvanizing** shall conform to Section 233.

(e) **Electrical items** shall conform to Section 238.

(f) **Wood for wooden posts and poles** shall conform to Section 236 and shall be treated in accordance with Section 236. Wood items shall be cut to size or design before treatment.

(g) **Steel for structural support of light poles and traffic control devices** shall conform to Section 226 and shall be fabricated, welded, and inspected in accordance with Section 407.

(h) **Anchor bolts** shall be high strength steel conforming to Section 226 unless otherwise specified. The anchor bolts shall be galvanized except when stainless steel is specified on the plans. Anchor bolts shall be straight with ring and plate or nuts and washers attached to the end of the anchor bolts embedded in the concrete. The Department will not permit the use of J-bolts except in the construction of controller cabinet foundations.

(i) **Aluminum for fabricated items** shall conform to Section 229 and shall be fabricated, welded, and inspected in accordance with Section 407.

(j) **Breakaway support systems** shall be tested and certified to conform to NCHRP Report 350, or be Manual for Assessing Safety Hardware (MASH) certified. The Contractor shall provide a certification letter stating the brands and models of breakaway systems planned for use have been tested and are in conformance with this requirement. Breakaway couplers shall not be used. The following systems shall be used when breakaway supports are specified on the plans:

1. **Frangible bases and skirt covers** shall be aluminum.

2. **Slip bases** shall be galvanized steel or other approved noncorrosive metal.

(k) **Miscellaneous hardware** shall be brass, bronze, stainless steel, or galvanized steel.

700.03—General Requirements

Cable wiring holes in traffic control device and ITS device structures shall be deburred and rounded, or fitted with a grommet. Damaged galvanization shall be repaired in accordance with Section 233. The size of the hole shall not exceed the sum of the diameter of the cables plus 1/2-inch.

The design of traffic control device and ITS device structures and foundations shall conform to the edition of *AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals* specified in the Structure & Bridge Division's S&B-IIM-90 Memorandum (VDOT Modifications to AASHTO's Standard Specifications) in effect at the time of project advertisement, as well as the following:

(a) **Sign Structures:**

Overhead Sign and DMS Structures (Span, Cantilever, Butterfly, etc.) shall be fabricated from galvanized steel material as specified herein. Aluminum structures will not be allowed. Base plates for overhead sign structures shall have at least the minimum number and diameter of anchor bolts specified in the Standard Drawings. Washers are required above and below the base plate. Tubular pole shafts shall have a removable cap fastened by at least three screws.

Ground Mounted Sign Structures shall be fabricated from galvanized steel unless otherwise indicated. Square tube posts shall conform to ASTM A1011, Grade 50 except the yield strength after cold-forming shall be 60,000 psi minimum for 12 and 14 gauge posts, and 55,000 psi minimum for 10 gauge posts. Posts (inside and outside) shall be galvanized in accordance with ASTM A653, Coating Designation G-90. Square tube sign posts shall have 7/16-inch (+/- 1/64-inch) openings or knockouts spaced 1-inch on centers on all four sides.

(b) **Lighting Structures** shall be of a one-piece or sectional single unit, tubular form, and shall be round or multisided. Multisided poles shall have at least eight sides. Pole shafts shall have a removable cap fastened by at least three screws.

1. **High Mast Lighting Structures** (Lengths of 55 feet or greater) shall be galvanized steel and shall have at least the minimum number and diameter of anchor bolts specified in the Standard Drawings. Aluminum structures shall not be allowed. Washers are required above and below the base plate.

2. **Conventional Lighting Structures** (Lengths less than 55 feet) shall be galvanized steel or aluminum and shall have at least the minimum number and diameter of anchor bolts specified in the Standard Drawings.

(c) **Signal Poles and Mast Arms** shall be galvanized steel of a one-piece or sectional single unit, tubular form, and shall be round or multisided. Multisided poles shall have at least eight sides. Pole shafts and mast arms shall have a removable cap fastened by at least three screws. If field adjusting of mast arm length is required, the end cap shall snugly fit the arm after adjustment.

1. **Mast Arm Signal Poles:** The mast arms shall not deflect below the horizontal plane or below the minimum vertical clearance under AASHTO Group I design loads. The rise shall not exceed 3 percent of the mast arm length after design loads are applied. The flange plate and pole shall have a 4 inch wiring hole centered in the pattern. Mast arms shall be secured to the pole with thru-bolt, nuts, and washer connections.

   Mast arm signal poles shall have a round base plate and at least the minimum number and diameter of anchor bolts specified in the Standard Drawings. Washers are required above and below the base plate.

   The structure and foundation shall be designed for the mast arm length shown on the plans; and the loadings and placement of loads shown on the plans or in Standard MP-1 of the Standard Drawings, whichever is greater. For the location specified on the plans, the Contractor shall confirm the pole height to achieve the required mounting height of the signal head assemblies and signs in accordance with the Standard Drawings. Standard mast arm signal structures shall be of the following types:

   - **TYPE A** mast arm poles are between 17 feet and 20 feet in height, and are manufactured for a single mast arm. The mast arm poles shall be the height specified on the plans. The mast arm poles shall be designed and fabricated (including arm attachment) to support the arm length specified on the plans; and the design loadings for that arm length specified in Standard MP-1 of the Standard Drawings or the loadings shown on the plans, whichever is greater.

   - **TYPE B** mast arm poles are between 20.5 feet and 24 feet in height, and are manufactured for a single mast arm. The mast arm poles shall be the height specified on the plans. The mast arm poles shall be designed and fabricated (including arm attachment) to support the arm length specified on the plans; and the design loadings for that arm length specified in Standard MP-1 of the Standard Drawings or the loadings shown on the plans, whichever is greater.

   - **TYPE C** mast arm poles are between 17 feet and 20 feet in height, and are manufactured for dual mast arms. The mast arm poles shall be the height specified on the plans. The mast arm poles shall be designed and fabricated (including arm attachment) to support the arm lengths specified on the plans; and the design loadings for those arm lengths specified in Standard MP-1 of the Standard Drawings or the loadings shown on the plans, whichever is greater.

   - **TYPE D** mast arm poles are between 20.5 feet and 24 feet in height, and are manufactured for dual mast arms. The mast arm pole shall be the height specified on the plans. The mast arm poles shall be designed and fabricated (including arm attachment) to support the arm lengths specified on the plans; and the design loadings for those arm lengths specified in Standard MP-1 of the Standard Drawings or the loadings shown on the plans, whichever is greater.

   - **TYPE E** mast arm poles are 26 feet in height, and are manufactured for single mast arm with luminaire arm. The mast arm attachment height shall be at the height specified on the plans. The mast arm poles shall be designed and fabricated (including arm attachment) to support the arm lengths and luminaire arms specified on the plans; and the design loadings for those arm lengths specified in Standard MP-1 of

the Standard Drawings or the loadings shown on the plans, whichever is greater. The luminaire arm shall be the length and type specified on the plans.

- **TYPE F** mast arm poles are 26 feet in height, and are manufactured for dual mast arms with luminaire arm. The mast arm attachment heights shall be at the heights specified on the plans. The mast arm poles shall be designed and fabricated (including arm attachment) to support the arm lengths and luminaire arms specified on the plans; and the design loadings for those arm lengths specified in Standard MP-1 of the Standard Drawings or the loadings shown on the plans, whichever is greater. The luminaire arm shall be the length and type specified on the plans.

2. **Strain Signal Poles** shall be galvanized steel and have a round base plate designed for at least the minimum number and diameter of anchor bolts specified in the Standard Drawings. Washers are required above and below the base plate. The structure and the foundation shall be designed for the loads shown on the plans. Strain signal poles shall be field drilled for the attachment of span wire and tether wire. Span wire shall be located at least 18 inches below the top of the pole. All loads shall be assumed to be tethered and no load reduction for breaking of the tether wire shall be used in the pole design.

3. **Pedestal Signal Poles** may be galvanized steel or aluminum.

4. **Luminaire arms** attached to signal poles shall be galvanized steel, and shall be as specified in the Standard Drawings. The luminaire arm shall have a maximum of 5 feet upsweep rise above the mounting point of the mast arm on the signal pole.

(d) **Camera Poles** for the support of ITS equipment shall be galvanized steel of a one-piece or sectional single unit, tubular form, and shall be round or multisided. They shall have at least the minimum number and diameter of anchor bolts specified in the VDOT Road and Bridge Standards. They shall be designed and fabricated in accordance with Section 803.

700.04—Working Drawings

The Contractor shall submit working drawings for traffic control device and ITS device foundations and structures to the Engineer in accordance with Section 105.10. Working drawings shall include design calculations, shop drawings and applicable catalog cuts. Each copy of catalogue cuts shall be submitted with the manufacturer's name and address clearly noted.

Any product that has been rescinded from the VDOT Pre-Approved Traffic Control Device List will not be allowed for use if the rescinded date is on or before the date of advertisement for the project without written approval from the Engineer.

Shop drawings shall be submitted in pdf electronic format.

The Contractor's engineer shall verify that the proposed traffic control device/ ITS device foundations and structures design are in accordance with the Plans, the Specifications, the Standard Drawings, and the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals* edition specified in the Structure & Bridge Division's Memorandum, S&B-IIM-90 (VDOT Modifications to AASHTO's Standard Specifications) in effect at the time of project advertisement; based on site conditions, required loadings, and required vertical clearances.

700.05—Procedures

(a) **Grounding Electrodes:** The Contractor shall install grounding electrodes (rods) according to the NEC or by other methods approved by the Engineer. The Contractor shall install the grounding electrodes using a hydraulic/pneumatic/electric hammer drill driving device with an electrode drive bit to minimize damage to the electrode tip. The electrode drive bit shall accommodate 3/4-inch electrodes. Grounding electrodes shall include a grounding electrode conductor and grounding electrode clamp.

Grounding electrode(s), when installed directly into the soil, shall be a single electrode driven to a depth of at least 4 inches below the finished grade.

The grounding electrode(s) shall be installed vertically such that at least 8 feet of length is in contact with the soil. Where rock bottom is encountered, the electrode shall be driven at an oblique angle no more than 45 degrees from the vertical point.

If refusal occurs due to encountering rock or other obstructions before installing the electrode to have at least 8 feet contact with the soil, the Contractor shall remove the electrode, or cut it off 6 inches below grade and abandon it.

Grounding electrodes and grounding electrode conductors shall be cleaned to remove oxidation and any other foreign material from their surfaces before connecting.

Grounding electrode(s) shall be inspected to ensure all connections are mechanically secure and electrically tested.

The following procedures apply to the installation of the grounding electrodes listed:

1. **Electrical service grounding electrodes:** The Contractor shall only apply the following procedures for installing electrical service grounding electrodes:

   - Primary grounding electrodes and grounding electrode conductors shall be installed in the presence of the Engineer at a date and time mutually agreed upon.

   - The Contractor shall install a junction box at the primary grounding electrode location for access to the electrode for connection and testing. Grounding electrode conductors shall be installed from the bottom of the junction box or through the conduit entrance. The grounding electrode shall be centered in the bottom of the junction box with at least 6 inches exposed.

   - Primary grounding electrodes shall be directly driven into the soil within 6 feet from the electrical service structure, unless otherwise specified on the plans.

   - Primary grounding electrodes shall be connected to grounding electrode conductor(s) using exothermic welds. Exothermic welds shall be designed for the size of conductors and grounding electrodes used and shall be installed in accordance with the manufacturer's instructions.

   - Primary grounding electrode(s) shall not have a resistance to ground of more than 25 ohms. A 10-foot section of grounding electrode shall have at least 8 feet contact with the soil.

- Primary grounding electrodes shall be installed vertically to a depth of 40 feet or until refusal. If the vertical grounding electrode cannot be installed with at least 8 feet contact with soil, that electrode shall be removed or cut off 6 inches below grade and abandoned. The Contractor shall then drive the removed or another grounding electrode at an oblique angle of no more than 45 degrees from the vertical point to a depth of 40 feet or until refusal.

- Primary grounding electrodes shall be joined at each section with couplers.

- Primary grounding electrodes complying with these requirements shall be augmented with an additional grounding electrode and connected in parallel to the primary grounding electrode to form a system. Primary grounding electrode(s) and augmented electrode(s) shall be spaced at least 10 feet apart.

The augmented electrode shall be a single electrode with minimum 8 foot contact with soil, driven to a depth of 4 inches below the finished grade. If refusal occurs, the augmented electrode shall be removed and then driven at an angle of not more than 45 degrees away from the primary grounding electrode.

The grounding electrode conductor shall be installed to a depth of at least 18 inches below grade when connecting the primary electrode and augmented grounding electrode(s).

The Contractor shall notify the Engineer of those location(s) where primary grounding electrodes do not conform to the following:

- Resistance does not measure 25 ohms or less.

- Grounding electrode does not have at least an 8-foot contact with soil.

For such locations, the Engineer will advise the Contractor on how to proceed.

Grounding electrode testing: The Contractor shall test the grounding electrode as required by the manufacturer's instructions for the type of earth testing equipment used for the test. The Contractor shall disconnect the grounding electrode conductor from the service equipment ground bus and bonding bushing before testing the grounding electrodes/system. The Contractor shall test primary grounding electrodes after each 10-foot grounding electrode and/or section thereof is installed using the fall of potential (three-point measurement) method. After the primary grounding electrode is installed and tested, the Contractor shall connect to the augmented electrode(s) to conduct a system test. The Contractor shall record the readings on a form provided by the VDOT Regional Traffic Engineering Office. The completed form shall be signed and submitted to the Engineer after installation of the electrical service grounding system.

2. **Additional grounding electrodes:** In addition to the electrical service grounding electrode system, each electrical junction box, metal cabinet, overhead sign structure, butterfly sign structure, lighting structure, ITS support structure, and signal structure shall be connected to its own grounding electrode. The Contractor shall drive grounding electrode directly into the soil within 6 feet from each structure, unless otherwise specified on the plans. Each foundation shall be permanently marked with 1/4 inch deep by 4 inch long arrow with "GE" on the tip to indicate the approximate direction and location of the grounding electrode. The grounding electrode for a junction box shall be centered in the bottom of

the junction box with at least 6 inches exposed. Metal structures used as electrical raceways shall be connected to earth/grounding electrode(s) to limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines.

(b) **Excavation for Foundations:** The Contractor shall excavate for foundations according to Section 401.

(c) **Concrete Foundations:** Concrete foundations shall be constructed and cured in accordance with Section 404 and shall rest on material that will adequately support the design load. The Contractor may secure the anchor bolts to prevent their movement during concrete placement with a No. 3 or smaller rebar. Rebar shall be attached to the anchor bolts with rebar twist ties. The Engineer will not permit welding (including tack welding) of rebar to anchor bolts. Exposed areas of concrete foundations shall be given a Class 7 finish in accordance with Section 404. Items shall not be erected on concrete foundations until the concrete has attained a 28-day design compressive strength of at least 3,000 pounds per square inch.

The Contractor shall provide half inch (1/2") diameter weep holes in the controller and lighting control cabinet foundations. Weep holes shall be located 2 inches inside of the back or side edges of the controller and lighting control cabinet foundations. The concrete foundation shall be sloped towards the weep holes. Weep holes shall be sloped to allow the outlet to be 3 inches below the top of foundation. Two inches (2") of the outlet end shall be fiber filled.

The Engineer will not permit any mortar, grout, or concrete between the base plate and the top of the foundation of overhead structures, mast arm, lighting, camera, and signal poles. No lock nuts or split washers will be allowed on the anchor bolts.

The Contractor shall permanently mark each foundation to indicate all sides through which conduits pass. This mark (1/4 inch deep and 4 inches long) shall be made with a trowel within one hour after pouring concrete or before finishing. The location(s) of empty conduits shall be delineated by 1/4 inch deep and 6 inches long markings.

All exposed concrete foundation surface edges and electrical service work pad edges shall be chamfered 3/4 inch. The Contractor shall ensure that the foundation placement allows for at least 60 inches of clear width of paved surface when placed in a sidewalk as measured at the point of greatest constriction, in order to comply with Americans with Disabilities Act (ADA) regulations. The top of foundation for lighting pole, controller cabinet, and pedestal pole foundations may be included as part of the clear sidewalk width if the foundation is flush with the sidewalk, unless otherwise restricted on the plans.

Foundations for cantilever, butterfly, and other single-pole sign structures shall be spread footings, drilled piers with at least two drilled piers per pole, or concrete foundations with driven piles. Foundations for multiple-pole overhead sign structures shall be spread footings, drilled piers with at least two drilled piers per foundation, or concrete foundations with driven piles.

The Contractor shall furnish the foundation designs for signal poles, high-mast lighting poles, and overhead sign structures to the Engineer for review and acceptance. Such designs shall be prepared by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia. Design calculations and drawings shall indicate the cubic yard quantity of concrete required for constructing the foundations. Foundations shall be designed for the structure it is supporting and for the loads the structure is being designed to support, unless indicated otherwise on the plans.

The Contractor shall perform at least one test bore, as approved by the Engineer, at each signal pole, high mast lighting pole, or overhead sign structure foundation location to determine the subsurface conditions of the proposed site before designing the foundation. Test bores shall be performed in accordance with any of the following three referenced methods:

1. ASTM D 420, ASTM D 1452, and ASTM D 1586.

2. ASTM D 3441.

3. ASTM D 4719.

The depth of all test borings shall be at least 30 feet. Soil conditions shall be tested at the ground level and then at depth intervals of every 3 feet in accordance with any of the three methods stated.

When auger refusal or a count of 50 blows per inch occur before the minimum required depth is reached due to the presence of rock, the Contractor shall continuously core the rock to a depth of at least 5 feet and sample the boring in accordance with ASTM 2113. Boring logs shall accurately identify the location of the test borings sites with the corresponding centerline stations and the perpendicular distances from the centerline indicated. On projects with existing roadways where no centerline is being surveyed, GPS coordinates or alternate methods that identify the location of the test boring to an accuracy of within 0.5 feet shall be submitted to the Engineer by the Contractor for the Engineer's consideration, acceptance, and records. Boring log data shall be submitted electronically in an approved format, in accordance with the VDOT Materials Division's *Manual of Instructions* and shall be included with the shop drawing submittals for the foundation designs.

Test bores shall be performed within 5 feet of the proposed foundation's location as shown on the plans, or as directed by the Engineer.

For all signal mast arm pole, signal strain pole, high mast light pole, overhead sign structure, and ITS device support pole foundations, a vented varmint screen constructed of double lapped ring screen of standard commercial grade 27 gauge hot dipped galvanized 1/8 inch woven wire mesh shall be placed inside the foundation's bolt circle. The height of the wire mesh ring barrier shall be from the concrete foundation to the top of the leveling nuts and washers plus 1/4 inch. The Contractor shall ensure the wire mesh ring remains in place to eliminate any access through the base plate opening of the tubular structure pole when erected and plumbed. The Contractor shall not weld or drill to the base plate of the pole. Alternative vented varmint screen designs and materials may be used when approved by the Engineer no additional cost to the Department.

The cubic yard quantity of concrete indicated in the contract per foundation location is an approximation. The Department will pay for the actual cubic yards of concrete based upon the foundation design supplied by the Contractor and approved by the Engineer.

(d) **Electrical Service:** Electrical service shall be installed according to the NEC and the local power company. The local power company will furnish meter bases and current transformer cabinets. All service conductors shall enter the meter base in accordance with utility company standards. The Contractor shall make arrangements with the local power company for pickup of the equipment. The Department will request and pay for electrical service and temporary electrical service to power items temporarily relocated or adjusted for traffic control as specified

in the Contract, or directed by the Engineer. If the Contractor desires temporary service for the Contractor's convenience, the Contractor shall arrange and pay for such service.

The Contractor shall construct an electrical service work pad in front of all service safety switches, and breaker boxes except when the service safety switch or breaker box is located in front of and immediately adjacent to a paved sidewalk. The work pad shall be at least 20 inches in width, 36 inches in length, and 4 inches in depth, and sloped to facilitate drainage away from the structure. Exposed areas of concrete foundations and service work pads shall be given a Class 7 finish in accordance with Section 404.

When required by the Standard Drawings or the Contract, the Contractor shall construct a concrete pad in front and/or back of electrical service cabinet doors. The concrete pad shall be sized to match the cabinet's front and/or back door(s), being at least 20 inches in width, 36 inches in length, and 4 inches in depth, and sloped to facilitate drainage away from the cabinet door(s). The concrete pad shall be omitted when the cabinet doors are located in front of and immediately adjacent to a paved sidewalk.

(e) **Poles, Posts, Sign Structures, and ITS Support Structures:** The Contractor shall establish the location of each pole, post, sign structure, and ITS support structure with a stake bearing the number or identification designated on the plans. The Engineer, accompanied by the Contractor, will inspect the locations and advise the Contractor of any necessary adjustments. The Contractor shall ensure that all poles, posts, sign structures, and ITS support structures are plumb after the installation of loads.

The Contractor shall immediately inform the Engineer if a structure or structure attachment will be located within the danger zone of an electric power line as measured in any direction, as defined by OSHA. The Contractor shall not proceed with the installation until the Engineer has advised the Contractor on how the Department wants to proceed with the work in accordance with Section 104.03.

The Contractor shall permanently attach a noncorrosive metal identification tag approximately 30 inches above the top of the foundation to each signal, pedestal, and lighting pole; overhead sign structure; ITS support structure; and steel I-beam sign post (excluding U-channel sign posts and square tube steel). The tag shall be of sufficient size to accommodate at least 1/4 inch high lettering, single-spaced between lines, and shall be securely attached by noncorrosive screws or rivets. The tag shall be imprinted with "VDOT" and VDOT's Asset Tag number (if provided); except when the structures are located within an incorporated town or city that will maintain the structure, in which case the tag shall be imprinted with the municipality's name and other identifiers unless otherwise noted on the plans or directed by the Engineer.

The tag shall also be imprinted with the following data unless otherwise specified:

1. Manufacturer's name and unique Manufacturer I.D. number for each structure on all tags.

2. Date of manufacture on all tags.

3. Signal poles: Pole number (from Signal Plans), gauge, diameter, pole type, and length of pole.

4. Signal mast arms/spans: Gauge, diameter, and length of mast arm(s) and monotube(s)/spans.

5. Pedestal poles: Gauge and length of pole.

6. Lighting poles and ITS support poles: Gauge and length of pole and luminaire arm(s); electrical phase circuit designation.

7. Overhead sign structures: Gauge, diameter, and length of pole(s) and span/cantilever.

8. Steel sign posts (I-beams only): Gauge, length, size, and weight per foot of I-beam.

9. Signal poles and arms, lighting poles, overhead sign structures, ITS support structures: Material yield strengths listed in the following order; anchor bolts (A), base plate (BP), pole (P), mast arms (Arm), cantilever (C), span (S), monotube (T).

10. Anchor bolts: ASTM number, diameter, and length on all tags.

All structures used as an electrical raceway shall be provided with handholes that face away from traffic. Handholes shall be at least 3 by 5 inches, unless otherwise specified, and shall be provided with a weatherproof gasket and cover. All handholes shall be hinged and lockable with the Department's standard approved lock. The Contractor shall furnish the Engineer at least one key for each 20 poles, or fraction thereof.

Lighting, signal, and overhead metal structures shall have a UL listed double barrel, bottom and top feed with headless setscrew grounding lugs welded to the inside of the pole or structure in front of the hand hole or transformer base door. The heads of the setscrews shall be faced towards the door for ease of accessibility to use a screwdriver for tightening of the conductors. The grounding lug shall be non-corrosive, accommodate #6 to #2 AWG solid or stranded copper conductors, and designed to secure the grounding electrode conductor and equipment grounding conductor by inserting the conductor under a setscrew.

Metal structures used as an electrical raceway with no handhole or transformer base shall be grounded externally within 1-foot above the foundation or as shown on the plans, to ensure an effective grounding path.

(f) **Breakaway Support Systems:** Unless otherwise specified on the plans, breakaway support systems shall be installed on pedestal and lighting poles, except high-mast lighting poles and pedestal poles used for electrical power source connection. Breakaway support systems shall be installed according to the manufacturer's instructions.

(g) **Conductor Cables:** Conductor cables, including the equipment grounding conductor (EGC) from the electrical service to the structure(s), shall be installed in accordance with the NEC. The EGC shall be the same size as the largest power conductor (minimum size No. 8 AWG) unless otherwise specified on the plans.

For lighting fixtures, the conductor cables and EGC to the grounding lug at the base of the pole or structure shall be minimum size No. 10 AWG single-conductor, or as specified by the manufacturer of the lighting fixtures.

Conductor cables in conduit runs shall be installed with an approved UL listed lubricant or pulling compound. The Contractor shall not use cleaning agents and lubricants that may or will have a deleterious effect on cable coverings.

The Contractor shall support aerial cables that extend more than 20 feet by a span wire or reinforced with a copper-clad, galvanized, or stainless steel wire for self-support. Cable rings shall be used to attach conductor cables to the supporting wire; but lash wire may be used to attach interconnect cable when no other conductor cables are attached to the same span wire. Vinyl tape shall be used as shown on the plans to prevent sag. The Contractor shall form an 8-inch drip loop when aerial cables enter a service entrance head.

Bends in single or multiple conductor cables shall have a bend radius of at least 5 times the outside diameter of the cable.

Conductor cables shall be installed with the slack length neatly coiled, and securely tied in junction boxes. The coiled length shall be sufficient to allow cables to extend at least 2 feet above junction boxes.

Solderless terminals shall not be used for connecting conductor cables having solid conductors to terminal posts.

The Department will only permit splices in lighting conductor cables at accessible locations. Splices in service entrance conductor cable will be permitted only for connection to the utility company's service conductor cables. Splices will not be permitted in signal and interconnect conductor cables.

The Contractor shall make splices in lighting and service entrance conductor cables according to the NEC and the following additions and exceptions: Conductor insulation shall be removed only to the amount necessary to install the connector. Exposed conductors shall be wire brushed and cleaned before splicing. Splices shall be made with properly sized non-insulated butt-end connector compression sleeves for single conductors, or split bolts for branch circuit connections. All conductor connections shall be mechanically and electrically secure. Crimping tools used on compression sleeves shall be designed for the application and sized to the splicing connectors.

Splices shall be covered with an insulation rated equal to or higher than the voltage rating of the conductor cable. The Contractor shall insulate and make water resistant single and branch circuit conductor splices by one of the following methods:

- Two layers of rubber electrical tape shall be applied half-lapped with the first layer extending the length of the disturbed insulation and the second layer extending at least 1 inch onto clean undisturbed insulation of each conductor. Rubber electrical tape shall be stretched and wrapped tightly during application to eliminate air gaps. Rubber electrical tape shall be molded around irregular shapes and multiple conductors for smooth insulation buildup and water resistance. Over the rubber electrical tape, at least two layers of vinyl electrical tape shall be applied half-lapped with each layer overlapping the end of the proceeding layer by at least 1 inch onto clean, undisturbed insulation. The splice and at least 1 inch of adjacent clean insulation shall be covered using an acceptable water-resistant sealing compound for electrical splices; or

- Heat-shrink tubing properly sized shall be installed extending at least 3 inches onto each end of clean, undisturbed insulation. End seams around two or more adjacent conductors shall be sealed and made water resistant; or

- The splice kit shall be properly sized to extend at least 3 inches onto each end of clean, undisturbed insulation.

Single conductor splices within a multi-conductor cable shall be insulated and made water resistant by using heat-shrink tubing. Re-jacketing of multi-conductor cables shall be accomplished using properly sized heat-shrink tubing. Heat-shrink tubing shall be heated using a non-contact flameless device or a flamed heat source device equipped with a shield to prevent the flame from coming in direct contact with the tubing.

Breakaway connectors shall be installed on all luminaire conductors for lighting poles, signal poles, and overhead sign structures. Breakaway connectors shall be fused for the hot conductors and non-fused for the grounded conductor. Breakaway connectors shall be located in the handhole or transformer base of the pole.

Breakaway connectors shall be installed for signal heads on pedestal poles and other breakaway supports. Breakaway connectors shall be fused for the hot conductors and non-fused for the grounded conductors. Breakaway connectors shall be located in the handhole or condulet of the support structure.

All conductors connected to breakaway connectors shall be secured at the bottom of the structures to ensure the breakaway connector will separate when the support structure is struck.

The Contractor shall seal signal and interconnect cable terminal strips with a moisture block compound or by other Department approved methods to prevent moisture from entering the open cable end. The compound shall be soft, pliable, easily removable, and shall be applied in accordance with the compound manufacturer's instructions.

The Department will only allow the termination of interconnect cable in a master controller cabinet, local controller cabinet, or terminal enclosure. The cable shield shall be grounded at each termination point. The Contractor shall ensure each wire of the cable is connected to a terminal post position whenever a cable enters the cabinet or enclosure to connect to equipment.

The Contractor shall conduct a Megger test on the installed interconnect cable and shield. The Engineer will require a reading of 100M ohms for acceptance. Testing for 300-volt cable shall be performed at 200 volts, and testing for 600-volt cable shall be performed at 500 volts. The Contractor shall disconnect cables from controller cabinet terminals during testing.

The Contractor shall mark service entrance and lighting conductor cables in accordance with the NEC. Markings shall be continuous and permanent. Signal and interconnect conductor cables shall be marked according to the applicable IMSA specification.

The Contractor shall demonstrate to the Engineer that the system is without short circuits, open circuits, and unintentional grounds before energizing an electrical system. The Contractor shall repair or replace faulty circuits at the Contractor's expense.

1. **Electrical service and lighting conductor color-coding identification:**

   Grounded conductors: Insulated grounded conductors (Neutrals) shall be identified by a continuous white or gray outer finish except that those larger than No. 6 AWG may be identified by three continuous white stripes on other than green insulation along its entire length.

Equipment grounding conductors (EGC): Equipment grounding conductors shall be bare, covered, or insulated. Covered or insulated equipment grounding conductors shall have a continuous outer finish that is either green or green with one or more yellow stripes.

Ungrounded conductors: Ungrounded conductors, whether used as a single conductor or in multiconductor cables, shall be finished to be clearly distinguishable from grounded, grounding, and equipment grounding conductors. Ungrounded conductors shall be identified by a continuous color-coding outer finish by phase and system except that those larger than No. 6 AWG may be identified only at readily accessible locations by marking tape, tagging, or other Engineer approved means in accordance with NEC requirements.

Color-coding shall be as follows:

2-wire circuits, 120 Volts; 3-wire circuits, 120/240 Volts; 3-phase, 4-wire wye circuits, 208/120 Volts and; 3-phase, 4-wire delta circuits, 240 Volts

Circuit Designation	Color Code
Phase A or Line A	Black
Phase B or Line B	Red or orange*
Phase C	Blue
Grounded Conductor (Neutral)	White or gray** (see exception above)
Equipment Grounding Conductor	Bare, green, or green with one/more yellow stripes

3-phase, 4-wire wye circuits, 480/277 Volts; 3-phase, 3-wire delta circuits, 480 volts

Circuit Designation	Color Code
Phase A	Brown
Phase B	Orange
Phase C	Yellow
Grounded Conductor (Neutral)	White or gray** (see exception above)
Equipment Grounding Conductor	Bare, green, or green with one/more yellow stripes

* For 3-phase, 4-wire delta circuits, Phase B shall be the high leg and shall be orange.
** For outer covering of conductors of different systems that is contained within the same enclosure, refer to Article 200 of the NEC.

The Contractor shall use non-ferrous metal tags or nylon tags attached to the conductor to permanently identify electrical service and lighting conductors in accessible locations (handholes, transformer bases, junction boxes, control centers, etc.). Identifications shall be stamped or engraved on metal tags, and lettered with permanent ink on nylon tags. Identifications shall be clearly legible and shall indicate the electrical phase. Lighting conductors shall also indicate the electrical phase circuit designation. When the conductors are within a multi-conductor cable, the tag shall be attached to the cable jacket and shall indicate the required information for all conductors on one tag. If the conductors of a multi-conductor cable have been exposed for splicing, connections, etc., the various conductors shall be so tagged instead of the cable jacket.

2. **Signal and interconnect cable color-coding identification:**

Signal and interconnect cable jackets shall be permanently identified by integral-impregnated color coding. Color coding for signal cable shall be as follows:

Cable Color-coding	**14/12 Cable**	**14/7 Cable**	**14/5 Cable**	**14/4 Cable**	**14/3 Cable**
Red	Red	Red	Red	Red	Don't Walk
Orange	Yellow	Yellow	Yellow	---	---
Green	Green	Green	Green	Green	---
Red with black tracer	Red	---	---	---	---
Orange with black tracer	Yellow	---	---	---	---
Green with black tracer	Green	---	---	---	---
Blue	Green	Green	---	---	---
White with black tracer	Yellow	Yellow	---	---	---
Black	Red	Red	Spare	Yellow	Walk
Black with white tracer	Spare	---	---	---	---
Blue with black tracer	Spare	---	---	---	---
White	AC Neutral	AC Neutral	AC Neutral	AC Neutral	AC Neutral

Signal and interconnect cables shall be permanently identified in the controller cabinet, junction boxes, handholes, and other accessible locations. Signal conductor cables shall also be identified in the handhole of poles if the cables are attached to terminal strips in the handhole. Identifications shall be indicated on nonferrous metal tags or nylon tags attached to the cable with nylon cable ties. The Contractor shall stamp or engrave the identification on the metal tags, and write the identification with permanent ink on the nylon tags. Identifications shall be clearly legible and shall conform to the following:

a. **Signal cable:** phase and location of signal head; e.g., 1 NB left-turn head; 1 NB inside left-turn head; 2 SB through-lane heads; 1 left-turn head and 6 through-lane heads; 2 Ped head NW Quad.

b. **Interconnect cable:** description and direction from location (if cable is a spare). The word "spare" shall be included after "inter." The direction from location is required only in the controller cabinet, e.g., Inter. NB; Inter. Spare NB; Inter. WB; Inter.

(h) **Conduit Systems:** Conduit systems shall be rigid except where the Contract specifies otherwise. PVC, fiberglass, and metal conduit runs shall have the minimum number of couplings permitted by the use of standard conduit lengths. Ends of conduit sections that must be field cut shall be reamed smooth. PE conduit shall be installed in continuous un-spliced runs between enclosures. Field-threaded portions of metal conduit shall be galvanized in accordance with Section 233 after threading. Except for expansion couplings, conduit sections connected with couplings shall be cut so that the ends of the conduits will abut squarely inside the couplings. No other conductor will be permitted in the same conduit with electrical service feeder cable.

The Contractor shall fuse each nonmetallic conduit joint with a joint sealing solvent recommended by the conduit manufacturer. Where necessary, ends of each length of nonmetallic conduit shall be tapered by machining to provide joints that are tight after assembly. All conduit(s) shall be terminated by means of approved fittings, bell ends, and/or bushings

in accordance with conduit manufacturer's installation instructions\recommendations before installation of any conductor cable(s).

The Contractor shall ensure conduits are continuous and watertight between outlets. The Contractor shall not use deformed conduit. Conduits shall be without kinks or defects that would cause damage to conductor cables when these are pulled through during their installation. Conduits shall be installed so that moisture will drain properly to electrical junction boxes or drainage tees with drip spouts.

The Contractor shall test each conduit in the presence of the Engineer for obstructions after installation. A suitable rigid or flexible mandrel having a diameter at least 80 percent of the inside diameter of the conduit shall be pulled through each conduit run. If any obstructions are discovered during the testing, the Contractor shall remove the obstructions and repair the conduit at the Contractor's expense.

After testing, the Contractor shall equip individual nonmetallic conduit runs more than 150 feet in length that are to remain empty for the present with woven polyester or aramid pull tape and a metallic locator strip having a tensile strength of at least 1,100 pounds and less than 15 percent elongation at yield. Pull rope shall not be used in nonmetallic conduit. The Contractor shall double back twelve inches of pull tape into the conduit at each end.

The Contractor shall install either a pull rope or tape having a tensile strength of at least 1,100 pounds in metallic conduit runs more than 150 feet in length that are to remain empty for the present. Twelve inches of pull tape or rope shall be doubled back into the conduit at each end.

The Contractor shall install either watertight plugs or caps in the open ends of unused conduit to seal the ends against moisture. Open ends of conduits with installed conductors shall be sealed with an approved soft, pliable, and easily removable waterproof sealant. The sealant shall not have a deleterious effect on cable coverings or the conductors. Empty conduit(s) shall be capped or plugged with material recommended by the conduit manufacturer to prevent moisture build up and rodent entry.

All conduit stub-outs installed on or in structures including, but not limited to, junction boxes, foundations, and poles shall be extended approximately 6 inches beyond the structure.

Metal conduit systems shall be bonded. When a nonmetallic conduit system is used, the Contractor shall furnish and install an equipment grounding conductor to maintain a bonded system in accordance with the NEC.

The Contractor shall install a No. 8 locator wire in all nonmetallic conduits containing fiber optic cable.

The Contractor shall provide the conduit with an expansion fitting wherever conduit crosses a structural expansion joint. The fitting shall permit longitudinal movement of the amount specified on the plans.

1. **Exposed conduit systems** shall be fabricated of heavy-wall PVC, fiberglass, or metal with not more than four bends between any two outlets. The angular sum of bends shall be not more than 360 degrees. When heavy-wall PVC or fiberglass conduit is accessible to public contact, the Contractor shall cover it with a protective shield conforming to Section 238 extending at least 8 feet above the adjacent finished grade. Splice boxes or pull

boxes shall be of a size that will allow the proper termination of conduit and connection of conductor cables in accordance with the NEC. Conduit shall be terminated with approved fittings or bushings.

2. **Buried conduit systems** shall be installed in straight lines between outlets and be the distance below finish grade specified in the Standard Drawings or on the plans. When obstructions are encountered during installation and the conduit cannot be economically located elsewhere, the obstruction shall be bypassed by offsetting the conduit alignment according to the details shown in the Standard Drawings. Required conduit bends shall be installed with a bend radius of at least 5 feet. Conduit bends in structures and foundations shall be installed in accordance with the NEC. The Engineer will not permit the use of a pipe tee or vice for bending conduit.

   The Contractor shall install conduit by the use of an approved directional boring method when conduit is to be installed under an existing roadway, entrance, or fixed object and open cutting is not allowed. Conduit for the directional boring method shall be Polyvinylchloride (PVC) or High-Density Polyethylene (HDPE) designed specifically for directional boring applications. If the Engineer approves, the Contractor may elect to install multiple conduits into a single bore at no additional cost to the Department when the plans show more than one conduit at a location is to be installed by directional boring.

MAXIMUM PILOT OR BACK REAMER BIT DIAMETER WHEN ROTATED 360°

Nominal Inside Pipe Diameter Inches	Bit (Reamer) Diameter Inches
1 - 2”	4” Bore Hole
2 - 2”	5” Bore Hole
3 - 2”	8” Bore Hole
1 - 3”	5” Bore Hole
2 - 3”	6 ½ “ Bore Hole
3 - 3”	8” Bore Hole
1 - 4”	6 ½ “ Bore Hole

The Contractor shall use an Engineer approved stabilizing agent mixed with potable water to create the drilling fluid (mud slurry) for lubrication and soil stabilization. The fluid viscosity may vary to best fit the soil conditions encountered. The Contractor shall not use any chemicals or polymer surfactants in the drilling fluid without written consent from the Engineer. The Contractor shall certify to the Engineer in writing that any chemical added to the drilling fluid is environmentally safe and not harmful or corrosive to the conduit system.

The Contractor may elect to use the jacked method to install a pipe sleeve for installation of the required conduit at no additional cost to the Department.

If an obstruction is encountered during the directional boring or jacking operation that requires abandonment of the hole (tunnel), the Contractor shall immediately backfill the hole with flowable fill for its full length at no additional cost to the Department.

Open cut areas shall be backfilled according to Section 302.

The Contractor shall install a bushing to protect the conductor cable from abrasion unless the design of the junction box or enclosure is such as to afford equivalent protection of the conductor cable when a conduit enters a junction box, or other enclosure.

(i) **Junction Boxes** shall be installed as follows:

The Contractor shall excavate the junction box site to a depth equal to the height of the junction box plus at least 12 inches to allow for the installation of aggregate bedding material. The width of the excavation shall be 6 to 8 inches wider than the junction box to allow proper aggregate backfill.

Bedding material shall conform to Section 203 and be No. 68, No. 78, or No. 8 aggregate. Aggregate shall be at least 12 inches in depth and entirely cover the bottom of the excavated area for the junction box. The Contractor shall level and tamp the bedding aggregate to compact it prior to installing the junction box.

Junction boxes shall be installed and leveled to grade prior to backfilling.

The Contractor shall brace the interior of polymer concrete junction boxes with 2 inch by 4 inch lumber using two braces across the width and one brace across the length of the box or as required by the junction box manufacturer prior to backfilling. Bracing shall be installed in a manner to allow removal by the Contractor once backfilling and compaction have been completed.

The cover of the junction box shall be installed prior to backfilling.

The junction box shall be backfilled and compacted around its perimeter using 6 to 8 inch horizontal lifts to the elevation where the concrete collar is to begin. The remaining area around the collar shall be backfilled and compacted as stated above once the concrete collar has cured. Compaction shall be at least ninety percent of the theoretical maximum density defined in Section 101.02. The Contractor shall use a mechanical tamping device to compact the backfill material and soil, layer by layer, around the perimeter of the junction box. The wheel of a backhoe or other type vehicle shall not be used for compaction of backfill and soil. The area around the junction box shall be graded and restored.

Junction boxes shall not be installed or backfilled where there is standing water. Backfill material shall be free of large stones, wood, or other debris and shall not be saturated with water.

If a special tool or wrench is required to remove the junction box cover, the Contractor shall furnish the Engineer with five such tools.

(j) **Hydraulic Cement Concrete Sidewalk:** When removal of sidewalk is specified on the plans to accommodate construction, existing sidewalk shall be removed from existing joint line to existing joint line. The Contractor shall construct replacement sidewalk in accordance with Section 504. When the Contractor requests to remove existing sidewalk for the Contractor's convenience, the Contractor shall remove and replace the sidewalk at no cost to the Department.

(k) **Anchor Bolts:** Foundations for traffic control device structures (signal poles, overhead sign, lane control, variable message signs, and high-mast lighting structures) shall have a bolt template positioned for the correct orientation of the structure with respect to the structure's location and roadway alignment and to maintain the anchor bolts vertical (plumb) and level during construction.

Bolt and/or anchor nut covers shall not be installed on any traffic control device structures, unless otherwise specified on the plans.

Anchor bolts in double-nut connections shall extend a minimum of 1/4 inch past the second top nut.

The threaded portion of the anchor bolts shall be lubricated with beeswax, the bolt manufacturer's recommended lubricant, or other lubricant as approved by the Engineer to assist in proper tensioning before the structure is installed.

Double-nut connections installation procedures shall conform to the following:

1. A minimum of three nuts and two hardened washers shall be provided for each anchor bolt.

2. If anchor bolt(s) are not plumb (vertical), determine if beveled washer(s) may be required prior to erection of the structure. Beveled washers shall be used on top of the leveling nut and/or under the first top nut if any face of the base plate has a slope greater than 1:20 and/or if any nut could not be brought in firm contact with the base plate.

3. Clean and lubricate the exposed thread of all anchor bolts, nuts and all bearing surfaces of all leveling nuts. Re-lubricate the exposed threads of the anchor bolts and the threads of the nuts if more than 24 hours has elapsed since earlier lubrication, or if the anchor bolts and nuts have become wet since they were first lubricated.

4. Verify that the nuts can be turned onto the bolts the full length of the threads by hand.

5. Turn the leveling nuts onto the anchor bolts and align the nuts to the required elevation shown on the shop drawings. The maximum distance between the bottom of the leveling nut and the top of the foundation shall be one inch (1").

6. Place structural hardened washers on top of the leveling nuts (one washer corresponding to each anchor bolt).

7. The post or end frame shall be plumbed or aligned as shown on the shop drawings. The maximum space between the bottom of the base plate and the top of the foundation shall be the diameter of the anchor bolt plus one (1) inch. Place structural hardened washers on top of the base plate (one washer corresponding to each anchor bolt), and turn the first top nuts onto the anchor bolts.

8. Tighten first top nuts to a "snug-tight" condition in a star pattern. Snug-tight is defined as the maximum nut rotation resulting from the full effort of one person using a 12-inch long wrench or equivalent. A star tightening pattern is one in which the nuts on opposite or near-opposite sides of the bolt circle are successively tightened in a pattern resembling a star.

9. Tighten bottom leveling nuts to a snug-tight condition in a star pattern.

10. At this point, verify again if beveled washers are necessary using the criteria from step 2. If a beveled washer is required, remove the structure if necessary, add the beveled washer(s) and retighten first top nuts and bottom leveling nuts (in a star pattern) to a snug-tight condition.

11. Mark the reference position of each first top nut in a snug-tight condition with a suitable method on one flat surface of the nut with a corresponding reference mark on the base plate at each bolt before final tightening of the first top nuts. Then rotate the first top nuts incrementally to one half the required nut rotation specified in Table VII-1 using a star pattern. Rotate the first top nuts again, using a star pattern, to the full required nut rotation specified in Table VII-1. For example, if total rotation from snug tight is 1/6 turn (60º), rotate 30º in each cycle.

TABLE VII-1
Nut Rotation

Anchor Bolt Diameter, (in.)	Nut Rotation beyond Snug-Tight	
	ASTM F 1554 Grade 36 (M314)	ASTM F 1554 Grade 55 (M314)
≤1½	1/6 turn (60º)	1/3 turn (120º)
>1½	1/12 turn (30º)	1/6 turn (60º)

Nut rotation is relative to anchor bolt. Anchor bolt nut tensioning shall not exceed plus 20º.
Unified Thread Standard (UNC) tensioning is applicable.

The Engineer will not permit the use of lock nuts and/or split washers with anchor bolts.

12. The Contractor shall inspect tightened anchor bolt connections by the use of a calibrated torque wrench in the presence of the Engineer. The torque wrench shall be used to verify that a torque at least equal to the verification torque provided in Table VII-2 has been achieved. A minimum of every other bolt shall be inspected.

TABLE VII-2
Torque Verification

Anchor Bolt Diameter, (in.)	Verification Torque	
	ASTM F 1554 - Grade 36 (M314) Tension/Torque kips/ft-lbs	ASTM F 1554 - Grade 55 (M314) Tension/Torque kips/ft-lbs
1	18 / 180	27 / 270
1 1/4	28 / 350	44 / 550
1 1/2	41 / 615	63 / 945
1 3/4	55 / 962	86 / 1,505
2	73 / 1,460	113 / 2,260
2 1/4	94 / 2,115	146 / 3,285
2 1/2	116 / 2,900	180 / 4,500
2 3/4	143 / 3,932	222 / 6,105
3	173 / 5,190	269 / 8,070
3 1/4	206 / 6,695	320 / 10,400
3 1/2	242 / 8,470	375 / 13,125
3 3/4	280 / 10,500	435 / 16,312
4	321 / 12,840	499 / 19,960

13. Install second top nut on each bolt to the snug tight condition.

14. After all prior steps are completed and all elements of the structure are fully erected, the Contractor shall perform an ultrasonic test on all anchor bolts in accordance with ASTM

E114 - Ultrasonic Pulse Echo Straight Beam Testing by the Contact Method. Ultrasonic testing personnel shall be qualified in accordance with ASNT SNT-TC-1A Level II and certified by the VDOT Materials Division. Equipment shall be qualified in accordance with AWS D1.5 Section 6, Part C. Anchor bolts shall have no indications that are above 10% Full Screen Height at the prescribed scanning level. All indications shall be noted on the test report and submitted to the Engineer and the VDOT Materials Division. A copy of the report, for both structures with and without indications, shall be submitted to the District Bridge Office and the Engineer.

700.06—Measurement and Payment

Concrete foundations will be measured units of each or cubic yards and will be paid for at the contract unit price per each or cubic yards of concrete as applicable for the standard, type and size designated. When paid for in cubic yards of concrete, no payment will be made for concrete in excess of the cubic yards of concrete required by the approved foundation design unless otherwise authorized by the Engineer. When extra concrete is authorized by the Engineer, the additional concrete will be paid for in cubic yards for the invoice material cost only. This price shall include providing foundation design and shop drawings; concrete, reinforcing steel, anchor bolts, washers, nuts, bolt circle templates, lubricant, torque, ultrasonic test on anchor bolts, grounding electrodes (including grounding electrode clamps, grounding electrode conductors, and installation), conduits, testing grounding conductor-to-electrode continuity, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring disturbed areas.

VA sign structure foundations will be measured in units of each and will be paid for at the contract unit price per each for the size specified. No payment will be made for concrete in excess of the cubic yards of concrete required by the foundation design unless otherwise approved by the Engineer. When excess concrete is approved by the Engineer, the additional concrete will be paid for in cubic yards for the invoice material cost only. This price shall include concrete, reinforcing steel, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring disturbed areas.

VIA sign structure foundations will be measured in units of each and will be paid for at the contract unit price per each for the size specified. No payment will be made for concrete in excess of the cubic yards of concrete required by the foundation design unless otherwise approved by the Engineer. When excess concrete is approved by the Engineer, the additional concrete will be paid for in cubic yards for the invoice material cost only. This price shall include concrete, reinforcing steel, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring disturbed areas.

Square tube post foundations will be measured in units of each and will be paid for at the contract unit price per each for the type specified. This price shall include anchor sleeve, post sleeve, slip base assembly, soil stabilizing plate, drive tube foundation, concrete, hardware, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring disturbed areas.

Electrical service will be measured in units of each and will be paid for at the contract unit price per each for the standard and type specified. This price shall include service poles, safety switches or breaker boxes, service entrance conductor cables from the utility company's service box, conductors to the safety switch and circuit breaker box, conduits and fittings on poles and steel supports, conduit straps or clamps, meter base, service entrance heads, thimble-eye bolts, steel supports, wire-way, junction boxes for grounding electrodes and utility service, excavation, pickup and installation of meter base and current transformer cabinet, concrete for foundation, coordination with the local electric utility company, and anchor bolts, washers, nuts when required.

Electrical service grounding electrodes will be measured in units of each per 10-foot electrode or portion thereof, and will be paid for at the contract unit price per each. This price shall include grounding electrodes, exothermic welds, electrode couplers, grounding electrode clamps, grounding electrode conductors, conduit, testing, and test report documentation.

Electrical service work pads will be measured in units of each and will be paid for at the contract unit price per each. This price shall include concrete, excavating, disposing of unsuitable material and restoring the disturbed area.

Luminaire arms will be measured in units of each and will be paid for at the contract unit price per each for the length specified. This price shall include providing design and shop drawings, luminaire arm, pole mounting brackets, rubber grommets, field drilling, galvanization repair if required, fittings, and mounting hardware.

Lighting poles will be measured in units of each and will be paid for at the contract unit price per each for the standard and luminaire mounting height specified. This price shall include providing design and shop drawings; pole shafts, grounding lugs, handholes and locking covers, caps, identification tags, anchor bases, bracket arms, breakaway support systems, field drilling, and galvanization.

Signal poles will be measured in units of each and will be paid for at the contract unit price per each for the standard, class, and type specified. This price shall include providing design and shop drawings, pole shafts, J-hooks, grounding lugs, locking handholes, caps, fittings, anchor bases, identification tags, field drilling, and galvanization.

Mast arms will be measured in units of each and will be paid for at the contract unit price per each for the length specified. The price bid shall include providing design and shop drawings, mast arms including mast arms caps, galvanization, fittings, nuts, bolts, washers, field drilling of wire outlet holes and rubber gaskets or grommets, field adjustment of arm lengths, and identification tags.

Overhead sign structures will be measured in units of each and will be paid for at the contract unit price per each for the location specified. The price shall include furnishing design and shop drawings, structural units and supports, field drilling and adjustment, galvanization, coating when required, base plate, handholes and locking covers, caps, grounding lugs, electrical systems including conduit, fittings, conductor cable, and identification tags.

Sign posts will be measured in linear feet and will be paid for at the contract unit price per linear foot for the type and size specified. This price shall include clamps, and identification tags when required.

VA sign posts will be measured in linear feet for the size specified and will be paid for at the contract unit price per linear foot for the size specified. This price shall include posts, clamps, identification tags, foundation stub post, and breakaway base assemblies.

VIA sign posts will be measured in linear feet for the size specified and will be paid for at the contract unit price per linear foot for the size specified. This price shall include posts, clamps, identification tags, foundation stub post, breakaway base assemblies, hinge plate assemblies and fuse plate assemblies.

Pedestal poles will be measured in units of each and will be paid for at the contract unit price per each for the standard and length specified. This price shall include caps, breakaway support systems, locking handholes, galvanization, grounding lugs, identification tags, and anchor bases.

Wood poles will be measured in units of each and will be paid for at the contract unit price per each for the class and length specified. This price shall include furnishing and installing wood poles, thimble-eye bolts, guy wires with guards and anchors, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring disturbed areas.

Conductor cables and Equipment Grounding Conductor (EGC) will be measured in linear feet and will be paid for at the contract unit price per linear foot for the size and number specified. This price shall include conductors, breakaway connections, markings and identifications, splice kits, electrical tape, testing, and connections.

Conduit will be measured in linear feet and will be paid for at the contract unit price per linear foot for the type and size specified. This price shall include conduit bodies, fittings, bonding system, pull ropes, pull tapes, plastic spacers, No. 8 locator wire when required, pull or splice boxes with an area of 512 cubic inches or less, supports, and protective metal shields.

Trench excavation will be measured in linear feet and will be paid for at the contract unit price per linear foot for the standard indicated. This price shall include metallic locator tape when required, performing trenching, encasing, backfilling, compacting, disposing of surplus and unsuitable material, and restoring disturbed areas.

Junction boxes will be measured in units of each and will be paid for at the contract unit price per each for the standard specified. This price shall include concrete collars, frames and covers, tools to remove the cover, grounding electrode (including grounding electrode clamps and grounding electrode conductors), grounding lugs, knockouts, cable racks, bracing, aggregate, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring disturbed areas.

Test bores will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the performing the test bore, rock sampling, determination of the soil and rock condition, providing test boring logs, and restoring disturbed areas.

Bored conduit will be measured in linear feet and will be paid for at the contract unit price per linear foot for the size specified. This price shall include conduit by boring; fittings; couplings; and, when required, No. 8 locator wire, pull rope or tape, disposing of surplus and unsuitable material, and restoring disturbed areas.

Payment will be made under:

Pay Item	**Pay Unit**
Concrete foundation (Standard, type, and size)	Each or Cubic yards
VA sign structure foundation (Size)	Each
VIA sign structure foundation (Size)	Each
Square tube post foundation (Type)	Each
Electrical service (Standard and type)	Each
Electrical service grounding electrode (10-foot)	Each
Electrical Service work pad	Each
Luminaire arm (Length)	Each
Lighting pole (Standard, luminaire mounting height)	Each
Signal pole (Standard, class and type)	Each
Mast arm (Length)	Each
Overhead sign structure (Location)	Each

Pay Item	Pay Unit
Sign post (Type and size)	Linear foot
VA sign post (Size)	Linear foot
VIA sign post (Size)	Linear foot
Pedestal pole (Standard and length)	Each
Wood pole (Class and length)	Each
Conductor cable (Size/number)	Linear foot
Conduit (Type and size)	Linear foot
Trench excavation (Standard)	Linear foot
Junction box (Standard)	Each
Test bore	Each
Bored conduit (size)	Linear foot

SECTION 701—TRAFFIC SIGNS

701.01—Description

This work shall consist of fabricating, refurbishing, furnishing, and erecting signs as specified on the plans or elsewhere in the contract.

701.02—Materials

(a) **Reflective sheeting** shall conform to Section 247 and shall be selected from the Materials Division's Approved Products List 46. The color for the legend and background shall be in accordance with the MUTCD, the Virginia Supplement to the *MUTCD,* and as specified in the plans.

(b) **Sign panel rivets** shall be powder coated to match the color of the portion of the sign sheeting that the rivets will protrude from. The rivets shall be fabricated in accordance with Standard Drawing SPD-1.

701.03—Procedures

(a) **Fabrication:**

1. **Aluminum welds:** Aluminum shall be welded according to Section 407.

2. **Sign panels:** Panels for permanent signs shall be fabricated of aluminum 0.100-inch in thickness and shall be smooth, flat, and free of metal burrs and splinters. Sign panels for overlays shall be aluminum alloy conforming to the Section 229.02(a), between 0.080 and 0.100 gage in thickness.

   Extruded sign panels shall conform to the Standard Drawings and Section 229.02(c).

3. **Applying retroreflective background sheeting:** Sheeting shall be applied according to the manufacturer's instructions and the detailed requirements herein.

The Contractor shall have sign panels 16 square feet or more in area fabricated from a single piece of applied sheeting, except in the case of sign panels fabricated with fluorescent orange prismatic lens sheeting. Fabricate fluorescent orange prismatic sign panels having an area of 16 square feet or more from sheeting at least 4 feet by 2 feet in dimension, except one piece of sheeting may be less than 2 feet wide to obtain the exact dimensions required. The Engineer will not permit joints, splices, or laps on sign panels less than 16 square feet in area except the following will be allowed:

a. One factory splice from a roll.

b. One joint on fluorescent prismatic lens orange signs when one dimension of the panel is greater than 36 inches but less than 48 inches.

When applying more than one width of reflective sheeting (except for fluorescent orange prismatic lens sheeting) to a sign panel, sheeting edges shall form a vertical butt joint having no gaps or may overlap, but not more than 3/8 inch. The bottom edge of the top width of sheeting shall lie continuously over the top edge of the next lower width of sheeting in a shingle style lap of not more than 3/8 inch when horizontal joints are required, except in the case of fluorescent orange prismatic lens sheeting. Multiple pieces of fluorescent orange prismatic lens sheeting shall be installed with a gap 1/32 to 1/16 inch between the edges, except in the case of fluorescent prismatic lens orange sheeting. Match sheeting carefully to maintain uniform shading and prevent contrast between widths of sheeting.

The finished sign shall be free from cracks, gaps, streaks, wrinkles, blisters, discoloration, buckles, and warps and shall have a smooth surface of uniform color.

4. **Letters, numerals, arrows, symbols, borders, and other features of the sign message:** Features of the sign message shall conform to the *MUTCD* and the *Virginia Standard Highway Signs Book.* The Contractor shall ensure fabricator shall Form units of the sign message to provide a continuous stroke width with smooth edges and a flat surface free from warps, blisters, wrinkles, burrs, and splinters. Features shall also conform to the following:

a. **Type L1, screen process, applied:** Features shall be produced by a direct or reverse screening process approved by the Engineer. Sign messages and borders that are darker than the sign field shall be applied to the reflective sheeting by a direct process. Sign messages and borders that are lighter than the sign field shall be produced by the reverse process in which the message and border are outlined by a color that is darker than the paint or the sheeting on the sign field. Transparent colors, inks, and paints used in the screening process shall be of the type, formulation, and quality recommended by the sheeting manufacturer.

Screening applications shall produce a uniform color and tone. Edges of the legend and borders shall not have blemishes.

Signs shall be air dried or baked according to the manufacturer's recommendations to provide a smooth, hard finish.

b. **Type L2, plastic film sheeting, applied:** Features of the sign message shall be cut from plastic film sheeting of the color specified on the plans. Sheeting shall be an

elastomeric pigmented film coated on one side with an adhesive and covered with a paper liner that is removable from the adhesive without being moistened. Adhesive shall be activated by heat or a solvent recommended by the sheeting manufacturer. Adhesive shall be suitable for application with a hand roller, squeeze roller, or vacuum applicator to form a durable bond to wood, metal, plastic, porcelain enamel, paint lacquer, and reflective sheeting. Sheeting shall be at least 0.002 and not more than 0.0035 inch in thickness and sufficiently opaque so that its color will be unaffected by the color of the sign field.

c. **Type L3, cutout, reflective sheeting, and pressure applied:** Features of the sign message shall be cut from approved reflective sheeting of the color specified on the plans. Sheeting shall have heat-activated or pressure-sensitive adhesive and be applied to the background sheeting according to the manufacturer's instructions.

d. **Type L4, overlay film, pressure applied:** Features of the sign message shall be created by using a background sheeting of the color needed for the sign message and then applying the overlay film with the sign message areas removed from the film. The overlay film shall be transparent and shall be of the color needed to provide the correct background color of the sign.

5. **Joining sign base panels:** Horizontal joints shall be constructed according to the Standard Drawing SPD-1. Where multiple vertical panels adjoin, the face and edges shall be milled or finished to a tolerance of ±1/32 inch from a straight plane such that no gap more than 1/16 inch is produced between panels.

   Extruded sign panels shall be assembled according to the Standard Drawing SPD-2.

6. **Applying the sign message:** The Contractor shall ensure features shall be straight, properly spaced, smooth to the applied surface, and free from irregular edges.

7. **Sign finishing:** The complete outer edge, splices, messages, and borders of signs shall be sealed after application to the sign panel. Sealant material and its application shall be according to the sheeting manufacturer's recommendations and instructions.

8. **Rejected sign messages:** The Contractor shall immediately obliterate sign messages on signs that the Engineer has rejected, and remove those signs from the project.

9. **Bracing:** Bracing shall be installed on the backs of all non-extruded signs when required by the Standard Drawings.

(b) **Transporting and Storing Signs from the Fabricator:** Transport signs according to either of the following methods.

1. The Contractor shall ensure signs are transported in cardboard cartons with a slipsheet covering the sheeting. The slipsheet shall be paper with a plastic coating on one side, with the plastic side faced against the sign sheeting according to the sheeting manufacturer's recommendations. Not more than 10 signs may be placed in any one carton. Signs shall alternate face-to-face, back-to-back, throughout the carton. A microfoam pad at least 1/16 inch in thickness shall be used between signs placed face to face. Cartons shall be placed vertically within a container designed to elevate boxes above ground level and

provide lateral structural support. Cartons shall not be exposed to moisture before or during transportation; or

2. Signs shall be transported on an open truck or trailer bed with vertical racks for attachment of signs. Racks shall be designed to provide lateral structural support and allow the free flow of air around the sign face. Large signs may be transported on an open truck or trailer bed in shipping containers consisting of framing around edges of signs. Framing shall be untreated lumber that provides support for the sign without allowing pressure on the sign sheeting. Each container may house two signs positioned with the sign sheeting facing toward the inside. Signs shall be held in place in containers through the use of metal stiffeners attached to the framing, such as T-bars, Z-bars, or horizontal stiffeners. The Contractor shall ensure shipping containers are secured in the vertical position for transportation.

Signs transported in cardboard cartons shall be stored in their original shipping containers in a dry, enclosed location providing protection from extreme heat and humidity. Signs transported on racks or in wooden containers shall be stored on vertical racks designed to elevate signs above ground level, provide lateral structural support, and permit the free flow of air around the sign face. The Contractor shall not store signs where they are subjected to water runoff.

The Contractor may remove signs from storage and install them on their structural supports before the structure is erected; however, in such cases, the structure along with the sign shall be erected within 24 hours after removal of the sign from storage. During this 24 hour time period, the sign and its structural support shall be stored at a sufficient angle to facilitate water runoff from the sign while preventing the sign from coming in contact with the ground.

The Contractor shall not band signs together, cover them with tarps, store them flat, or subject the sign sheeting to pressure during storage.

The Engineer will reject any signs that have been transported or stored in cardboard cartons that have been exposed to moisture to the extent that moisture has entered the cartons. The Contractor shall immediately obliterate sign messages on signs rejected by the Engineer, and remove the rejected signs from the project.

(c) **Transporting and Storing Relocated Signs:** The Contractor shall transport and store signs designated for relocation in a manner that will not allow pressure to be placed on the sign sheeting. Relocated signs shall be stored in their vertical position above ground level. Relocated signs that have been removed from their structure shall be stored according to paragraph (b) herein.

(d) **Erection:** The Contractor shall install sign panels on overhead sign structures so that the vertical clearance is no less than 19 feet and no more than 21 feet from the bottom of the lowest mounted sign panel to the crown of the roadway, unless otherwise specified on the plans. Walkway or luminaire assemblies shall have a vertical clearance of not less than 17 feet 6 inches from the bottom of the assembly to the crown of the roadway.

If possible, the Contractor shall install sign panels at a time when covering of the sign message will not be needed. When this is not possible, a porous cloth cover rendering the sign message nonvisible shall be placed over the sign sheeting, folded over the sign edges, and secured to the back of the sign panel.

Sign panels shall be securely fastened to posts or supports and erected plumb.

Ground-mounted signs shall be horizontally angled at 93 degrees between the face of the sign panel and the centerline of the roadway, unless otherwise indicated on the plans or directed by the Engineer.

Vertical and horizontal spacing between installed signs shall be 1 inch where multiple signs are installed on the same structure.

A 1/16 inch thick neoprene gasket shall be used between the seat of the galvanized steel post clamps and the framing unit.

Illumination of signs shall be according to Section 705.

Damage to reflective sheeting may be repaired and edges sealed in accordance with the manufacturer's instructions and the following:

Sign patch material shall be of the same type and color as the surrounding sheeting and shall have at least the same life expectancy. Patching will not be permitted on any letter, numeral, arrow, symbol, or border. The Engineer will reject signs where the number, size, or spacing of patches is more than the following, and the signs shall be replaced at the Contractor's expense:

Sign Face Area (sq. ft.)	**Max No. of Patches**	**Max. Size of Patches (sq. ft.)**	**Min. Spacing Between Patches (in)**
24.99 or smaller	No patching allowed		
25 to 49.99	1	1	0
50 to 99.9	2	1	6
100 to 199.9	3	2	6
200 or larger	4	3	12

The Contractor shall repair superficial damage to sign panels using methods recommended by the sheeting manufacturer that result in a smooth, flat, and completely legible panel. The Engineer will reject sign panels that have more than superficial damage, such panels shall be replaced at the Contractor's expense.

Existing overlays and demountable messages including borders, present on signs designated to receive overlays shall be removed to facilitate the installation of the new overlay. Bullet holes and bent sections shall be flattened so that the sign face is free of projections and large indentations to facilitate installation of the new overlay.

Overlayments 3 feet or less in total horizontal dimension shall be accomplished with one panel. Overlayments greater than 3 feet in total horizontal dimension shall be accomplished with panels no less than 3 feet wide except that one panel per overlayment may be less than 3 feet wide to obtain the exact horizontal dimension required. Joints of overlays shall be tightly butted and not overlap.

Overlay panels shall be erected with aluminum rivets. Rivets shall be no less than 3/16 inch in diameter and of such length as to fasten the panels securely and form a compressed head

conforming to the manufacturer's recommendations. Rivets shall be located on 1-foot centers, positioned 1 inch from each panel's edges, completely around the sign's perimeter. Where overlayment panels are 30 inches or greater in width, a column of rivets shall be installed on 1-foot centers down the centerline of the panel. Rivets shall be installed in such a sequence as to prevent buckling of the panels.

Overlay panels shall be performed on a flat surface with no protruding bolts or bolt heads on the existing sign panel.

Overlay of overhead sign panels shall be according to details on the Plans.

(e) **Warranty Requirements:** The Contractor shall provide a manufacturer's warranty in accordance with Section 247 for permanent traffic control signs. Providing a manufacturer's warranty of the type and length specified in Section 247 will be considered incidental to the cost of the sign panel or overlay sign panel.

(f) **Documentation Requirements:**

For warranty requirements, each permanent traffic control sign shall be labeled on the blank side of the sign panel in a location, not to be obscured by sign supports or mounting hardware, with the following information:

1. Sheeting Manufacturer's name or logo.
2. product designation or number.
3. lot number.
4. Sign fabricator's name or logo.
5. Month and year the sign was fabricated. The month and year may be indicated by punch-out numerals.
6. Installation date.
7. VDOT acronym or logo.

Labels shall be made of a self-adhesive, permanent, weather resistant material and shall be a minimum 4" by 4" in size. Label may be made from permanent sign material provided the finished label meets all other aspects required for warranty documentation.

The Contractor shall ensure information required for warranty documentation is supplied by permanent means capable of resisting weathering for the full duration of the warranty period, such as sign ink, where the information required for the label is not furnished by punched-out numerals.

Prior to applying the label, the area shall be thoroughly cleaned to ensure proper adhesion or application of ink.

The Contractor shall provide an .xlsx formatted file to the Engineer, using a sign inventory template provided by the Engineer. The file shall include the information required above for the label, as well as the following:

1. Route no.
2. Project UPC no. (if applicable).
3. Station or milepost information.
4. Lane designation.
5. *MUTCD* or *VA Supplement to the MUTCD* sign code, if applicable and if denoted on the plans.
6. Sign message.
7. Sign width.
8. Sign height.

The cost of preparing and submitting the .xlsx formatted file shall be included with the cost of the sign panel pay items.

701.04—Measurement and Payment

Sign panels will be measured in square feet and will be paid for at the contract unit price per square foot. This price shall include background sheeting, sign messages, finishing, framing units, hanger assemblies, bracing, stiffeners, splicing, backing strips, post clips/post clamps, warranty, and labeling.

Overlay sign panels will be measured in square feet of sign panels without deductions for rounded corners. Overlay sign panel will be paid for at the contract unit price per square foot. This price shall include verifying the size and color of overlayment panel; removing existing overlayment and demountable messages including borders; fabricating, and new overlayment.

Payment will be made under:

Pay Item	Pay Unit
Sign panel	Square foot
Overlay sign panel	Square foot

SECTION 702—DELINEATORS

702.01—Description

This work shall consist of furnishing and installing road-edge, barrier, flexible post, or guardrail delineators of the type specified in accordance with these specifications and in conformity with the lines and dimensions on the plans or as established by the Engineer.

702.02—Materials

(a) **Fabrication** of aluminum panels with reflective sheeting shall conform to Section 701.

(b) **Reflective sheeting** shall conform to Section 247.02(f) and shall be selected from the VDOT's Approved Products List 46.

(c) **Plastic lens retroreflector delineators** shall conform to Section 235.

(d) **Plastic panels** shall conform to Section 235.

(e) **Aluminum panels** shall conform to Section 235.

(f) **Adhesive** for attaching delineators to guardrail and barrier shall be as recommended by the delineator manufacturer.

(g) **Flexible Post Delineators** and anchoring systems shall conform to Section 235 and shall be selected from the VDOT Materials Division's Approved Products List 16. Surface-mount flexible post delineators shall contain an anchoring system for attaching the flexible post delineator to the pavement, median, or island. Ground-mount flexible post delineators shall contain an anchoring system for anchoring the flexible post delineator in earth.

702.03—General Requirements

Retroreflectors for road edge, flexible post, barrier, and guardrail delineators shall be the same color as the adjacent pavement marking, unless otherwise specified on the plans. Barrier delineators on the top of barriers separating opposing directions of traffic shall be yellow on both sides.

(a) **Road-edge Delineators:**

1. **Interstate road-edge delineators** shall consist of two types.

   Type I shall be an aluminum panel with reflective sheeting.

   Type II shall be a plastic lens retroreflector.

2. **Standard and special road-edge delineators** shall be an aluminum alloy panel with reflective sheeting.

(b) **Barrier and Guardrail Delineators** shall have no less than 7.0 square inches of retroreflective sheeting and shall have no more than 5 inches of vertical projection when installed. The delineator shall be fabricated from a flexible plastic panel.

702.04—Procedures

(a) **Roadedge delineators** shall be placed as shown on the Standard Drawings, ED-2 or ED-3, as appropriate. Posts shall be installed plumb and to the details and dimensions shown.

(b) **Barrier and guardrail delineators** shall be applied to clean, dry surfaces in accordance with the delineator manufacturer's recommendations. Loose material and dirt shall be removed

from concrete by wire brushing and from steel surfaces by other appropriate methods. When recommended by the manufacturer, a primer shall be used to aid adhesion.

Delineators shall be installed on all barriers and guardrails that are within 15 feet of the edge of the pavement.

Barrier delineators shall be installed on the respective barriers at the locations shown on the Standard Drawings, MB-Series, or on the relevant bridge parapet/railing detail shown on the plans. Barrier delineators shall be installed using an adhesive recommended by the delineator's manufacturer.

The Contractor shall install guardrail delineators at the midpoint of the offset block, if an offset block is used, or on the web of the guardrail posts if an offset block is not required in the installation. The Engineer will not permit field cutting or adjustments where weak post guardrail and cable guardrail systems are installed, delineators shall be manufactured to fit. If a bolting system is used to attach the delineators to the posts, the bolting system shall be such that drilling of the guardrail posts or offset blocks is unnecessary. Delineators shall be attached with screws or by an adhesive system recommended by the manufacturer where delineators are to be attached to wood or recycled plastic offset blocks. Screws shall be stainless steel or galvanized.

Spacing for delineators on barrier or guardrail shall be on 80-foot centers unless otherwise indicated. Delineators mounted on guardrail and barriers located in curves on interchange ramps shall be spaced in accordance with the spacing for interstate road-edge delineators as shown on the Standard Drawing ED-3, except that the maximum spacing shall be 80 feet.

Where the center-to-center spacing for delineators on guardrail cannot be obtained due to post spacing, the delineators shall be installed to provide spacing that is not greater than the spacing indicated herein.

(c) **Flexible Post Delineators** – Surface-mount delineators shall be attached to clean, dry roadways, medians, or concrete island surfaces in accordance with the manufacturer's instructions. Loose material and dirt shall be removed from concrete surfaces by wire brushing. When recommended by the manufacturer, a specified primer shall be used to aid in adhesion.

Ground-mount flexible post delineators shall be embedded in the ground in accordance with the manufacturer's instructions.

702.05—Measurement and Payment

Road-edge delineators will be measured in units of each and will be paid for at the contract unit price per each for the standard and type specified. This price shall include post, fasteners, retroreflective elements, excavation, and backfill.

Barrier and guardrail delineators are considered incidental to barrier and guardrail construction and will not be measured for separate payment unless otherwise specified in the Contract. When specified in the Contract for installation on existing barriers and guardrail, delineators will be measured in units of each and will be paid for at the contract unit price per each. This price shall include surface preparation, delineators, primer if required by the manufacturer, adhesive, fasteners, and retroreflectors.

Flexible Post Delineators will be measured in units of each and will be paid for at the contract unit price per each for the type specified. This price shall include flexible post, surface preparation, primer if required by the manufacturer, anchors, adhesives, and retroreflective elements.

Payment will be made under:

Pay Item	Pay Unit
Road-edge delineator (Standard and type)	Each
Barrier delineator	Each
Guardrail delineator	Each
Flexible post delineator (Type)	Each

SECTION 703—TRAFFIC SIGNALS

703.01—Description

This work shall consist of furnishing and installing traffic signal equipment in accordance with these Specifications and as specified in the Contract or as directed by the Engineer.

703.02—Equipment

Traffic signal controllers, master controllers, auxiliary equipment used to add supplementary features to controller and traffic signal equipment cabinet operations, and flashers for operating flashing beacons shall be certified by the manufacturer as conforming to NEMA *Standards Publication* TS-2-2003 (R2008), dated November 1, 2012, including Amendment 3-2009 and Amendment 4-2012, or to CALTRANS *Transportation Electrical Equipment Specifications* (TEES), dated March 12, 2009, including Errata 1 dated January 21, 2010, and shall conform to any exceptions and additions stated herein unless otherwise specified. The manufacturer shall also provide certification that the model of controller, auxiliary equipment, and flasher conform to applicable TS-2 or CALTRANS environmental standards and test procedures. Controllers and auxiliary equipment shall be the manufacturer's standard design. Controllers shall be completely housed in a weatherproof traffic signal equipment cabinet. Controllers and auxiliary equipment shall operate from a 120-volt, 60-Hz, single-phase, AC power supply. The manufacturer's name, model number, serial number, and part identification number shall be permanently attached to the cover of the equipment. The Contractor shall also furnish the manufacturer's instructions for installing and maintaining the equipment.

The Department will furnish controller timings including coordination and preemption timings to the Contractor for implementation unless specified otherwise in the Contract.

(a) **Traffic Signal Controllers:** Controllers shall completely interface via National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) communication protocols with the existing or proposed master controllers and central system software, as specified in the Contract.

All types of traffic signal controllers shall include the following functionality and programmable features:

- Controller shall include a separate flash memory device (data key or USB device) for storage of all controller timing data and configuration settings which shall be easily removable and directly accessible.

- Controller shall have a front panel multi-line alphanumeric backlit display to show all operational parameters and states.

- Controller shall have an alphanumeric keypad to allow the controller to be programmed without requiring an external device.

- Controller shall include an on-board comprehensive help menu. The menu shall include a description and range of applicable values that may be entered for the function in question.

- Controller shall store all settings, including timing and control parameters, in non-volatile memory and shall not be lost during power outages or disruptions.

- The software shall be updatable from an external device via a USB flash drive, serial connection, or Ethernet connection.

- Shall support traffic control features including, but not limited to, at least 16 Vehicle Phases; at least 16 Pedestrian Phases; at least 4 Timing Rings; at least 16 Overlaps; at least 64 Detectors; at least 16 System Detectors; at least 48 coordination plans that define values for cycle length, offset and split.

- Shall support Time-Base Control including at least 64 Events configurable by months, days of weeks, and days of month, and 16 Exception Day Programs that can override normal day programs.

- Shall support Preemption/Priority Control including 4 Preemption Routines, 4 Priority Routines.

- Shall support conditional service that allows an odd phase to be re-serviced after the even phase but before crossing the barrier.

- Shall support logs and diagnostics including, but not limited to, local alarms, preemption, coordination, cycling, communications, detectors, and monitors.

- Shall be IP addressable.

- Shall support security codes such that, when enabled, at a minimum, shall require a user-specified security code be entered before data may be changed. Security access shall be automatically rescinded 10 minutes after the last user keystroke or 10 minutes after access if there are no user keystrokes. Viewing of data shall not require the entering of the security code. In closed loop systems, central equipment shall have full access to data within the local controllers via the master controller regardless of security codes imposed at the local controllers.

- Loop detector delay features. When the delay feature is used, it shall be inhibited during the green interval of its associated phase.

1. **Local Controllers** shall be Type A or Type B, as specified in the Contract.

   a. **Type A local controllers** shall be NEMA TS-2, Type 1 and conform to NEMA *Standards Publication* TS-2-2003 (R2008) dated November 1, 2012 including Amendment 3-2009 and Amendment 4-2012.

      Controllers shall be equipped with a fully functional 10-Base T Ethernet network data port and an additional RS232C communication port. Controllers that are being installed in a system using hardwire or wireless interconnect shall be capable of supporting full communications with the master controller.

   b. **Type B local controllers** shall conform to CALTRANS *Transportation Electrical Equipment Specifications* (TEES) dated March 12, 2009, including Errata 1 dated January 21, 2010 and *Advanced Transportation Controller* (ATC) Standard, version 5.2b dated June 26, 2006.

      Provide Model 2070 ATC controllers with the following modules and assemblies:

      - Model 2070-ATC, CPU Module.
      - Model 2070-2E, Field I/O Module.
      - Model 2070-3B, Front Panel Module.
      - Model 2070-4A, Power Supply Module, 10 AMP.
      - Model 2070-7A, Serial Communication Module.

   Controllers shall have the latest version of the Linux operating system supporting third (3rd) party software installation.

   Controllers shall have the circuitry and memory to collect and store detector count information. The count information shall be stored in 15 minute increments. Each increment shall be stored for at least 72 hours before the memory location is overwritten. The count information values shall include volume, density (occupancy), and speed.

2. **Master controllers** shall be Type A or Type B, as specified in the Contract. A master controller may be combined within a local controller unit or be a separate unit.

   a. **Type A master controllers** shall be identical to and from the same manufacturer as the Type A local controller.

   b. **Type B master controllers** shall be fully identical to and from the same manufacturer as the Type B local controller with the addition of a second Model 2070-7A, Async Serial Communication Module with a 9-pin RS-232C port.

(b) **Traffic Signal Equipment Cabinets:** Traffic signal equipment cabinets for all types of traffic signal controllers shall be weatherproof and constructed of welded sheet aluminum, 0.125-inch minimum. Traffic signal equipment cabinet mounting attachments shall be durable, corrosion resistant, and of heavy-duty construction.

1. **Doors** shall provide full access to the cabinet interior and shall have gaskets to ensure weatherproofing. Both the front and rear doors shall have the same dimensional size. Traffic signal equipment cabinet doors shall be equipped with the Department's standard tumbler lock No. 9R48773, unless otherwise indicated in the Contract, and shall be keyed. The Contractor shall provide two keys to the Engineer. Hinges shall be stainless steel and continuous. All doors shall have a door stop arrangement that will allow them to be firmly positioned at 90 and 135 degrees, ±10 degrees. The locking mechanism for traffic signal equipment cabinets shall be a three-point draw roller system. Rollers shall be fabricated from nylon with a diameter of at least 8/10 inch. All door openings shall be double flanged on all four sides.

2. **Police panel** shall be small and recessed with a separate access door located in the front door of the traffic signal equipment cabinet with a standard police panel lock and shall be keyed. The Contractor shall provide two keys to the Engineer. The police panel shall be furnished with two police panel toggle switches (PPS), each labeled for its purpose as indicated below. Police panel toggle switches shall be installed so that the normal mode operation is when the switch is in the "up" position.

    a. **PPS1** will be used to place the signal in flashing operation and shall not affect the power being supplied to the controller or the cyclic operation of the controller. Upon placement of this switch from the automatic (up) position to the flash (down) position, the intersection shall immediately be placed in flashing operation and stop timing shall be applied to the controller. Upon placement of this switch from the flash (down) position to the automatic (up) position, the signals shall immediately be placed in automatic operation in the major street through phase green interval, and stop timing to the controller shall be cancelled.

    b. **PPS2** shall be used to allow manual operation of controller phasing. A 1/4 inch phone jack shall be installed adjacent to this toggle switch for the connection of a corded pushbutton control device. Cabinet shall be wired to prevent force-off of the yellow change and red clearance intervals programmed in the controller when manual operation is used.

    Toggle switches may be added or modified as specified in the Contract.

3. **Interior** shall be of sufficient size to provide adequate ventilation of the equipment housed therein.

4. **Wiring panels** (terminal blocks) shall be neatly finished and clearly and permanently marked with identifications applied by silk screening. Communications cables and conductors shall be neatly arranged in the traffic signal equipment cabinets and bundled in groups with cable ties. Conductors running to panels other than the resistor panel of the traffic signal equipment cabinet shall be positioned below the resistor panel with the nearest conductor being at least 3 inches from the bottom resistor position. Conductors connected to terminals located on the door shall be bundled and sheathed. The bundled conductors shall not obstruct access to other circuits and terminals in the traffic signal equipment cabinet. The controller equipment and terminals shall be installed within the traffic signal equipment cabinet so that they will not restrict the entrance, placement, and connection of conductors. Unless cable is passing through the traffic signal equipment cabinet uninterrupted, incoming and outgoing conductors shall have each wire connected to terminal post positions.

When protected-permissive left-turn phasing is being used, the red output from the load switch for the left-turn phase shall be connected to ground through a 1.5K-ohm resistor. The resistor shall conform to MIL-R18546D, Type RE70G1501. Heat sink compound shall be applied to the housing base before attachment. Wiring shall be soldered to the resistors and the connections shall then be covered with heat shrink tubing. On unused phases, red outputs shall be wired to Signal Bus AC+. Wiring shall be readily accessible and shall not require the back panel to be lowered for disconnection of the wiring.

When protected left-turn phasing is being used, the red output from the load switch for the left-turn phase shall not be connected to ground through the resistors. These four (4) load resistors shall be mounted on a separate panel from the main load switch back panel. Wiring shall be provided from this panel to the main load switch back panel and shall not interfere with the signal field wiring. When specified in the Contract, load resistors for phases 1, 3, 5, and 7 shall be mounted directly to the back panel.

Wiring shall be provided for railroad preemption whereby the selection of the following is easily accomplished using simple hand tools: 1) 115 VAC or ground true outputs, and 2) normally open or normally closed contacts. Six (6) emergency preemption controller inputs shall be included on this panel for connection of preemption devices using simple hand tools.

The Contractor shall provide one electronic version (PDF format on CD) and six prints of the controller circuit diagram to the Engineer. The prints shall be produced from the original drawing and shall be clear and legible. The Contractor shall install two copies of the circuit diagram inside the traffic signal equipment cabinet in a readily accessible waterproof enclosure and shall furnish four additional copies to the Engineer. The waterproof enclosure shall be securely attached to the traffic signal equipment cabinet with studs welded to the traffic signal equipment cabinet and nuts applied to the studs. The enclosure shall also have noncorrosive metal grommets for use with the studs.

A listing indicating terminal numbers with a description of their use shall be attached to the traffic signal equipment cabinet door and overlaid with a clear, plastic covering. Edges of the plastic shall be sealed with a clear waterproofing compound.

Harness cables shall be stranded copper and shall be No. 22 AWG or larger and rated at 300 volts. Other AC and DC circuit wiring shall be in accordance with NEMA *Standards Publication* TS-2-2003 (R2008) dated November 1, 2012 including Amendment 3-2009 and Amendment 4-2012 or CALTRANS TEES dated March 12, 2009 including Errata 1 dated January 21, 2010, as applicable.

When specified in the Contract, the Contractor shall furnish traffic signal equipment cabinets with an advance flashing beacon auxiliary panel for independent approach flashers. The panel shall provide a flash output to beacons that allows the user a programmable amount of time, three seconds minimum, for flashing to begin before the beginning of yellow of the phases associated with the flashing beacons. The panel shall operate at least two phases and phases shall be user programmable through the controller software. Additional phases to be operated may be specified in the Contract. The Department will not permit the use of overlaps to achieve this functionality.

The Department will not permit the use of ribbon cable and printed circuit boards for traffic signal equipment cabinet wiring.

Outgoing traffic signal circuits shall be the same polarity as the line side of the power supply. The common return of signal circuits shall be the same polarity as the ground side of the power supply. The power supply shall be grounded to the ground bus of the traffic signal equipment cabinet. The ground bus, neutral bus, and logic ground bus in the traffic signal equipment cabinet shall be copper. The signal bus shall be connected to the incoming AC+ through a signal bus with a solid state relay.

The traffic signal equipment cabinet power distribution contactor for transfer and control of 120VAC power to the signal load switches shall be an electronic contactor.

Electronic contactor shall control the signal bus 120 VAC power to the signal load switches. The electronic contactor shall be designed for continuous duty operation under load conditions.

The traffic signal equipment cabinet power distribution electronic contactor shall be installed in the traffic signal equipment cabinet power distribution assembly.

Electronic contactors shall conform to the following:

- 120 VAC 60 Hz operation.
- AC current: 30 amps (resistive/Inductive).
- Temperature: -30ºF to 165ºF.
- Continuous duty operation.
- Switching Time: ON – 1 msec, OFF – 0-8 msec.

5. The Contractor shall provide transient protection in traffic signal equipment cabinets for the following:

   a. **Main AC power input:** Transient protection for the AC power input shall be connected on the load side of the main AC circuit breaker. Transient protection shall consist of a modular package with a base and socket and matching plug–in transient device. The transient protector shall include LEDs for failure indication, a contact closure alarm output, and remote sensing output circuitry designed for polling remotely. The transient protection shall be able to 1) withstand a 20,000-ampere surge current with an 8 by 20 microsecond wave form, 20 times at 3-minute intervals between surges without damage to the suppressor, 2) limit the surge voltage to a 2,000-volt peak, and 3) limit follow current to an appropriate level to prevent tripping of the main circuit breaker of the traffic signal equipment cabinet or enclosure.

   b. **Field wiring:** Transient suppression for field wiring shall be installed on the front of the back panel. Transient suppression for field wiring, except loop detector lead-in cable, shall be able to 1) limit the surge voltage to a level no greater than twice the peak operating voltage of the circuit being protected and 2) withstand a surge current of 1,000 amperes with an 8 by 20-microsecond wave form six times at 1-second intervals between surges without damage to the suppressor.

   c. **Loop detector lead in cable:** The panel shall be located on the left side near the front of the traffic signal equipment cabinet and above the level of the lowest shelf.

A preemption test switch with necessary wiring shall be located on this panel. Transient suppression for loop detector lead in cables shall not affect the operation of inductive vehicle loop detectors and shall 1) protect detector unit loop inputs against differential (between the loop lead) surges and against common mode (between loop leads and ground) surges, 2) clamp the surge voltage to 25 volts or less when subjected to repetitive 300-ampere surges and 3) withstand repetitive 400-ampere surges with an 8 by 20-microsecond wave form without damage to the suppressor.

6. **Accessory and auxiliary equipment:** Traffic signal equipment shall be furnished with the following:

   a. At least one 120-Volt, 20-ampere Ground-Fault Circuit Interrupters (GFCI) duplex receptacle with LED indicator and at least one 120-Volt, 20-ampere non GFCI duplex receptacle, which shall be located next to each other.

   b. Removable, noncorrosive metal power panel (13-gage minimum) near the front of the traffic signal equipment cabinet. A clear Plexiglass shield with openings to permit manual operation of breakers shall be installed over the panel with standoffs and thumbscrews. The Plexiglass shield shall extend at least to the edges of the power panel. An additional clear Plexiglass shield shall be securely attached with an adhesive to the top edge of the power panel shield. The width of this shield shall be the same as the power panel shield and the depth shall be as necessary for the shield to contact the top of the power panel. Incoming wires to the power panel shall be brought in from the side of the panel.

   c. Two circuit breakers. One circuit breaker, shall be isolated from the power supply for the signal and control equipment, be rated at least 20 amps, and shall operate the vent fan, ground fault convenience receptacle, and traffic signal equipment cabinet lighting. The second circuit breaker shall be rated at least 20 amps or as required by the loading and shall operate all other equipment including the signal load. Separate terminal strips shall be provided for each circuit breaker and an unfused terminal for the neutral side of the power supply line. Additional circuit breakers shall be provided as specified in the Contract.

   d. The filter tray shall be sized to house and secure the filter in place. The screen shall be constructed from at least 0.031 inch aluminum with 1/8 inch diameter openings positioned on 3/16-inch staggered centers. The screen shall be placed on the inlet side of the filter and held in place by the filter or silicone adhesive.

   e. Screened air exhaust opening under the top overhang.

   f. Two ball bearing type thermostatically controlled vent fans with a screened guard in the top section of the traffic signal equipment cabinet. Each fan shall have the capability of exhausting at least 100 CFM. Each fan shall have an independent thermostat that shall be adjustable from 80°F to 130°F. Degree markings shall be indicated on the thermostat in 10-degree increments.

   g. Radio frequency interference filter rated at 50 amps.

   h. Transient protection devices as described in Section 703.02(5).

i. Traffic signal equipment cabinet lighting system shall be activated by two automatic on/off door switches located in the traffic signal equipment cabinet frame (the first switch shall be operated by the front door and the second switch shall be operated by the back door). Each door switch shall be connected to the 120-volt, single-phase, AC power line for operation of the LED lamp (number of lamps and wattage depends on the traffic signal equipment cabinet size). The switches shall turn light on continuously when any door is in the open position. Traffic signal equipment cabinet lighting shall be installed on the inside top of the traffic signal equipment cabinet and directly above the back panel to provide for the unobstructed illumination of electrical and electronic items located inside the traffic signal equipment cabinet as specified in the Contract.

j. Wired signal, pedestrian, and overlap load switch mounting bases (16) wired for the following from left to right: 8 phases, 4 overlaps, and pedestrian movement for phases 2, 4, 6, and 8.

k. One or more field wiring terminal(s) for each light circuit and one terminal for the common conductors but not less than one for every four signal circuits. Signal common terminals shall be grounded to the traffic signal equipment cabinet.

l. Removable, noncorrosive metal resistor panel (13-gage minimum) located on the left side near the bottom of the traffic signal equipment cabinet. The panel shall be of sufficient size to adequately mount four resistors. Resistors shall be mounted horizontally, one below the other, in the following order from top to bottom: phase 1, phase 3, phase 5, and phase 7.

7. **Type A traffic signal equipment cabinets** shall be provided when installing Type A signal controllers. Type A traffic signal equipment cabinets shall conform to the general requirements for cabinets as specified in section 703.02(b)1-6 and NEMA *Standards Publication* TS-2-2003 (R2008) dated November 1, 2012 including Amendment 3-2009 and Amendment 4-2012, except as specified below.

Type A traffic signal equipment cabinets shall be at least 54 inches in height, 44 inches in width, and 24 inches in depth and shall be large enough to provide for ease of maintenance of the controller and auxiliary equipment. The Type A traffic signal equipment cabinet shall fit entirely on the proposed signal cabinet foundation.

Type A traffic signal equipment cabinets shall contain at least three adjustable shelves or equivalent supports with enough space to hold the controller, two 16-channel detector racks, required auxiliary equipment, and all other equipment as specified in the Contract. Vertical mounting channels for the shelves shall be continuous and shall allow for adjustable shelf placement ranging 5 inches from the bottom to 5 inches from the top of the traffic signal equipment cabinet.

Type A traffic signal equipment cabinets shall have a full extension sliding drawer with flip-up cover attached to the middle shelf suitable for document storage and as a support station for an external device. Minimum drawer dimensions are 24 inches wide, 12 inches deep and 1-1/2 inches high.

Type A traffic signal equipment cabinets shall be wired in accordance with Section 5 of NEMA *Standards Publication* TS-2-2003 (R2008) dated November 1, 2012 including

Amendment 3-2009 and Amendment 4-2012, sixteen channel, NEMA configuration 3 and the changes and additions noted herein. The Type A traffic signal equipment cabinet shall also be wired to produce controller pin connector functions, including those on auxiliary connectors. Wiring that is connected to the back panel shall be of adequate length to allow the back panel to be easily placed in position for maintenance.

Type A traffic signal equipment cabinets shall contain removable, noncorrosive metal back panel (13-gage minimum) that shall incorporate a swing-down design to allow it to be placed in at least a 60-degree angle below the vertical position when the top attachment mechanisms are removed. The design shall use noncorrosive metal hinges or pins of adequate number and strength to support the back panel and attached equipment.

Type A traffic signal equipment cabinets shall contain detector interface panels for the purpose of connecting field loops and vehicle detector amplifiers. The panels shall be manufactured of aluminum and use barrier type terminal blocks. The detector interface shall be provided with the following:

- One sixteen-position interface panel for each detector rack.
- Each interface panel shall provide the connection of sixteen independent field loops. A ground bus terminal shall be provided between each loop pair terminal to provide a termination for loop lead-in cable ground wire. Terminals shall be screw type.
- Each interface panel shall provide a barrier style terminal block to terminate the field wires for up to two 2-channel preemption devices.
- Each interface panel shall be provided with lightning protective devices for all channels.
- A cable consisting of 20 AWG twisted pair wires shall be wired directly from the interface panel to the detector rack. No connectors shall be used to connect the interface panel to the detector rack.
- All termination points on the interface panel shall be identified by a unique number silk screened on the panel.

Type A traffic signal equipment cabinets shall include removable, noncorrosive metal detector test panel (13-gage minimum), readily accessible when the main cabinet door is opened, providing vehicle inputs through a momentary switch to each of the 8 phases and pedestrian inputs to phases 1-8.

Type A traffic signal equipment cabinets shall include sixteen solid-state signal load switches (signal and overlap) conforming to NEMA standards each having LED indicators for active input and output circuits. The load switch shall have a 15-amp rating over a temperature range of -29 degrees F to +165 degrees F.

Type A traffic signal equipment cabinets shall include a sixteen channel malfunction management unit (MMU). MMU shall conform to Section 4 of the NEMA Standards Publication TS-2-2003 (R2008) dated November 1, 2012, including Amendment 3-2009 and Amendment 4-2012, be equipped with an LCD display, and be functional

with the Flashing Yellow Arrow display for permissive left turns. The MMU shall be IP addressable.

Type A traffic signal equipment cabinets shall include the required number of Bus Interface Units (BIUs). The BIUs shall conform to Section 8 of the NEMA *Standards Publication* TS-2-2003 (R2008) dated November 1, 2012, including Amendment 3-2009 and Amendment 4-2012.

Type A traffic signal equipment cabinets shall include vehicle detector racks. The configuration for each rack shall be as follows:

- One BIU slot.

- Sixteen channels of NEMA TS-2 type detection (eight 2-channel detector cards). The detector rack shall be provided with the two end slots wired for four channel emergency pre-emption cards. Detector card slots shall be labeled to indicate channel of detector and the function of emergency vehicle preemption.

- The detector racks shall be capable of being combined with additional auxiliary detector racks to support additional detector cards. Auxiliary detector racks shall be 2 channel 4 slot configuration.

- The detector racks shall meet the requirements of Section 5.3.4.3 of the NEMA *Standards Publication* TS-2-2003 (R2008) dated November 1, 2012 including Amendment 3-2009 and Amendment 4-2012 and shall also meet the requirements of all other applicable sections of the NEMA *Standards Publication.* The detector frame shall be constructed of aluminum of sufficient thickness to prevent bending or flexing when the detector or other cards are being inserted or removed. The detector rack shall be designed to fit on a Type A traffic signal equipment cabinet shelf that is 10” deep to accommodate the detector rack power supply.

- If one or more printed circuit boards are used in the construction of the detector rack, they shall meet the NEMA requirements for printed circuit boards and the following:

    - All plated through holes and exposed circuit traces shall be plated with solder. Both sides of the printed circuit board shall be covered with a solder mask material.

    - The circuit reference designation for all components and the polarity of all capacitors and diodes shall be clearly marked adjacent to the component. Pin 1 for all integrated circuit packages shall be designated on both sides of all printed circuit boards. All electrical mating surfaces shall be gold-plated for the BIUs and detectors. The detector rack inputs and outputs shall interface with Type A traffic signal equipment cabinet wiring and terminals through a series of paired connectors. One side of the connector shall be mounted on the detector rack and the other side shall be connected on the interface cable. It shall be possible to isolate the detector rack from the Type A traffic signal equipment cabinet wiring by disconnecting the connections. It shall not be necessary to remove any wires from terminals or to cut any wires to isolate the rack wiring from the Type A traffic signal equipment cabinet wiring.

The grounding system in the Type A traffic signal equipment cabinet shall be divided into three separate circuits with jumpers, each labeled for their purpose (AC Neutral, Earth Ground, or Logic Ground). These ground circuits shall be connected together as outlined in Section 5.4.2.1 of the NEMA *Standards Publications* TS-2-2003 (R2008) dated November 1, 2012 including Amendment 3-2009 and Amendment 4-2012.

Screened and louvered vent shall be designed to prevent rain entry, with a 14 inch by 20 inch by 1 inch standard furnace vent filter.

Switches: Type A traffic signal equipment cabinets shall include seven door toggle switches (CDS) inside the main traffic signal equipment cabinet on the cover behind the police panel. All toggle switches shall be installed so the normal mode of operation is when the switches are in their "up" positions. Each switch and toggle position shall be labeled with its purpose:

a. **CDS1** will be used to place the signal in flashing operation while not affecting the power being supplied to the controller or the cyclic operation of the controller. Upon placement of this switch from the up (automatic) to the down (flash) position, the intersection shall immediately be placed in flashing operation. Upon placement of this switch from the down (flash) to the up (automatic) position, the signals shall immediately be placed in automatic operation in the major street through phase green interval.

b. **CDS2** shall be used to disconnect power to the controller.

c. **CDS3** shall be a two position switch with the up position being used for automatic signal operation and the down position used to apply stop time to the controller.

d. **CDS4** shall be a free/system switch. In the up position the controller shall operate in the coordinated mode if programmed with coordination timings Max II or Max Ill. Upon moving the switch to the down position the controller shall immediately be placed into free operation regardless of programming. Upon placing the switch back into the up position the controller shall return to coordinated operation if coordination programming is in place.

e. **CDS5** shall be a switch to disconnect power to the traffic signal indications while the traffic signal equipment cabinet components continue normal operations.

f. **CDS6** shall be a spring loaded stop time override switch and shall be used to assist with fault diagnosis. In the up position the switch shall allow normal operation if the intersection is in conflict flash. Pressing and holding the switch down shall allow the controller, MMU and other traffic signal equipment cabinet interior devices to operate normally while the intersection remains in flash mode.

g. **CDS7** shall be a switch that applies and removes power to a two gang duplex receptacle.

The 7 toggle switches inside the main traffic signal equipment cabinet on the cover shall be covered by a hinged Plexiglass shield. The shield shall be hinged on the top and extend at least to the edges of panel. Access to the toggle switches shall be accomplished by raising the Plexiglass shield up. Upon releasing the Plexiglass shield, the shield shall easily

return to the closed position. The purpose of the shield is to protect the toggle switches from accidental movement during traffic signal equipment cabinet maintenance.

Toggle switches may be added or removed as specified in the Contract.

8. **Type B traffic signal equipment cabinets** shall be provided when installing Type B signal controllers. Type B traffic signal equipment cabinets shall conform to the general requirements for cabinets as specified in CALTRANS *Transportation Electrical Equipment Specifications* (TEES) (dated March 12, 2009, including Errata 1 dated January 21, 2010) and *Advanced Transportation Controller (ATC) Standard* (version 5.2b dated June 26, 2006), except as specified below.

- Type B traffic signal equipment cabinets shall be Model 332 cabinets with the following modules and equipment:

  - Housing 1B.
  - Mounting Cage 1.
  - Power Distribution Assembly No. 2.
  - Input files I and J.
  - Output File No. 1.
  - Auxiliary Output File No. 2 (Model 420).
  - C1 Harness No. 1.
  - Service Panel No. 1.
  - Input Panel No. 1.
  - Lower Input Panel.
  - Two Flashers (Model 204).
  - Six Flash Transfer Relays (Model 430).
  - Eighteen Switch Packs (Model 200).
  - Six DC Isolators (Model 242).
  - Three AC Isolators (Model 252).

- The base adapter shall be a hollow aluminum box, 12 inches high, 30 inches wide, and 30.25 inches deep (the same depth as the Type B traffic signal equipment cabinet). It shall have a cutout opening centered in the top, 15 inches wide and 21 inches deep, matching the opening in the bottom of the Type B traffic signal equipment cabinet. It shall have a similar cutout on the bottom, directly below the top cutout. Around the top cutout shall be four punched holes that match the anchor bolt holes

in the Type B traffic signal equipment cabinet. The Contractor shall provide bolts, nuts, washers, and lock washers to bolt the Type B traffic signal equipment cabinet to the base adapter through these holes. Around the bottom cut out shall be four punched holes that also match the anchor bolt holes in the Type B traffic signal equipment cabinet. The adapter shall be constructed so that it does not sag under the weight of the fully loaded Type B traffic signal equipment cabinet. The adapter shall be of the same material used for the Type B traffic signal equipment cabinet and have a matching finish. All seams shall be continuously welded and ground smooth. The Contractor shall provide two close nipple four-inch galvanized rigid metallic conduit fittings and four sealing lock washers for the fittings for each pair of base adapters.

- Type B traffic signal equipment cabinets shall have a sliding drawer mounted in the rack assembly directly under the signal controller. Drawer dimensions shall be at least 16 inches wide, 14 inches deep, and 1.75 inches high.

- Type B traffic signal equipment cabinets shall be wired for 8 vehicle phases, 4 pedestrian phases, and 4 overlaps. Cabinets may be wired for additional phases as specified in the Contract.

- Type B traffic signal equipment cabinets shall include an enhanced signal monitor. The monitor shall be capable of monitoring an intersection with at least four approaches that use a Flashing Yellow Arrow traffic signal head for permissive and/or protected-permissive left turn displays as defined by NCHRP 3-54. The monitor shall be IP addressable. The monitor shall also be capable of monitoring the absence of red signal. A red signal shall require the presence of a minimum 60 (+/- 10) VAC for an indication and a FAILED state shall be caused if the absence of voltage condition has a duration of 1000 ms or longer. Install an auxiliary red interface connector on the front panel of the monitor.

- Type B traffic signal equipment cabinets shall also include an external communications interface box. The box shall be fabricated from the same material as the Type B traffic signal equipment cabinet and be 16 inches wide, 24 inches tall, and 5 inches deep. The box shall have two 1 inch knockout holes on the lower side and two 1.25 inches pass-through holes protected with rubber grommets on the back side. The box shall include one 20 amp GFI duplex receptacle. The box shall include a lock that is keyed according to Regional Traffic Operations Center current operations.

- Provide materials and perform all work in accordance with NEC.

- Screened and louvered vent shall be designed to prevent rain entry, with a 16 by 12 by 1 inch standard furnace filter.

9. **Switches:** Type B traffic signal equipment cabinets shall include three (3) door switches:

   a. Cabinet door open/closed switch for alarm notification.

   b. Cabinet light switch.

   c. Monitor interlock switch that will not allow the conflict monitor to be removed from the cabinet without putting the cabinet in flash mode.

(c) **Flashers for operating flashing beacons** shall be solid state, double circuit, and shall be complete in a weatherproof flasher cabinet. The flasher cabinet shall be fabricated of welded sheet aluminum at least 0.125 inch thick.

The flasher cabinet shall have transient protection conforming to Section 703.02 (b) 5 herein for field wiring, a door gasket, and a standard police panel lock and shall be keyed. Two keys shall be provided to the Engineer. A radio frequency interference filter rated at 20 amps, a terminal block, and a 20-amp circuit breaker shall be mounted in the flasher cabinet. The flasher cabinet shall be provided with removable hub plates tapped for 1-inch conduit at the top and bottom and shall be equipped with brackets for wood-pole mounting or with adjustable bands for steel pole or steel post mounting as specified in the Contract.

(d) **Signal heads** include Vehicle Traffic Control Signal Heads, Pedestrian Signal Heads and Lane Control Signal Heads. Flashing Beacons and Hybrid Beacons shall be the same as those described herein for Vehicle Traffic Control Signal Heads. All signal heads shall conform to Section 238.

Cast aluminum shall be used for all vehicle traffic control and pedestrian signal head sections unless polycarbonate signal heads are specified in the Contract. Cast aluminum shall be used for all lane use control signals.

Signal head housings shall be Federal Yellow unless otherwise specified in the Contract. The inside of visors shall be flat black.

Backplates shall be included with all vehicle traffic control signal heads unless otherwise specified in the Contract. Backplates shall be specifically manufactured for the types and brands of signal heads used to ensure proper fit with a border width of 5 inches. Backplates shall be without louvers and of one-piece construction unless otherwise specified in the Contract.

Backplates (both sides) and signal leveling attachments shall be flat black. Backplates shall be aluminum unless ABS plastic is otherwise specified in the Contract. Aluminum shall conform to Section 229. ABS plastic shall conform to Section 238.

Cap visors shall be included with all vehicle traffic control signal head sections unless otherwise specified in the Contract. Visors for all signal heads shall be the same material as the signal head.

Serrated teeth on hanger assemblies shall be of the correct number and size to mate properly with the teeth on vehicle traffic control signal heads and pedestrian signal heads as specified in the ITE Specification for Vehicle Traffic Control Signal Heads.

(e) **Illuminated traffic control signs** shall be square or rectangular weatherproof units. The sign face or cover shall consist of a polycarbonate lens. The housing shall be sheet aluminum at least 0.125 inch thick finished with two coats of flat black paint.

When illuminated, the size, color and arrangement of letters and/or symbols forming the message shall conform to the Federal Highway Administration's *Standard Highway Signs,* the Department's *Virginia Standard Highway Signs,* or as specified in the Contract. When activated, the message shall be clearly readable at all times at a distance of 200 feet in all atmospheric conditions except dense fog and blizzard. The message shall be controlled by a time clock or

as specified in the Contract. Signs shall illuminate instantly without a "warm-up" requirement or continuously energized ballast. When signs are de-energized, the message shall not be readable.

(f) **Detectors:**

1. **Inductive loop detectors** performance characteristics shall conform to NEMA *Standards Publication* TS-2-2003 (R2008) dated November 1, 2012 including Amendment 3-2009 and Amendment 4-2012 or CALTRANS TEES dated March 12, 2009 including Errata 1 dated January 21, 2010, as applicable.

   a. For use with Type A controllers, the manufacturer of the loop detector amplifier shall provide a certification from an independent testing laboratory that the model furnished complies with the environmental, transient voltage, and size requirements of NEMA Standards and Test Procedures TS-2, as applicable, and meets the design, operation, electrical, functional, performance, and testing procedures of these Specifications. Detector amplifiers shall automatically tune to and operate on the loop inductance and within the environmental conditions present at the installation site.

      TS-2 loop detector amplifiers shall have two operationally independent channels, be rack-mounted as applicable, and shall meet the requirements of Section 6.5 of NEMA *Standards Publication* TS-2-2003 (R2008) dated November 1, 2012 and including Amendment 3-2009 and Amendment 4-2012. The detector amplifier shall be adequately fused, and fuses shall be easily replaceable from the front panel.

   b. For use with Type B controllers, provide Model 222 loop detector sensor units that comply with Chapter 5, Section 2 of the CALTRANS TEES dated March 12, 2009 including Errata 1 dated January 21, 2010 and that have user-selectable pulse and presence modes and user-selectable sensitivity settings.

2. **Video detection equipment** shall consist of a video camera housed in a sealed weather proof enclosure and a video processor located in the camera or controller traffic signal equipment cabinet shelf unit. Rack mount detection modules shall be furnished for video detection systems with rack mount systems. Video detection equipment shall include a power supply for the system and/or equipment as applicable, video isolation/surge arrestors, cabling, mounting brackets, USB mouse, and video monitor.

   When installed in a new traffic signal equipment cabinet, video detection equipment shall be compliant with Type A or Type B controllers and traffic signal equipment cabinets standards as applicable. When installed in an existing traffic signal equipment cabinet, video detection equipment shall fully interface with the existing traffic signal controller, the traffic signal equipment cabinet, and the existing detection equipment.

   Mounting assemblies for the video detectors shall be fabricated from corrosion resistant materials or shall be galvanized. Miscellaneous hardware shall be stainless steel.

   Video detection equipment shall provide the following features:

   - Shall detect vehicles in real time as they cross each detection zone by processing video images and providing detection input for traffic signal controllers.

- Shall provide up to 24 detection zones per camera.
- Video detection zones shall be programmable by either menu driven operation using a video monitor and programming device or a PC with the Department's current version of Microsoft Windows.
- Camera settings shall not be lost during power outages.
- Video detection zones shall be displayed for each camera for user programming and provide flexible detection zone placement within the camera field of view.
- Video processor unit shall store detector configurations created by the user and allow user adjustments of the created detection zones.
- Video detection equipment shall detect vehicle presence in day, night, and adverse weather conditions and not be affected by shadows from fixed or moving objects within the detection zone.
- The processor shall provide stop line presence, advance vehicle presence, delay, extension and directional detection.
- When a vehicle is detected, the detection zone will indicate in some manner on the video overlay display a detection of the vehicle.
- Detection zones shall be directional to reduce false calls from objects traveling in directions other than the desired direction of travel for that detection area.
- The processor shall provide traffic data collection to include count, speed, occupancy, and classification. Traffic data shall be exportable, as indicated in the Contract.
- The processor shall output a constant call for each detector output channel if a loss of video occurs.

Video detection equipment shall include the following components meeting minimum requirements as described below.

a. **Camera**

- Color CCD camera.
- Horizontal resolution 540 Television Lines (TVL).
- Signal to Noise > 50 dB.
- Temperature Range -30ºF to 140ºF.

b. **Lens**

- Continuous focus zoom.
- Minimum 10X zoom.

- Horizontal Viewing Angle 5.0º to 40.5º.

c. **Camera housing**

- Enclosure sealed to meet NEMA-4, (IP 66).
- Integrated thermostatically controlled window heater/defogger.
- Temperature Range -30ºF to 140ºF.
- Humidity 0 to 100% relative, non-condensing.
- Adjustable sunshield with drip guard.

d. **Cables and mounting hardware**

- Cables shall be per manufacturer's recommendations.
- Mounting hardware shall be connected using the mast arm attachment bracket and tube shown in Standard SM-3 of the Standard Drawings.

e. **Video detection modules (VDM)**

- Plug directly into the applicable detector racks.
- LED status indicators.
- Video Input/output compatible with PAL or NTSC.
- Temperature Range -29ºF to 165ºF.
- Ethernet Port and IP addressable.

The video detection system shall be warranted to be free of defects in material and workmanship for two years from the date of final acceptance by the Department. Ongoing software support by the supplier shall include software updates of the sensor, modular traffic signal equipment cabinet interface unit, and supervisor electronic applications. These updates shall be provided free of charge during the warranty period. During the warranty period, the supplier shall repair with new materials\components, or replace at no charge, any product containing a defect covered by the warranty. All materials returned for warranty repairs shall be made through the product distributor at no added charge to the Department.

3. **Wireless vehicle detection system** shall consist of battery-powered sensors installed in the pavement in each traffic lane, digital radios mounted on the side of the roadway and contact closure interface cards to provide sensor information processing and support the interface between the digital radio and a standard traffic controller using contact closure signals. The system shall also include software to control and configure the system, sensors, and repeaters, display sensor battery life, store and retrieve detection data.

Each sensor shall detect a vehicle by measuring changes in the earth's magnetic field near the sensor as caused by a stopped or passing vehicle (i.e., magnetometer-type detection).

The sensor shall sample the earth's magnetic field at a rate of 128 Hz. The sensor shall communicate time-stamped ON and OFF vehicle detection events. Each sensor shall automatically recalibrate if there is a detector lock and shall wirelessly communicate to a nearby access point or repeater. The system shall provide for monitoring of sensor battery life.

Each sensor shall transmit its detection data within 150 ms of a detected event and shall automatically re-transmit a detected event if no acknowledgement is received from the system. Each sensor shall stop retransmission after 8 attempts. Each sensor shall transmit a unique identifying code and shall respond within 100 seconds when the system is powered on and transmitting.

Each sensor in an installation shall be capable of being individually configured with its own sensitivity level. A single sensor shall be capable of being configured with a sensitivity level that approximates the detection zone of a standard 6' x 6' inductive loop. Each sensor shall be capable of being configured with relatively higher or lower sensitivity levels as needed to detect bicycles, motorcycles, or light rail. As an option, up to two sensors properly configured shall be capable of detecting motorcycles in a standard traffic lane or bicycles in a designated bicycle lane as specified in the Contract.

The system shall support the relay of sensor detection data through several interfaces as required by the application. Detection data shall be communicated to a standard roadside traffic controller via contact closure interface cards capable of being installed in standard contact closure input shelves.

As specified in the Contract, the system shall be capable of simultaneously communicating detection data via the supplied contact closure interface and additional optional interfaces. Optional interfaces shall include an integrated 10Base-T Ethernet interface and a cellular data modem interface.

Each sensor, system component, and wireless repeater shall be capable of accepting software and firmware upgrades. The wireless vehicle detection system shall provide software operating on conventional notebook/portable PCs to store and retrieve detection data, and support configuration of a sensor, system component and a wireless repeater.

Wireless vehicle detection equipment shall include the following components meeting the minimum requirements as described below.

a. **Wireless detection system**

- Shall provide detector data as contact closure signals to the traffic controller.
- Contact closure card shall directly plug in to standard 170/2070 input files or NEMA detector racks.
- Shall provide contact closure signals in either presence or pulse mode.
- Shall provide up to 31 seconds of delay timing and 7.5 seconds of extension timing.
- The front panel shall provide status LEDs to monitor detection channel status, line quality and fault monitor.

- Shall be configurable to provide presence or pulse mode, delay timing, extension timing.
- Shall be surge protected to GR-1089 standards.
- Shall operate at temperatures from -37ºF to 176ºF.
- Shall operate in humidity up to 95%, non-condensing.
- Shall support at least 48 sensors.
- Any externally mounted components shall be contained within a maximum of two housings.
- Housing shall conform to NEMA Type 4X and IEC IP67 standards.
- Externally mounted components shall be mounted in communication range of either a wireless detection sensor or wireless repeater.
- Shall provide digital radio communications.
- Shall provide sensor data relay, storage, and processing.
- Shall provide master time base for all supported wireless sensors.

b. **Wireless detection sensor**

- All components shall be contained within a single housing.
- The housing shall conform to NEMA Type 6P and IEC IP68 standards.
- The components shall be fully encapsulated within the housing to prevent moisture from degrading the components.
- The housing shall be capable of being installed in a 4-inch diameter hole a minimum 2 1/2 inches deep.
- Shall operate at temperatures from -37ºF to 176ºF.
- Shall be battery-powered with an average lifetime of ten years when the sensor is configured for and operating under normal traffic conditions.

c. **Wireless repeater**

- Communicating directly to wireless detection system shall support at least ten sensors.
- Communicating via an intermediate wireless repeater shall support at least six sensors.
- Shall have a battery that is field replaceable.

- Shall operate at temperatures from -37ºF to 176ºF.

- All components shall be contained within a single housing that shall conform to NEMA Type 4X and IP67 standards.

The wireless vehicle detection system shall be warranted to be free of defects in material and workmanship for five years (5) from date of final acceptance by the Department. Ongoing software support by the supplier shall include software updates of the sensor, system equipment, and wireless repeater. These updates shall be provided free of charge during the warranty period. During the warranty period, the supplier shall repair with new materials\components, or replace at no charge, any product having or exhibiting a defect covered by the warranty. All materials returned for warranty repairs shall be made through the product distributor at no added charge to the Department.

4. **Emergency vehicle preemption (EVP) detection system** shall be optically activated and consist of the detectors including all accessories, mounting brackets, mounting hardware, cable, and all incidental items necessary to provide full vehicle detection, confirmation lights when specified in the Contract, phase selector(s), detector panels, and detector card racks. EVP detection system shall fully interface with the traffic signal controller, the traffic signal equipment cabinet, and the existing emergency preemption system. EVP detection equipment shall be classified as "[ ] Way," which indicates the number of detected approaches with at least one detector per detected approach.

   Mounting assemblies for the detectors and confirmation lights shall be fabricated from corrosion-resistant materials or shall be galvanized.

   EVP detection system shall provide the following:

   a. **Vehicle detection** - The preemption device shall interface with the existing on-board equipment without modifying existing main switch function. The optical detectors shall sense optical pulses from emitters at low (10 Hz) and high (14 Hz) frequencies and transform these pulses into electrical signals. The detectors shall sense emitter signals over an adjustable range of 200 feet to 2500 feet in optimum atmospheric conditions. The detector(s) shall provide a minimum conical detection angle of 12 degree per each detected approach. The detector will be designed for mounting at or near an intersection on mast arms, pedestals, pipes, span wires, or as specified in the Contract.

      The electrical signals from the detector shall be transmitted to the phase selector via the detector cable. The phase selector shall determine if the signals originate from a valid emitter, and have sufficient frequency for low or high priority preemption. The phase selector shall determine if more than one input has been received and arbitrate to assign the priority of signal preemption for each detected approach. The preemption detector cable shall be per the manufacturer's recommendation.

   b. **Logging detected vehicles** - The phase selector shall be designed to be installed in the traffic controller traffic signal equipment cabinet to decode the electrical signals from the detector. The phase selector shall be able to recognize emergency vehicle signals and shall give output to the signal controller by ensuring that only authorized vehicles with valid and unique vehicle ID's are granted preemption. This device shall

also be able to read and store preemption requests data locally and communicate this data to a remote database management system, including but not limited to date, time, direction, and vehicle ID.

c. **Confirmation light** – When specified for installation in the Contract, a confirmation light shall illuminate upon receiving a signal from the phase selector to confirm to the vehicle's operator that the EVP system is active and that the preemption request has been received.

d. **Communication** – The phase selector shall be provided with local and remote monitoring and control functions. The phase selector shall include a 10/100 Ethernet port and a DB-9 serial port located on the front panel. The phase selector shall be supplied with standard, readily available Cat5e and RS232 data cables and all software necessary to interface with existing Department platforms and protocols (SNMP, Telnet). The system remote access and monitoring shall be accomplished by connecting through a Web browser and/or IP-based Telnet system.

EVP detection system software shall be Contractor provided, and installed for the operational needs of the system. The software shall be compatible with the Department's current version of Microsoft Windows and provide the ability to perform the following functions in real time: retrieve activity logs, view preemption activity, manage security, and troubleshoot equipment problems.

The EVP detection system, excluding strobe lamps or flash tubes used in confirmation lights, shall be warranted against defective material and workmanship by the manufacturer for at least five years from the date of final acceptance by the Department. During the warranty period, the supplier shall repair with new materials\components, or replace at no charge, any product having or exhibiting a defect covered by the warranty. All materials returned for warranty repairs shall be made through the product distributor at no added charge to the Department. The Contractor shall transfer the manufacturer's warranty to the Department at the date of final acceptance.

5. **Pedestrian push buttons** shall be electronic operation and a minimum of 2 inches and a maximum of 4 inches in diameter. The Department will not allow the use of push button mechanical contact closure devices for the push button operation. The force required to activate the push button shall be no greater than 2.5 pounds. Push buttons shall comply with the Americans with Disabilities Act and the MUTCD.

Pedestrian push buttons, housings, and assemblies shall be weather-tight and tamperproof. Pedestrian push buttons, housings, and assemblies shall be designed to prevent electrical shock in all types of weather and shall have provisions for grounding. Push buttons shall have electrical spade connections on the switch. Wire and wire-nut connections will not be acceptable.

Push button switch assemblies shall have a minimum life of 10 million actuations and shall operate on low voltage (not more than 15 volts AC or 24 volts DC). Switch and assemblies shall be certified or approved by UL or CSSA.

(g) **Uninterruptible power supply (UPS)** shall consist of an on-line power conditioning UPS for traffic signal control (vehicle and pedestrian) and communication equipment. The UPS inverter shall be in operation at all times to provide power conditioning and battery backup for

clean and regulated power (both voltage and frequency) to all loads. This system shall be fully functional with utility power and any type of auxiliary power generator.

The UPS system, including the batteries, shall be installed in the traffic signal equipment cabinet or in a separate UPS cabinet as specified in the Contract. The UPS system shall be the manufacturer's standard production model. The UPS system shall include a solid state electronic converter and inverter for output, battery bank, automatic bypass-transfer circuit, integral maintenance bypass switch, and all necessary hardware and connecting cables, generator connection, external LED confirmation light, and when required, UPS cabinet and UPS cabinet foundation.

The UPS system shall include Digital Signal Processing for direct digital control of all UPS control and monitoring functions. The UPS system, including batteries and necessary hardware, shall be easily installed/replaced without the use of special tools.

Operating temperature range for the entire UPS system shall be -40 °F to +165°F, 5 to 95 percent relative humidity, non-condensing.

The UPS shall use a temperature-compensated battery charging system. The charging system shall compensate over a range of 2.5 – 6.0 mV/degree C per cell. The temperature sensor shall include sufficient connecting wire between the temperature monitoring circuit and batteries to monitor the battery temperature. Batteries shall not be recharged when battery temperature exceeds 122°F ± 6°F. An integral system to prevent battery from destructive discharge and/or overcharge shall be provided.

The UPS shall include displays to indicate current battery charge status and conditions, and a battery capacity indicator with readings from 0 to 100 percent.

The UPS shall have lightning surge protection compliant with IEEE/ANSI C.62.41.

The UPS shall be designed to operate continuously at rated capacity as an on-line, double-conversion system in the following modes:

- NORMAL – The inverter shall continuously regulate AC power to all connected loads. The converter shall change utility AC power to regulated DC power, which shall then serve as the inverter input and simultaneously as a float charge input to the storage battery(s).

- BYPASS – If the UPS must be taken off-line due to an overload condition or UPS failure (e.g. inverter failure), the load shall be transferred to the bypass source without interruption of power to the load. A paralleling wrap-around contactor shall be used to maintain the bypass source. This bypass switch shall only be utilized for automatic emergency transfers. Retransfer from bypass to inverter shall be performed automatically in overload conditions. Retransfer shall be inhibited if satisfactory synchronization of the inverter and bypass is not accomplished. The use of the bypass switch shall not be required during the manual or automatic retransfer process.

- MAINTENANCE BYPASS – The UPS system shall be equipped with an external maintenance bypass switch (MBS) to allow safe and reliable maintenance of the UPS system. The bypass shall be of the break-before-make, zero-energy type to ensure maximum load reliability and personnel safety.

The Contractor shall be responsible for determining the appropriate size/capacity of the UPS system based on the intersection design as specified in the Contract. UPS shall be sized with a minimum load of 1000 watts and to provide at least 8 hours of full run-time operation.

In situations where the utility line voltage drops below 85 VAC or exceeds 140 VAC, the UPS shall generate a SNMP trap event for notification of a utility power anomaly including a complete loss of power.

The output voltage from the system shall be between 110 VAC and 125 VAC inclusive, pure sine wave output, ≤ 3 percent THD, 60 Hz ± 3Hz.

The UPS shall be equipped to prevent a malfunction feedback to the traffic signal equipment cabinet or feedback to the utility service. If the converter, inverter, charger, and/or battery fails or if there is a complete battery discharge, the power transfer relay shall revert to the normally closed (NC) and de-energized state when the utility power is connected to the traffic signal equipment cabinet and/or UPS cabinet.

1. **Uninterruptible power supply (Type 1)** shall be provided with local monitoring and control functions. The UPS shall include a DB-9 serial port located on the front panel of the UPS. The UPS shall be supplied with a standard, readily available RS232 data cable and all software necessary to interface with the unit.

   The serial port shall provide the user the option to select certain output functions. These functions shall be open collector type contact closures that the user can assign as signal utility interrupt, low battery, and inverter active or utility fail conditions. These signals shall be capable of being interfaced to a controller's auxiliary alarm inputs.

2. **Uninterruptible power supply (Type 2)** shall be provided with local and remote monitoring and control functions. The UPS shall include a 10/100 Ethernet port and a DB-9 serial port located on the front panel of the UPS. The UPS shall be supplied with a standard, readily available Cat5e and RS232 data cable and all software necessary to interface with existing Department platforms and protocols (SNMP, Telnet).

   The UPS system remote access and monitoring shall be accomplished by connecting through a Web browser and/or IP-based Telnet system.

   UPS system software shall be provided and installed for the operational needs of the system. The software shall be compatible with the Department's current version of Microsoft Windows and provide the ability to determine in real time the following conditions:

   - NORMAL – When the UPS is conditioning utility power.

   - ON BATTERY – When the UPS system is operating on battery power and batteries are not being charged.

   - LOW BATTERY – When the batteries approach 40 percent of their remaining useful capacity.

   - TIMER – When the UPS has been operating on battery power for a user programmable period of time.

3. **Battery system** shall be shelf-mount, rack-mount, swing-tray mount, or a combination thereof. Shelves, racks, trays, and vertical mounting channels shall be corrosion-resistant, heavy duty, with sufficient strength to hold the batteries without deforming, bending, or breaking.

   Batteries shall be easily replaced and commercially available as "off the shelf" items. Individual batteries shall weigh no more than 50 pounds. Battery construction shall include heavy-duty, inter-cell connections for low impedance between cells, and heavy-duty plates to withstand shock and vibration. The top cover shall use tongue and groove construction and shall be epoxied to the battery case for maximum strength and durability.

   Batteries shall be extreme temperature, deep cycle, and sealed prismatic lead-calcium based Absorbed Glass Mat/Valve Regulated Lead Acid (AGM/VRLA). Batteries shall be certified to operate at extreme temperatures (from -40 degrees F to +165 degrees F) and shall not require aid of any external devices to cool or heat the batteries.

   Batteries shall indicate maximum recharge data and recharging cycles. Battery recharge time from protective low cutoff to 80 percent or more of full charge capacity shall not exceed 20 hours. Batteries shall be provided with appropriate interconnect wiring and corrosion resistant mounting trays and/or brackets.

   Batteries shall be stored below the level of all traffic signal control electronic equipment or in the lowest space within the traffic signal equipment or UPS cabinet. Batteries shall not be stored in direct contact with concrete.

   The number and amp-hour rating for the batteries shall be determined by the manufacturer of the system to provide the required voltage/wattage while on battery power.

   Battery terminals shall be automotive style battery corrosion-resistant top post and terminal wire connectors. Battery terminals shall be covered and insulated with appropriate colored molded boots to prevent accidental shorting.

4. **Battery harness:** Battery interconnect wiring shall be via a two-part modular harness.

   a. **Part I** shall be equipped with red (+) and black (-) cabling that can be permanently connected to the positive and negative posts of each battery. Each red and black pair shall be terminated into an Anderson-type power connector or equivalent.

   b. **Part II** shall be equipped with the mating Anderson-type power connector for the batteries and a single insulated power pole style connection to the inverter/charger unit. Harnesses shall be fully insulated and constructed to allow batteries to be quickly and easily connected in any order to ensure proper polarity and circuit configuration.

   Power connectors may be either one piece or two-piece. If a two-piece connector is used, a locking pin shall be used to prevent the connection from separating.

   The lateral length of the harness between battery connectors shall be at least 12 inches.

   All battery interconnect harness wiring shall be UL Style 1015 CSA TEW or Welding Style Cable or approved equivalent, and shall be of the proper gage with respect to design current and have a sufficient strand count for flexibility and ease of handling.

5. **Wiring** for the UPS shall be sized in accordance with the NEC and shall conform to Sections 238, 700, and 703.

   Wiring panels and terminal blocks shall be neatly finished and clearly and permanently marked with identifications applied by silk screening. Conductors shall be neatly arranged and bundled in groups with cable ties. The bundled conductors shall not obstruct access to other circuits and terminals in the traffic signal equipment or UPS cabinet. Unless cable is passing through the traffic signal equipment or UPS cabinet uninterrupted, incoming and outgoing conductors shall have each wire connected to terminal post positions.

6. **Uninterruptible power supply cabinet:** When a separate UPS cabinet is required, the UPS cabinet shall be of sufficient size to house the batteries, wiring, related equipment, and the UPS, which includes converter/inverter/charger unit, power transfer relay, power management unit, manually operated bypass switch, and other control panels and wiring harnesses. UPS cabinet shall be weatherproof and constructed of welded sheet aluminum, 0.125-inch minimum. UPS cabinet mounting attachments shall be durable, corrosion resistant, compatible with the aluminum of the traffic signal equipment cabinet, and of heavy-duty construction. The UPS cabinet shall include screened openings to allow adequate ventilation. The openings shall be evenly spaced and centered on the vertical sides of the UPS cabinet. The UPS cabinet shall have sufficient space to hold batteries, wiring, and related equipment and allow for easy servicing.

   a. **Uninterruptible power supply cabinet (Detached)** shall be located adjacent to the traffic signal equipment cabinet. The UPS cabinet door shall be hinged to open in the opposite direction of the associated traffic signal equipment cabinet, such that when the traffic signal equipment cabinet door and the UPS cabinet door are both opened simultaneously, the doors will not interfere with one another nor will they block the entrance to either cabinet.

   b. **Uninterruptible power supply cabinet (Attached)** shall be bolted onto the traffic signal controller UPS cabinet with no less than four high strength bolts. All connections between the UPS cabinet and the traffic signal equipment cabinet shall be sealed and weatherproof.

   c. **Uninterruptible power supply cabinet doors:** UPS cabinet doors shall provide full access to the UPS cabinet interior and shall have durable gaskets to ensure weatherproofing. The door shall be equipped with the Department's standard tumbler No. 9R48773. Two keys shall be provided to the Engineer.

      Hinges shall be stainless steel and continuous. Doors shall have a doorstop arrangement that will allow it to be firmly positioned at 90 and 135 degrees, ± 10 degrees. The locking system for UPS cabinets shall be a three-point draw roller system. Rollers shall be fabricated from nylon with a diameter of at least 8/10 inch. The door opening shall be double flanged on all four sides.

      The door shall have a screened and louvered vent design to prevent rain entry, with a standard size furnace vent filter. The filter tray shall be sized to house and secure the filter in place. The screen shall be constructed from at least 0.031-inch aluminum with 1/8-inch diameter openings positioned on 3/16 inch staggered centers. The screen shall be placed on the inlet side of the filter and held in place by the filter or silicone adhesive.

d. **External generator connection:** The signal cabinet shall be equipped with an external generator connection unless otherwise specified in the Contract. The connection access point shall be located on the AC power side of the cabinet and shall have a fully gasketed, weatherproof, lockable door. The connection shall be wired such that power from the generator and the utility line passes through the UPS system, and when utility power has been restored, the generator shall be automatically bypassed to utility power. The connector shall be a watertight, flange inlet, male, 30-amp, 125 VAC, NEMA L5-30, twist lock type receptacle, and shall be approved by the Engineer. The door shall be equipped with the same lock as specified for new controller cabinets.

e. **External Confirmation Light:** The traffic signal controller cabinet shall include a red external LED confirmation light indicating when the traffic control system is not operating on utility power. The LED confirmation light shall be located on the top side of the cabinet, viewable at a 90 degree angle, and have a durable gasket to ensure weatherproofing.

f. **Uninterruptible power supply cabinet interior:** Shelves and vertical mounting channels shall be heavy duty and have sufficient strength to hold the batteries without deforming, bending, or breaking.

A water resistant enclosure to store documentation shall be securely attached to the UPS cabinet with studs welded to the UPS cabinet and nuts. The enclosure shall have noncorrosive metal grommets for use with the studs.

A listing, indicating terminal numbers with a description of their use, shall be attached to the UPS cabinet door and overlaid with a clear, plastic covering. Edges of the plastic overlay shall be sealed with a clear, exterior grade waterproofing compound.

A screened air exhaust opening under the top overhang shall be provided. Two thermostatically controlled vent fans with a screened guard in the top section of the UPS cabinet, each with the capacity of exhausting at least 100 cubic feet per minute (CFM), shall be provided. The thermostat shall be adjustable from 80 degrees F to 130 degrees F. Degree markings shall be indicated on the thermostat in 10-degree increments. The fans shall be AC operated from the same line output of the Manual Bypass Switch that supplies power to the traffic signal equipment cabinet. A two position terminal block shall be provided on the fan panel. Proper over-current protection shall be provided for the fan circuit.

UPS cabinet lighting system shall consist of an automatic on/off door switch located in the UPS cabinet frame. Each door switch shall be connected to the 120-volt, single-phase, AC power line for operation of the LED lamp (number of lamps and wattage depends on the UPS cabinet size). The switches shall turn the light on continuously when the door is in the open position. UPS cabinet light shall be installed on at the top of the UPS cabinet and directly above the back panel to provide for the unobstructed illumination of the electrical and electronic items inside the UPS cabinet, as specified in the Contract.

Wiring for the lamp, fans, and other auxiliary equipment shall be connected via terminal blocks.

(1) **Uninterruptible power supply cabinet (Detached)** shall contain at least three adjustable shelves or equivalent supports, with enough space to hold UPS, batteries, battery trays and brackets, wiring, and related equipment. Vertical mounting channels for the shelves shall be continuous and shall allow for adjustable shelf placement ranging from 5 inches from the bottom to 5 inches from the top of the UPS cabinet. Wiring from the UPS cabinet to the traffic signal equipment cabinet shall be accomplished via a conduit passing through the UPS foundation underground to a spare conduit in the traffic signal equipment cabinet.

(2) **Uninterruptible power supply cabinet (Attached)** shall contain two shelves with enough space to hold batteries, battery trays and brackets, wiring, and related equipment. The shelves shall be continuous and shall allow for shelf placement at 12.5 inches and 25 inches on center from the base of the UPS cabinet. A 2 inch diameter hole shall be cut in the rear of each shelf, centered between the UPS cabinet sides. The hole shall allow for the battery harness and all connectors to pass through without modification or assembly. Wiring from the UPS cabinet to the traffic signal equipment cabinet shall be accomplished via a 3 inch diameter coupling passing through the shared vertical side of the two cabinets.

g. **Uninterruptible power supply cabinet foundation for detached cabinets:** Detached UPS cabinets shall be installed on the same foundation as the traffic signal equipment cabinet unless otherwise specified in the Contract. Detached UPS cabinets shall fit entirely on the proposed foundation.

7. **Documentation:** The Contractor shall provide one electronic version and six prints of the UPS control circuit diagram (two in the cabinet and four to the Engineer). Prints shall be produced from the original diagram and shall be clear and legible. The two copies of the circuit diagram inside the traffic signal equipment cabinet or inside the UPS cabinet shall be installed in the readily accessible water resistant enclosure.

   The Contractor shall provide four sets of the following: equipment list, operation and maintenance manuals, board level schematic diagrams and wiring diagrams of the UPS, and battery data sheets. The Contractor shall install one copy of these materials inside the traffic signal equipment cabinet or inside the UPS cabinet in the readily accessible water resistant enclosure and shall furnish three copies to the Engineer.

8. **Warranty:** The UPS system, in its entirety, shall carry a manufacturer's warranty against defective material and workmanship of no less than three years. The battery packs shall carry a warranty of no less than three years.

   Warranty periods for the UPS system and the battery packs shall begin on the date of final acceptance by the Department.

703.03—Procedures

Equipment shall be installed so that it is ready for full operation.

(a) **Prosecution of signal work:** The Contractor shall not discontinue the operation of an existing signal without the prior approval of the Engineer. When applicable, the Contractor shall

notify the Engineer of his intent to discontinue operation of an existing signal on a certain date during the weekly progress meeting as required per Section 108.03. Requests for discontinuance shall be made at least 2 business days in advance of the proposed date of discontinuance. The date of the discontinuance of a signal shall be included in the progress schedule as required per Section 108.03.

While modifying or replacing existing traffic signals, the Contractor shall provide necessary traffic controls for maintenance of traffic in accordance with Section 512.

(b) **Refurbishing existing equipment:** Existing equipment to be retained will not need to be refurbished unless there is a specific pay item requiring such. When specified, refurbishment of existing equipment shall be performed in accordance with Section 510 and the specific Contract requirements.

(c) **Remove and relocate existing equipment:** The Contractor shall remove and relocate existing equipment at existing signals as specified in the Contract and as directed by the Engineer. Items to be salvaged by the Contractor and delivered to the Department shall be identified in the Contract and stored at a designated location as specified in the Contract or directed by the Engineer. The removed items shall be stored above ground in a manner that will preclude damage. When specified in the Contract for salvage, the Contractor shall maintain existing controller assemblies, inclusive of auxiliary equipment, as a unit. Any item that is damaged or lost because of the fault of the Contractor shall be repaired or replaced at no additional expense to the Department, including repair of damage to galvanized or painted finishes. Costs for removing, storing, protecting, relocating and delivering such items shall be included in the price for these items in the Contract, and no additional compensation will be made.

1. **Remove equipment:** Items designated to be removed shall be salvaged and returned to the Department or disposed of in accordance with Section 106.04 as specified in the Contract. Items to be disposed of shall become the property of the Contractor. Items to be salvaged shall be delivered to the Department at a location specified in the Contract. The Contractor shall give notice to the Department at least two business days before delivering such equipment. The Contractor may abandon underground items such as conduit and conductors, however, in-ground items, such as foundations and junction boxes, shall be removed at least 2 foot below finished grade or as directed by the Engineer. The Contractor shall fill and compact the resulting cavity and restore the area including providing topsoil, grading, seed, fertilizer, and lime as necessary.

2. **Relocate equipment:** Items designated to be relocated are to be removed from their existing locations and reinstalled at the locations indicated in the Contract. Work under this section includes relocation of equipment to its permanent location. Relocation of equipment to facilitate traffic flows during construction shall be accomplished in accordance with Section 512 and, where applicable, the specifics of the Contract.

   If equipment requires removal from an existing location but is not to be relocated to the permanent location immediately, the Contractor shall store equipment as indicated in the Contract. The Contractor shall assess the field condition of all equipment slated for relocation and shall notify the Engineer if any equipment needs to be repaired or replaced. If repair or replacement is required, and the Engineer approves the Contractor to perform this work, it shall be accomplished in accordance with Section 109.05.

(d) **Installing traffic signal equipment cabinets:** Ground-mounted traffic signal equipment cabinets shall be installed on a concrete foundation in conformance to Section 700.

The Contractor shall attach pole-mounted traffic signal equipment cabinets to metal poles or signal pedestals using brackets secured by encircling clamps. Pole-mounted traffic signal equipment cabinets shall be attached to wood poles using lag screws and plates bolted through the back of the traffic signal equipment cabinet or by encircling clamps.

(e) **Installing signal heads:** At new or modified traffic signal installations, each signal head shall be covered with a durable, nontransparent cover upon installation. When a backplate with retroreflective strip is being used, the backpate shall also be covered. The Contractor shall maintain the cover(s) until the signal is put into operation. Signals and backplates not in use shall not obstruct visibility of other signals or other traffic control devices actively in use for intersection control.

Housings shall be joined at the top and bottom in accordance with the manufacturer's specifications to form complete signals as shown in the Standard Drawings.

The internal conductor insulation of signal conductor cables shall be located entirely within the signal head housing and not be exposed to external elements. The external insulation of signal conductor cables shall be stripped no more than six (6) inches from the terminal block within the signal head.

1. **Vehicle traffic control signal heads:** The Contractor shall verify the location and alignment of each signal head for orientation to its approach lane(s) before installing the signal conductor cable. If the location of the signal head designated in the Contract is not oriented correctly with the applicable approach lane(s), the Contractor shall notify and submit supportive data to the Engineer for review and further direction.

   The Contractor shall install hinges on signal head housings to the same side of a signal head for vertically-arranged signal faces. Hinges shall be located on the outer sides of all signal faces where two signal faces are aligned horizontally in any single row such that both signals can be opened simultaneously to permit unobstructed access to both signal heads at one time.

   a. Backplates shall be attached with bolts, washers, and lock nuts or self-tapping screws and washers.

      The minimum number of bolts or self tapping screws shall be 4 for each traffic signal head section.

   b. Visors shall be attached with bolts, washers, and self-tapping screws and washers. The bolts or self-tapping screws shall be stainless steel.

2. **Pedestrian signal heads** shall be aligned in the line of vision of pedestrians using the applicable crosswalk.

3. **Lane-use control signal heads** shall be installed approximately over the center of the lane controlled. Mounting height shall be the same as for mast arm vehicle traffic control signal heads installations and shall be measured to the bottom of the signal housing. When the lane-use control signal head is mounted on a canopy or other structure above

the pavement, the mounting height may be reduced to no lower than the vertical clearance of that structure.

(f) **Installing illuminated traffic control signs:** Illuminated signs shall be mounted at the height prescribed for mast arm mounted vehicular traffic control signals. When mounted adjacent to vehicle traffic control signals, illuminated traffic control signs and signals shall be separated to prohibit physical contact.

(g) **Installing detectors:** Detector and detector lead-in cable shall be installed with the slack length coiled in the junction boxes. The coiled length shall be sufficient to allow the cables to extend at least 2 feet above the junction boxes.

Detector and detector lead-in cable jackets shall be permanently identified in the traffic signal equipment cabinet and each junction box. Identifications shall be indicated on nonferrous metal tags or nylon tags securely attached to the cable with nylon cable ties. The identification shall be stamped or engraved on the metal tags and lettered with permanent ink on nylon tags. Identifications shall be legible and shall conform to the following:

- Loop Detector lead-in cable: Labeled with phase and location (lane and setback distance from stop line) of detector: e.g., 1 NBL stop line inside lane loop; 2 SBT 200 feet through lanes loop; 6 NBT stop line inside lane loop.

- Loop detector cable: Labeled with phase and location of detector: e.g., 1 NBL loop; 2 SBT mag.; 6 NBT inside lane loop; 6 NBT outside lane loop.

- Video detection cable: Labeled with phases, cable type and location: e.g., 2 & 5 NB vid; 4 EB vid, Vid Power, Vid Power/Comm.

- Emergency preemption detection cable: Labeled with cable type and location of detector: e.g., 1 & 6 WB EVP detection, 4 & 7 EB EVP conf. light.

- Pedestrian pushbutton cable: Labeled with phase and location of pushbutton; e.g., 2 Ped NW Quad.

1. **Inductive loop detectors:** The location of detectors shall not deviate more than 2 feet from the location(s) as specified in the Contract unless the Contractor submits a detailed drawing showing the exact location of the detector(s) in question and secures the written approval of the Engineer to move the detector.

   Splices between loop and the lead-in conductors will be allowed only in signal junction boxes. A separate splice kit shall be used for each lead-in cable. The lead-in cable(s) shall be continuous and unspliced from the junction box splice to the detector panel terminals.

   Conductors shall be cleaned to remove any residue and mechanically joined using the inline splice method where the conductors are twisted together to make a mechanically secure connection. The mechanical connection shall then be soldered using rosin core solder and a soldering iron to provide full penetration of solder into the mechanical joint. Heat shrink tubing shall be installed over all conductors before the mechanical and soldering connections are performed. Each conductor splice shall then be covered with heat shrink tubing. The heat shrink tubing shall be cut to extend beyond the bare conductor mechanically joined splice a minimum of 2 inches on both sides. The heat shrink tubing shall

provide an inner coating of hot-melt adhesive and an outer layer that shrinks to provide electrical and mechanical protection. The heat shrink tubing shall be shrunk using a heat gun for heat shrink tubing installations. The Engineer will not permit open flame heating for heat shrink tubing installations.

The splice shall be sealed in a splice kit conforming to Section 238.

Slots shall be sawed into the pavement at the depth and width specified in the Standard Drawings for concrete or asphalt concrete as applicable, cleaned with pressurized potable water (at least 50 psi), and then dried with filtered compressed air before loop conductors are installed and sealed. One-inch lengths of PE foam backer rod shall be installed in the slot at slot intersection points and on 2-foot-maximum centers between those points after installation of the loop conductors. The backer rod diameter shall be 1/2 inch for 3/8 inch slots, 5/8 inch for 1/2 inch slots, and 3/4 inch for 5/8 inch slots. Sealant shall conform to Section 212. The Contractor shall install loops in the presence of the Engineer.

Loop detectors shall not be installed in pavement that has been open cut, repaired, or rebuilt in a manner where the pavement structure is not sound and continuous in the area of the proposed loop installation. When loop detectors are to be installed in existing pavement, the Contractor shall first field inspect the loop locations and advise the Engineer of any such locations that have been open-cut, repaired, or rebuilt. In such cases, the Engineer will direct the Contractor where to locate the proposed loop detectors.

Loop cable shall be installed without damaging the cable or its insulation. The Contractor shall repair damaged cables at the Contractor's expense. Cable shall be installed with no kinks or curls and no straining or stretching of the insulation, and shall be secured as deep in the slot as possible. When loop cable crosses pavement joints, an 8-inch section of flexible plastic sleeve shall be installed to prevent damage from pavement shifts. The Contractor shall use a blunt object, similar to a wooden paint stirrer, to seat the loop cable.

The lead-in cable shield (drain wire) shall be connected to ground at the traffic signal equipment cabinet only. The lead-in cables shall have soldered on spade connectors for attachment to the detector panel terminals. Heat shrink tubing shall be installed over the soldered connections.

2. **Video detectors:** Cameras installed on mast arms and luminaire arms shall be installed using the mast arm attachment bracket and tube shown in Standard SM-3 of the Standard Drawings.

   Cameras shall be mounted at a sufficient height to prevent occlusion of a detection zone. A six foot maximum length of internally reinforced tube shall be attached to the bracket for camera mounting above the mast arm or luminaire arm. The camera shall be mounted to the top of the tube with the camera manufacturer's recommended bracket. Camera bracket shall provide adjustments for both vertical and horizontal positioning of the camera. Camera attachments shall be designed to securely fasten the camera and prevent the camera and extension tube from falling into the path of vehicles or becoming loose. Cameras shall be designed and installed to minimize movements caused by prevailing wind loads.

The Contractor shall submit the camera manufacturer's installation method to the Engineer for review and approval. Alternate camera mounting methods proposed by the Contractor may be submitted to the Engineer for approval.

The locations of video cameras shall be as specified in the Contract. The locations of all equipment shall be reviewed by the manufacturer's representative in the field to verify the equipment will operate and detect vehicles as specified. The Contractor shall bring to the Engineer's attention any equipment locations that the Contractor determines to require relocation to function properly. The Contractor shall submit any proposed equipment relocations to the Engineer for review and approval.

The Contractor shall provide the manufacturer's installation, operational and maintenance manuals to the Engineer for each piece of equipment.

3. **Wireless vehicle detectors:** Wireless vehicle detection equipment shall be installed in accordance with manufacturer's instructions. The Contractor shall provide documentation to the Engineer he has performed previous successful installations of this manufacturer's system (job description, client, contact for verification) or alternately, obtain training from the manufacturer's representative before beginning the installation and provide documentation (certification if offered by the manufacturer) of the date(s) such training was received and completed.

   The locations of wireless vehicle detector systems, inclusive of wireless sensors, system equipment and wireless repeaters, shall be as specified in the Contract. The locations of all equipment shall be reviewed by the manufacturer's representative in the field to verify the equipment will operate and detect vehicles as specified. The Contractor shall bring to the Engineer's attention any equipment locations that the Contractor determines to require relocation to function properly. The Contractor shall submit any proposed equipment relocations to the Engineer for review and approval.

   The Contractor shall provide the manufacturer's installation, operational and maintenance manuals to the Engineer for each piece of equipment.

4. **Emergency vehicle preemption detectors:** Installation of all emergency vehicle preemption equipment shall be in accordance with the manufacturer's instructions.

   The locations of detectors as specified in the Contract are approximate; exact locations shall be determined by the Contractor and the manufacturer's representative, as required for proper alignment. The location of optical detectors shall not deviate more than 5 feet from the location(s) specified in the Contract unless the Contractor submits a detailed drawing showing the proposed location of the detector(s) in question and secures the written approval of the Engineer.

   The Contractor shall provide the manufacturer's installation, operational and maintenance manuals to the Engineer for each piece of equipment.

5. **Pedestrian detectors:** Pedestrian detectors (pushbuttons) shall be mounted on supports as specified in the Contract.

(h) **Installing Uninterruptible Power Supply:** The UPS system shall be installed in accordance with the manufacturer's instructions. The Contractor shall install the system software and set the initial UPS installation parameters.

The Contractor shall notify the Engineer at least 5 business days before beginning work when an existing or temporary traffic signal will be disconnected from utility power for installation of the UPS system.

The Contractor shall supply the size/capacity calculations for the UPS system to the Engineer at the time of catalog cut sheet submission.

The Contractor shall provide the manufacturer's installation, operational, and maintenance manuals to the Engineer for each piece of equipment.

(i) **Span and tether wire rigging details:** Span wire and tether wire shall be unspliced and unjointed. Saddle clamps and bolt clamps shall be designed for the size of the span wire or tether wire and shall meet the strength of the applicable wire. Tether wire strength shall conform to Section 238. Span wire strength shall be as recommended by the manufacturer.

1. **Overhead span wire:** Span wires shall be installed to the height and position required as specified in the Standard Drawings while the pole is maintained in the vertical position.

   Down guys shall be used on wood poles, shall be the same type of cable used in span wires, and shall be installed as shown in Standard WD-2. The guy wire angle thimbleye shall be bolted to the span wire thimbleye bolt.

   Lateral guys placed over the roadway shall be strung to maintain a vertical clearance of at least 17 feet 6 inches. Lateral guys and down guys shall be tightly drawn in a manner to secure the pole while its vertical alignment is maintained. Metal or approved plastic guy guards shall be installed on down guys. Sidewalk struts shall be provided where the vertical distance from the lowest point of a sidewalk, accessible pedestrian route, or shared use path to the lowest point of the down guy is less than 8 feet. There shall be a lateral clear space of no less than 2 feet between the down guy and the nearest edge of a shared use path.

   Integral messenger cable may be used for interconnect cable runs in place of span wire support. Signals, signs, or other equipment shall not be suspended from integral messenger cable.

   The Contractor shall bypass obstructions by the use of special brackets or pole extensions.

2. **Tether wire:** Signal heads and signs suspended from span wires shall be tethered unless otherwise specified in the Contract. Tether wire shall be installed to secure the attached signal heads and signs to minimize movements caused by wind loads. Signals, signs, or other equipment shall not be suspended from tether wire. Signals shall be tethered in accordance with Standard TA-1. Signs shall be tethered in accordance with Standard SMD-1.

(j) **Testing equipment:** The Contractor shall arrange for and provide all necessary field tests to demonstrate the traffic signal installation is in proper working order and in accordance with the applicable requirements of the Contract. All tests and test equipment shall be supplied by the Contractor unless specifically noted herein. All tests must be successfully completed for each intersection before final acceptance of the project.

1. **Controller and traffic signal equipment cabinet testing:** Controllers and traffic signal equipment cabinets shall be tested before installation. Assemble and configure each

controller and traffic signal equipment cabinet according to the proposed signal design. Test each controller and traffic signal equipment cabinet for proper color sequence, flashing operation, phase timings, coordination and signal monitor or malfunction management unit programming. Ensure that simultaneous conflicting phase outputs will cause the traffic signal equipment cabinet to revert to flashing operation. Test the traffic signal equipment cabinet and controller for at least eight hours. The test shall take place on a weekday during normal Department business hours at a location approved by the Engineer. The Contractor shall notify the Engineer at least 5 business days before commencing controller testing. The Contractor shall submit written documentation to the Engineer that the controller has successfully completed the Controller Testing.

2. **Inductive loop detector testing:** The Contractor needs to conduct testing on each detector with the results recorded and submitted to the Engineer before initiating the Local Intersection Acceptance Testing.

   A Megger reading of at least 100M ohms shall be obtained for each loop detector (cable and shield). The Contractor shall perform this test at 500 volts immediately before the sealant is installed and again after the sealant has set at least 24 hours. The cable shall be disconnected from the detector amplifier during testing.

   Each reading shall include information that will allow it to be readily identified to the location of a specific loop installation. The Contractor shall place a copy of the test results in the waterproof enclosure with the traffic signal equipment cabinet circuit diagram in the traffic signal equipment cabinet. Testing equipment for conducting these tests shall have been calibrated within the past two years in accordance with the manufacturer's recommendations. The Contractor shall provide the manufacturer's recommendations along with the calibration documentation to the Engineer for each test unit which will be installed under the Contract. This information shall be provided to the Engineer before taking any Megger readings.

3. **Video detection testing:** The Contractor shall demonstrate to the Engineer that the video detection equipment functions in accordance with the signal design, inclusive of video detection zone locations, detector features, and communicates with the local intersection controller and the Department's computers at the jurisdictional Traffic Operations Center or other Department traffic control facility. The Contractor shall also demonstrate to the Engineer all features of the video detection equipment as specified herein or in the Contract.

   Initial testing of the video detection system shall be accomplished in the presence of the Engineer. The Contractor shall contact the Engineer at least 2 business days in advance to arrange system testing. Deficiencies shall be addressed and corrected by the Contractor at no expense to the Department. Faulty equipment shall be replaced by the Contractor at no expense to the Department.

4. **Wireless detection testing:** The Contractor shall perform initial testing of the wireless vehicle detection sensors, system equipment and wireless repeaters upon completion of electrical tests. The Contractor shall demonstrate that the wireless detection equipment functions in accordance with the signal design, inclusive of detection locations and detector features, and communicates with the local intersection controller and, when applicable, the Department's computers at the jurisdictional Traffic Operations Center or other Department traffic control facility. The Contractor shall also demonstrate all

features of the wireless detection equipment as specified herein or in the Contract to the Engineer.

Initial testing of the system shall be accomplished in the presence of the Engineer. The Contractor shall contact the Engineer at least 2 business days in advance to arrange system testing. Deficiencies shall be addressed and corrected by the Contractor at no expense to the Department. Faulty equipment shall be replaced by the Contractor at no expense to the Department.

5. **Emergency vehicle preemption detection testing:** The Contractor shall conduct initial testing of the emergency vehicle preemption equipment upon completion of electrical tests. Initial testing of the emergency preemption system shall be accomplished in the presence of the Engineer. The Contractor shall contact the Engineer at least 2 business days in advance to arrange system testing. The Department will provide an operator and vehicle equipped with an emitter compatible with the proposed EVP detection system for the test to determine if equipment is operating properly and logging vehicles. Deficiencies shall be addressed and corrected by the Contractor per the guidance of the Engineer at no expense to the Department. Faulty equipment shall be replaced by the Contractor at no additional expense to the Department.

6. **Uninterruptible power supply testing:** Upon completion of the installation, the Contractor shall notify the Engineer at least 2 business days in advance to arrange demonstration and testing of the UPS system. Initial testing of the UPS system shall be accomplished in the presence of the Engineer. The Contractor shall demonstrate that the UPS is completely operational and shall demonstrate the various features to show compliance with the Specifications and Contract requirements. Testing shall include, but not be limited to, verifying proper functioning of the following automatic and manual operations:

   - **Loss of utility** - Initiate a normal power failure with connected load. Record voltage and frequency overshoot and components/loads are operating within designated thresholds. Confirm battery levels are within manufacturer's specification for initial installation. Operate UPS on battery power for 2 hours. Verify that network management transmits loss of utility power alert to central software (Type 2 system).

   - **Return of utility** - Return to normal power and record time to recharge batteries. Verify that return of utility power and time to recharge batteries is recorded/transmitted by network management (Type 2 system).

   The Contractor shall provide the Engineer with a written test report within 15 calendar days of the end testing date showing the tests performed and the results of each test upon successful test completion. The report shall include the completed test data and certification from the Contractor that the test results fall within the manufacturer's recommended limits and meet the specified performance requirements.

   Deficiencies shall be addressed and corrected by the Contractor per the guidance of the Engineer at no expense to the Department. Faulty equipment shall be replaced by the Contractor at no additional expense to the Department.

7. **Local intersection acceptance testing:** Each intersection shall complete an intersection acceptance test before Department acceptance of the intersection. The local intersection acceptance testing shall demonstrate that all field equipment is installed prop-

erly and all signal functions are in conformance with the requirements herein and the Contract. Local intersection acceptance testing shall include local intersection equipment testing, signal systems communication testing, and demonstration testing.

a. **Local Intersection Equipment Testing:** The Contractor shall demonstrate, in the presence of the Engineer, that all components of the signal installations are complete and in-place in accordance with the Contract. The Engineer may furnish the Contractor a punch-list of items and/or deficiencies that must be corrected before local intersection equipment testing is considered acceptable. Faulty components repaired or replaced by the Contractor shall be done at no additional expense to the Department. Local intersection equipment testing shall consist of two tests:

   (1) **Signal hardware test:** All non-electrical signal equipment, including signal heads, support structures, detectors (vehicular and pedestrian), junction boxes, conduit, etc. are complete and functional in accordance with the Contract.

   (2) **Electrical and electronic component test:** All electrical and electronic components, including but not limited to local controllers, malfunction management units/monitor units, detector amplifiers, etc. are in proper working order and functioning per the Contract.

b. **Signal Systems Communications Testing:** The Contractor shall conduct testing of the traffic signal system communication after completing of Local Intersection Equipment Testing and before the 30-Day Demonstration Testing. The Signal Systems Communications Testing shall demonstrate that all field equipment and all system communication functionalities are in conformance with the Contract requirements. The Engineer may furnish the Contractor a punch-list of items and/or deficiencies that must be corrected before signal systems communications testing is considered acceptable.

   Signal Systems Communications Testing shall consist of performing actual on-line functions between the local equipment and the Department's Traffic Operations Centers or other Department traffic control facilities as specified in the Contract. The Engineer may furnish the Contractor a punch-list of items and/or deficiencies that must be corrected before signal systems communication testing is considered acceptable. Faulty components shall be replaced by the Contractor at no additional expense to the Department.

c. **Demonstration Testing:** The Contractor shall conduct a demonstration test of each signalized intersection for 30 continuous days upon completion of the Local Intersection Equipment Testing, and the Signal Systems Communications Testing, and satisfaction of any punch list(s) items.

   The signal shall provide on-line traffic control and the signal communications system shall be programmed to provide local and remote communication with all equipment that has connectivity for the same 30 continuous days.

   The Contractor shall provide personnel to fine-tune and correct deficiencies in traffic signal installation(s) during the Demonstration Test period at no additional expense to the Department. If any portion of the signal installation(s) or signal communications system is replaced or repaired, that portion shall be subjected to an additional 30-day Demonstration Testing period, beginning immediately after the replacement

or repair. The Demonstration Testing shall not be considered complete until all punch-list items identified during the Equipment Testing have been resolved to the satisfaction of the Engineer.

Upon successful completion of the Local Intersection Acceptance Testing, the Engineer shall issue acceptance notification to the Contractor stating that the Local Intersection Acceptance Testing is complete, relieving the Contractor of maintenance responsibility of the intersection. Unless otherwise identified in the Contract, the Department will perform separate Local Intersection Acceptance Testing for each intersection and may assume maintenance responsibility for project intersections individually.

Within 5 business days of Department acceptance of the traffic signal installation, the Contractor shall furnish the Engineer written certification that the system control equipment is installed in accordance with the manufacturers' instructions, the Specifications and the Contract, as well as the equipment and material guarantees or warranties requirements and written certification of the in-service operation guaranty required according to Section 106.01.

703.04—Measurement and Payment

Remove existing pole will be measured in units of each and will be paid for at the contract unit price per each. This price shall include removing the pole, mast arm, span wire, tether wire, signs, conductor cables, all rigging hardware. When required by the Contract, this price shall also include storing, protecting, and delivering to designated Department facility.

Remove existing foundation will be measured in units of each and will be paid for at the contract unit price per each. This price shall include removing the foundation and anchor bolts to an elevation at least two (2) feet below the natural grade or finished subgrade grade and restoring the disturbed area.

Remove existing signal head will be measured in units of each and will be paid for at the contract unit price per each. Signal head is defined as an arrangement of vehicular or pedestrian traffic signal head sections, hanger assembly, and/or tether assembly to form one complete signal head assembly. This price shall include the disconnecting the signal head from existing conductor cables, removing signal head, and removing all associated mounting equipment, hardware, and accessories. When required by the Contract, this price shall also include storing, protecting, and delivering to designated Department facility.

Remove existing controller will be measured in units of each and will be paid for at the contract unit price per each. This price shall include removing the controller, traffic signal equipment cabinet, and all auxiliary equipment within the traffic signal equipment cabinet, associated UPS equipment and UPS cabinet. When required by the Contract, this price shall also include storing, protecting, and delivering to designated Department facility.

Remove existing junction box or manhole will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the removing and disposing of the junction box or manhole, and restoring the disturbed area.

Relocate existing signal head will be measured in units of each and will be paid for at the contract unit price per each. Signal head is defined as an arrangement of vehicular or pedestrian traffic signal head sections, hanger assembly, and tether assembly to form one complete signal head assembly. This price shall

include the removing existing signal cable and removing, storing, protecting, and relocating the existing traffic signal head as indicated in the Contract.

Cleaning, painting, and grouting of existing equipment retained in signal modifications will not be measured for separate payment but will be considered incidental to other items of work.

Local controller will be measured in units of each for the type specified and will be paid for at the contract unit price per each. This price shall include timing implementation, traffic signal equipment cabinets, traffic signal equipment cabinet power supply, GFCI and GFCI enclosure, back panels, power panels, detector panels, detector rack, auxiliary panels, police panels, thermostatically controlled fan units in the cabinet with a vent, air filters, LED lamp(s), drawer, flash memory device, flashers, local flasher switches, radio frequency interference filters, signal load switches, bus interface units (as required), main switches, police hand controls, malfunction management units/monitor unit(s), flasher relay assemblies, power relays, signal control assemblies, lamp receptacles, ground fault convenience receptacles, circuit diagrams, conductor cables, grounding systems, transient protection devices, gaskets, conduits, fittings, testing, and warranty. When required by the contract, this price shall also include timing data, base adapter, and external communications interface box.

Master controller will be measured in units of each for the type specified and will be paid for at the contract unit price per each. This price shall include timing data (if specified in the Contract), timing implementation, master controller unit (when a separate master controller unit is required), master controller unit functionality (when master controller functionality is combined with a local controller unit), circuit diagrams, manufacturer's instructions, relays, auxiliary equipment, conductor cables, grounding systems, wiring, and fittings.

Auxiliary detector rack will be measured in units of each and will be paid for at the contract unit price per each. This price shall include detector card rack.

Flasher for flashing beacons will be measured in units of each and will be paid for at the contract unit price per each. This price shall include flasher cabinets, mounting hardware, transient protection devices, radio frequency interference filters, power panels, grounding systems, and fittings.

Flashing beacon will be measured in units of each for the standard specified and will be paid for at the contract unit price per each. This price shall include post or pole, conduit, concrete foundation, grounding electrode, ground conductor, signal heads, breakaway connectors, sign panel(s), and mounting hardware.

Traffic signal head section will be measured in units of each for the size and type specified and will be paid for at the contract unit price per each. This price shall include mountings, molded terminal blocks, visors, backplates, fittings, realignments, and LED modules.

Pedestrian signal head will be measured in units of each for the standard specified and will be paid for at the contract unit price per each. This price shall include mountings, molded terminal blocks, visors, fittings, realignments, and LED indication modules.

Lane use control signal will be measured in units of each and will be paid for at the contract unit price per each. This price shall include mountings, housings, molded terminal blocks, visors, louvers, doors, fittings, wiring, lamps, and optical adjustments.

Hanger assembly will be measured in units of each for the standard and number of ways ([]-way) specified and will be paid for at the contract unit price per each. This price shall include tube, brackets, clamps, balance adjusters, tether wire attachments, leveling devices, mast/span attachment, and fittings.

Illuminated traffic control sign will be measured in units of each and will be paid for at the contract unit price per each. This price shall include enclosure cabinets, sign messages, lens, lamps, internal electrical wiring and components, optical components, louvers, mounting attachments, grounding systems, and fittings.

Loop detector amplifiers will be measured in units of each for the type specified and will be paid for at the contract unit price per each. This price shall include the loop detector amplifier, connecting cables, and fittings.

Loop saw cuts will be measured in linear feet for the width of cut specified and will be paid for at the contract unit price per linear foot. This price shall include cutting, cleaning, drilling, disposing of surplus material, backer rods, and loop sealant material.

Loop detector cable, lead-in cable, and preemption confirmation light cable will be measured and paid for in accordance with Section 700.05.

Video detection system will be measured in units of each per traffic signal equipment cabinet installation and will be paid for at the contract unit price per each. This price shall include the video processor unit, software, power supply, shelf mounted rack option, video isolation/surge arrestors, traffic signal equipment cabinet connecting cables, video detection module(s) (VDM) sufficient to provide vehicular video detection as specified in the Contract, video monitor and mouse for detection zone programming, all accessories, all mounting brackets, mounting hardware, testing, warranty, and technical support.

Video detection camera will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the camera, lens, environmental housing, mounting bracket, tube, brackets, clamps, mast/pole attachment, fittings, mounting hardware, testing, and incidentals.

Video detection cable between the camera and controller will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include video detection cable, markings and identifications, all necessary cable connectors, and testing.

Wireless detection sensor will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the in-roadway sensor, cutting pavement and sealing cut with epoxy, programming, testing, technical support, and warranty.

Wireless detection system will be measured in units of each and will be paid for at the contract unit price per each. This price shall include a complete system capable of communicating to sensors and wireless repeaters, processing detection data, communicating detection data to controllers, programming, all accessories, mounting brackets, hardware (e.g., screws, nuts, bolts, etc.), testing, technical support, and warranty.

Wireless detection repeater will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the wireless repeater, all accessories, mounting brackets, hardware (e.g., screws, nuts, bolts, etc.), programming, testing, technical support, and warranty.

Emergency vehicle preemption detection system will be measured in units of each for the number of ways (approach directions) the system will receive inputs from emitters and will be paid for at the contract unit price per each. This price shall include the optical detector(s), phase selector(s), confirmation light(s), mounting assemblies, relay(s) detector panel(s), traffic signal equipment cabinet connecting cables, transient protection, all system documentation, testing, and warranty.

Emergency preemption detector cable between the optical detectors and the phase selector(s)/system chassis will be measured in linear feet and will be paid for at the contract unit price per linear foot. This

price shall include preemption detector cable, markings and identifications, electrical tape, testing, and connections.

Auxiliary preemption optical detector will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the preemption optical detector, mounting assembly, traffic signal equipment cabinet connecting cables, transient protection, all system documentation, testing, and warranty.

Pedestrian actuation will be measured in units of each for the standard specified and will be paid for at the contract unit price per each. This price shall include pedestrian pushbutton, fittings, sign panel(s), mounting hardware, and when required, pole, caps, breakaway support systems, handhole and cover, conduit, condulet, supplementary grounding electrode, grounding conductor, and concrete foundation.

Uninterruptible Power Supply will be measured in units of each for the type specified and will be paid for at the contract unit price per each. This price shall include the complete uninterruptible power supply system including converter/inverter/charger, power management unit, transfer switches, bypass switches, switches, two-part modular battery harnesses, temperature sensor, sensor cable, software, DB-9 connecting cables, conductor cables, over-current protection devices (fuses/circuit breakers), terminal blocks, power panels, surge protection devices, circuit diagrams, documentation, transient protection devices, system testing, certification, and warranty. This price shall also include complete integration with the traffic signal control equipment and integration testing.

Uninterruptible Power Supply battery pack will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the battery pack configuration required for one complete backup supply system as recommended by UPS manufacturer for the signal equipment supported by the UPS.

Uninterruptible Power Supply cabinet will be measured in units of each for the type specified and will be paid for at the contract unit price per each. This price shall include UPS cabinet, thermostatically controlled fan(s), thermostat, switches, air filter, LED lamp receptacle, LED lamp, conductor cables, over current protection devices (fuses/circuit breakers), terminal blocks, power panels, surge protection devices, flanged twist-lock generator connector, twist-lock generator connector door with police lock, external LED confirmation light, circuit diagrams, grounding systems, gaskets, bolts, weatherproofing, conduits, and fittings.

When separate cabinet foundations are required for Uninterruptible Power Supply they will be measured and paid for in accordance with Section 700.

Span wire will be measured in linear feet for the size specified, from connection point to connection point, and will be paid for at the contract unit price per linear foot. This price shall include span wire, thimbleye bolt assemblies, clamps, conductor cable supports, and fittings.

Tether wire will be measured in linear feet for the size specified, from connection point to connection point, and will be paid for at the contract unit price per linear foot. This price shall include tether wire, thimbleye bolt assemblies, clamps, and fittings.

Payment will be made under:

Pay Item	Pay Unit
Remove existing pole	Each
Remove existing foundation	Each
Remove existing signal head	Each

Pay Item	Pay Unit
Remove existing controller	Each
Remove existing manhole/junction box	Each
Relocate existing signal head	Each
Local controller (Type)	Each
Master controller (Type)	Each
Auxiliary detector rack	Each
Flasher	Each
Flashing beacon (Standard)	Each
Traffic signal head section (Size and type)	Each
Pedestrian signal head (Standard)	Each
Lane use control signal	Each
Hanger assembly (Standard, [ ]-way)	Each
Illuminated traffic control sign	Each
Loop Detector amplifier (Type)	Each
Loop saw cut (width)	Linear Foot
Video detection system	Each
Video detection camera	Each
Video detection cable	Linear Foot
Wireless detection sensor	Each
Wireless detection system	Each
Wireless detection repeater	Each
Emergency vehicle preemption detection system ([ ] Way)	Each
Emergency vehicle preemption detector cable	Linear Foot
Auxiliary preemption optical detector	Each
Pedestrian actuation (Standard)	Each
Uninterruptible power supply (Type)	Each
Uninterruptible power supply battery pack	Each
Uninterruptible power supply cabinet (Type)	Each
Span wire (Size)	Linear foot
Tether wire (Size)	Linear foot

SECTION 704—PAVEMENT MARKINGS AND MARKERS

704.01—Description

This work shall consist of establishing the location of retroreflective pavement markings and installing pavement markings and pavement markers in accordance with the *MUTCD,* the *Virginia Supplement to the MUTCD,* these Specifications, the Plans, and as directed by the Engineer.

704.02—Materials

(a) **Pavement Markings** shall conform to Section 246.

(b) **Glass Beads** and retroreflective optics materials shall conform to Section 234.

(c) **Pavement Markers** shall conform to Section 235.

All pavement marking materials shall be selected from the Materials Division's Approved Products List 17. For Type B, Class VI pavement marking materials that are to be applied to latex emulsion or slurry seal surfaces. The selected Type B, Class VI manufacturer shall be a manufacturer that approves and warranties their product for application on that type of surface.

The Contractor shall use a Department approved inventory tracking system for all materials received from the manufacturer. Shipment of materials from such inventory shall be accompanied by a signed Form C-85 containing the following certification statement:

> *Material shipped under this certification has been tested and approved by VDOT as indicated by laboratory test numbers (MS#) listed hereon.*

704.03—Procedures

Once received by the Contractor, the Contractor shall store all materials in accordance with the manufacturer's instructions until the day of installation, unless the Engineer otherwise authorizes. Pavement marking material shall not be installed if the material has exceeded its shelf life, has been improperly stored, has deteriorated or is otherwise damaged. The Contractor shall furnish a copy of the manufacturer's installation instructions to the Engineer prior to installation.

The Contractor shall have a certified Pavement Marking Technician present during all temporary pavement marking, permanent pavement marking, and pavement marker operations.

All pavement markings and markers shall be installed on new roadways prior to opening the roadways to traffic. Temporary or permanent pavement marking installation, including edge lines and message markings, shall be completed within the time limits stated herein on existing roadways where the pavement markings have been removed or obscured and the roadway is to be reopened to traffic, unless otherwise directed by the Engineer. The Engineer will only authorize exceptions to these time limits for weather conditions preventing installation, when pavement surface conditions required by the manufacturer or these specifications such as cooling, curing, or aging limit application prior to the installation of permanent markings, or when Type B, Class VI marking material is to be inlaid into the freshly paved asphalt concrete roadway surface. Epoxy resin and polyurea pavement markings shall be installed on new pavement in accordance with the manufacturers' instructions. Pavement markings shall not be installed on new asphalt concrete pavement until the pavement mat has cooled sufficiently to support the pavement marking equipment without deformation. Time limits for installation are as follow:

- Pavement marking installation on interstates, other freeways (fully limited-access, divided roadway with two or more lanes per direction) with posted speed limit of 55 mph or greater, and interstate/freeway ramps, where the corresponding pavement markings were removed, eradicated, or obscured shall be completed prior to opening the lane to traffic.

- Pavement marking installation on non-freeway roads having traffic volumes of 10,000 ADT or more shall be completed within 24 hours after the end of the workday when the corresponding existing pavement markings were removed, eradicated, or obscured.

- Pavement marking installation on non-freeway roads having traffic volumes between 3,000 and 10,000 ADT shall be completed within 48 hours after the end of the workday when the corresponding existing pavement markings were removed, eradicated, or obscured.

- Pavement marking installation on non-freeway roads having traffic volumes of less than 3,000 ADT shall be completed within 72 hours after the end of the workday when the corresponding existing pavement markings were removed or obscured.

  If an approach to a signalized intersection has (a) two or more approach through lanes, (b) 45 mph or greater speed limit, (c) greater than 3000 ADT, and (d) all markings on that approach are obliterated, then all lane lines and centerlines within 250 feet of the stop line location shall be temporarily or permanently marked within 24 hours of opening the approach to traffic, unless a time extension is approved by the Engineer and "Unmarked Pavement Ahead" or "No Center Line" warning signs were properly installed when the unmarked approach was first opened to traffic as per the VWAPM.

- Temporary symbol/message markings and temporary edge lines, if required by the Contract, shall be marked within 72 hours after the end of the work day when the corresponding existing markings were obscured, removed, or eradicated on roads with 10,000 or greater ADT, and shall be marked within 96 hours after the end of the work day when the corresponding existing markings were obscured, removed, or eradicated on roads with less than 10,000 ADT.

If the Contractor cannot have permanent pavement markings installed within the time limits specified, the Contractor shall install temporary pavement markings within the same time limits and maintain such markings until the permanent pavement markings can be installed. The cost of installing, maintaining, and removing/eradicating temporary pavement markings shall be at no additional cost to the Department unless otherwise indicated in the Contract or directed by the Engineer.

The Contractor may mark the locations of proposed permanent markings on the roadway by installing premarking materials. Premarkings may be accomplished by installing Type D (removable, any class) tape, chalk, or lumber crayons, except pavement markings such as stop lines, crosswalks, messages, hatching, etc., shall be premarked using chalk or lumber crayons. Premarkings shall be of the same general color as the pavement markings being premarked.

When tape is used as a premarking material, premarking shall consist of 4- inch by 4-inch-maximum squares or 4-inch-maximum diameter circles spaced at 100-foot minimum intervals in tangent sections and 50-foot minimum intervals in curved sections. At locations where the pavement marking will switch colors, e.g., gore marking, the ends of the markings may be premarked regardless of the spacing.

When the Contractor uses chalk or lumber crayon as a premarking, the entire length of the proposed pavement marking may be premarked.

Premarkings shall be installed so their installation will not affect the adhesion of the permanent pavement markings. When Type D tape is used as the premarking material and the lateral location of such premarkings to location of the final pavement markings exceeds 6 inches, the Type D premarkings shall be removed at no additional cost to the Department.

Permanent pavement markings shall not be installed over temporary paint if the paint exceeds the maximum allowable specified thickness in Table VII-3 or is not fully dry. If the temporary paint is not located directly underneath the location where the permanent markings are to be installed, it shall be 100% eradicated prior to installation of the permanent markings at no additional cost to the Department.

The Contractor shall exercise caution and protect the public from damage while performing pavement marking operations. The Contractor shall be responsible for the complete preparation of the pavement surface, including, but not limited to, removing dust, dirt, loose particles, oily residues, curing

compounds, concrete laitance, residues from eradication, and other foreign matter immediately prior to installing pavement markings. The pavement surface shall be clean and dry at the time of pavement marking installation and shall be tested in accordance with VTM-94 prior to permanent installation. The Contractor shall provide the apparatus indicated in VTM-94 that are needed to perform the moisture test prior to application.

Liquid markings shall be applied so as to prevent splattering and overspray and shall be protected from traffic until track free by the use of traffic control guarding or warning devices as necessary. If a vehicle crosses a pavement marking and tracks it or if splattering or overspray occurs, the affected marking and resultant tracking, overspray, or splattering shall be completely removed and new markings applied at the Contractor's expense.

Truck-mounted equipment for application of liquid long line Type B markings shall be capable of hot applying liquid and/or plastic markings and broadcasting glass beads uniformly over the entire surface of the marking. Truck mounted equipment tanks shall be equipped with a mechanical agitator to keep the pavement marking materials thoroughly mixed at all times. Materials shall be blended, heated, and applied in accordance with the manufacturer's installation instructions. Markings shall be applied in widths of 4 through 8 inches in accordance with the the Plans and Specifications. Equipment shall be capable of applying two pavement lines, either solid or skip, at the same time when double line markings are required.

Non-truck mounted equipment shall be self-propelled and regulated to allow for calibration of the amount and type of material applied.

The Contractor shall be responsible for ensuring that equipment is thoroughly cleaned between changes in colors or types of materials.

Markings shall not be installed directly over longitudinal pavement joints, except to cross the joint perpendicularly or at an angle.

Pavement markings shall have clean and well-defined edges without running, bleeding or deformation. Markings shall be uniform in appearance, free of waviness; (waviness is defined as the edge of the marking shall not vary from a straight line more than 1/4 inch in three feet or more than one inch in fifty feet for a maximum distance of 500 feet); shall be straight on tangent alignment; and shall be on a true arc on curved alignment.

The widths of pavement markings shall not deviate more than 1/4 inch on tangent nor more than 1/2 inch on curves from the required width. The length of the gap and the length of the individual stripes that form skip lines shall not deviate more than two inches from their required lengths. The length of the gap and individual skip line shall be of such uniformity throughout the entire length of each that a normal striping machine shall be able to repeat the pattern and superimpose additional striping upon the existing marking.

Glass beads and retroreflective optics shall be applied at the rate specified herein or as specified in the Materials Division's Approved Products List for the specific pavement marking product. Beads and optics shall be evenly distributed over the entire surface of the marking. The Contractor shall apply beads to the surface of liquid markings with a bead dispenser attached to the applicator that shall uniformly dispense beads simultaneously on and into the just-applied marking. The bead dispenser shall be equipped with a cut-off control synchronized with the applied marking material cut off control so that the beads are applied totally on the marking. Beads shall be applied while the liquid marking is still fluid. Approximately seventy (70) percent of beads shall be buried in the marking, and the remaining 30 percent shall be 50 to 60 percent embedded in the marking's surface unless otherwise specified by the pavement marking

manufacturer. Beads installed on crosswalks and stop lines on roadways with curbs only (no gutter) may be hand applied for two feet at the end of each line next to the curb with 100 percent of the beads embedded 50 to 60 percent into the marking's surface.

The Engineer will make a visual evaluation of the pavement marking material to assess the condition, retroreflectivity, and color after its installation and again prior to final acceptance. The Department, the Contractor, and the marking manufacturer's representative will make a further inspection if problem areas are suspected to identify specific areas of concern. If required by the Engineer, the suspect areas shall be tested by the Contractor in the presence of the Engineer in accordance with VTM-125 to define the evaluation sections and the number of measurements needed. Acceptable test results shall meet the retroreflectivity and color requirements specified in Section 246. Markings that do not meet the requirements for retroreflectivity and day and nighttime color specified in Section 246 shall be eradicated and replaced by the Contractor at no cost to the Department. Pavement markings that exhibit signs of significant tearing, deformation, shrinkage, roll back, lifting, or other signs of poor adhesion shall also be replaced by the Contractor at no cost to the Department.

All costs associated with testing the marking material for retroreflectivity, color, and adhesion shall be borne by the Contractor. The Contractor will be paid for maintenance of traffic during this testing at the contract unit price for the maintenance of traffic items used.

Pavement marking manufacturer's material guarantees shall be obtained by the Contractor and assigned to the Department in writing prior to final acceptance.

(a) **Pavement Line Markings:** Pavement markings shall be white or yellow markings (unless another color is specified in the Contract) as required by the *MUTCD* and plans for the specific location or as specified by the Engineer. Line markings shall be installed in accordance with Table VII-3 unless otherwise recommended by the manufacturer and approved by the Engineer. The Contractor shall furnish a copy of the manufacturer's installation instructions for the specific marking to the Engineer prior to installation.

The Contractor shall perform quality control testing for application thickness and glass bead rate in accordance with VTM-94 at the beginning of each workday and every 3 hours thereafter. The Contractor shall provide the apparatuses needed to perform the quality control testing in accordance with VTM-94. Compliance testing using VTM-94 shall be performed in the presence of the Engineer and shall be documented on the Pavement Marking, Contractor's Daily Log and Quality Control Report, Form C-85, immediately after testing is completed. If requested by the Engineer, the Contractor shall provide a quality control (QC) test plate and the provision of the test plate shall be documented on the Form C-85. The Contractor shall also provide a printed or electronic copy of the signed Form C-85 to the Materials Division Quality Assurance Technician for materials notebook evaluation.

The Contractor shall maintain a daily log, Form C-85, for both temporary and permanent pavement markings and markers. The C-85 form shall not be modified; all log entries shall be made in ink; and shall be legible. The log shall be signed by the Contractor and delivered to the Engineer by the end of each workday. If the C-85 is in electronic format, it shall be kept current with VTM-94 testing throughout the day and a printed copy, signed by the Contractor, shall be delivered to the Engineer at the end of each workday.

Pavement line markings shall consist of solid and skip lines, including but not limited to, lane division lines, edgelines, channelizing, outlining and marking safety zones around objects, and forming islands and parking lot stalls.

1. **Type A markings** shall be applied to asphalt concrete and hydraulic cement concrete pavements in accordance with the manufacturer's installation instructions. Paint shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent worn away or eradicated. Paint may be applied over existing painted markings if the existing paint is clean and well adhered.

   Paint shall be thoroughly mixed and heated such that it will not track within 60 seconds after its application.

   Glass beads and retroreflective optics shall be applied to the entire surface of the marking at the minimum rate of 6 pounds per gallon of paint, unless specified otherwise in the Materials Division's Approved Products List 20 for the selected pavement marking product.

2. **Type B markings** shall be applied to asphalt concrete and hydraulic cement concrete pavements in accordance with the manufacturers' installation instructions. Type B markings shall not be applied over existing pavement markings materials unless the existing marking is 90 percent removed.

   The Contractor shall furnish a properly calibrated infrared instrument to measure the actual temperature of molten thermoplastic material. Multi-component material shall be applied using internally injected guns for the proper mixing of components.

   Non–truck mounted equipment for application of thermoplastic material shall be of the screed extrude type with a screw drive.

   a. **Thermoplastic (Class I)** material shall be applied by screed extrusion, ribbon gun, or spray equipment in accordance with the manufacturer's installation instructions. A primer/adhesive manufactured or recommended by the thermoplastic marking manufacturer shall be applied to hydraulic cement concrete surfaces and to asphalt concrete surfaces in accordance with the manufacturer's installation instructions.

      Alkyd thermoplastic may be applied directly after the paving operations if the paved surface can support the equipment. Hydrocarbon thermoplastic shall not be applied to asphalt surfaces less than 30 days after paving operations are complete, hydrocarbon thermoplastic may be applied to hydraulic cement concrete surfaces as soon as permitted by the manufacturer's instructions.

      Alkyd and hydrocarbon materials shall not be mixed together.

      Thermoplastic shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent percent worn away or eradicated; or over previously applied temporary paint that is fully dry and is at a thickness of 10 mils or less. Thermoplastic shall only be applied over existing thermoplastic markings, if the existing thermoplastic markings are clean, chalk free (not powdery), and well adhered.

      Thermoplastic marking material shall be applied at thickness of 90 mils (+/- 5 mils) above the riding surface, whether dense or open graded surface.

      Glass beads and retroreflective optics shall be surface applied at the rate of 7 pounds per 100 square feet unless specified otherwise on the Materials Division's Approved Products List 43 for the specific thermoplastic product.

b. **Preformed thermoplastic (Class II)** material shall be installed as lines, stop bars, message markings, legends, and symbols in accordance with the manufacturer's installation instructions. A primer/sealer manufactured by or recommended by the preformed thermoplastic manufacturer shall be applied to all hydraulic cement concrete surfaces and to asphalt concrete surfaces in accordance with the manufacturer's installation instructions.

Preformed thermoplastic shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent worn away or eradicated; or over previously applied temporary paint that is fully dry and is at a thickness of 10 mils or less. Preformed thermoplastic may be applied over existing thermoplastic markings, provided the the existing thermoplastic marking is clean, chalk free (not powdery), and well adhered.

Preformed thermoplastic shall be 125 mils thick (+/- 5 mils) unless otherwise approved by the Engineer.

Additional glass beads and retroreflective optics shall be evenly applied at a rate of 7 pounds per 100 square feet (unless another rate is specified in the Materials Division's Approved Products List 73 for the selected pavement marking product) to flood the entire surface immediately after installation while the material is molten.

c. **Epoxy resin (Class III)** material shall be applied in accordance with the manufacturer's installation instructions and shall not be applied over existing pavement markings unless the existing marking is 90 percent worn away or eradicated. Epoxy marking material shall be applied at a wet film thickness of 20 mils (+/- 1 mil).

Glass beads and retroreflective optics shall be applied to the surface of the marking at the rate of 25 pounds per gallon of material, unless otherwise specified in the Materials Division's Approved Products List 75 for the specific epoxy resin product.

d. **Plastic-backed preformed tape (Class IV)** shall be installed in accordance with the manufacturer's installation instructions. Tape may be applied to asphalt concrete and hydraulic cement concrete pavements. Tape may be installed immediately following the final rolling of new asphalt concrete surface provided installation is done is strict conformance with the preformed tape manufacturer's instructions for this type of application. Tape shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent worn away or eradicated.

Primer/adhesive shall be used to enhance adhesion in accordance with the manufacturers' installation instructions, except when tape is inlaid immediately following the final rolling of the new asphalt concrete surface.

Tape for pavement line markings shall be applied by an application cart as recommended by the manufacturer. Tape shall be tamped into place with a tamper cart with a weight as recommended by the manufacturer. Vehicle wheels may be used to tamp line markings if allowed by the manufacturer's installation instructions. If vehicle wheels are used to tamp the markings, the Contractor shall ensure that the vehicle tires ride true down the length of the tape marking.

e. **Patterned preformed tape (Class VI)** shall be installed either under the guidance of the manufacturer's representative or by a manufacturer's certified technician.

Type B, Class VI markings applied to new plant mix asphalt surfaces shall be installed as per manufacturer's installation instructions, except that non-embedded (adhesive) surface application will not be permitted; the markings shall be inlaid in the freshly installed asphalt surface before the pavement mat has cooled. The temperature of the asphalt mat shall be between 100 and 180 degrees. The Type B, Class VI markings shall be inlaid with a roller (minimum 2 tons) operating in a non-vibratory mode when the asphalt mat is between 100 and 180 degrees.

The Contractor shall ensure that markings are not degraded by subsequent paving and shoulder operations. Markings that are improperly inlaid during the pavement operations shall be completely eradicated and reapplied via non-embedded surface application at the Contractor's expense.

Type B Class VI markings shall not be installed directly over existing markings, except that Type B Class VI markings may be installed over previously applied temporary paint that is fully dry and is at a thickness of 10 mils or less.

When Type B, Class VI markings are specified for an asphalt roadway that includes a concrete bridge deck greater than 75 feet in length within the limits of the road, Type B Class VI contrast (black-bordered) tape shall be surface-applied on the concrete bridge deck for the lane lines and edge lines unless otherwise specified in the Contract or directed by the Engineer.

f. P**olyurea (Class VII)** shall be applied in accordance with the manufacturer's installation instructions. Polyurea marking material shall not be applied over existing pavement markings unless the existing marking is 90 percent worn away or eradicated; or over previously applied temporary paint that is fully dry and is at a thickness of 10 mils or less.

Polyurea marking material shall be applied at a wet film thickness of 20 mils (+/- 1 mil). Glass beads and retroreflective optics shall be applied at the rate specified in the Materials Division's Approved Products List 74 for the specific polyurea product.

3. **Type D and E temporary pavement markings** shall be installed in accordance with the manufacturers' installation instructions and will be paid for in accordance with Section 512.

(b) **Pavement message and symbols markings** shall be the color required by the *MUTCD* or the plans for the specific location or as specified by the Engineer. The Contractor shall install message and symbols markings in accordance with Table VII-3, unless otherwise recommended in the manufacturers' installation instructions and approved by the Engineer.

Pavement message and symbol markings shall be installed using Type B, Class I (Alkyd), Class II, Class IV, or Class VI material as specified on the plans. Message and symbol markings include, but shall not be limited to, those detailed in Standard PM-10 of the Standard Drawings.

TABLE VII-3
Pavement Markings

Type	Class	Name	Surface Temp. at Time of Application	Film Thickness (mils)	Pavement Surface	Application Limitations	Appr. List No.
A		Traffic paint	(Note 5)	15 ± 1 when wet	AC HCC	May be applied directly after paving operations	20
B	I	Thermoplastic Alkyd	(Note 5)	90 ± 5	AC HCC	May be applied directly after paving operations	43
	I	Thermoplastic Hydrocarbon	(Note 5)	90 ± 5 when dry	AC HCC	Do not apply less than 30 days after paving operations	43
	II	Preformed Thermoplastic	(Note 5)	120-130	AC HCC	Manufacturers installation instructions	73
	III	Epoxy resin	(Note 5)	20 ± 1 when wet	AC HCC	Manufacturers installation instructions	75
	IV	Plastic-backed preformed Tape	(Note 5)	60 - 120	AC HCC	Manufacturer's installation instructions	17
	VI	Patterned preformed Tape	(Note 5)	20 min (Note 1) 65 min (Note 2)	AC HCC	(Note 4)	17
	VII	Polyurea	(Note 5)	20 ± 1	AC HCC	Manufacturer's installation instructions	74
D	II	Removable tape	(Note 5)	(Note 3)	AC HCC	Temporary pavement marking	17
	III	Wet Reflective Removable tape	(Note 5)	(Note 3)	AC HCC	Temporary pavement marking	17
E		Removable black tape (Non-Reflective)	(Note 5)	(Note 3)	AC	Temporary pavement marking for covering existing markings	17

TABLE VII-3 NOTES

Note 1: Thinnest portion of the tape's cross section.
Note 2: Thickest portion of the tape's cross section.
Note 3: In accordance with manufacturer's installation instructions.
Note 4: In accordance with the manufacturer's installation instructions, except that Type B, Class VI markings on new plant mix asphalt surfaces shall be inlaid into the freshly installed asphalt surface and not surface-applied.
Note 5: Surface temperature at time of application shall be in accordance with manufacturer's installation instructions. If the installation instructions do not specify minimum surface temperature, then the markings shall not be installed unless the surface temperature at time of application is 50 degrees F or higher.

Pavement messages and symbols markings shall be installed at locations shown on the plans or at locations designated by the Engineer. The pavement message or symbol shall have clean and well-defined edges without running, bleeding or deformation; shall be uniform in appearance throughout, and free of overlaps.

Type B, Class I hydrocarbon thermoplastic material shall not be used for messages or symbols.

(c) **Eradication:** Eradication of existing pavement markings shall be in accordance with Section 512 except only 90 percent removal is required where the new markings will completely cover existing markings.

(d) **Pavement markers:** Retroreflectors for pavement markers shall conform to Section 235 and be the same color as the adjacent pavement marking except the backsides of the markers shall be as follows:

- One-way markers: The backside shall be red and the front side white.
- Two-way markers: The backside shall match the adjacent pavement marking.

1. **Snow-plowable raised pavement markers** shall be installed by cutting two parallel grooves into the pavement at the depth and dimensions recommended by the marker manufacturer. Grooves shall be parallel to the adjacent pavement marking. Grooves shall be cut with saw blades having a diameter to match the curvature of the steel casting bottom and keels. Keel surfaces and the cut grooves shall be free from moisture, scale, dirt, oil, grease, debris, or any other contaminant that might reduce bonding. Snow-plowable raised pavement markers shall not be installed on existing or new bridge decks. When pavement markers are required on concrete bridge decks, raised pavement markers shall be used and bonded to the surface using an adhesive in accordance with the manufacturer's recommendations.

   Snowplowable raised pavement markers shall be installed at least 2 inches from any joint, crack, or seam.

   Casting keels shall be bonded in the saw-cut grooves in accordance with the manufacturers' installation instructions. The bonding material shall be from the Materials Division's Approved Products List 22 for the specific marker. Front and rear keel tips of the casting shall be installed flush with or below the pavement surface. The installed height of the raised pavement marker shall be approximately 1/4 inch to 1/2 inch above the pavement surface. The ambient air temperature, ambient moisture condition, and pavement surface condition shall be in accordance with the manufacturer's installation instructions at the time of installation.

The top of reflectors shall be mounted flush with or below the top of the casting.

If the snowplowable raised pavement marker retroreflector becomes soiled or damaged during installation (including dirtying from duct tape or similar adhesive residue), the retroreflector shall be replaced by the Contractor at no additional cost to the Department.

2. **Raised pavement markers** shall be bonded to the pavement surface in accordance with the manufacturer's installation instructions. The bonding material shall be from the Materials Division's Approved Products List 22 for the specific marker.

704.04—Measurement and Payment

Pavement line markings will be measured in linear feet and will be paid for at the contract unit price per linear foot for the type and/or class and width specified. This price shall include surface preparation, premarking, furnishing, installing, quality control tests, daily log, guarding devices, primer/adhesive, glass beads, reflective optics materials when required, and warranty.

Pavement message markings will be measured in units of each per location or in linear feet as applicable and will be paid for at the contract unit price per each or linear foot. This price shall include surface preparation, premarking, furnishing, installing, quality control tests, daily log, guarding devices, primer/adhesive, glass beads, reflective optics materials when required, and warranty.

Pavement markers will be measured in units of each for the type specified and will be paid for at the contract unit price per each. This price shall include surface preparation, furnishing, installing, prismatic retroreflectors, pavement cutting, adhesive, castings, quality control tests, and daily log.

Eradication of pavement markings will be measured and paid for in accordance with Section 512.

Payment will be made under:

Pay Item	Pay Unit
Pavement line marking (Type and/or class and width)	Linear foot
Pavement message marking (Message)	Each or linear foot
(Type) Pavement marker (type pavement)	Each

SECTION 705—LIGHTING SYSTEMS

705.01—Description

This work shall consist of furnishing, installing, and testing proposed lighting systems and removing, modifying, or relocating existing systems in accordance with these specifications and in conformity to the lines and details shown on the plans or established by the Engineer.

705.02—Materials

Photoelectric controls shall conform to Section 238.

705.03—Procedures

The Contractor shall verify or locate the origin of the power source and verify voltage when modifying, removing, or relocating existing electrical systems. The Contractor shall also inform the Engineer at least 48 hours prior to the anticipated time of de-energizing any portion of the electrical system in order to facilitate such work. Work shall be performed in accordance with the NEC and the requirements of the local power company, unless otherwise specified on the Plans.

(a) **Luminaires for Roadway Lighting:** The Contractor shall install luminaires in accordance with the manufacturer's recommendations. Luminaires shall be adjusted for maximum illumination and uniform dispersion on the pavement or sidewalk as directed by the Engineer.

(b) **Sign Luminaires:** The Contractor shall ensure luminaires are shielded to eliminate glare or extraneous light on the roadway so that these provide a maximum-to-minimum uniformity ratio of 6:1 or better once installed. When tested at the center of a 10-foot-square test panel, the luminaire shall provide at least 30 average initial foot-candles and a gradient (ratio of illumination on any two adjacent square feet of sign surface) of 2:1 or less.

(c) **High-Mast Luminaire Assemblies:** Assemblies shall consist of a head frame assembly; luminaire ring; luminaire(s); winch assembly; a fail-safe mechanism to prevent accidental lowering of the luminaire ring; and incidentals necessary to raise, lower, supply, and control power to the luminaire ring. When an electric drill is required for raising and lowering the assembly, the Contractor shall furnish one drill for each set of five high-mast luminaire assemblies or fraction thereof.

1. **The lowering system** shall be compatible with the lighting pole and capable of raising and lowering a luminaire ring with eight luminaires.

2. **The head frame assembly, luminaire ring, and canopy** shall be constructed of a material that is resistant to weather, corrosion, and ultraviolet rays. The centering arms of the assembly shall provide stabilization of the luminaire ring during raising and lowering operations and shall maintain contact with the lighting pole for at least 2/3 of its length. A fail-safe latching mechanism shall be included in the head frame assembly that will remove the tension from the lowering cables when the luminaire ring is attached.

3. **The winch assembly** shall include power cables of 600-volt, multi-conductor No. 10 (minimum), UL Type SO; lowering system cables of stranded stainless steel of sufficient strength and number to support and lower the luminaire ring and luminaires; and a 1/2-inch heavy-duty reversible electric drill or electric motor suitable for operation of the lowering\raising of the luminaire ring and luminaires at the voltage shown on the plans. The winch assembly shall have a remote control that allows operation at least 15 feet from the lighting pole and shall be designed for alternatively lowering and raising the assembly by hand if necessary.

4. **A junction box with a prewired terminal block** shall be furnished on the lowering ring with provisions for a photoelectric control. A circuit breaker shall be mounted in the hand-hole area of the lighting pole. A watertight twist-lock power receptacle and plug shall be provided for de-energizing the luminaire ring during raising and lowering operations and providing power for testing luminaires in the lowered position.

(d) **Ballast:** The ballast shall be compatible with the luminaire and shall be a multi-volt type capable of operating on 120-, 208-, 240-, and 277-volt electrical services. Ballasts for luminaires with lamp wattages of 150 watts or less may be non-regulating or regulating, having a power factor of more than 90 percent. Ballasts for luminaires with lamp wattages more than 150 watts shall be regulating. Non-regulating ballasts shall regulate lamp wattage within a line voltage variation of ±5 percent. Regulating ballasts shall regulate lamp wattage within a line voltage variation of ±10 percent. The Contractor shall certify that ballasts serving high-pressure sodium luminaires have a volt watt characteristic curve that intersects the lamp voltage limit lines at points between the wattage limit lines throughout the full range of the lamp life and rated ballast line voltages. The basic and allowed variable volt-watt characteristic curves shall not intersect the wattage limit lines.

Ballasts and starting aids shall be capable of operating with the lamp in an open condition for 6 months without significant loss of ballast life and starting the lamp at temperatures as low as -20 degrees F.

(e) **Control Centers:** Enclosures for control centers shall be NEMA 3R with provisions for locking. Electrical equipment shall be UL listed for the use indicated on the plans. Door openings for control center cabinets shall be at least 8 inches wider than the enclosed widest panelboard or other installed equipment, whichever is wider. When multiple door control centers are provided, the door openings for each door shall be identical.

Control Centers shall have an automatic on/off door switch located in the cabinet frame so that it will provide for the unobstructed illumination of electrical items inside the cabinet. Each door switch shall be connected to the 120-volt, single-phase, AC power line for operation of the lamp (number of lamps and wattage depends on the cabinet size). The switches shall turn light on continuously when any door is in the open position. At least one 120-Volt, 20-ampere Ground-Fault Circuit Interrupter (GFCI) duplex receptacle with LED indicator shall be installed in each electrical cabinet.

(f) **Testing Electrical Components:** After energizing the lighting system, the Contractor shall demonstrate to the Engineer that electrical components are in proper working order. Faulty components shall be repaired or replaced by the Contractor at his expense.

The Contractor shall perform an operational test of the completed lighting system under normal operating conditions for at least 3 consecutive days. The Contractor shall provide the Engineer at least 48 hours notice prior to the start of the operational testing. Defective materials or improper installations shall be corrected by repairs or replaced by the Contractor at his expense.

(g) **Electrical Equipment Containing Polychlorinated Biphenyl (PCB)**: This work shall consist of determining, removing and disposing of electrical equipment containing PCB present as a dielectric fluid or paste. Electrical equipment that may contain PCB consists of, but is not limited to, capacitors, ballasts and transformers.

1. **Determination:** The Contractor shall determine if the electrical equipment that is to be removed contains PCB. This determination shall be made prior to removal of the equipment in accordance with the following:

a. Check the nameplate on the equipment to determine if any of the following trade names for PCB is indicated:

ALC	DK	Nepolin
Apirolio	Dykanol	Non-Flammable Liquid
Aroclor	EEC-18	No-Flamol
Aroclor B	Elemex	Phenoclor
Asbestol	Eucarel	Pydraul
ASK	Fenclor	Pyralene
Askarel	Hyvol	Pyranol
Capacitor 21	Iclor	Pyroclor
Chlorextol	Interteen	Saf-T-Kuhl
Chlorinol	Kanechlor	Santotherm
Clorinol	Kennechlor	Santotherm FR
Clorphen	Magvar	Santovac 1 and 2
Diaclor	MCS 1489	Therminol

b. If these trade names are not indicated on the nameplate of the equipment and the equipment is not labeled as containing PCB, the Contractor shall contact the equipment manufacturer for a determination of the existence of PCB in that equipment. The Contractor shall provide the information requested by the manufacturer, which will include at least the type, model, and serial number of the equipment. If the manufacturer indicates PCB does not exist in the equipment, the Contractor shall request that documentation in writing on the manufacturing company's letterhead stationery. The documentation shall include all information needed to verify the absence of PCB in the piece of equipment referenced.

c. If the procedures herein do not allow determination of the existence of PCB or if the manufacturer will not provide the necessary documentation in writing, the Contractor shall assume that PCB is contained within that equipment.

d. The Contractor shall notify the Engineer in writing of the determination of the existence of PCB in each piece of electrical equipment that contains or could contain PCBs. This documentation shall also include the equipment company's name, representative's name, and telephone number for each company contacted to determine the existence of PCB. If the Contractor is able to obtain written confirmation from the manufacturer that PCB was not in a particular piece of equipment, the Contractor shall furnish the manufacturer's original letter to the Engineer and retain a copy for their records.

2. **Removal and Disposal:** The Contractor shall follow the Environmental Protection Agency's guidelines and the Virginia Department of Environmental Quality's guidelines for the spills, removal, transportation, and disposal of PCB-laden materials. The Contractor shall provide the shipping manifest and all other correspondence concerning the proper removal and disposal of PCB-laden materials to the Engineer.

705.04—Measurement and Payment

Luminaires will be measured in units of each and will be paid for at the contract unit price per each for the wattage and type specified. This price shall include the luminaire body; slip fitters, refractors,

ballasts, reflectors, sockets with lamps, conductor cables to the termini at the base, photoelectric controls and sockets, and adjustment and testing. Luminaires for sign lighting will not be measured for separate payment but shall be included in the price for overhead and sign structures.

High-mast luminaire assemblies will be measured in units of each and will be paid for at the contract unit price per each for the number of luminaires, wattage, and type specified. This price shall include the luminaire rings, lowering devices with head frames and assembly, winch assembly, electric raise/lower units, lowering cables, conductor cables to the termini at the base, luminaire units, lamps, photoelectric controls and sockets, testing and adjustments.

Control centers will be measured in units of each and will be paid for at the contract unit price per each for the standard and type specified. This price shall include the control center metal enclosures, conduits including fitting and straps, grounding electrode(s), conductor cables, anchor bolts and templates, excavating, concrete, safety switches, panel boards, contactors, circuit breakers, photoelectric controls, terminal blocks, selector switches, transient voltage surge suppressor, GFCI and GFCI enclosure, lighting fixture(s) including housing and lamp(s), door activated light switch, testing, and adjustment.

Determination of electrical equipment containing PCB will not be measured for separate payment but the cost thereof shall be included in the price bid for the removal of the electrical equipment.

Removal and disposal of electrical equipment containing PCB will be paid for in accordance with Section 109.05 for extra work.

Payment will be made under:

Pay Item	**Pay Unit**
Luminaire (Wattage, and type)	Each
High-mast luminaire assembly (Number of luminaires, wattage, and type)	Each
Control center (Standard and type)	Each

Division VIII
INTELLIGENT TRANSPORTATION SYSTEMS

SECTION 801 – ITS INFRASTRUCTURE COMPONENTS

801.01—Description

This work shall consist of furnishing and installing Intelligent Transportation Systems (ITS) infrastructure components in accordance with these specifications and as shown on the plans or as directed by the Engineer. ITS infrastructure consists of: ITS controller cabinets; ITS Communication Hub cabinets; Solar Power Assemblies; surge protection devices including but not limited to those at the service entrance, at the main disconnect, at the power entry point, as well as point-of-use and low-voltage power surge protection devices; and associated ancillary items. See also NEMA Surge Organization glossary for terms and Acronym used herein.

801.02—Materials

(a) **Concrete** shall conform to Section 217.

(b) **Reinforcing steel** shall conform to Section 223.

(c) **Aluminum** shall conform to Section 229 and shall be fabricated, welded, and inspected in accordance with Section 407.

(d) **Electrical items** shall conform to Section 238.

801.03—Equipment

(a) **Surge Protection Device (SPD) at Power Entry Points**

1. **Electrical Specifications**

The SPD for the ITS devices power source shall have an operating voltage of 120 V single phase and a maximum continuous operating voltage of 150 V single phase. The SPD shall be configured to operate at 120 V single phase (i.e., two wires) or 120/240 V single phase (i.e., three wires) as required to match the supply circuit configuration. The Contractor shall verify that the SPD has been labeled to indicate that the unit is UL listed and meets the requirements of UL 1449, Third Edition. The power entry point SPD shall also be compliant with NEC Article 285.

The SPD shall be rated at a minimum of 80 kiloamps (kA) per phase.

The SPD shall meet or exceed the following ratings:

L-N (Line to Neutral), L-G (Line to Ground), N-G (Neutral to Ground)

	L-N	L-G	N-G
a. Voltage Protection Rating (VPR):	700V	700V	700V

b. I-nominal rating of 20kA

c. Short Circuit Current Rating (SCCR) shall be equal to or exceed 50kA or the available short circuit current, whichever is greater.

2. **Environmental Specifications**

The enclosure for a SPD shall have a NEMA 4 rating, or better.

3. **Physical Specifications**

The Contractor shall install a SPD at the closest termination/disconnection point where the 120-volt (V) supply circuit enters the ITS device cabinet. The SPD shall be located on the load side of the service disconnect and ahead of any and all ITS electronic devices.

4. **Communication Standards**

The suppression device shall have visual indication monitoring the operation status of each Metal Oxide Varistor (MOV) including N-G. The SPD shall include one set of Normally Open (NO), Normally Closed (NC) Form C contacts for remote monitoring.

(b) **Low-Voltage Power Surge Protection Devices (SPD) Devices, Control, Data, and Signal Systems**

1. **Electrical Specifications**

These devices shall be of hybrid multi-staged design with maximum let-through voltage as shown in Table VIII-1. Testing shall be for all available modes (i.e. power L-L, L-G; data and signal center pin-to-shield, L-L, L-G, and shield-G where appropriate).

The Contractor shall install SPD within the cabinet on all conductive circuits. The SPD shall have an operating voltage matching the characteristics of the device, such as 24 volts of direct current (VDC) and less than 5 VDC for data and video functions. These specialized SPDs shall be UL 497B or UL 497C listed, as applicable.

2. **Communication Standards**

Connections shall include, but are not limited to, Category 5 data cables, coaxial video cables, twisted pair video cables, and low-voltage control cables that comply with Electronic Industries Alliance (EIA) requirements as detailed in the EIA-232/422/485 Standards.

(c) **Controller and Hub Assembly Cabinets**

Cabinets shall conform to NEMA 3R requirements. The cabinet enclosure top shall be crowned to prevent standing water and shall be constructed so that it is weather resistant under all conditions.

Cabinets shall be constructed using unpainted sheet aluminum alloy 5052-H32 with a minimum thickness of 0.125 inch. The cabinets shall have a smooth, uniform natural aluminum finish without rivet holes, visible scratches, or gouges on the outer surface. The Engineer may approve other finishes as acceptable prior to ordering equipment.

TABLE VIII-1
SPD Minimum Requirements

Circuit Description	**Continuous Current**	**Frequency/ Bandwidth/ Data Rate**	**Capacity Capacity**	**Let-Through Voltage** (All voltages are measured from zero)
Coaxial Video	300 mA	10 MHz 10 Mbps	10,000 amps per mode (8x20 µs)	<100 Vpk (IEEE Cat C Low 6 kV/3 kA)
Power and Control Up to 12 V	5 A	Up to 60 Hz (sensitive loads)	5,000 amps per mode (8x20 µs)	<150 Vpk (IEEE Cat C Low 6 kV/3 kA)
Power and Control Up to 24 V	5 A	Up to 60 Hz (sensitive loads)	5,000 amps per mode (8x20 µs)	<175 Vpk (IEEE Cat C Low 6 kV/3 kA)
Power and Control Up to 48 V	5 A	Up to 60 Hz (sensitive loads)	5,000 amps per mode (8x20 µs)	<200 Vpk (IEEE Cat C Low 6 kV/3 kA)
Power and Control Up to 120 VAC	10 A	Up to 60 Hz (sensitive loads)	10,000 amps per mode (8x20 µs)	<550 Vpk (IEEE Cat C Low 6 kV/3 kA)
RS422 Up to 12 V	500 mA	35 MHz 10 Mbps	10,000 amps per mode (8x20 µs)	<30 Vpk (IEEE Cat C Low 6 kV/3 kA)
RS485 Up to 12 V	500 mA	35 MHz 10 Mbps	10,000 amps per mode (8x20 µs)	<30 Vpk (IEEE Cat C Low 6 kV/3 kA)
T1 Up to 7.5 V	500 mA	55 MHz 10 Mbps	10,000 amps per mode (8x20 µs)	<20 Vpk (IEEE Cat C Low 6 kV/3 kA)
Cat 5 Up to 12 V	500 mA	100 Mbps	3,000 amps per mode (10x1000 µs)	<30 Vpk (10 x 1000 µs)

1. **Mechanical Specifications**

All exterior cabinet and door seams shall be continuously welded and smooth. All welds shall be neatly formed and free of cracks, blow holes, and other irregularities. All exterior cabinet welds shall be made using the gas tungsten arc (TIG) welding method. All internal cabinet welds shall be made using the gas metal arc (MIG) or TIG process. The Engineer may permit other welding methods if preapproved by the Engineer. All inside and outside edges of the cabinet shall be free of burrs. All edges shall be filed to a radius of 0.03125 inch minimum. ER5356 aluminum alloy bare welding electrodes shall be used and welds shall conform to American Welding Society standard AWS A5.10 requirements for welding on aluminum. Procedures, welders, and welding operators shall conform to AWS requirements as contained in AWS B3.0 and C5.6 for aluminum.

The cabinet shall be furnished with two lifting eye plates on either side of the top for lifting the cabinet and positioning it. Each lifting eye opening shall have a minimum diameter of 0.75 inch and support a weight load of 1,000 pounds. All external bolt heads shall be tamperproof.

a. **Doors**

The cabinet shall be supplied with front and rear doors, each equipped with a lock and handle. Each cabinet door shall have no fewer than three stainless steel hinges or alternately, one full-length piano hinge. Hinges shall be made of 14-gauge stainless steel and the stainless steel hinge pins shall be spot-welded at the top. The hinges shall be mounted so that they cannot be removed from the door or cabinet without first opening the door. The doors and hinges shall be braced to withstand a 100-pound-per-vertical-foot of door height load applied vertically to the outer edge of the door when standing open. There shall be no permanent deformation or impairment of any part of the door or cabinet body when the load is removed.

Each door opening shall be double-flanged on all four sides. The doors shall include a closed-cell, neoprene gasket seal permanently bonded to the inside of each door such that the neoprene forms a weather-tight seal when the door is closed The Engineer may approve the use of alternative cabinet designs that use special material combinations and gauges provided the door materials are non-corrosive, weatherproof in their design, and meet or equal the structural requirements stated herein.

b. **Latches**

All cabinet doors shall be furnished with a three-point latching system. The latching system shall consist of the following latching points:

1. Center of the cabinet (lock).
2. Top of the cabinet – controlled by the door handle.
3. Bottom of the cabinet – controlled by the door handle.

Latching points 2 and 3 shall remain in the locked position until the main cabinet door lock is unlocked. When the locks in points 2 and 3 are unlocked, rotation of the door handle shall allow the main door to swing open. The locking mechanism shall be equipped with nylon rollers to secure the top and bottom of the door. Rollers shall be fabricated from nylon with a diameter of at least 8/10 inch.

All cabinets shall be furnished with a door stop that retains the main door open in a 90-degree and 135-degree position.

The doors shall be equipped with the Department's standard tumbler lock, Number 9R48773, or shall be keyed as directed by the Engineer, with stainless steel hardware that allows the door to be secured using a padlock. Two heavy duty keys shall be provided with each cabinet.

2. **Electrical Specifications**

All equipment furnished shall conform to applicable UL, NEC, EIA, ASTM, ANSI and IEEE requirements. Surge Protection Devices (SPD) shall be provided for the main AC power input at the service panel assembly, and on both sides of all electronics as required by the sections above in this specification. The SPD shall be accessible from the front of any panel used in the cabinet. The SPD for the cabinet's main AC power input shall be connected on the load side of the cabinet circuit breaker.

All wiring in the ITS controller cabinet shall conform to NEC requirements. Only stranded copper conductors shall be used. All wiring shall be laced.

a. **Service Panel Assembly**

A service panel assembly shall be provided to function as the entry point for AC power (50 Amp, minimum, at 240V) to the cabinet and the location for power filtering, surge protection and equipment grounding. Branch circuits, SPD, and grounding shall be provided only as required for the ITS device-connected load served by the cabinet, including ventilation fans, internal lights, electrical receptacles, etc.

Only circuit breaker panels that are UL listed, conforming to Federal Specification W-P-115C, and complying with NEMA standards shall be used. Circuit breaker panels shall be mounted so that the switches are accessible without having to reach around any other equipment in the cabinet. Branch circuit breakers shall be molded case units with quick make, quick break, and trip free mechanisms. Circuit breakers shall be UL listed, conform to Federal Specification W-C-375B, and comply with NEMA standards. Circuit breakers shall be fixed trip type.

ITS controller cabinets shall be equipped with a 240V/50A pin-and-sleeve receptacle and manual transfer switch for connection to an external portable generator. The pin-and-sleeve receptacle shall be compatible with CS6369-type generator plugs, or the Contractor shall furnish a mating adapter cable.

b. **Terminal Blocks**

All electrical inputs and outputs shall be terminated on terminal blocks where the voltage and current rating of the terminal block is greater than or equal to the voltage and current rating of the wire(s) connected to it.

The connector harnesses for the ITS devices and other accessory equipment shall be wired into the cabinet circuitry.

All conductors shall be either terminated on terminal blocks using insulated, crimp-type terminal lugs of the appropriate size to accommodate the conductor to be terminated, or terminated on DIN-rail terminal blocks. Insulated, crimp-type lugs shall be used for the termination of conductors when two or more conductors are terminated on field wiring terminal block screws or a terminal ring. All terminal block circuits shall be numbered. The terminal blocks shall be covered with a clear insulating material to prevent inadvertent contact.

Grounding electrode and grounding electrode conductors shall be connected using exothermic welds as indicated in Section 700.05.

c. **Ground Bus Bar**

All ground bus bars shall be fabricated from a copper alloy material compatible with copper wire. All ground bus bars shall have at least two positions where a #6 AWG stranded copper wire can be attached.

The ground bus bar shall be mounted on the side of the cabinet wall adjacent to the service panel assembly for the connection of AC neutral wires and chassis ground

wires. If more than one ground bus bar is used in a cabinet, use a minimum of a #8 AWG copper wire to interconnect them.

d. **Power Distribution Assembly**

A power distribution assembly shall be furnished that fits in the EIA 19-inch rack and provides for protection and distribution of 120/240 VAC power.

e. **Interior Lighting**

The controller cabinet shall be furnished with two 20-watt fluorescent lamps (or equivalent LED lighting) and clear shatter-proof shield assemblies mounted on the inside front and rear top of the cabinet. The lamps shall be unobstructed and able to cast light on the equipment. The controller cabinet shall be equipped with door-actuated switches so that the lamps automatically turn on when either cabinet door is opened and go off when the doors are closed.

f. **Power Distribution Strips**

Each controller cabinet shall be equipped with a power distribution strip. The power distribution strip shall have six NEMA 5-15 receptacles. Overcurrent protection shall be provided by a resettable overload 15 amp circuit breaker. The power distribution strip shall also provide receptacle isolation to prevent plugged-in components from interfering with one another. Power distribution strips shall be IP-addressable and have the ability to reset each receptacle remotely.

The power strips shall have integral indicator lights that are lit while the strip is powered on. The cord and plug shall conform to standards addressed in Article 400 (Flexible Cords and Cables) and Article 210 (Branch Circuits) of the NEC. The power strips shall provide integral EMI/RFI protection conforming to UL 1283.

g. **UPS Receptacle**

A receptacle shall be included in the controller cabinet that enables the Uninterruptible Power Supply (UPS) to be powered as described below in this specification.

(d) **Controller Cabinets**

1. **Mechanical Specifications**

a. **Rails**

The controller cabinet shall be supplied with four cabinet rails that form a cage for the purpose of mounting miscellaneous wiring panels and various mounting brackets. Rails that extend the length of the cabinet's sides shall be used, starting from the bottom of the enclosure. The rails shall be either 0.1345-inch thick plated steel or 0.105-inch thick stainless steel. The rails shall be keyhole designed with slots 2 inches on center with a top opening of 5/8 inch in diameter to allow the insertion of a 5/8-inch by 1-inch carriage bolt. The rails shall be 1 1/2 to 2 inches wide by 1/2 inch deep. Unistruts or other rail types shall not be used.

The rails supplied shall be drilled and tapped for 10-32 screws or rack screws with EIA universal spacing.

b. **Racks**

The ITS controller cabinet shall include a standard 19-in EIA/TIA equipment rack centered in the cabinet for mounting of the devices. The clearance of the racks between the rails shall be 17.75 inches.

c. **Shelf**

A level, rollout internal shelf, with a minimum work area measuring 10 inches by 10 inches shall be installed in each cabinet. The shelf shall be capable of maintaining a constant 20-pound load without deflection. The shelf position shall be adjustable, with a maximum of 2-inch increments, from the top of the load panel to 12 inches from the top of the controller cabinet.

d. **Ventilation**

A louvered vent at the bottom of the main door shall be provided to maintain ventilation throughout the cabinet. The louvered vent depth shall not exceed 0.25 inch. The intake vent shall be made rain tight through the use of a water-deflecting ventilation panel on the inside of the main door securing the filter to the door. This panel shall form a shell over the filter to give it mechanical support, and shall be louvered to direct the incoming air downward.

An easily removable, reusable filter shall be provided that is held in place with a bottom trough and a spring-loaded upper clamp. A filter that measures no less than 16 inches by 12 inches by 7/8 inch thick shall be provided. No incoming air shall bypass the filter. The bottom trough holding the filter shall be designed in such a manner that any accumulated moisture shall be drained to the outside of the controller cabinet.

The ITS controller cabinet shall be equipped with dual thermostatically controlled fans located inside at the top of the cabinet. UL-listed exhaust fans having a minimum air flow rating of 100 cubic feet per minute shall be used. The electric fan motors shall have ball or roller bearings and be rated for continuous duty, with a service life of at least five years. Exhaust air shall be vented through openings in the roof of the controller cabinet.

The thermostats that activate the fans shall be mounted on the inside top of the cabinet. The thermostats shall be user-adjustable to allow temperature settings ranging from a minimum of 70° F to a maximum of 160° F. The thermostat shall activate the fans within ±3° of the set temperature. The thermostats shall be rated for continuous on-off use and have a service life of at least five years.

e. **Sunshields**

If the cabinet is provided with sunshields, as indicated in the plans, the sunshields must be mounted on standoffs that provide an air gap of at least one inch between the exterior cabinet walls and the sunshields. Sunshields shall be fabricated from

5052-H32 aluminum sheet that is 0.125 inch thick. Sunshield corners shall be rounded and smoothed for safety.

2. **Physical Specifications**

The ITS controller cabinet shall be constructed of unpainted sheet aluminum alloy 5052-H32 with a minimum thickness of 0.125 inch. The cabinet shall have a smooth, uniform natural aluminum finish without rivet holes, visible scratches, or gouges on the outer surface. The Engineer may approve the use of other finishes provided approval is obtained from the Engineer in advance of the Contractor ordering such equipment.

The minimum dimensions for cabinets are listed below.

Cabinet Type	**Required Cabinet Dimensions in Inches**		
	Height	Width	Depth
Pole Mount - 336S	46 - 48	24 - 26	22 - 24
Ground Mount - 334	66 - 68	24 - 26	30 - 32

(e) **Communications Hub Assembly**

A Communications Hub Assembly shall consist of an air conditioned, double wide cabinet with UPS and backup generator assembly. The Communications Hub Assembly shall serve as the housing for the field installation of a Primary Network Switch and associated termination and connectivity of fiber optic backbone cables, as well as other ITS field equipment when specified in the Contract.

1. **Mechanical Specification**

The Contractor shall furnish a double wide cabinet meeting the following minimum requirements:

- Interior cabinet dimensions shall be sufficient to house all of the equipment proposed to be installed within the cabinet, including but not limited to: two (2) 96-fiber (minimum) Fiber Distribution Centers, Primary Network Switch, rack mount air conditioner, surge suppression, grounding bars, UPS, transfer switch, and cabinet power.
- Two (2) full size front doors and two (2) full size back doors
- Two (2) 19” EIA racks
- Louvered air intake in doors with filters
- Base mount cabinet with anchor bolts
- Insulation (doors, walls and ceiling)
- One full shelf minimum rack width

The Contractor shall furnish a 19" rack-mountable or exterior cabinet mountable, air-cooled, air conditioner with heater that is intended for use in an outdoor traffic cabinet when required. The air conditioner shall be thermostatically controlled. The air cooling capacity of the air conditioner shall be appropriately sized for the cabinet in which it will be housed with consideration of the heat produced by the equipment to be installed in the cabinet; the internal cabinet temperature due to the environmental conditions; and the temperature requirements (operating range) of the equipment to be installed. The air conditioner shall be UL certified and shall be CFC free.

The cabinet shall be designed so that ambient air intake will be through a vent in the front door of the cabinet to the condenser section of the air conditioner. Warm air from the condenser shall be expelled through a vent in the back door of the cabinet.

2. **Uninterruptible Power Supply (UPS)**

A UPS shall be provided at cabinet locations designated for backup power on the Plans. The Contractor shall provide UPS that meets the requirements of Section 802 and the following:

- The UPS assembly for use in the Hub shall provide complete non-interruptible power protection, voltage regulation and surge and spike protection for all ITS devices and communications equipment that are powered from within the Hub.

- The capacity shall be at least 3 kVA, but shall be sized to meet the power needs of the Hub enclosure-installed equipment for the duration as stated below.

    - The UPS shall be of sufficient design to fully operate all Hub-installed devices and communications equipment that are powered from the Hub and installed in the Hub enclosure/environmental enclosure for a minimum of four hours. The Contractor shall be responsible for determining the appropriate size/capacity of the UPS.

    - The Contractor shall supply the power and sizing calculations and all software and hardware manuals at the time of catalog cut submission.

    - Surge protection shall be rated at 4,000 joules, internal or external to the UPS.

The Contractor shall provide services to set up each UPS assembly as defined herein for installation in each cabinet.

3. **Physical Specifications**

The minimum dimensions shall be equivalent to a Type 334 cabinet with dimensions of approximately 66.9" (H) x 44.5" (W) x 30.2" (D). A full-sized door shall be approximately 58" (H) x 22" (W). Each cabinet door shall be full size and meet all the requirements of this specification.

Insulation shall be Low-e type, shall have an "R" value of 5 or better, and have aluminum facings. Insulation shall provide a Class A, Class 1 fire rating.

(f) **Permanent Generator Assembly**

1. **Mechanical Specifications**

The generator assembly shall operate on liquid propane (LP) fuel. The generator shall be a fixed mount type. The generator enclosure shall be coated with electrostatic applied powder paint, baked, and finished to the manufacturer's specifications. The color will be manufacturer's standard.

The generator set shall be packaged with a sound attenuating enclosure. The enclosure shall be completely lined with sound deadening material. This material must be of a self-extinguishing design. The generator shall be rated for an audible noise level of 65 dBA (or better) at 3 feet.

The Contractor shall provide a concrete foundation designed to accommodate the generator and fuel tank equipment designated in this Specification. Concrete pad foundation design to be provided by the Contractor. The design shall be submitted to the Engineer of Record for approval prior in installation. The Contractor shall provide all hardware and materials necessary for the associated concrete pad foundation.

The operating end of the equipment (including all material handling equipment and the entire dispensing system) and any part of the LP gas system or container which is exposed to vehicular traffic shall be protected from damage by vehicular traffic by concrete bollards. The bollards shall extend at least 24 inches beyond any part of the LPG transfer system or container which is exposed to vehicular traffic. Bollards shall be round, six (6) inch diameter by four (4) feet tall, steel sleeved, and filled with hydraulic cement concrete. The Contractor shall place steel sleeves in the concrete foundations. Bollard tops shall be rounded off by hand. Bollards shall be painted Federal Yellow after curing. Bollards shall be spaced no further apart than 4 feet around the perimeter of the foundation area.

The fuel tank shall be an above ground tank sized and designed to ensure starting and running of the generator set under the anticipated full load for a period of not less than seventy-two (72) hours, at an ambient temperature of 20 degrees F. The fuel tank shall be fabricated and marked in accordance with Section VIII, Division 1, of the edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, latest revision. Fuel tank shall include a percentage full indicating device. The fuel tank shall include the required pressure/gas flow regulator(s) and shut off valves in accordance with NFPA 54, NFPA 58, and as required by local and/or state regulations. The fuel tank shall include all required components for a complete and functional delivery of LP gas to the generator set including, but not limited to, manual shut-off valve, fuel filter, line service regulator, solenoid fuel shut-off valve to open when generator engine runs, and gas flow regulator. The fuel tank shall be securely anchored to the concrete foundation per manufacturer's recommendations.

An 80% charge of LP gas in the fuel storage tank shall be provided at the time of final acceptance by the Owner. Complete charges of antifreeze and oil shall also be provided. LP gas shall meet the Gas Processors Association (GPA) Standard 2140-97 Liquefied Petroleum Gas Specification and Test Methods.

The LP gas tank shall be grounded by a separate, adequate ground. Grounding shall consist of a grounding electrode placed at a sufficient depth to ensure grounding of any static charge generated, and shall be connected to the tank by copper wire equivalent in conductive capacity sized per tank manufacturer's recommendations. The ground wire shall be attached by a means that ensures a good electrical bond.

The LP gas storage tanks shall not be introduced to a source of possible ignition within 10 feet of tank having volumes of 125 to 500 gallon, or 25 feet of tanks having volumes having volumes of 501 to 2,000 gallons. Combustible materials, i.e., weeds, brush, trash, etc., shall not be kept in close proximity to propane tanks.

The LP gas tanks and any of its parts shall not be located within 10 feet of a vertical plane beneath overhead electric power lines that are more than 600 volts.

Tank shall be labeled with the following:

- A "no smoking," sign or decal with red letters at least 2 inches high on a white or aluminum background prominently displayed.

- A sign with letters at least 1/2 inch high with the following instructions: "Extinguish all pilot lights and open flames"; "Vehicle must be vacated during filling process"; "Turn off engine."

- The nature of the tank contents (Propane). The letters will be at least four inches high, easily visible to the public and in sharp contrast to any background color.

- Sign displaying, "Propane Emergency Shutoff." The letters shall be at least one inch high and in sharp contrast to any background color.

- Provide a metal band on an adjacent bollard with the following information engrave/stamped: The vendor's company name and an emergency vendor point of contact, and shall be current throughout the contract.

- Vendor point of contact shall be available 24 hours a day, seven days a week.

2. **Electrical Specifications**

The generator assembly shall be sized to provide backup power to all ITS Communications Hub Assembly components and any equipment it provides power to, including but not limited to the air conditioner and primary network switch, for a minimum of 3 days at 100% load. This sizing shall not take into account the time during which the cabinet will receive backup power from the UPS. The generator shall be a minimum of 8 kW.

The generator assembly shall include an automatic transfer switch (ATS) sized in accordance with the cabinet electrical requirements and that of the generator.

3. **Environmental Specifications**

The generator assembly shall be capable of operating in temperatures ranging from -10C to +50C, with a relative humidity of 5 to 95%.

4. **Physical Specifications**

The generator assembly shall include a minimum of two propane fuel tanks, an appropriately sized transfer switch, and all necessary wiring, conduit, etc. that are required for a complete installation.

5. **Communication Standards**

The generator assembly shall include a management port for communications by laptop computer in the field, as well as an RJ-45 port for Ethernet communications through the Primary Network Switch.

6. **Management Standards**

The generator assembly shall include a controller system that records information about the generator's status. The controller shall provide alerts when the generator comes on, indicating a power loss in the field.

(g) **Solar Power Assembly**

This work shall consist of furnishing and installing a solar power assembly to provide power for CCTV cameras, VDS and/or RWIS and associated controller cabinets with ITS equipment and network devices including, but not limited to, managed field Ethernet switches, digital video encoders, CCTV interface panels, and Vehicle Detector interface assemblies.

1. **Mechanical Specifications**

The solar panel must be able to function in different climate conditions. The solar power assembly shall include all solar panels, batteries, voltage regulator, wiring, conduit, and a NEMA 3R pole-mount cabinet to house the batteries and voltage regulator. The size and quantities of the solar panels and batteries shall be designed to enable the associated ITS devices to operate for up to 7 consecutive sunless days. The solar panel assembly design, with calculations (including solar array sizing calculations and parameters used) shall be submitted to the Engineer for review and approval prior to ordering equipment. Each solar cell shall be bypass diode protected to prevent power loss if a module is temporarily shaded. The crystalline silicon solar module shall consist of cells that are permanently encapsulated between a tempered glass cover and layers of ethylene vinyl acetate (EVA) pottant or encapsulant with a polyvinyl fluoride (PVF) and aluminum foil back sheet to provide a moisture free environment. Units without foil backing sheets must have Underwriter Laboratory (UL) approval. The module frame shall be made from extruded aluminum alloy and be adequately sized to attach the required size and quantity of solar panels. The mounting bracket shall use tamper proof hardware to secure the Photovoltaic (PV) module to the frame. An ultraviolet (UV) resistant, weatherproof junction box providing wire termination for up to #8 AWG wiring shall be provided with the PV module.

2. **Electrical Specifications**

The solar power assembly shall be configured for nominal 12 VDC and be capable of recharging the system to full capacity after 6 hours of continuous operation, in 3 hours +/- 0.5 hours during optimum sun conditions in December.

The batteries shall meet the following minimum requirements:

- Rechargeable for photovoltaic application
- Valve regulated lead-calcium gelled electrolyte

- Polypropylene case

The voltage regulator shall meet the following minimum requirements:

- Minimum of 15v for battery charging
- Begin charging when battery voltage is 13.3v or less
- Discontinue charging when battery voltage is 14.5v
- Dormant current of 15mA or less

3. **Environmental Specifications**

The cabinet shall be pole mounted and NEMA 3R rated. All components of the solar power assembly shall comply with NEMA TS-2 Standards.

4. **Physical Specifications**

The NEMA 3R cabinet shall be of sufficient size to house all of the batteries and the charge regulator plus a minimum of 10% additional capacity. The Contractor shall furnish and install all mounting materials required for the cabinet installation.

The solar panels shall meet the following minimum requirements:

- Cells are laminated between ethylene vinyl acetate and tempered glass
- Capable of multiple arrays and series or parallel wiring configurations
- Extruded aluminum frame
- Mounting hardware

The Solar Panel mounting bracket shall be designed to conform to the current edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.*

801.04—Procedures

(a) **Controller Cabinets**

Cabinet installations, whether ground-mounted on concrete foundations or pole-mounted on wood or steel poles, shall be in accordance with the detail drawings provided in plans. The Contractor shall furnish the cabinet with the necessary hardware for either ground-mounted or pole-mounted installations. Pole-mounted field cabinets shall have mounting brackets on both sides so that the cabinet doors are fully functional. The cabinet foundation for ground-mounted cabinets shall be in accordance with Section 700.

The ground mounted controller cabinet shall be supplied with a removable base plate. The cabinet shall have two aluminum plates welded inside for anchoring the cabinet to a concrete or

composite type base. The plates shall be fabricated from aluminum alloy 5052-H32 and shall be 4 inches wide by 0.125 inch thick and shall have four 1-inch diameter holes.

Controller cabinets for DMS shall be ground mounted and placed 100 feet in advance of the DMS structure such that messages can be clearly observed from the cabinet, unless otherwise noted on the Plans and/or approved by the Engineer.

Provisions shall be made for all telephone, data, control, and confirmation connections between the ITS device and controller cabinet, and for any required wiring harnesses and connectors. All wiring panels (terminal blocks) shall be neatly finished and clearly and permanently marked with identifications applied by silk screening. All conductors and communication cable shall be neatly arranged in the cabinet and bundled in groups with cable ties. The Contractor shall use permanent labeling for all cabling in the cabinet to identify direction of communications for fiber jumpers and communications connections for ITS devices. The SPD shall be wired in such a fashion as to allow removal and replacement without disconnecting power to the entire cabinet (i.e., using a dedicated breaker).

The cabinet manufacturer's name shall appear only on the inside of the main cabinet door, along with the year and month of the cabinet's manufacture. This information shall be attached to the door by a method that is water resistant. The controller cabinet shall be provided with a unique serial number that is engraved on a metallic plate epoxied to the inside of the cabinet on the upper right-hand side wall.

A heavy-duty re-sealable plastic bag shall be mounted on the backside of the main cabinet door for storing cabinet prints, a list of terminal block connections, and other documentation that may be subject to damage when exposed to direct sunlight or moisture.

All equipment shall be placed in the cabinet according to the manufacturer's recommendations. A minimum clearance of 6 inches shall be provided between the top of the cabinet and the top of any equipment placed on the top shelf of the cabinet. A minimum clearance of 2 inches shall be provided between each side of the cabinet and the equipment placed on the cabinet shelves.

(b) **Communications Hub Assembly**

Prior to the installation of the ITS Communications Hub Assembly, the Contractor shall submit details of the proposed assembly for review and approval by the Engineer. Submittal information shall include but is not limited to product cut sheets, proposed plan view of the assembly in its entirety, wiring diagrams, cabinet equipment layout, and calculations for the required generator and UPS run times. All materials shall be installed in accordance with manufacturer recommendations.

The cabinet shall be installed on the foundation in accordance with requirements detailed in these specifications and shall include a concrete technician pad as shown in Road and Bridge Standards installed at the front and rear sides of the cabinet.

(c) **Generator Assembly**

The generator shall be installed to minimize the possibility of theft. A proposal outlining the installation approach shall be submitted to the Engineer for approval. The generator, fuel tanks and fuel lines shall be installed in accordance with all relevant and appropriate state and local

standards and codes. Fuel tanks shall be filled with gas upon installation to enable testing of the assembly during the acceptance period and to enable proper functioning during automatic runs thereafter. Provide the generator manufacturer's operation and repair manuals, schematics, cut sheets and any other documentation required for generator operation, maintenance and repair. The documentation shall be in English.

(d) **Solar Power Assembly**

This work shall consist of mounting the solar panel(s) with mounting bracket and the battery cabinet on the CCTV, VDS or RWIS structure at heights specified by the Engineer. The installation locations of poles and structures may require slight adjustments to maximize sun exposure for the solar panel assembly. The Contractor shall obtain approval of final site location and orientation from the Engineer prior to installation.

The solar power assembly shall be installed in accordance with the manufacturer's recommended installation procedures and the Plans. The Contractor shall mount and orient the solar panel(s) to maximize sun exposure in accordance with the manufacturer's recommendations. Solar panels shall be mounted at an angle to enable runoff of rain and snow. Power shall be provided from the solar power assembly to the controller cabinet by connecting to the UPS in the cabinet. No wires from the solar panel(s) to the battery and from the battery to the controller cabinet shall be exposed. Wires shall be installed in liquid tight flexible conduit, run inside a pole, or other method approved by the Engineer. The cost to furnish and install any conduit for the solar power assembly installation shall be included in the cost of the Solar Power Assembly. The solar power assembly shall be electrically grounded in accordance with manufacturer recommendations.

The Contractor shall submit an installation plan to the Engineer for approval prior to mounting the solar power assembly equipment in the field. The installation plan shall include details of the wire routing and any associated conduit, as well as grounding.

The Contractor shall provide the solar power assembly manufacturer's operation and repair manuals, schematics, cut sheets and any other documentation required for solar power assembly operation, maintenance, and repair. The documentation shall be in English.

(e) **Broadband Service**

Where leased line services are designated in the Plans, the Contractor shall coordinate with the utility provider for the installation of broadband telephone service (e.g. T-1, DSL, etc.) for each designated CCTV location on the Plans. The Contractor shall request approval from the Department a minimum of three (3) weeks prior to service installation. Telephone services shall be ordered from services available through the VITA statewide telecommunication contracts unless otherwise approved by the Engineer. The Contractor shall install the proposed equipment cabinets prior to requesting telephone service unless otherwise approved by the Engineer. The Network Interface Device (NID) shall be supplied and installed by the communications provider in coordination with the Contractor.

The Network Interface Device (NID) shall be considered the demarcation point for the leased line communications installations. All cables and connectors up to the NID shall be provided by the communications provider. The Contractor shall be responsible for all interconnectivity of communications from the NID to the equipment cabinet and for all coordination with the communications provider.

(f) **Electrical Service**

Install electrical service poles or service entrance panels at the locations shown in the Plans in conformance with Section 700. Electrical service will be measured and paid for in accordance with Section 700.

Where electrical services are designated in the Plans, coordinate with the utility provider for the installation of the electrical service for each designated ITS device location on the Plans. Approval shall be requested from the Department a minimum of three (3) weeks prior to the service installation.

(g) **Warranty**

1. **General**

The manufacturers' warranties on SPD and controller cabinets shall be fully transferable from the Contractor to the Department. The Contractor shall ensure that these warranties require the manufacturer to furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department within 10 calendar days of notification by the Department.

Warranty periods shall begin on the date of final acceptance by the Department.

2. **Surge Protection Devices (SPD)**

The Contractor shall provide a SPD that is warranted by its manufacturer against any failures caused by electrical events for a period of not less than 5 years or the SPD device manufacturer's standard warranty period, whichever is greater.

The term "failure" for warranty replacement is defined as follows:

- Parallel-connected, power-rated SPD units are considered in failure mode when any of the indicating lamps shows failure mode when power is applied to the terminals at the unit's rated voltage, or the properly functioning over-current protective device will not reset after tripping.

- Series-connected, low-voltage power, data, or signal units are considered in the failure mode when an open circuit condition is created and no data/signal will pass through the SPD device.

In the event that the SPD, including any component of the unit, should fail during the warranty period, the entire SPD shall be replaced by the manufacturer at no cost to the Department.

3. **Controller Cabinet**

The controller cabinet, including all components, shall have a manufacturer's warranty covering defects in assembly, fabrication, and materials for a minimum of two years from the date of final acceptance. If the manufacturer's warranties for the cabinet and components are for a longer period, those longer period warranties will apply.

4. **Communications Hub**

The communications hub with UPS, generator and all associated components shall have a manufacturer's warranty covering defects in assembly, fabrication, and materials for a minimum of two years from the date of final acceptance. If the manufacturer's warranties for the communications hub and components are for a longer period, those longer period warranties will apply.

5. **Solar Panel Assembly**

The solar power assembly and all associated components shall have a manufacturer's warranty covering defects in assembly, fabrication, and materials for a minimum of two years from the date of final acceptance. If the manufacturer's warranty(ies) for the solar power assembly are for a longer period, those longer period warranties will apply.

(h) **Testing**

The Contractor shall provide a 10-day advance notice of dates and times scheduled for tests that require the presence of Department's representative. The Contractor shall provide labor, equipment, fuel, and consumables required for the specified tests.

1. **Electrical Equipment Tests**

Low-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the automatic transfer switch. Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energizing. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be equal to or greater than manufacturer's requirements.

Cabinet electrical, equipment grounding, and solar charging equipment shall be tested in accordance with manufacturer recommendations.

2. **Inspection for Generator Installation and Setup**

The following inspections shall be performed by the Contractor, after complete installation of the engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Checks applicable to the installation shall be performed. The results of these physical inspections shall be documented by the Contractor and submitted to the Engineer. The Contractor shall present manufacturer's data for the inspections designated at the time of inspection. Inspections shall verify that equipment type, features, accessibility, installation, and condition are in accordance with the manufacturer's recommendation\instructions and the contract specification requirements. Inspect the following:

- Coolant fill level
- Coolant line connections
- Coolant hoses
- Combustion air filter

- Oil filter
- Oil fill level
- Oil line connections
- Oil lines
- Fuel type
- Fuel level
- Fuel-line connections
- Fuel lines
- Fuel filter
- Battery-charger connections
- Wiring and terminations
- Instrumentation
- Hazards to personnel
- Base
- Exhaust system
- Enclosure
- Engine & generator mounting bolts (proper application)
- Inspect physical and mechanical condition of the generator set
- Verify correct connections
- Verify that all required grounding and shorting connections provide good contact
- Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

3. **Inspections for Cabinet**

   Inspections shall verify that equipment cabinet type, features, accessibility, installation and condition, and internal wiring/labeling are in accordance with the contract specification requirements.

4. **Safety Run Tests for Communication Hub Assembly Generator**

   - Perform and record (document) engine manufacturer's recommended pre-starting checks and inspections. Include as a minimum: checking of coolant fluid, fuel, and lube-oil levels.

- Start the engine, record the starting time, conduct and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

- Activate the manual emergency stop switch and verify that the engine stops.

- Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set at no load until the output voltage and frequency stabilize.

- Operate the engine generator-set for at least 1 hour under actual load.

If the generator fails to start or run in accordance with manufacturer's provided data, the Contractor shall notify the Department.

5. **Functional Acceptance Tests for Communication Hub Assembly Generator**

The tests shall be performed at each site. Upon successful test completion, the Contractor shall provide the Engineer with a written test report within 15 calendar days of test completion showing the tests performed, date of testing, and the results of each test. The report shall include the completed test data and certification that the test results fall within the manufacturer's recommended limits and meet the specified requirements performance. The Engineer reserves the right to witness final acceptance tests. Testing shall include but not be limited to verifying proper functioning of the following automatic and manual operations. The Contractor's testing shall include but not be limited to:

- Loss of Utility: Initiate a normal power failure with connected load. Record time delay on start, cranking time until engine starts and runs, time to come up to operating speed, voltage and frequency overshoot, and time to achieve steady state conditions with all switches transferred to emergency position.

- Return of Utility: Return normal power and record time delay on retransfer for each automatic transfer switch, and time delay on engine cool down and shutdown.

- Manual starting

- Emergency stop

(i) **Training/Demonstration**

Upon completion of the work and at a time approved by the Engineer, the Contractor shall provide training by a qualified instructor to Department personnel in the proper operation and maintenance of the equipment. Department personnel shall receive training comparable to the equipment manufacturer's factory training. The minimum training shall be one 2 hour instruction session for generator system monitoring and cabinet electrical/mechanical equipment, one 2 hour instruction session for generator and general cabinet equipment operation, and one 2 hour instruction session for generator and cabinet maintenance, where included in the contract. One 2 hour instruction minimum training session shall be required for solar power systems operation and maintenance, where solar powered systems are included in the contract.

801.05—Measurement and Payment

The work specified for surge protection devices will not be paid for directly, but will be considered incidental to the installation of ITS devices and systems requiring their installation as specified herein.

No separate payment will be made for the conduit or other incidental items necessary to provide a fully functional deployment.

ITS Controller cabinet will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing, installing and testing of all equipment and materials, and for all tools, labor, hardware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work. The unit price for pole mounted and ground mounted controller cabinets shall include the cost to furnish and install a concrete technician pad (4' wide x 3' long x 4" deep) on the front and back sides of the cabinet.

Concrete foundations for controller cabinets will be measured in units of each and will be paid for at the contract unit price per each in accordance with Section 700.

Communications hub will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing, installing and testing of all equipment and materials, and for all tools, labor, hardware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work. The unit price for communications hubs shall include the cost of the cabinet, UPS, generator, fuel tanks, transfer switch, bollards, foundation air conditioner, generator/fuel tank foundation, providing design and any associated items for a complete installation. A (4' wide x 3' long x 4" deep) technician pad on the front and back sides of the hub shall be included in the contract unit price for each ITS communications hub.

Where designated on the Plans for standard ITS controller cabinets, the cost of the Uninterruptible Power Supply (UPS) will be measured and paid for separately in accordance with Section 802. For Dynamic Message Sign (DMS) locations, UPS will be measured and paid for in accordance with Section 804 as applicable to the contract.

Generator assembly, when specified separately, will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing, placement, and testing of all equipment and materials, and for all tools, labor, hardware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work.

Solar power assembly (CCTV), (VDS), or (RWIS) will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing, installing and testing of all equipment and materials, and for all tools, labor, hardware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work. The unit price for solar power assemblies shall include the cost of the solar panel, mounting bracket, batteries, battery cabinet, and any associated items to provide backup power to the designated ITS device(s) and/or controller cabinet.

Broadband service will be measured in units of each and will be paid for at the contract unit price per each. The price bid shall be full compensation for the telephone service network interface device, coordinating with VITA and the service provider, mounting, fittings, miscellaneous cabling, installation and testing, documentation, and for all materials, tools, labor, and incidentals necessary to complete the work. Network devices (e.g. routers, switches, etc.) will be measured and paid for separately.

Payment will be made under:

Pay Item	Pay Unit
ITS Controller cabinet	Each
ITS Controller cabinet w/ sunshields	Each
Communications hub	Each
Generator assembly	Each
Solar power assembly (CCTV)	Each
Solar power assembly (VDS)	Each
Solar power assembly (RWIS)	Each
Broadband service	Each

SECTION 802 - UNINTERRUPTIBLE POWER SUPPLY FOR ITS APPLICATIONS

802.01—Description

This work shall consist of furnishing and installing an Uninterruptible Power Supply (UPS) assembly at ITS asset locations consisting of CCTV Cameras, Vehicle Detectors, and Roadway Weather Information Systems in accordance with these specifications and as shown on the plans or as directed by the Engineer.

802.02—Equipment

The UPS shall be specifically designed for commercial ITS applications. UPS shall be UL 1778 and FCC, Part 15, Cat. B approved.

A UPS assembly shall be furnished and installed in all assets designated in the Plans to provide complete non-interruptible power protection, voltage regulation and surge and spike protection for electrical and communication components. The UPS assembly shall be a commercially available package containing a UPS with batteries, surge suppression, LED indicators, customizable output relays and input contacts, and network management cards (IP addressable) wiring connectors, software, mounting brackets, and cables.

The UPS shall be provided with remote monitoring, control functions, and a software/firmware package that is web-based and, at a minimum, provides the ability to determine in real time the status of the commercial power (on-off), the status of the available UPS backup battery time at the rated UPS load (Hours/Minutes), on or off backup, and errors. The UPS shall be provided with a standard RJ-45, 10/100 network interface and a Cat5e jumper for interfacing to the Layer 2 Managed Field Ethernet Switch (MFES) located in the ground/pole mount ITS controller cabinet.

The UPS shall be of sufficient design and capacity to fully operate all devices and communications equipment for a minimum of three (3) hours. The Contractor shall determine the appropriate size/capacity of the UPS. In no case shall the UPS be smaller than 2KVA. The Contractor shall supply the calculations used to determine the appropriate size and capacity of the UPS and all software and hardware manuals at the time of catalog cut submission. The Contractor shall be responsible for installing the software, testing all functions, and setting the initial UPS parameters. The UPS shall instantly transfer the ITS controller cabinet to the battery back-up mode in

the event the main AC power source goes offline and shall conform to the following minimum requirements:

- The UPS size shall be suitable for installation in the ITS controller cabinet in which it is to be installed
- LED status indicators for “On-line”, “Battery On”, “Replace Battery”, and “Overload”

The Contractor shall provide services to setup each UPS assembly as defined herein for installation in each cabinet. The Contractor shall provide Uninterruptible Power Supply equipment and components meeting the following requirements:

(a) **Mechanical Specifications:**

The input line shall be a NEMA 5-20P plug with a 6 foot cord. It shall have five 5-15R (5 IEC 320) Standard backup receptacles and one 5-15R (5 IEC320) Standard surge-only receptacle.

If the UPS does not meet the minimum receptacle specifications above, the Contractor may opt to supply a UPS with a separated Power Distribution Unit (PDU). The standalone PDU shall meet the Electrical and Communications specifications below (except where noted), as well as these additional requirements:

1. **Physical Specifications**

The standalone PDU shall be rack or DIN rail mountable and shall not be larger than 2 rack units in size. The standalone PDU input line shall be a NEMA 5-20P with a 5’ cord (min.) or a terminal block connection compatible with the UPS connections.

2. **Environmental Specifications**

The PDU shall have the following minimum characteristics:

- Operating Temperature: -34 to 60° C (-30 to 140° F)
- Operating Relative Humidity: 10 to 80%

(b) **Electrical Specifications**

The acceptable input voltage shall be 75-164 VAC. The nominal input frequency shall be between 44 and 66 Hz, auto-selectable. Input protection shall be accomplished by resettable circuit breakers. UPS shall also conform to the following requirements:

- Power Output: 115 VAC single phase 60 Hz
- Output Connections: six (6) NEMA 5-15R
- Input Connections:
- NEMA 5-20P
- Surge protection shall be rated at 320 joules.
- Line filtering shall be full time multi-pole noise filtering (Does not apply to PDU)

- 0.3% IEEE surge let through, zero clamping response time meeting UL-1449 Brown-out voltage protection, 95 VAC, user adjustable

- Capable of recharging the batteries to 90% capacity within twenty-four (24) hours maximum (Does not apply to PDU)

1. **UPS Controller/Power Regulator**

   The UPS shall be have a transfer time of 10 milliseconds maximum. The UPS shall produce pure sine wave outputs that automatically conditions and stabilizes the line voltage. The UPS shall incorporate line-interactive voltage regulation that protects against all voltage irregularities. The UPS shall include EMI/RFI filtering to eliminate line noise and harmonics.

2. **Battery**

   External battery packs shall be supplied by the manufacturer of the UPS. The battery packs shall be 12 to 48 VDC and a minimum of 14.4 AH. The battery housing shall be rack mounted in a standard 19 inch rack. The external battery unit shall incorporate an internal charger with an unlimited runtime.

   - Battery output shall have selectable voltages of 108, 113, and 117 VAC. The on-line operation output voltage for the standard 115 VAC unit shall be 105-128 VAC.

   - The on-battery wave shape shall be true sine wave.

   - Typical recharge time shall be 2 to 5 hours from total discharge

   - Batteries shall be user replaceable and be maintenance free, leak-proof, sealed lead acid with suspended electrolyte with a minimum of three (3) year lifetime.

(c) **Environmental Specifications**

The UPS shall have the following characteristics:

- Operating Temperature: -35 to 74° C (-31 to 165° F)

- Operating Relative Humidity: 10 to 95%

(d) **Physical Specifications**

The UPS shall be no more than 16” deep and rack-mountable in a standard 19 inch wide rack.

(e) **Communication Standards**

The UPS unit shall include an Ethernet port and be supplied with a data cable and all software necessary to interface with existing Department platforms and protocols (SNMP, Telnet).

(f) **Management Capability**

The UPS supply access and monitoring shall be accomplished by remotely connecting through a Web browser and/or IP-based Telnet system.

802.03—Procedures

The Contractor shall install and integrate UPS components in the respective Communication Hub Cabinets and ITS Controller Cabinets in accordance with the electrical requirements for the respective asset as shown in the Contract.

(a) **Testing**

The Contractor shall be responsible for providing training and documentation to the Engineer and Department staff on logging in, configuration of IP addresses, and alarm capabilities. Test procedures shall be approved by the Department prior to commencement of testing.

The Contractor shall perform testing at each site. Upon successful test completion, the Contractor shall provide the Engineer with a written test report within 15 calendar days of the date testing is completed, showing the tests performed and the results of each test. The report shall include the completed test data and certification that the test results fall within the manufacturer's recommended limits and meet the specified performance requirements as stated herein and in the contract. The Contractor shall notify the Engineer at least one week in advance of testing so that the Engineer can be present to witness final acceptance tests. Testing shall include but not be limited to verifying proper functioning of the following automatic and manual operations. Testing shall include but not be limited to:

1. **Loss of Utility Power**

   Initiate a normal power failure with connected load. Record voltage, frequency overshoot, and if components/loads are operating within designated thresholds. Confirm battery levels are within manufacturer's specification for initial installation. Verify that network management transmits loss of utility power alert to central software. Run on battery power for an extended period of time (e.g. at least 3 hours).

2. **Return of Utility Power**

   Return normal power and record time to recharge batteries using network management communications. Verify that return of utility is recorded/transmitted by network management.

(b) **Warranty**

The UPS shall carry a manufacturer's warranty of no less than 3 years. The battery packs shall carry a warranty of no less than 3 years.

Warranty periods shall begin on the date of final acceptance of all work under the contract by the Department.

802.04—Measurement and Payment

Uninterruptible power supply for ITS Controller Cabinet (ITS-CC) will be measured in units of each and will be paid for at the contract unit price per each. The price shall include furnishing and installing the complete Uninterruptible Power Supply including batteries (with the number of batteries as recommended by UPS manufacturer), surge suppression, LED indicators, separated PDU (if opted for), customizable output relays and input contacts, network management cards (IP addressable), cables and cabling, soft-

ware, testing, training, certification, complete documentation, and all incidental items necessary for a complete and fully functioning uninterruptible power supply.

No additional payment will be made for UPS used in Dynamic Message Signs and in the Communications Hub. UPS for each of these type installations shall be incidental to the items as noted in Section 801 and 804, respectively.

Payment will be made under:

Pay Item	Pay Unit
Uninterruptible power supply (ITS-CC)	Each

SECTION 803 - CCTV VIDEO EQUIPMENT

803.01—Description

This work shall consist of furnishing and installing a closed circuit television (CCTV) camera (either analog or digital), digital video encoder, decoder, and mounting poles. The installed equipment shall provide unobstructed video images of the roadway, traffic, and other current conditions around a roadside CCTV field site, respond to camera control signals from the operator, and ensure video images can be transmitted to remote locations for observation.

803.02—Materials

(a) **Concrete** shall be Class A3 conforming to Section 217.

(b) **Reinforcing steel** shall conform to Section 223.

(c) **Aluminum** shall conform to Section 229 and shall be fabricated, welded, and inspected in accordance to Section 407.

(d) **Electrical items** shall conform to Section 238 and this specification.

(e) **Galvanizing shall** conform to Section 233.

(f) **Structural Steel** shall conform to Section 226.

(g) **Dissimilar metals,** when used together, shall have the contact surfaces isolated with an approved durable nylon washer, gasket, or other approved isolation material to prevent corrosion.

803.03—Equipment

(a) **Camera General Specifications** – The Contractor shall furnish a closed circuit television camera system meeting the following requirements:

1. **Electrical Specifications**

The CCTV camera system shall operate using a nominal input voltage at the cabinet of 120 volts alternating current (VAC). If the camera or any camera-related ancillary device requires operating voltages other than 120 VAC, appropriate voltage converters shall be provided. Ground loop isolators shall be provided and installed for affected each CCTV or any camera-related ancillary device. Power consumption shall not exceed 125 watts.

2. **Environmental Specifications**

The camera housing shall be a weather-tight enclosure carrying a National Electrical Manufacturer's Association (NEMA) 4X/IP-66 rating, or better. The non-pressurized dome-type and non-dome type housings shall be vented with a thermostat-controlled heater and blower. The pedestal housing for a non-dome type camera shall carry a NEMA 4x/IP-66 rating (or better).

All external connectors and cable through-holes shall have weather-tight fittings compatible with the size and type of cable/connectors used. Wires shall not protrude outside of the housing enclosure when mounted on metal poles.

The CCTV camera shall perform all required functions during and after being subjected to an ambient operating temperature range of -30º to 165º F, as defined in the environmental requirements section of the NEMA TS 2 standard. Humidity rating shall be 5% to 95%, non-condensing. The Contractor shall provide the Engineer documentation from the CCTV camera manufacturer certifying that the device has successfully completed environmental testing as defined in the environmental requirements section of the NEMA TS 2 standard. The heater/blower shall maintain internal temperatures within the manufacturer's required operating temperatures.

The housing shall protect the camera and other internal components from rain, dust, corrosive elements, and typical conditions found at a roadside environment. Verify and document that the CCTV camera, mounting hardware, and any other camera-related material exposed to the environment shall be designed for 90 mph winds, with a 30% gust factor, in accordance with the current AASHTO Standard Specifications.

3. **Mechanical Specifications**

CCTV cameras shall support a minimum of 64 presets, shall be capable of programmable tours; and include a minimum of eight (8) programmable sector/blackout privacy zones.

a. **Dome-type Cameras**

The positioner within the dome-type CCTV camera shall have a minimum automatic pan speed of 90 degrees per second to a preset camera position; maximum manual pan and tilt speeds that are programmable; maximum manual pan speed range that is adjustable from 1 degree to 90 degrees per second; and maximum manual tilt speed range that is adjustable from 1 degree to 90 degrees per second.

b. **Non-Dome Type Cameras**

The non-dome-type CCTV camera shall include an integrated pan/tilt mechanism capable of providing 360 degree continuous pan with a minimum 90 degree tilt range

(i.e. 0 to -90 degrees); provide variable speed control; have a preset position return accuracy of ± 0.36 degree, or less than 0.10% or better;

The positioner within the non-dome-type CCTV camera shall have a minimum automatic pan speed of 60 degrees per second to a preset camera position; that maximum manual pan and tilt speeds are programmable; that the maximum manual pan speed range is adjustable from 1 degree to 60 degrees per second; and that maximum manual tilt speed range is adjustable from 1 degree to 30 degrees per second.

The non-dome type camera may be equipped with a wiper mechanism that can be activated and deactivated remotely. When deactivated, the wiper shall park out of view of the camera for any zoom level. The wiper shall be made of a soft and durable material that when worn will not scratch the clear lens of the housing. The addition of the wiper shall not decrease the Ingress Protection Rating (IP) rating of the housing below IP-66.

4. **Physical Specifications**

a. **Dome-type Camera Housing**

The total weight of the outdoor-rated dome-type CCTV cameras (including the housing, sunshield, and all internal components) shall be less than 18 pounds. The outer body of the camera housing shall be distortion free clear plastic over the lens area. The outer body of the camera housing shall be white in color for the remainder of the housing.

b. **Non-Dome-type Camera Housing and Pedestal**

The total weight of the outdoor-rated non-dome-type CCTV cameras (including the pedestal, housing, sunshield, and all internal components) shall be less than 25 pounds. The housing window shall be distortion free clear plastic. The pedestal and camera housing of the camera shall be white in color.

c. **Cabling**

Each camera assembly shall be equipped with cables used for video feed, camera control including pan; tilt; zoom; (PTZ), communications signaling, and power supply. CCTV composite cables shall be connectorized at the camera end and unconnectorized in the cabinet. The unconnectorized end shall be terminated to the surge protection device (SPD). The cables shall be the full length of cable from the CCTV camera to the cabinet with an additional 10 feet of slack in the cabinet and with sufficient length for lowering device connectivity (full range) and splicing where applicable. The Contractor shall determine the appropriate cable lengths required for each site.

Spliced cable (shield or conductor) used for video, control, communications signaling, or power supply shall not be allowed. All conductors shall be identified by color and number. The Contractor shall identify the conductor function in the documentation included in the camera assembly documentation. The connectorized end connector shall be designed for use with the CCTV camera.

The cable furnished for power, signaling, control, and video must be compatible with these installation materials.

5. **Management Capabilities**

The CCTV camera shall be compatible with the current version of the Transportation Operations Center (TOC) software and any other camera operating software in the Contract. The CCTV camera shall be capable of remote control PTZ functions via the TOC software user interface.

(b) **Analog Camera**

Analog cameras shall be PTZ day/night color. The analog CCTV camera shall have a minimum 35X motorized optical zoom lens with automatic iris and Electronic Image Stabilization (EIS). The camera shall be capable of automatic and manual focus and iris control. The depth-of-field shall provide a clear image of roadside areas under all lighting conditions and have a maximum aperture of f/1.6. The cameras shall meet the camera general specifications and the following minimum requirements:

1. **Mechanical Specifications**

The CCTV camera shall provide the following features and capabilities:

- Day (color)/night (monochrome) switchover and iris control, with user-selectable manual and automatic control capabilities.
- Scene Illumination Sensitivity at 35 IRE:
- 0.6 Lux @ 1/60 shutter, or better (color mode)
- 0.002 Lux @ 1/2 second shutter, or better (mono mode)
- The camera shall be fully compliant with all aspects of the National Television Standards Committee (NTSC) specification, and produce NTSC compatible video.
- Minimum resolution of 470 horizontal and 350 vertical TV lines.
- Ability to produce clear, detailed, and usable video images of the areas, objects, and other subjects visible from a roadside CCTV field site. The video produced by the camera shall be true, accurate, distortion free, and free from transfer smear, over-saturation, and any other image defect that negatively impacts image quality under all lighting and weather conditions in both color and monochrome modes.
- User-selectable automatic gain control (AGC) that is peak-average adjustable to 30 decibels (dB).
- A minimum signal-to-noise ratio (S/N) of 48 dB, with AGC off, un-weighted, and a 4.5MHz filter.
- Automatic color balance that references the white areas of the scene through the lens.

- Automatic electronic shutter that is user-selectable from 1/60 to 1/10,000 of a second.

- A digital signal processor that provides a minimum 10X digital zoom.

- Programmable azimuth and compass display with ability to display pan and tilt position with a 1 degree resolution.

- The camera enclosure shall minimize glare and provide overexposure protection for the camera when pointed directly at the sun.

The camera shall provide titling and masking features, including, but not limited to: programmable camera title, programmable preset titles for each preset position, and programmable privacy zones. The programmable titles shall be a minimum of 18 characters per line, and shall be capable of generating and superimposing lines of English language text on the video image/stream. The text messages shall be stored in non-volatile memory.

2. **Communication Standards**

The CCTV camera shall produce National Television System Committee (NTSC) composite video output of 1 volt peak-to-peak (Vp-p) at 75 ohms. Command/control communications interfaces shall be compatible with video encoders using RS-222 and/or RS-485 (user selectable).

The camera shall be capable of communicating with other devices using Electronics Industry Alliance (EIA)-232 or EIA-422/485 at a rate of 9600 bps and higher. Default configuration shall be 19.2 kbps, unless otherwise approved by the Engineer. The camera system shall report camera position in relation to true north and field configured; provide status report data such as housing temperature, heater on/off, lens zoom position, auto iris on/off, and any other special feature status from the assembly.

The CCTV camera shall support the appropriate National Transportation Communication for ITS Protocol (NTCIP) 1205 communication protocol (version 1.08 or higher) or approved equal for full functionality/compatibility with the Regional Traffic Operations Center's (TOC's) ATMS software.

(c) **Digital Camera**

Digital cameras shall be PTZ day/night color. The cameras shall meet the camera general specifications and the following minimum requirements:

1. **Mechanical Specifications**

a. **Sensor**

- 1.2MPixel, or better, progressive scan digital imaging sensor camera

- Sensor Resolution: 1280 x 960

- Effective resolution of 1280 x 720p

- Optical Zoom: 18x
- Lens: 4.7mm to 84.6mm, minimum
- Sensor size: 1/3”
- Electronic-Shutter: electronic shutter with speed range from 1/30 of a second (off) to 1/10,000 of a second
- Overexposure protection: The camera shall have built-in circuitry or a protection device to prevent any damage to the camera when pointed at strong light sources, including the sun
- Low light condition imaging
- Scene Illumination Sensitivity at 50 IRE:
    - 1.8 Lux (0.18 fc) @ 1/30 shutter, or better (color mode)
    - 0.02 Lux (0.002 fc) @ 1/4 shutter, or better (mono mode)
- Aspect Ratios Supported: 4:3 and 16:9
- Wide dynamic range (WDR) operation with manual override option
- White Balance (Auto/Manual)
- Electronic image stabilization
- Automatic focus with manual override
- Iris control (Auto/Manual)
- Day/Night IR cut filter

b. **Operations/Environment:**

- high-speed positioner-style camera
- Auto-flip at bottom of tilt travel
- Built-in Title Generation (Camera ID, and Preset Titles, at a minimum)

Each CCTV assembly shall accept status information from PTZ equipment for preset positioning of those components. The CCTV assembly shall accept “goto” preset commands from the test panel and central software, decode the command data, perform error checking, and drive the pan/tilt and zoom lens to the correct preset position. The preset commands will consist of unique values for the desired pan, tilt, zoom, and focus positions.

2. **Communication Standards**

The CCTV camera shall support the appropriate NTCIP 1205 communication protocol (version 1.08 or higher), ONVIF, or approved equal for full functionality/compatibility with the Regional Traffic Operations Center's (TOC's) ATMS software.

3. **Networking Standards**

- Network Connection: 10/100 Mbps auto-negotiate
- Frame Rate: (30, 15, 7, 4, 2, 1 fps min.)
- Data Rate: scalable from 64k to 5Mbps per stream
- Built-in Web Server
- Unicast & multicast support
- Two simultaneous video streams (Dual H.264 and MJPEG):
    - o Video 1: H.264 (Main Profile, at minimum)
    - o Video 2: H.264 or MJPEG
- Multiple camera protocol support compatible with VDOT's central system software
- Supported Protocols: DNS, IGMPv2, NTP, RTSP, RTP, TCP, UDP, DHCP, HTTP, IPv4

The video camera shall allow for the simultaneous encoding and transmission of the two digital video streams: one in H.264 format (high-resolution) and one in H.264 or MJPEG format (low-resolution). High resolution streams shall allow video bit rates from 1 to 5 Mbps and the low resolution stream shall allow video bit rates from 64 kbps to 2 Mbps. Initially configure these formats for 2.5 Mbps and 384kbps, respectively.

Initially use UDP/IP for video transport and TCP/IP for camera control transport unless otherwise approved by the Engineer.

The camera shall support resolutions of 720p, CIF (352 (H) x 240 (V)), and D1 (720 (H) x 480 (V)) at a minimum.

The 10/100BaseTX port shall support half-duplex or full-duplex and provide auto negotiation, and shall be initially configured for full-duplex.

The camera unit shall be remotely manageable using standard network applications via web browser interface administration. Telnet or SNMP monitors shall be provided.

(d) **Digital Video Encoder and Decoder**

Digital video encoders (DVE) and digital video decoders (DVD) shall be network based specialized devices that convert analog signal to digital, transport digital packets via UDP/IP over

fiber optic, copper Ethernet, wireless, or leased line networks, and convert the digital packets back to an analog signal for viewing on a display monitor. The decoding of the digital packets shall be accomplished using existing software based decoders where applicable or hardware based decoders.

The encoders and decoders provided shall be fully compatible with each other and allow end to end transmission of 30 fps (frames per second). The end-to-end latency between the encoder and decoder shall not exceed 250ms.

The complete video and data transmission system, defined as the combination of DVE and DVD hardware, together with the existing or planned network infrastructure, shall simultaneously transport video and data from multiple remote field locations to multiple monitoring locations for roadway surveillance and traffic management.

The digital video encoders (DVE) and digital video decoders shall meet the following specification requirements:

1. **Mechanical Specifications**

   a. **Format**

      The DVE and DVD shall be capable of supporting standard multicast discovery protocols as recommended by the Internet Engineering Task Force (IETF) RFC 2974, and Differentiated Services/Quality of Service (DiffServ/QoS) software components. The DVE shall provide 99% error-free operation.

   b. **DVE and DVD, H.264/MPEG-4**

      H.264/MPEG-4 DVEs and DVDs shall utilize H.264 video compression technology in accordance with the International Telecommunications Union (ITU-T) H.264 and the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) MPEG-4 AVC requirements detailed in the ISO/IEC 14496-2 standard.

      The DVE shall provide digital video streams that are compatible with the Regional Traffic Operation Center's (TOC) central software viewing interface.

   c. **Digital Video Encoder (DVE)**

      The DVE shall be temperature hardened, hardware based and accept a minimum of one analog National Television System Committee (NTSC) video input and digitize the input for transport over an IP network. The DVE shall have a minimum of two serial data interfaces for transmission of command and control data for PTZ camera control and a console interface. The serial interfaces shall be configurable to EIA-232, RS-422, and RS-485 based on project requirements. Each serial interface shall be configurable as command and control or console. The digital video encoder shall support authorized user login by username and password. The DVE shall support interface/protocol compatible (e.g. ONVIF, NTCIP) with the Regional TOC's Central software for management and control.

   d. **Digital Video Decoder (DVD)**

The DVD shall be a hardware-based network centric device and that is fully compatible with the video encoders provided. The DVD shall include an Ethernet interface for connection to IP networks. The decoder shall provide a minimum of one analog NTSC video output. The DVD shall be able to decode the digital video and data streams present on an IP network and convert them to an analog video stream for interconnection with other devices. The DVD shall have a minimum of two serial data interfaces. The serial interfaces shall provide for the transmission of command and control data to other devices and shall provide for console support. The serial interfaces shall be configurable as command and control or console. The digital video decoder shall support authorized user login by username and password. The DVD shall support interface/protocol integration for controlling/modifying the video source origin to be decoded from the Regional TOC's Central software.

e. **Video Specifications**

Video inputs shall utilize BNC connectors and deliver 1 volt peak-to-peak (Vp-p) NTSC composite video signals for encoding. The DVE and DVD shall operate with either color or monochrome video. The DVE and DVD shall allow configuration and adjustment of video resolution. The DVE and DVD shall support resolutions that include, but are not be limited to, those defined in Table VIII-2. The DVE and DVD shall be capable of delivering color and monochrome video at 30 fps regardless of resolution using programmable bit rates from 30 kbps to 4 Mbps for both MPEG-4 and H.264. The DVE shall be capable of encoding a single analog video source and simultaneously streaming two digital outputs. One output will be configured for high-bit rate transmission initially, and the other will be configured for low-bit rate transmission. The DVE shall provide fixed and variable bit rate modes. The Contractor shall coordinate with the Regional TOC for specific bit rate requirements prior to configuring individual DVE and DVD units.

TABLE VIII-2
Resolution Specifications

Resolution	NTSC Requirements
D1	720 horizontal x 480 vertical
1/2 D1	352 horizontal x 480 vertical
SIF	352 horizontal x 240 vertical

Note: The resolutions attained depend on the data transmission rate.

2. **Electrical Specifications**

All wiring of the DVEs and DVDs shall meet NEC requirements and standards. All equipment shall operate on a nominal voltage of 120 volts alternating current (VAC). The operating frequency range for power shall be 60 hertz ±3 Hz. The power supply shall be integral to the DVE and DVD unless otherwise approved by the Engineer.

3. **Environmental Specifications**

The digital video encoder shall meet ambient operating temperature of -30° F to 165° F as defined in the environmental requirements section of the NEMA TS2 standards, with a maximum non-condensing humidity of 95%. The DVE shall be resistant to vibration

and shock, and conform to Sections 2.1.9 and 2.1.10, respectively, of the NEMA TS 2 standard.

Digital video decoders (DVD) shall be installed in a climate-controlled environment. DVDs shall meet all specification requirements during and after being subjected to an ambient operating temperature range of 32° to 113° F (0° to 45° C).

4. **Physical Specifications**

DVEs and DVDs shall have light-emitting diode (LED) displays, liquid crystal displays (LCDs), or similar illuminated displays to indicate status for power, data activity, link status, and video transmission. Rack mounting kits shall be supplied for each DVE and DVD. The DVE and DVD shall not be larger than 2 rack units (RU) in height and shall fit into the equipment cabinet with sufficient space for cabling, connectors, and adapters.

The DVE shall be rack mountable and/or shelf DIN rail, and designed for use in roadside control cabinets without climate control. The dimensions of the DVE shall allow installation in a ITS controller cabinet as specified in Section 801. Front panel status indicators shall remain unobstructed and visible. Only stainless steel external screws, nuts, and locking washers shall be used. All other parts shall be made of corrosion-resistant materials, such as plastic, stainless steel, anodized or painted aluminum, brass, or gold-plated metal.

Non-hardened DVDs shall be shelf and rack mountable, and designed for use in a climate-controlled Traffic Operations Center or computer room. The rack-mounted DVD shall be designed to fit in a standard EIA 19 inch rack and shall not require shielding from other electronic devices, such as power supplies and other communication equipment. The dimensions of the DVD shall allow installation for the specific application.

DVEs and DVDs furnished shall be immediately replaceable when units are defective or damaged. The Department will return defective units to the manufacturer for warranty repair or replacement.

5. **Networking Standards**

The DVE and DVD local area network (LAN) connection shall support the requirements detailed in the IEEE 802.3 standard for 10/100 Ethernet connections. The Contractor shall provide DVEs and DVDs having a minimum of one Ethernet port, with a 10/100 Base-TX connection (at a minimum). The connector shall comply with applicable EIA and Telecommunications Industry Alliance (TIA) requirements and shall provide copper-based network interface ports that utilize RJ-45 connectors.

All Category 5E, unshielded twisted pair/shielded twisted pair network cables shall be compliant with the EIA/TIA-568-A standard. The network communication shall conform to User Datagram Protocol (UDP), Version 4 of the Internet Protocol (IP) and Version 2 of the Internet Group Multicast Protocol (IGMP).

6. **Communication Standards**

The Contractor shall furnish hardware-based DVEs and DVDs having a minimum of two serial data interfaces and connectors that support EIA-232/422/485 standards. The serial interfaces shall support EIA-232 as well as 2-wire and 4-wire EIA-422/485 connections.

The serial interfaces shall support data rates up to 115 kbps. The serial interface parameters, such as data format, number of bits, handshaking, and parity, shall be software programmable through the DVE or DVD web interface, through local console port connection or through Telnet. Serial interface ports shall utilize RJ-45 connectors. The Contractor shall furnish any serial adapters/connectors necessary for integrating interconnected devices with the DVE or DVD.

7. **Management Capability**

DVEs and DVDs shall support local and remote configuration and management. Configuration and management functions shall include access to all user-programmable features, including but not limited to IP addressing, serial port configuration, video settings, device monitoring, diagnostic utilities, On Screen Display (OSD) settings, reset or restart functions, network settings, and multicast and unicast address settings. The DVE and DVD shall support user configuration and management using serial login, Telnet login, and Simple Network Management Protocol (SNMP).

Provide DVEs and DVDs with software for graphical user interface for control and settings.

(e) **CCTV Composite Cables Analog**

The cable for connection to CCTV unit shall contain video feed, camera control including PTZ, communications signaling, and power supply conductors in a single cable jacket rated for outdoor use meeting outdoor temperature, water blocking, ultraviolet and insulation characteristics. The cable shall be equipped with standard connections on both ends compatible with the equipment to which it will be connected. Power connections shall be of the conductor size required to fully operate with voltage drop and signal loss characteristics of the equipment being connected.

Video input/output connections shall be BNC type and shall be compatible with existing TOC video encoders, video encoders specified elsewhere in the Specifications or in the Contract.

(f) **CCTV Composite Cables Digital**

The cable for connection to CCTV units shall contain CCTV Ethernet and power lead-in conductor wires in a single cable jacket that is rated for outdoor use meeting outdoor temperature, water blocking, ultraviolet and insulation characteristics. The Contractor shall furnish a shielded CAT6 twisted pair cable that prevents cross-talk and RFI/EFI between conductors. Cable shall be equipped with standard connections on both ends compatible with the equipment to which it will be connected. The power connections shall be of the conductor size required to fully operate with voltage drop and signal loss characteristics of the equipment being connected.

(g) **Camera Poles**

The camera poles shall support ITS components, including but not limited to, CCTV cameras, solar panels, battery cabinets, vehicle detectors, antennas, and/or equipment cabinets. The camera poles shall be round tapered galvanized steel poles. Standard pole heights shall be 40 feet, 45 feet, 60 feet, and 80 feet. A CCTV camera lowering device is required on poles 60 feet and 80 feet in height. The camera pole designs shall include the steel pole and foundation and

shall account for all loads for the ITS components it may support as shown in the plans. The camera pole and foundation design shall be certified, sealed, and signed by a licensed Professional Engineer in the Commonwealth of Virginia. Unless otherwise stated herein, steel poles and foundations shall conform to Section 700, the *VDOT Road and Bridge Standards,* and the edition of *AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* specified in the Structure and the VDOT Structure and Bridge Division's S&B-IIM-90 (VDOT Modifications to AASHTO's Standards Specifications) in effect at the time of project advertisement for bids.

The Contractor shall perform at least one test bore, as approved by the Engineer, at each camera pole foundation location in accordance with Section 700 to assist in determining soil classification for use in foundation design.

1. **Mechanical Specifications**

a. **Lowering Device**

All 60 ft. and 80 ft. camera (steel) poles shall be equipped with a CCTV lowering device. The lowering device shall provide the electrical connections between the cabinet and the equipment installed on the lowering device without reducing the function or effectiveness of the equipment installed on the lowering device or degrading the overall system in any way. A stainless steel lowering cable shall be located inside conduit within the pole to avoid cable twisting and shall ensure that only the lowering cable is in motion when the lowering device is operated. All other cables shall remain stable and secure during lowering and raising operations.

The lowering device shall include a disconnect unit for electrically disconnecting the equipment installed on the lowering device's equipment connection box from the power, data, and video cables (as applicable); a divided support arm, a pole adapter for the assembly's attachment to the rotatable pole-top tenon, and a pole-top junction box. Weights and/or counterweights shall be provided to assure the alignment for the camera connection can be raised into position without binding and that it can be lowered properly, unless otherwise approved by the Engineer.

The lowering device's external components shall be corrosion-resistant powder-coated, galvanized materials, or otherwise protected from the environment by industry-accepted coatings that can withstand exposure to a corrosive environment. The lowering device system shall not conflict with other devices attached to the pole. The lowering device shall not be mounted directly below the camera. The Contractor shall provide written certification from the manufacturer of the qualifications for Contractor personnel authorized to perform the installation of the lowering device. If the certified personnel should leave prior to completion of the lowering device installations, it shall be the Contractor's responsibility to provide another manufacturer certified employee or have another employee certified by the manufacturer to finish the installation at no additional cost or delay to the Department.

b. **Disconnect Unit**

The disconnect unit shall have a minimum load capacity of 200 pounds with a 4:1 safety factor. The fixed and movable components of the disconnect unit shall have

a locking mechanism between them. A minimum of two mechanical latches for the movable assembly shall remove all weight from the lowering cable when latched. The fixed unit shall have a heavy-duty cast tracking guide and a means for latching in the same position each time.

The disconnect unit shall be capable of securely holding the lowering device and the equipment installed on the lowering device. The interface and locking components shall be stainless steel or aluminum.

2. **Electrical Specifications**

An equipment connection box shall connect the CCTV camera or other ITS devices to the lowering device. The equipment connection box shall have an ingress protection rating of no less than IP55.

3. **Environmental Specifications**

a. **Disconnect Unit Housing**

The disconnect unit housing shall have a gasket to seal the interior from dust and moisture. The disconnect unit housing shall have an ingress protection rating of no less than IP55.

4. **Physical Specifications**

Steel camera poles shall be manufactured with appropriate handholes, cable entry points, and weatherheads so that all cabling, grounding conductors, lowering device, etc. for the complete ITS device installation are run inside the pole. These details shall be included on the shop drawing submittals for review and approval by the Engineer prior to fabrication.

a. **Camera (Steel) Pole (40 and 45 ft.)**

CCTV installations on 40 ft. and 45 ft. camera (steel) poles shall use a typical CCTV camera mounting bracket to attach the CCTV camera to the pole.

b. **Camera (Steel) Pole (60 ft and 80 ft) with Lowering Device**

CCTV installations on 60 ft. and 80 ft. camera (steel) poles shall include a CCTV camera lowering device. The lowering device and camera pole shall be considered as two interdependent components of a single unit and shall be furnished together to ensure compatibility of the pole and lowering device. The handhole shall be of sufficient size to provide access to the camera pole interior and for temporarily securing and operating the lowering tool. The pole-top tenon shall be rotatable.

The camera pole shall include an attachment point inside the pole for attaching the lowering device cable. This attachment point shall be easily and fully accessible from the handhole. The attachment point material and means of attachment to the pole shall be designed to provide sufficient strength and durability to hold the lowering device cable in place if the camera lowering device were to release at the top of the pole.

Details of the handhole, lowering device cable attachment point, etc., shall be included on the shop drawing submittals for review and approval by the Engineer prior to fabrication.

c. **Lowering Cable**

The lowering cable shall be a minimum diameter of 0.125 inch and constructed of 7 strands, 19 gauge, stainless steel aircraft cable with a minimum breaking strength of 1,740 pounds. The prefabricated components for the lift unit support system shall prevent the lifting cable from contacting the power or video cables.

d. **Connector Block**

A connector block as specified by the manufacturer, or as furnished with the lowering device shall be equipped with modular self-aligning and self-adjusting female and male socket contact halves. The lowering device shall be equipped with enough contacts to permit operation of all required functions of the camera, up to a maximum of 20 contacts with at least two spare contacts. The lowering device connections shall be capable of carrying the signals, voltages, and current required by the device(s) connected to them under full load conditions. The Contractor shall submit pin assignment documentation to the Engineer.

The female socket contacts and the male contact halves shall be of heavy-duty construction and the connector blocks shall be molded synthetic rubber, molded chlorosulfonated polyethylene, polymer body or Department approved equal. The connector pins shall be brass or gold-plated nickel, or gold-plated copper.

The current-carrying male and female contacts shall have a minimum diameter of 0.1 inch.

The connector block shall include cored holes in the rubber to create moisture-tight seals when mated with the male connector. All wire leads from both the male and female contacts shall be permanently molded in a body of chlorosulfonated polyethylene, or a Department approved equal.

The contacts shall be self-wiping with a shoulder at the base of each male contact so that it is recesses in the female block for a moisture-tight seal when mated.

e. **Lowering Tool**

The lowering tool shall be metal-framed with a winch assembly, a quick release cable connector, an adjustable safety clutch, and a cable with a combined weight of less than 35 pounds. The lowering tool shall be powered using a half-inch chuck, variable-speed reversible industrial-duty electric drill to match the manufacturer-recommended revolutions per minute or be supplied with a drill motor for powering the lowering tool.

The lowering tool shall support itself and the load. The lowering tool shall be equipped with a positive braking mechanism to secure the cable reel during raising and lowering operations and to prevent freewheeling or freefall.

The lowering tool shall be equipped with gearing that reduces the manual effort required to operate the lifting handle to raise and lower a capacity load. The lifting handle shall be provided with an adapter for operating the lowering device with the portable half-inch chuck drill using a clutch mechanism.

The lowering tool shall be manufactured of durable, corrosion-resistant materials that are powder-coated, galvanized, or otherwise protected from the environment by industry accepted coatings that can withstand exposure to a corrosive environment.

The Contractor shall furnish a minimum of one lowering tool plus any additional tools required to operate the lowering device for each set of five poles or fraction thereof. Upon the final acceptance of the project, the Contractor shall deliver the lowering tool to the Engineer.

(h) **CCTV Camera Attachment**

The mounting hardware shall allow for mounting of the CCTV camera assembly as shown on the VDOT Road and Bridge Standards for ITS.

The CCTV assembly shall be attached to the pole with stainless steel banding, clamps, brackets, or other method approved by the Engineer, that allows for the removal and replacement of the CCTV enclosure as well as providing a weather tight seal that does not allow moisture to enter the enclosure.

(i) **Surge Suppression**

All equipment at the top of the pole shall be protected by grounded metal oxide varistors connecting each power conductor to ground.

Communication Interface Requirements: Optical isolation shall be provided with an isolation of no greater than 2000 VAC for data signals and ground.

(j) **Communication Standards**

1. **Wiring**

Wiring shall meet NEC requirements and follow the equipment manufacturers' recommendations for each device connected on the pole at the lowering device and in the cabinet.

2. **Connector Block**

Contact connections between the fixed and movable lowering device components shall be capable of passing EIA-232, EIA-422, EIA-485, and Ethernet data signals and 1 volt peak to peak (Vp-p) video signals, as well as 120 VAC, 9-24 VAC, and 9-48 VDC power.

803.04—Procedures

(a) **Digital Video Encoder and Decoder**

The Contractor shall furnish and install all mounting brackets and hardware necessary to install DVEs in field cabinets and to install DVDs in existing equipment racks at the Regional Traffic Operations Center or at locations shown in the Plans.

Furnish and install all power supplies, cables, etc. that are required to properly power on DVEs and DVDs at each location.

Furnish and install all video and communications cabling, such as coaxial jumpers, Cat5e cables, etc. that are required for communication from the DVEs and DVDs to Ethernet switches, video switches, CCTV cameras, etc. in the field and at the Traffic Operations Center for a fully functional system meeting the requirements as detailed herein. The end-to-end latency between the encoder and decoder shall not exceed 250ms. The Contractor shall notify Engineer if existing network conditions exceed latency requirements.

(b) **Camera (Steel) Poles**

The Contractor shall install steel poles and foundations for mounting cameras in accordance with Section 700. Anchor bolts shall be installed and tightened in accordance with Section 700.

Install and permanently mount the CCTV camera to a steel pole in accordance with these specifications and as shown in the plans. Use banding, clamps, brackets or other methods as shown on the VDOT Road and Bridge Standards for ITS equipment or as approved by the Engineer to fasten CCTV camera to pole. All cables from the pole to the camera shall be routed inside the mounting hardware and protected from exposure to the outside environment.

Furnish and install all cables and connectors necessary for connecting the analog camera to the Video Encoder in the cabinet and install video feed, camera control including PTZ, communications signaling, and power supply conductors between the CCTV and the cabinet.

Furnish and install all cables and connectors necessary for connecting the digital camera to the Field Ethernet Switch in the cabinet and install lead-in power and communication conductors between the CCTV and the cabinet.

The installed equipment shall provide unobstructed video of the roadway, traffic, and other current conditions around a roadside CCTV field site; respond to camera control signals from an operator of the system; and transmit video images to remote locations interfaced to the system for observation. The CCTV shall be mounted facing perpendicular to the roadway unless otherwise noted in the Plans or as directed by the Engineer. The Engineer will approve CCTV camera views at locations as shown in the Contract prior to acceptance.

Furnish and install the power supplies, local control equipment, any other camera-related field electronic equipment, and SPD in a pole or base-mounted, lockable cabinet and ensure that the cabinet protects these electrical and electronic devices from rain, dust, dirt, and other harmful elements of nature.

Furnish and install in the cabinet all power, video, and data cables necessary to provide connection points for camera video and PTZ control signals and all ancillary equipment required to provide a complete and fully operational CCTV camera system. This shall include any fiber jumpers, video cables/connectors, Ethernet Cat5e jumpers, and other incidentals between the cabinet and the CCTV camera and between the cabinet and any upstream and downstream cabinets that may be required for complete functionality of the ITS project (including interface

with existing equipment) or portion thereof as specified in the Contract. The Contractor shall verify that all wiring meets NEC requirements where applicable.

(c) **Lowering Devices**

The divided support arm and receiver brackets shall self-align with the pole centerline during installation so that the contact unit cannot twist when subjected to the wind speed requirement as specified by the Structure & Bridge Division's S&B-IIM-90 (VDOT Modifications to AASHTO's Standard Specifications) in effect at time of project advertisement.

All pulleys installed for the lowering device and portable lowering tool shall have sealed self-lubricated bearings, oil-tight bronze bearings, or sintered bronze bushings.

Provide 1.25-inch-diameter PVC conduit in the pole for the lowering cable. A conduit mount adapter shall be furnished for the interface between the conduit and the internal back side of the lowering device.

Furnish and install the appropriate connection on the dome-type or non-dome-type camera assembly for mounting to the camera lowering device for all cameras installed on lowering devices. Demonstrate to the Engineer that the camera assembly and associated cabling will properly connect and operate with the camera lowering device.

Furnish and install a mounting arm and bracket provided by or recommended by the CCTV manufacturer for use with the proposed CCTV camera and housing including all necessary banding, hardware and fittings on CCTV camera installations on camera (steel) poles without a lowering device required for a complete installation. Poles shall be drilled for cable wiring prior to galvanizing and fitted with rubber grommets; field drilling will not be permitted unless approved by the Engineer. Damaged galvanization shall be repaired in accordance with Section 233 and the holes fitted with rubber grommets. The size of the hole shall not exceed the sum of the diameter of the cables plus ½-inch.

(d) **CCTV cameras**

The Contractor shall coat the exterior distortion free lens of the non-dome-type or dome-type enclosure's lower half with a clear, rain repellant product prior to final acceptance. Rain repellent product shall be acceptable to the Engineer.

(e) **CCTV Retrofit Installations**

The work required for a CCTV retrofit includes replacing an existing CCTV camera and composite cable. The cabinet, all conduits, and the structure on which the existing CCTV is mounted will be reused unless otherwise stated in the Contract. The new CCTV camera and composite cable for the retrofit shall meet the specification requirements for new CCTV installations.

Furnish and install CCTV and cable with appropriate connectors hardware, fittings, etc to enable the installation of the new CCTV camera and cable with the existing lowering device on existing structures with lowering devices.

Furnish and install a new mounting arm and hardware on existing structures without lowering devices in accordance with these specifications. The CCTV shall be mounted at the same

height as the current installation unless directed otherwise by the Engineer. No field drilling of the existing structure will be permitted unless approved by the Engineer.

Power and communications for the new CCTV camera shall be obtained from the existing cabinet. The Contractor shall verify that the new CCTV camera is compatible with the existing power source for the existing CCTV camera. Furnish and install any additional materials required for a fully functional site according to the requirements stated herein

Terminate the video and communications wiring of the composite cable in the cabinet in accordance with the existing connectivity.

Furnish and install new SPD for power and communications for the CCTV retrofits in accordance with these specifications.

Obtain approval from the Engineer prior to taking the existing CCTV camera and cable out of service and removing the camera and cable. The new CCTV camera and cable shall be installed and fully operational within 24 hours of taking the existing CCTV camera and cable out of service.

All other requirements herein shall apply to CCTV retrofits.

(f) **Testing**

The equipment covered by these specifications shall be subjected to three types of testing. Field Acceptance Test (FAT), VDOT Traffic Operations Center Integration Test (TOCIT), and 30-Day System Acceptance Test (SAT). The Contractor shall meet the requirements of the Department's test plan, unless otherwise approved by the Engineer. The test plans can be found on the Department's website.

Each device must satisfy all parts of the Department's test plan. If a device fails any one portion of the test plan, that device shall be retested for compliance with the test plan. If the same device fails any one test (FAT, SAT, or TOC Integration testing) three times, the device shall be replaced with a new device and the testing shall begin at the start of the test. If a device fails five or more times across the entire test plan, the device shall be replaced with a new device and the testing shall begin at the start of the test plan.

(g) **Training**

Upon completion of the work and at a time approved by the Engineer, the Contractor shall provide training by a qualified instructor to Department personnel in the proper operation and maintenance of the equipment. Department personnel shall receive training comparable to the equipment manufacturer's factory training for each new type of camera equipment that has not previously been installed within the region. The minimum training shall be one 2 hour session for instruction of device operation and maintenance.

The Contractor shall also provide the Department training on installing presets in the CCTV, DVE, and DVD.

(h) **Warranty**

All CCTV cameras, DVEs, DVDs, cables, mounting materials, camera poles, and lowering devices furnished, assembled, and installed shall have a manufacturer's warranty covering

defects in assembly, fabrication, and materials for a minimum of three years from the date of final acceptance. If the manufacturer's warranties for the components are for a longer period, those longer period warranties shall apply.

The manufacturer's warranties on CCTV cameras, cables, mounting materials, camera poles, and lowering devices shall be fully transferable from the Contractor to the Department. These warranties shall require the manufacturer to furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department within 10 calendar days of notification by the Department.

Warranty periods shall begin on the date of final acceptance by the Engineer in accordance with Section 108.09.

(i) **Documentation**

Two Operations and Maintenance (O&M) Manuals shall be supplied for each type of individual component, one of which shall be in a reproducible format. The off-the-shelf item manuals provided shall be those supplied by the equipment manufacturer. Contractor developed manuals shall be provided to the Engineer digitally. The manuals shall contain, as a minimum, the following operational and maintenance information:

- Installation and set-up procedures
- System operating instructions
- Recovery procedures to be followed in case of malfunction
- Complete performance specifications (both electrical and mechanical) on each unit
- Instructions for gaining maintenance assistance from manufacturer

The documentation shall be in English.

803.05—Measurement and Payment

No separate payment will be made for coordinating with the utility companies or installing and integrating items associated with the work as described herein but the cost thereof will be considered incidental to other appropriate items of work.

The cost of furnishing and installing the electrical bonding/grounding system shall be included in the unit price bid for each type and size of conduit wherein no separate measurement or payment will be made.

CCTV Camera (Type) will be measured in units of each and will be paid for at the contract unit price per each for the type specified. This price shall include furnishing and installing the CCTV camera, mounting arms, fittings, miscellaneous cabling, testing, operational software package(s) and firmware(s), supplies, technical support, training, shop drawings, and documentation. Seventy percent (70%) of the unit bid price will be paid upon successful completion of the Field Acceptance tests. Thirty Percent (30%) of the unit bid price will be paid upon successful integration, successful completion of the VDOT Traffic Operations Center Integration test, and successful completion of the 30-day System Acceptance Test.

CCTV Retrofit (Type) will be measured in units of each and will be paid for at the contract unit price per each for the type specified. This price shall include removing and disposing of the existing camera and cable, furnishing and installing new CCTV camera, CCTV composite cables, mounting arms, fittings, miscellaneous cabling, installation and testing, operational software package(s) and firmware(s), supplies, support, training, shop drawings, and documentation. Seventy percent of the unit bid price will be paid upon successful completion of the field acceptance test. Thirty Percent of the unit bid price will be paid upon successful integration, successful completion of the VDOT Traffic Operations Center Integration test, and successful completion of the 30-day System Acceptance Test.

Digital Video Encoder (Type) will be measured in units of each and will be paid for at the contract unit price per each for the type specified. This price shall include furnishing, installing, integrating, testing, training, documentation, providing software protocols and complete description thereof as required and as verified by the Engineer to install and integrate the encoder. The Contractor will be paid seventy percent of the unit bid price following successful completion of the Field Acceptance Test. The remaining thirty percent (30%) of the unit bid price will be paid upon successful completion of the VDOT Traffic Operations Center Integration Test, Training, and the delivery of all related documentation.

Digital Video Decoder (Type) will be measured in units of each and will be paid for at the contract unit price per each for the type specified. This price shall include furnishing, installing, integrating, documentation, providing software protocols and complete description thereof as required and verified by the Engineer, testing, and training. The Contractor will be paid seventy percent (70%) of the unit bid price following successful completion of the Field Acceptance Test for each item. The remaining thirty percent (30%) of the unit bid price will be paid upon successful completion of the VDOT Traffic Operations Center Integration Test, Training, and delivery of all related documentation.

CCTV Composite Cable (Type) will be measured in units of linear feet and will be paid for at the contract unit price per linear foot for the type specified when designated as a pay item. This price shall include furnishing and installing the cabling and, connectors.

Camera Poles (length) will be measured and paid for at the contract unit price per each for the length specified. This price shall include furnishing and installing the camera pole, hardware, camera mount, wiring, pole design, shop drawings, mounting brackets and hardware (e.g., screws, nuts, bolts, etc.), documentation, grounding electrodes, grounding conductors, grounding lugs, caps, J-hooks, Identifications Tags, galvanization and testing. When required by height of poles specified in the Contract, the price bid shall include lowering device, lowering tool, lowering cable, and lowering cable conduit.

Materials required for installation, including but not limited to, cabling, wiring, hardware inside the controller cabinet and TOC, will not be measured for separate payment but shall be included in the contract unit price bid for each item.

Concrete foundations for camera poles including vented rodent barrier, clearing and grubbing, and incidentals necessary to complete the work will be measured and paid for separately in accordance with Section 700.

Work pads will be measured and paid separately in accordance with Section 700.

Test bores will be measured and paid separately in accordance with Section 700.

Payment will be made under:

Pay Item	Pay Unit
CCTV Camera (Type)	Each
CCTV Retrofit (Type)	Each
Digital Video Encoder (Type)	Each
Digital Video Decoder (Type)	Each
CCTV Composite Cable (Type)	Linear Foot
Camera Pole (Length)	Each

SECTION 804 – DYNAMIC MESSAGE SIGNS

804.01—Description

This work shall consist of furnishing and installing light emitting diode Dynamic Message Signs (DMS), control equipment, support materials, testing, training and miscellaneous equipment and services in accordance with these Specifications and as shown on the Plans or directed by the Engineer.

804.02—Materials

(a) **Concrete** shall conform to Section 217.

(b) **Reinforcing steel** shall conform to Section 223.

(c) **Aluminum** shall conform to Section 229 and shall be fabricated, welded, and inspected in accordance with Section 407.

(d) **Electrical items** shall conform to Section 238.

(e) **Galvanizing** shall conform to Section 233.

(f) **Steel** for structural support devices shall conform to Section 226 and shall be fabricated, welded, and inspected in accordance with Section 407.

(g) **Anchor bolts** shall be high strength steel conforming to Section 226 unless otherwise specified. Anchor bolts shall be galvanized except when stainless steel is specified on the plans. Anchor bolts shall be straight with retaining plates attached to the end of the anchor bolts embedded in the concrete. The Department will not permit the use of J-bolts except in the construction of controller cabinet foundations.

(h) **Miscellaneous hardware** shall be brass, bronze, stainless steel, or galvanized steel.

(i) **Dissimilar metals** when used together, the contact surface shall be isolated with a Department approved durable nylon washer, gasket, or other approved isolation material to prevent corrosion.

804.03—Equipment

(a) **General**

The DMS shall be either Type 1 or Type 2/2A. Type 1 is a walk-in sign assembly and Type 2/2A is a non-walk-in sign assembly, and both shall be available in either amber or full color as specified in the Plans. Unless specifically indicated, these Specifications apply to all types of DMS exclusive of the sign case and mounting hardware.

Each sign shall be provided with the mounting hardware necessary to attach the sign assembly to the DMS support structure. All structural components of the DMS, support structure attachment hardware, and foundation shall be designed, signed, and sealed by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia.

The DMS communications protocol shall be the National Transportation Communication for ITS Protocol (NTCIP) Version 02.35 (1203 v02.35). The protocol shall be downward compatible with the Department's NTCIP V1 protocol currently in use at the VDOT Transportation Operations Centers (TOCs).

The DMS shall meet all applicable electrical, structural, and environmental requirements of the Commonwealth of Virginia including but not limited to the Specifications, the MUTCD, the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, the National Electrical Code, and any Commonwealth of Virginia addendums and supplements to these standards. The DMS shall be designed to comply with minimum NEMA TS-4 2005 standards.

Internal DMS access for all maintenance shall provide unobstructed viewing, removal, and replacement of any non-structural component within the sign case and ground or pole mounted equipment cabinets.

The DMS front face shall not distort in a manner that adversely affects LED message legibility when subjected to adverse weather conditions including those involving wind, rain, sleet, and snow.

The removal of any combination of one or more modules shall not alter the structural strength of the sign display assembly or sign case. The removal of any combination of display modules shall not affect the operation of the remaining functional modules in any way. All serviceable components (except the Uninterruptible Power Source) shall weigh 50 pounds or less.

Each DMS shall consist of the following minimum components and general requirements:

- Light Emitting Diode (LED), Full Matrix Display technology.
- Structural support to DMS sign case mounting brackets, I-beams, Z bars, bolts, nuts, washers and other hardware required for the installation to the DMS support structure.
- Roadside Control Cabinet mounted DMS Controller Unit, DMS Controller Unit Software, DMS maintenance Software and documentation, Fiber Optic Cable (or approved manufacturer's cable) for connection between the sign case control and the Roadside Control Cabinet Control.

- All materials shall be new and free of defects and blemishes. Materials shall be handled so that no stress is introduced during the fabrication, assembly, or storage processes that reduces the strength or durability of the material from the material vendor's specifications. Protective coatings shall be applied in conformance with the manufacturer's recommendations to achieve maximum coating life.

- All hardware and fasteners shall be stainless steel with the exception of the DMS sign case lifting eyes which shall be hot dipped galvanized high strength steel. Lifting eyes shall be attached to the DMS sign case with hex nuts and flat washers. Washers shall be placed on each side of the sign case (interior/exterior) and be fabricated of stainless steel or other structurally capable metal that is chemically nonreactive with the aluminum sign case material. Lifting eyes shall be left in place. DMS sign case intrusions for lifting eyes shall be sealed to prevent liquid or vapor infiltration. Alternative lifting configurations shall not be used unless preapproved by the Engineer.

- All electronic components shall be rated for NEMA TS-4 environmental conditions. Electrical / electronic component power, signal, data, board to board, board to connector and grounding connections shall be non-corrosive, low loss, vibration resistant points that pass the minimum and maximum current levels without loss levels that reduce the performance of the inter-mating assemblies when subjected to NEMA TS-4 environmental conditions.

804.04—DMS Equipment

(a) DMS Housings Design

The minimum height of the interior of the Type 1 DMS from the top of the walkway to the lowest framing member or other obstruction shall be 78 inches. The minimum distance from the interior rear wall of the DMS housing to the closest display components shall be 24 inches. The minimum distance between electrical equipment mounted on the rear wall of the DMS housing to the closest display components shall be 36 inches. This free space shall be maintained across the entire interior of the sign housing. Structural members shall be designed and positioned to not be an obstruction to the free movement of maintenance technicians throughout the 78 inch height of the interior of the housing.

A level walkway shall be installed in the bottom of the DMS housing on which maintenance personnel access the sign housing. This walkway shall be 24 inches wide, and shall run the entire length of the sign. The walkway's top surface shall be non-slip and free of obstructions. The walkway shall support a concentrated load of 50 pounds per square foot at any location and a total of at least 1,000 pounds within any ten-foot section of the walkway. The walkway shall be removable for access to the area under the walkway. The walkway shall be constructed in panels that are no longer than 36 inches. The panels shall be fabricated from the same type of aluminum as the outer shell of the sign case and shall have provisions for lifting the individual panels without adverse ventilation impact under the panels during normal ventilation system operation.

All sign equipment, components, modular assemblies, and other materials located in the sign housing shall be removable, transportable, and capable of being installed by a single technician utilizing a one-person aerial lift truck. Structural members and components thereof are not included in this requirement.

Housings shall have interior non-corrosive, metal cage support frames to mount the display clusters. The cage support frame shall be designed to withstand and minimize vibrational effects to the display and/or electronics.

Doors shall be installed on each side of the walk-in housing and shall open to the outside rear of the DMS housing. DMS housing doors shall be rain and dust-tight doors with minimum doorway opening dimensions of 72 inches high by 24 inches wide. The doors may be larger to support air filter assemblies. Doors shall be provided with continuous stainless steel hinges and hinge pins. A four inch kick plate shall be provided at the base of both DMS door openings above the internal walkway. DMS housing doors shall have a stop to retain the door open at the 90 degree open position. The door stop shall be located at the top of the door opening/sign case housing and shall be designed to remain in place and not obstruct ingress or egress of the sign case. The door stop shall be fitted to a retainer that will securely store the door stop when not in use. The doors shall be reinforced to prevent bowing, racking and flexing in any direction. The DMS housing doors shall be furnished with a door lock that is keyed to the Department's standard brass tumbler lock number 9R48773.

The lock shall be lubricated internally with a graphite based lubricant. The latching and locking mechanism shall include a handle on the interior of the housing to prevent entrapping a person inside the housing. The door latch shall be three points and adjustable to correctly tension the door when closed. The three point latch shall be equipped with nylon, long lasting rollers that roll onto strike plates to hold the door securely against the gasketed surfaces when the door is closed.

The door opening shall be fitted with positionable rails inside the housing. Rails shall be installed so that they may be positioned to block the opening from accidental movement by personnel outside of the DMS sign case. Size and spacing of rails shall conform to OSHA and all other applicable regulations. Rails shall be attached to the sign housing with stainless steel hardware and shall be designed for storage without the use of tools. Signs provided with a landing for only one entry door shall have warning signs or other approved means used to alert/prevent maintenance personnel from opening the door (from inside the sign housing) on the side without a landing.

A three step ladder and retaining bracket shall be provided with each Type 1 DMS. The ladder shall be fiberglass and non-conducting electrically to 600 volts. The ladder shall be retained positively in the retaining bracket when not in use. No tools shall be required to remove or replace the ladder in the retaining bracket.

Fans or other forced air devices for maintenance personnel shall be provided in accordance with the Virginia Uniform Statewide Building Code and the International Mechanical Code, Section 400. The Contractor's DMS vendor shall provide copies of applicable regulations dealing with personnel ventilation systems, and proof of compliance with each requirement. These fans may also be used by the DMS environmental control system for the DMS ventilation system.

The maintenance personnel ventilation system shall be controlled by an adjustable timer that will turn off the fans after the set time has expired. The adjustable timer shall be adjustable to provide an "on" time of at least 4 hours in nominally 15 minute increments and shall be located just inside the DMS housing door, within easy reach of a maintenance technician, without having to enter the DMS housing. The timer shall be permanently labeled and shall be fitted with a blade or wing shaped knob with integral pointer and dial plate that shall identify the

approximate amount of time before the manually set fan time expires. The timer shall be rated at least 1.5 times the maximum current draw of the fans.

Walk-in DMS housings shall include an internal vibration resistant lighting system to provide maintenance personnel with a minimum of 60 watts of fluorescent lighting or Department approved equal per 96 inches of sign length within each sign housing. Fluorescent ballast (or Department approved alternative) shall be rated for operation in zero degree temperatures and operated from the electrical service of the DMS sign case. Fluorescent (or Department approved alternative) lighting shall include protective cover over the lamps. Maintenance personnel operated three-way switches shall control the interior lighting system and shall be located just inside each DMS door housing, within easy reach from outside the DMS housing through each housing door. Lighting switches shall be of the time out timer type that is adjustable from 0 to 4 hours of on time. The timer shall be permanently labeled and shall be fitted with a blade or wing shaped knob with integral pointer and dial plate that shall identify the approximate amount of time before the manually set lighting time expires. The timer shall be rated at least 1.5 times the maximum current draw of the total current draw of all lighting fixtures.

The lighting fixtures shall be positioned to avoid interference with personnel head room and shall cast light at levels to allow a technician with normal vision to identify the make and model of each component within the housing and to locate the fasteners and connections necessary to service or replace module or assembly.

The sign housing and display panel shall be designed to minimize visible internal light outside the DMS during nighttime maintenance activities.

(b) **Sign Housings, Faces, Framing, and Mounting Members**

Sign housings, faces, framing, and mounting members shall comply with Section 801. The housing top shall be crowned to prevent standing water and shall be constructed so that it is weather resistant under all conditions. The Type 1 DMS housing and all of its equipment and materials shall be designed and constructed so that all maintenance and repair is performed from within the DMS housing with the exception of maintenance and repair to structural members and components. Maintenance and repair of Type 2/2A DMS shall be from the outside through either front or back access doors. Front doors and other panels required to be moved out of their normal closed position for maintenance or repair of the Type 2/2A DMS shall not impede access of a maintenance person to the internal components of the DMS from a bucket truck or boom lift.

Sign housings shall be constructed of aluminum, alloy 5052 H32 or H34, and with a minimum thickness of 0.125 inch. Seams shall be continuously welded (chemically bonded only as approved by the Engineer) and smooth except for the KYNAR 500 polyvinylidene fluoride (PVDF) or approved equal coated sign face. All welds shall be neatly formed and free of cracks, blow holes, and other irregularities. All exterior cabinet welds shall be made using the gas tungsten arc (TIG) welding method. All internal cabinet welds shall be made using the gas metal arc (MIG) or TIG process. Other welding methods may be used only if approved by the Engineer in advance. All inside and outside edges of the cabinet shall be free of burrs or sharp edges. All edges shall be filled. ER5356 aluminum alloy bare welding electrodes shall be used and conform to American Welding Society standard AWS A5.10 requirements for welding on aluminum. Procedures, welders and welding operators shall conform to AWS requirements as contained in AWS B3.0 and C5.6 for aluminum. Framing structural shapes shall be constructed of aluminum, alloy 6061-T6. Non-corrosive materials shall be used and corrosion protection

shall be provided between dissimilar metals. Sign cases shall be cleaned and de-oxidized after welding. The cases shall have a smooth, uniform finish without rivet holes, visible scratches or gouges on the outer surfaces. The front of the cases shall be finished matte black. The remaining exterior surfaces shall be natural aluminum finish. Other finishes may be acceptable if preapproved by the Engineer. The sign case interiors shall be unpainted.

Signs shall have polycarbonate sign face coverings. Coverings shall be weather tight, ultraviolet protected, non-diffusing, polycarbonate (non-matte finish) nominally 1/4-inch thick unless otherwise approved by the Engineer. Polycarbonate sign face shall be covered with an aluminum mask that meets minimum AASHTO standards for thickness for Type 1 and 2/2A DMS LEDs. The aluminum mask shall provide openings directly in front of each pixel unless surface mount technologies are utilized. Alternately, the front of each LED display module shall be black and contain louver-type openings for the LED pixels. When louvers are used, the LED pixels in the module shall be protected by a black contrast-enhancing silicone elastomer or approved equal that surrounds the base of the LEDs and seals the entire front face of the module to prevent penetration by the elements and corrosion and that does not obstruct the viewing angles of the LEDs. Pixel openings shall be of sufficient size as to not interfere with LED light output from the road viewing angles stipulated for the display. The sign face shall be designed to minimize deflection.

Sign housing, face coverings, framing and mounting members shall be designed to conform to the edition of *AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* specified in the VDOT Structure & Bridge Division's S&B-IIM-90 Memorandum (VDOT Modifications to AASHTO's Standard Specifications) in effect at the time of project advertisement, and the following clarifications:

- Basic wind speed shall be used in the designs. Alternate method for wind pressures shall not be used.

- When the installation location of the structures being designed lies between isotachs, the basic wind speed shall be determined by using the higher adjacent isotach. Any optional design parameters indicated in the AASHTO specification that are allowed when acceptable to the owner shall not be used for the designs.

Signs shall be constructed to present a clean, neat appearance; and the equipment located within shall be protected from moisture, dust, dirt and corrosion. Sign enclosures shall contain small weep holes for draining moisture that accumulates in the signs from condensation. Weep holes shall be designed to prevent the entrance of insects or roadway debris.

Signs shall be attached to the vertical truss of the butterfly and overhead sign structure with I-beams. DMS signs shall be furnished with all required attachments and hardware for attachment to the I-beams on overhead and butterfly sign structures. The number of I-beams needed and the method of attaching the I-beams to the sign housing and the vertical truss of the overhead sign structure shall conform to AASHTO requirements and the following:

- Any optional design parameters indicated in the AASHTO specification that are allowed when acceptable to the owner shall not be used for the designs.

Lifting eyes or the equivalent shall be provided for moving and mounting signs. Sign housings shall be designed so that the sign(s) can be shipped and temporarily stored without damage or undue stresses prior to installation on the support structure. Signs shall be shipped with a

temporary wood support frame that permits the shipping/storage of the sign in an above ground vertical position without damage to the sign housing.

The exterior of sign housing shall not have any manufacturer decals or identification plates of any kind attached to the housing. The interior of the sign housing shall have a permanent label with the date of manufacture, the model number, the serial number and the manufacturer identified. The label data shall match the documentation package provided with each DMS.

(c) **Power Supplies**

Power supplies shall operate from 120 VAC power. The LED displays shall be operated at low internal DC voltage not exceeding 24 VDC. Power supplies shall be solid state electronic regulated output comprised of ferro-resonant components, or a Department approved equivalent. Power supplies shall provide N+1 redundancy, or approved equivalent method. Power supplies shall be rated so that if one supply fails, the other(s) can operate the entire LED section under nominal load conditions. A minimum of one LED driver per display module shall be provided unless otherwise approved by the Engineer. A failure of one display module driver shall not cause a failure of the others. A single failure of one power supply shall not cause a failure of the other(s). Power supplies shall meet NEMA TS-4 temperature requirements operating from -31°F to +165°F (-35°C to +74°C). Power supplies shall have over-voltage protection devices that supplement the DMS assembly's overvoltage, surge, and transient voltage protection devices.

Power supplies shall be short circuit protected by turning the DC power off and shall reset automatically after 5 seconds of AC power off. Power supplies shall also be protected by a minimum overload allowance of 125 percent and have an efficiency rating of at least 80 percent. Power supplies shall be UL listed and RoHS compliant. Power supplies shall be installed with the terminals or connectors, unobstructed by hardware or mounting brackets. The operator shall be able to read the terminal designations and measure voltages without removing the power supply or obstructions.

Power supplies shall have a visible means of determining power status of individual supplies via the DMS controller and the supplies themselves. Indicators shall identify whether the supplies are functioning properly and outputting power at the correct and calibrated levels. The DMS controller shall indicate that a power supply has failed and supply shall have an identifier that indicates the specific power supply that has failed.

DMS locations shall be equipped with backup Uninterruptible Power Supply (UPS) and shall be sized to power the controller and the message sign for a minimum of 1 hour at a 50% LED pixel intensity rating. Design calculations for UPS and battery sizing shall be submitted to the Engineer for approval along with the associated shop drawings/data sheets. The DMS UPS shall conform to the environmental and technical requirements in Section 802.

The regulated DC power supplies shall conform to the following specifications, and shall be compatible with the DC voltage requirements set forth by the DMS equipment manufacturer:

- Nominal output power rating of 500 watts minimum
- Operating input voltage range shall be a minimum of 90 to 264 VAC
- Operating temperature range shall be a minimum of –30ºF to +165ºF (-34º C to +74º C)

- Maximum output power rating shall be maintained over a minimum temperature range of –30ºF to +140ºF (-34º C to +60º C)
- Power supply efficiency shall be a minimum of 80%
- Power factor rating shall be a minimum of 0.95
- Power supply input circuit shall be fused
- Automatic output shut down and restart if the power supply overheats or one of the following output faults occurs: overvoltage, short circuit, or overcurrent
- Power supplies shall be UL listed
- Printed circuit boards shall be protected by an acrylic conformal coating

(d) **Duplex Outlets for Walk-In Housings**

The DMS housing shall include a minimum of two 15 Ampere, 120 VAC duplex electrical outlets, with ground fault circuit interrupters in the DMS sign case. The two duplex outlets, one at each end, shall be located inside the DMS housing.

(e) **Electrical Panel**

The sign housing shall include an electrical panel with circuit breakers inside the sign case for 120/240V AC power distribution that is required for equipment in the sign case.

The in-sign case electrical panel shall be rated for a minimum 100 amperes and 20 single pole circuit breakers and a two pole 120/240V main breaker. Circuit breakers and wiring shall be rated and in accordance with the NEC and the anticipated loads that will be experienced by equipment and interior lighting and power receptacles located within the sign case. Circuit breakers of the appropriate size shall be provided with each panel and wiring shall be rated and in accordance with the NEC and the anticipated loads that will be experienced by equipment, interior lighting, and power receptacles within the DMS housing and the branch circuit feeding the sign case. The power wiring shall be sized to accept a short circuit current up to the maximum rating of the connected circuit breaker tripping current. The conductors shall not sustain any damage or reduction in current capacity at this maximum current level.

(f) **Temperature Sensor**

Sign cases shall be fitted with programmable temperature sensor(s) to monitor the interior temperature of the sign. The temperature sensor(s) shall be placed near the top of the display face to monitor the nominal high temperature of the LED area. Temperature sensor(s) shall monitor temperature within the range of -220F to +1850F (-30C to +85C) and shall be calibrated to accurately report temperatures within +/- 5°F (3°C). Temperature sensor data shall be monitored by the sign controller in order to respond to temperatures fluctuations affecting the equipment installed in the sign case and the LED pixels in the display of the sign face.

(g) **Cooling Fans**

Type 1 signs shall contain vented thermostatically controlled and monitored fans with filters which shall be used to draw filtered air into the sign case and circulate the air inside the

enclosures for cooling the installed equipment and personnel. Fans shall be located to circulate cooling air around the heat generating components, including the LED pixels and the respective electronic control and monitoring equipment in the sign case. The ventilation system shall control the fans based on a programmable temperature curve consistent with the temperature monitoring devices in the DMS sign case. Fans shall provide the CFM required to properly cool the enclosure and display modules. Fans shall operate from 120-volt, 60-Hz, single phase, AC power. Vents for fan intake and exhaust shall be weatherproof. Fans shall be sealed ball bearing type, brushless with balanced assemblies including the blower assembly. Type 2 signs shall use cooling fans as required to comply with NEMA TS-4 environmental requirements.

(h) **Communication between Controller Cabinet and DMS Sign Case**

1. **DMS Communications Cable**

Communication between the DMS sign case located equipment and the DMS controller in the ITS controller cabinet shall be by fiber optic interfaces unless otherwise approved by the Engineer. Electrical conductor data or control cable circuits shall be used as an interface or transmission media for interconnection between the ground control cabinet and the sign case equipment. Support shall be provided for other standard communication media including Fiber and Category 5e/ IEEE 802 Ethernet. The Contractor shall install fiber optic cable (unless otherwise approved by the Engineer) including termination facilities and system compatible transceivers as incidental to the DMS equipment.

2. **Electrical Transient Protection**

All electrical connections internal to the DMS sign case where an electrical conductor of any type is terminated shall be provided with one or more transient noise suppression devices. The devices shall be of the multiple strike type and shall not require resetting or replacement when exposed to 100 times the electrical current capacity of the electrical conductor or terminator which it is fitted to as a protection device. A bonding conductor connected to earth ground shall be the voltage drain point for each of the transient protection devices. The device and grounding shall suppress the transient to a level of no more than the normal operating voltage and current of the connected circuit. No transient protection device shall be bonded to any Direct Current connection point or the Electrical Service neutral. The metal case of each sign shall be electrically bonded to the support structure at all mounting bolt locations using non corrosive connections soldered to the equipment grounding conductors. The sign case bonding shall consist of an electrical bond wire or properly prepared electrical contact plate. The structure, in turn, shall be exothermically bonded to earth ground through a grounding electrode array which provides a minimum of 5 ohms to true ground conductivity. The Contractor's DMS vendor shall provide a DMS compatible with the grounding requirements.

Other items that are required to form and install complete and fully functional DMS assemblies that are not described in this document and that may be Vendor specific, shall be identified as to function and supplied with the DMS assemblies. These items shall be included in the products provided for the contract and shall be considered incidental to the work.

(i) **Displays**

Displays shall be full matrix. Signs shall be designed to provide proper spacing between the lines of text for the characters and lines of text as indicated herein. Sign displays shall have

sufficient borders on all four sides for display clarity and background contrast. Characters and shapes shall be formed on a matrix comprised of rows and columns forming a continuous line.

Pixel columns and rows shall be perpendicular. Individual characters shall be formed by pixels within a character matrix defined by the character font. All upper case characters shall be displayed over the entire height of each character matrix. Character to character spacing shall be determined by the font selected by the user. Lower case letters that extend below the bottom of the line base shall be proportional in location and style per line. Both fixed and proportional spaced fonts shall be supported.

Legibility distance shall be defined as the legibility of displays from a specified distance and shall include daylight hours with direct sunlight on the face and behind the DMS.

Each sign shall be able to display a message composed of any combination of the following characters and shapes:

- All upper case letters A through Z
- All lower case letters a through z
- All decimal digits 0 through 9
- A blank or space
- Punctuation marks shown in the brackets [. , ! ? – ‘”/( )]
- Special characters shown in brackets [# $ % & * + < >]
- 32 or more special graphics shapes editable by the user.

The sign displays shall support text and graphic displays in accordance with the NTCIP communication protocol specified and shall be downward compatible with the Department’s implemented NTCIP V1 protocol. All fonts shall be editable through the vendor’s maintenance laptop and from the TOC’s ATMS software. Ensure DMS fonts have character dimensions that meet the MUTCD, Section 2L.04, paragraph 08. Ensure that full-color signs can display the colors prescribed in the MUTCD, Section 1A.12.

The time required to clear any display and post any new display shall not exceed 500 milliseconds.

The DMS shall conform to the display characteristic requirements shown in Table VIII-3 unless otherwise approved by the Engineer.

TABLE VIII-3
Display Characteristics

Requirement	TYPE 1	TYPE 2	TYPE 2A	TYPE 1	TYPE 2	TYPE 2A
	Amber			Full Color		
Pixel Pitch (max.)	66 mm	44 mm	66 mm	20 mm	20 mm	20 mm
Characters per Line (min.)	21	15	15	21	15	15
Character Height	18 in	12 in	18 in	18 in	12 in	18 in
Inter-line Spacing (pixels – min.)	3	3	3	12	8	12
Inter-character Spacing (pixels – min.)	1	1	1	4	3	4
Rows (pixels – min.)	27	27	27	96	64	96
Columns (pixels – min.)	125	90	90	400	192	288
Default Font Array	5 x 7	5 x 7	5 x 7	15 x 23	10 x 15	15 x 23
Border Horizontal Dimension – approx.	12 in	8 in	12 in	12 in	8 in	12 in
Border Vertical Dimension – approx.	12 in	8 in	12 in	12 in	8 in	12 in
Legibility Distance	1000 ft	700 ft	1000 ft	1000 ft	700 ft	1000 ft

(j) **Light Emitting Diodes (LEDs)**

All LED's provided for the manufacture of DMS shall conform to the following requirements:

- LEDs shall be non-diffused, high-output, solid state lamps utilizing aluminum indium gallium phosphide (AllnGaP) LED technology. All LEDs used in all DMSs shall be from the same manufacturer.

- LEDs shall emit a true amber color at a wavelength of 592 nm (±5nm).

- Size of the LED shall be T-1~ (5mm), or approved equivalent for surface mount technologies.

- LEDs shall be nominally rated for 100,000 hours of operation under 100% intensity (at manufacturer's stated current for non-surface and surface mount technology) under NEMA TS-4 environmental conditions but with temperature extremes of -30°F and +165°F (-34° C and +74° C).

- LED life is defined as the time it takes for the LED light output to degrade to one-half of the LED's initial light output.

- All LEDs shall have a minimum viewing angel of 30 degrees (15 degrees from the center to each side of center).

- LEDs shall have no less than 50% of the normalized intensity at 50% of their maximum viewing angles.

- LEDs shall be secured in perpendicular alignment to the 0 degree centerline of the LED.

- Current flow through the LED shall not exceed manufacturer's stated current for non-surface and surface mount.

- Where through-hole LEDs are used, LEDs shall be soldered to the display module circuit board with through-hole type circuit board mounting techniques.

All full color LEDs provided for the manufacture of DMS shall conform to the following requirements in addition to those above:

- Red LEDs shall utilize AlInGaP semiconductor technology and shall emit red light that has a peak wavelength of 618-630nm.

- Green LEDs shall utilize InGaN semiconductor technology and shall emit green light that has a peak wavelength of 519-539nm.

- Blue LEDs shall utilize InGaN semiconductor technology and shall emit blue light that has a peak wavelength of 460-480nm.

- Each color LED module shall contain a minimum of 256 surface mount LED pixels, configured in a two dimensional array. The pixel array shall be a minimum of 16 pixels high by 16 pixels wide.

- The distance from the center of one pixel to the center of all adjacent pixels, both horizontally and vertically, shall be .81-inch (~20 mm).

- The LED manufacturer will perform color sorting of the bins. Each color of LEDs will be obtained from no more than 2 consecutive color "bins" as defined by the LED manufacturer.

- The LED manufacturer will perform intensity sorting of the bins. LEDs will be obtained from no more than 2 consecutive luminous intensity "bins" as defined by the LED manufacturer.

- The various LED color and intensity bins will be distributed evenly throughout the sign and will be consistent from pixel to pixel. Random distribution of the LED bins will not be accepted.

- The LED manufacturer will assure color uniformity and consistency on the LED display face within the 30 degree cone of vision. Inconsistent color shifts or intensity will be cause for rejection.

(k) **Pixels**

Each light emitting pixel of an LED display shall consist of a cluster of closely spaced LEDs. LED pixels shall conform to the following requirements:

- Pixels shall be constructed with strings of LED's.

- Each amber pixel shall consist of the minimum number of LEDs per pixel determined by the DMS manufacturer to meet the minimum optical requirements and redundancy requirements of the NEMA TS-4 standard. LED power supply redundancy requirements shall comply with Section 804.04(c).

- Each color pixel shall consist of a minimum of one LED for each color (Red, Green, Blue). LED power supply redundancy requirements shall comply with Section 804.04(c).

- Each pixel shall illuminate a minimum of 40 candelas (for Type 1) or 33 candelas (for Type 2/2A) with no more than 50% reduction in intensity at 15 degrees from center viewing angles. The average illumination of the display shall be determined by measuring the display intensity within a square meter of display area. The intensity shall be a minimum of 7,440 candelas per square meter for amber signs, measured through the polycarbonate display face sheeting and determined from three measurements taken for the furnished display or sign.

- Where multiple strings are employed, the failure of an LED within one string of a pixel shall not affect the LEDs in any other string or pixel.

- Drive current shall be within the manufacturer's specifications to provide the overall sign intensity as specified herein.

- All LEDs used in a sign shall be from one luminous intensity bin from which the dimmest LED does not emit less than 70% of the luminous intensity of the brightest LED when driven with identical currents.

- Pixels shall be driven with direct-drive pulse width modulation. Maximum pulse amplitude shall not exceed 30 mA, and shall be adjustable in no greater than 5 mA increments.

- Materials used in the fabrication of LED clusters shall contain a UV light inhibitor and shall be designed for direct exposure to sunlight.

- Each LED pixel shall be operated over the environmental range defined herein.

- LED pixels shall be mounted perpendicular to the display panel.

All full color LED pixels provided for the manufacture of DMS shall conform to the following requirements in addition to those above:

- Each pixel shall contain the quantity of discrete LEDs needed to output white colored light at a minimum luminous intensity of 12,000 candelas per square meter when measured using a photometric meter through the DMS front face panel assembly.

- Each pixel shall also be capable of displaying amber colored light with a minimum luminous intensity of 9,000 candelas per square meter when measured using a photometric meter through the DMS front face panel assembly.

Pixel modules shall be replaceable from the inside rear of the display for walk-in enclosures and from outside of the enclosures for non-walk-in sign enclosures without the use of specialized tools. Display modules shall be interchangeable between signs employing the same display technology and pixel pitch furnished by a DMS manufacturer.

The number of pixels making up the character width shall vary by character and shall be in accordance with the characters described herein but the number of characters per line shall be based on the default font sizes identified in Table VIII-3.

(l) **Serviceable Parts**

LED driver boards shall be quickly replaceable and hot swappable within the sign housings for all signs. Plug-in locking connectors shall be provided on each pixel driver board for all connections. Connectors shall be held in place with positive retaining latches. Spring clips, screws or any connector requiring tools to engage or disengage shall not be used. Driver boards shall be easily removable for service and replacement with simple hand tools. Driver boards and all electronic circuit boards installed in the sign housing shall be thoroughly coated with an acrylic or urethane conformal coating for moisture-resistance.

(m) **Multiple Sign Control Maintenance Positions**

The DMS controller operation shall be accessible from both the ground or pole mounted controller and from inside the DMS sign case through a remote control panel or local communication port in the sign case for maintenance. If a separate remote control panel is not deployed, the laptop computer interface shall be Ethernet. The activation and use of the remote control facilities shall not require disconnection of the normal communication service between the ground or pole mounted controller and the sign case connections or removal of any equipment. The DMS shall be provided with the necessary hardware and software to support the Network, Local Network interface to the ground or pole mount cabinet, and the in-sign case interface or remote control panel.

The remote control panel or an Ethernet interface located in the sign case shall have the same capabilities as a laptop computer used for maintenance purposes connected to the local port of the ground or pole mounted DMS controller and shall be used for field maintenance.

(n) **DMS Support Equipment**

The Contractor shall provide the following spare support equipment for each type of DMS installed in the Contract per each Support Material Package quantified:

- 10 LED display modules
- 10 LED driver cards
- 2 Power supplies (including surge suppressors)
- 2 complete fan assemblies (for DMS sign case) including timers
- 1 Heater
- 1 Temperature Sensor
- 1 Photocell
- 1 Low voltage power panel circuit board

These items shall be identical to those that are provided within each type of DMS assembly provided by the Contractor. Each item shall be individually boxed with a label attached to the

box that includes a description of the item, date of manufacturer, part number and manufacturer or vendor of the item. A description of the item's function and installation or replacement (remove and install) procedures shall be included with each item on 8.5"X11" sheets of paper. If multiple sheets are required, the sheets shall be stapled together in sequential order. The top sheet shall have the item name and vendor's name at the top of the sheet. The sheets shall be placed in the boxes with the item.

(o) **DMS Controller Materials**

1. **General**

Each sign shall include a controller which shall be installed in a ground or pole mounted ITS controller cabinet. The Contractor shall provide software compatible with the Department's laptop computers and the laptop to DMS controller cables and any other material equipment needed to program the DMS controllers. The Contractor shall also provide a maintenance technician interface to the DMS controller installed in the ground mounted cabinet, and any sign case remote connection shall be provided by the DMS manufacturer and shall be retained by the Department.

Controllers shall be installed to operate over a communication system between the Central Control (e.g. Regional TOC) facility and at a minimum the following communication media:

- 10/100 Ethernet over copper and/or fiber through a managed switch supporting layer 2 and layer 3
- Wireless modems
- Short haul microwave

Communications interface shall be configured per the Department's local regional office IP and serial addressing requirements. Contractor shall coordinate with the Engineer and the Department's existing System Integrator to obtain site-specific parameters.

Controllers shall be a microprocessor based intelligent unit, capable of controlling and monitoring all of the DMSs and associated functions described in the Contract. Controllers shall be integral units with their own power supplies. Controllers shall be housed in durably fabricated aluminum enclosures. The controller's volume and power supplies shall not exceed two cubic feet and shall be shelf and 19 inch EIA rack mountable.

2. **Memory**

Controllers shall have both permanent and changeable memory. Permanent memory shall be in the form of plug-in EEPROM integrated circuits, or an approved equivalent flash memory technology, and shall contain the operating system, application software, and firmware. Changeable memory shall be in the form of NVRAM integrated circuits (or other approved backup) that retains the data in memory for a minimum of one year following a power failure. Changeable memory shall contain all of the changeable operating parameters including the set-able data defined by the NTCIP V1 and V02.35 requirements.

3. **Data Transmission Requirements**

Each controller shall have a minimum of one 10/100 Ethernet technician local support port, one 10/100 Ethernet Central Control, one serial communication control port, one TIA/EIA-232E communication technician support port and one 10/100 Ethernet or dedicated data over RS-485 to the sign case interface port. Each of these ports shall be permanently labeled Local Ethernet, Central Ethernet, Local Serial and Sign Data. The maintenance technician local ports shall be located on the front of the controller easily accessible and quickly identifiable for the maintenance technician. The RS-232 port shall be capable of operation at all industry standard speeds up to 115Kbps and shall support all of the Subnet Profiles defined in paragraph (p)1. herein. A maintenance technician shall be able to directly connect a laptop computer to the LOCAL ports via a direct Ethernet or serial cable and carry out all central computer "CENTRAL" port operations. The controller shall meet all other communication requirements, such as checksum and parities, specified by NTCIP standards. All ports shall be permanently labeled.

Controller Addressing - A configurable IP Network Address shall be assigned to each controller in coordination with the Engineer in the local Traffic Operations Region.

4. **Clock**

The controller shall contain a computer-readable time-of-year clock with a lithium battery or other equivalent backup. The clock shall automatically adjust for daylight saving time and leap year through upgradeable software. The clock shall be set by the sign controller's microprocessor and shall be accurate to within 1 minute per month.

5. **Local Interface Functions**

The controller shall support a local user interface that allows the maintenance technician to perform DMS configuration, maintenance, diagnostics and repair activities as well as compose, display, and blank messages through a laptop connected to one of two local ground or pole mounted controller ports, or the interface panel internal to the sign case or sign case local port that will accommodate a laptop computer. The local user interface shall allow display of the available display test patterns on the sign, blank the current message and perform available canned tests (pixel, power supply, etc.). The display of other messages or DMS configuration changes shall require an optional password. The default password shall be coordinated and selected by the Department. The password shall not be echoed on the operator interface when entered by the user. Controllers shall be initially shipped with the default password selected by the Department. The sign controller shall store a minimum of 3 user configurable passwords.

6. **Controller Software**

The DMS controller software shall support NTCIP V02.35 and shall be backward compatible with the Department's current Version 1 of the NTCIP communication protocol and the functions and features contained within the Department's existing TOC central control software. Local controllers shall be configurable by the user to define the number of LED display elements (pixels) to fail either in an off or on state before the controller blanks the sign.

a. **Display Presentation:**

The sign controller shall control the driver modules to create the desired display on the sign. At a minimum, the signs shall be able to display the characters as described in the respective NTCIP supported protocols. Space allocated to each character shall be proportional to the character's true width and a non-proportional spacing as commanded by the supported character fonts.

b. **Display Selection:**

The controller shall implement the display per the logic defined in the referenced NTCIP documentation.

c. **Dimming System:**

Each DMS shall be provided with a DMS display intensity control system. The system shall contain a minimum of three DMS sign case installed photo-electric sensors to measure light striking the sensor and report the levels within 255 increments to the display control system. The sensors shall be positioned so that one sensor shall monitor the light levels on the front of the DMS, a second sensor shall monitor the light striking the back of the DMS and a third sensor shall monitor the light striking the top of the DMS (Ambient light). The levels reported to the DMS control system shall be processed so that the highest light level sensed shall be considered the controlling level and shall be compared against a table containing a minimum of 160 configurable intensity levels.

The intensity levels shall be configurable from the local or central control points. Each intensity level shall consist of an entry and exit value that allows the overlapping of levels to prevent display fluctuation with minor ambient light changes and flickering of the display during intensity level changes.

The dimming system shall conform to the following requirements:

(1) **Photocells** may be externally mounted or enclosed within the sign case with transparent covered windows that allow light to pass from the exterior of the sign case to the surface of the photocell. The photocell shall be vibration and temperature extreme hardened to withstand NEMA TS-4 Environmental conditions for the life of the DMS. The sensors shall be capable of being continually exposed to direct sunlight without impairment of performance.

The sensors shall be immune to transient voltages and vibration. The connections to the sensor shall be through solder connection plugs and sockets with interlocking latches. The wiring shall be tinned, stranded copper conductors in shielded cables with electrical noise protection.

(2) **Dimming Levels** - Manual and automatic dimming modes shall be provided enabling the user to select the desired mode of operation. The dimming system shall be capable of selecting a minimum of 160 levels from the sensed ambient light table containing values from 0 to 255 light levels in increments of 10. The set points for each of the ambient light levels shall be set by user adjustable software.

(3) **Interference -** The dimming circuit and sign power system shall have electrical devices installed to minimize RFI noise generated by the sign both on the power line and radiated by sign circuitry.

(4) **Temperature Limit** - Internal DMS sign case temperatures shall be monitored in concert with the fan forced ventilation to prevent an over temperature from damaging the LED display. Upon reduction of the temperature below the current reduction level the logic shall increase the power to the LEDs consistent with the preconfigured threshold. In cases where the thermal calculation indicates that a primary and secondary fan system is warranted, the primary fans shall start as the initial reaction to reaching the threshold temperature. If temperatures rise to the next threshold, the secondary fans shall start.

Whenever internal sign temperature continues to increase beyond the programmed safety limit, the sign controller shall issue reduction in power applied to the pixels. This power reduction process shall be repeated until the temperature fails to increase beyond the threshold established for the power applied or the display is turned off completely. The configuration table shall provide limits that are constrained within those operable limits defined by the sign manufacturer's specifications.

In conformance with the NTCIP communication protocols, over temperature alarms and alerts and display status reports shall be provided.

d. **Diagnostics and System Failure**

(1) **Failure Reports -** The sign controller shall detect DMS status reports and have them available from a poll from central or the Local Connection. Sensors shall be provided in the DMS controller hardware and firmware that shall detect abnormal or current status data. Data acquired by the DMS controller shall be provided to the central system.

(2) **Diagnostic Test** - Upon command from a remote computer, the controller shall test the electrical operation of all drivers and the over current, under current and normal current of the pixels. The field controller shall analyze the pixel current and determine whether the pixel is operating with "normal/on", "under/off", or "over/short" current and shall communicate the results using standard NTCIP data objects.

(3) **Power Interruptions -** The contents of the controller's memory shall be preserved by backup power during power interruptions and the controller shall resume operation automatically when power is restored. Upon recovering from a power interruption, the controller shall report to the central computer that it has recovered from a power interruption.

e. **DMS Software Rights**

The Contractor shall provide a non-assignable software use license in support of the DMS on an exclusive perpetual basis. The Contractor shall provide documentation to the Department or its designee of any incompatibility identified between the central control software and the DMS firmware and software to the level that

a resolution plan may be formulated. It is anticipated that there may be minor incompatibilities between the Contractor's DMS vendors' NTCIP V02.35 implementation and that of the Department's NTCIP V02.35 central implementation. The Contractor's vendor software shall be compatible with the Department's NTCIP V02.35 central implementation at no additional cost.

(p) **Communication Requirements**

The interfaces between the ground or pole mount ITS controller cabinet and the DMS sign case shall support single mode fiber connection media (or other as approved by the Engineer) and others defined in the DMS hardware requirements herein.

The communication requirements shall be in conformance with the Department's implemented NTCIP V1 communication protocol and the NTCIP V02.35 communications protocol. The NTCIP V02.35 shall be downward compatible with the Department's NTCIP V1 communication protocol.

1. **VDOT NTCIP Requirements**

The following pertains to the existing NTCIP V1 communication protocol implemented by the Department.

The following terms shall apply within the scope of the NTCIP V1 requirements and is provided as background information only and as documentation that should be supplemented by the Contractor's DMS vendor with other data and used for downward compatibility testing of the NTCIP Version 2 software/firmware.

- **FSORS** - Full, Standardized Object Range Support: Support for, and proper implementation of, all valid values of an object as defined in the object's OBJECT-TYPE macro in the NTCIP standard; further defined in two distinct sub-requirements: 1. If the ACCESS of an object is read-write, a Management System shall be able to set the object to any valid value as defined by the SYNTAX and DESCRIPTION fields (except that the value of 'other' need not be supported when such a value is defined) and the indicated functionality shall be provided. 2. The value indicated by an object (e.g., in response to a 'get'), regardless of the ACCESS, shall reflect the current condition per the rules specified in the object's DESCRIPTION.

- **Management System** - A computer system used to control an NTCIP component. This includes any laptop software used for field control as well as the central control software.

- **NTCIP** - National Transportation Communication for ITS Protocol.

- **NTCIP Component** - A DMS or a Management System.

- **NTCIP System** - A Management System plus the various interfaces and DMSs controlled by the Management System.

- **Response Time** - The time required to prepare and begin transmission of a complete

response containing the requested Application Layer (communications protocol) information. This is measured as the time from receipt of the closing flag of the request to the transmission of the opening flag of the response when the device has immediate access to transmit.

This specification references several standards through their NTCIP designated names. The following list provides the reference to the version of each of these standards. In many cases, the standard may also be known by its original NEMA assigned number, in these cases, the NEMA number is also identified. The content of the NEMA standard is identical to that of the NTCIP standard.

Each NTCIP component covered by these specifications shall implement the most recent version of the Standard at the stage of Recommended or higher as of November 30, 2010, including any and all Approved or Recommended Amendments to these Standards as of the same date. For any referenced document which is not yet at the Recommended level, the version cited below shall be used. If the Contractor wishes to use later versions of these Standards, the Contractor shall first obtain the Engineer's approval. The Contractor shall monitor NTCIP activities to ascertain any more recent documents that apply to the project and use them as required.

a. **NTCIP Standards**

(1) **General Requirements/Subnet Level:**

Each serial port on each NTCIP Component shall support NTCIP 2101 at data rates of 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.

All "CHAP" secrets shall be user configurable via the CHAP Secret Table.

NTCIP Components may support additional Subnet Profiles. At any one time, only one Subnet Profile shall be active on a given serial port of the NTCIP Component. The NTCIP Component shall be configurable to allow the field technician to activate the desired Subnet Profile and shall provide a visual indication of the currently selected Subnet Profile.

(2) **Transport Level:** Each NTCIP Component shall comply with NTCIP 2202 when using the NTCIP 2103 Subnet Profile. NTCIP Components may support additional Transport Profiles. Response datagrams shall use the same Transport Profile used in the request.

(3) **Application Level:** Each NTCIP Component shall support:

- All requirements for an agent and all requirements for a protocol entity identified in Section 3 and Section 6 of NTCIP 1103.
- All requirements contained in Clause 8.1 of NTCIP 1103.
- All objects defined in clauses A.3, A.6, A.7, A.8, A.9, and A.10 of Annex A of NTCIP 1103.
- Each NTCIP Component shall support the receipt of Application data packets at any time allowed by the subject standards.

An NTCIP Component may support additional Application Profiles. Responses shall use the same Application Profile used by the request.

(4) **Information Level:** Each NTCIP Component shall provide Full, Standardized Object Range Support of all objects required by these specifications unless otherwise indicated. The maximum Response Time for any object or group of objects shall be 200 milliseconds. The sign shall support all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1201 and NTCIP 1203. Table VIII-4 indicates the modified Object requirements for these mandatory objects.

TABLE VIII-4
Modified Object Ranges for Mandatory Objects

ModuleTableEntry shall contain at least one row with module Type equal to 3 (software). The moduleMake shall specify the name of the manufacturer, the moduleModel shall specify the manufacturer's name of the component and the modelVersion shall indicate the model version number of the component.
maxGroupAddresses shall be at least 1
communityNameMax shall be at least 3
ChapMaxSecrets shall be at least 3, upon delivery, the names shall be DMSVDOT, DMSVDOT2, and DMSVDOT3, and the secrets shall be identical to the name.
dmsNumPermanentMsg shall be at least 1
dmsMaxChangeableMsg shall be at least 21
dmsFreeChangeableMemory shall be at least 20 when no messages are stored
dmsControlMode shall support at least the following modes: local, central, central Override

The Permanent Messages shall display the content shown below:

PermMessage 1 shall be a test message that allows the user to determine if all pixels are working properly and configured for their actual locations in the display.

The NTCIP Component shall also implement all mandatory objects of the following optional conformance groups:

(a) Time Management, as defined in NTCIP 1201, and shall also include setting time zone and daylight savings modes.

(b) Timebase Event Schedule, as defined in NTCIP 1201.

(c) Report, as defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group:

- maxEventLogConfigs shall be at least 50

- eventConfigurationMode - The NTCIP Component shall support the following Event Configuration Modes:

- o onChange
- o greaterThanValue
- o smallerThanValue
- o maxEventLogSize shall be at least 200
- o maxEventClasses shall be at least 16

(d) Font Configuration, as defined in NTCIP 1203, including configuring, deleting, and validating a font.

Upon delivery: The first font shall be a standard 18” font (12” for Type 2), the second font shall be a double-stroke 18” font (12” for Type 2), the third font shall be a 28”, the fourth font shall be empty, and the first three font sets shall be configured in accordance with the ASCII character set for the following characters:

- “A” thru “Z”-All upper case letters.
- “0” thru “9”-All decimal digits.
- Space (i.e., ASCII code Ox20).
- Punctuation marks shown in brackets [. , ! ? -”””” I ()]
- Special characters shown in brackets [# &* +< >]

(e) DMS Configuration, as defined in NTCIP 1203.

(f) DMS shall support monitoring the sign housing environment, remotely resetting the sign controller, configuring Low Fuel Threshold values and default background and foreground colors, and controlling bi-directionally connected external devices.

(g) Multi Configuration, as defined in NTCIP 1203. Table VIII-5 indicates the modified object requirements for this conformance group.

(h) Sign Status, as defined in NTCIP 1203

(i) Status Error, as defined in NTCIP 1203

(j) Pixel Error Status, as defined in NTCIP 1203

The NTCIP Component shall also implement the optional objects shown in Table VIII-6.

TABLE VIII-5
Modified Object Ranges for the Multi Configuration Conformance Group

defaultBackgroundColor	The DMS shall support the following background colors: black
defaultForegroundColor	The DMS shall support the following foreground colors: amber
defaultJustificationLined	The DMS shall support the following forms of line justification: left, center, right, full
defaultJustificationPage	The DMS shall support the following forms of page justification: top, middle, bottom
defaultPageonTime	The DMS shall support the full range of these objects with steps sizes no larger than 0.5 seconds
defaultPageOffTime	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds .
defaultCharacterSet	The DMS shall support the following character sets: eightBit

TABLE VIII-6
Optional Object Requirement

globalSetIDparameter
eventConfigLogOID
eventConfigAction
eventClassDescription
defaultFlashOn
defaultFlashOff
dmsSWReset
dmsMessageTime Remaining
dmsShortPowerRecoveryMessage
dmsLongPowerRecoveryMessage
dmsShortPowerLossTime
dmsMessageReset
dmsCommunicationLostMessage
dmsTimeCommLoss
dmsEndDurationMessage
dmsMemoryMgmt
dmsMultiOtherErrorDescription
dmsIllumLightOutputStatus
WatchDogFailureCount
dmsStatDoorOpen
FanFailure
FanTestActivation
TempMinCrtlCabinet
TempMinSignHousing
TempMaxSignHousing

The DMS shall support controlling external beacons (2 with opposing flash, at a minimum).

Full software documentation shall be supplied including a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

- The relevant version of each official standard MIB Module referenced by the device functionality.

- If the device does not support the full range of any given object within a Standard MIB Module, a manufacturer specific version of the official Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX and DESCRIPTION fields of the associated OBJECT TYPE macro. The filename of this file shall be identical to the standard MIB Module, except that it will have the extension ".man".

- A MIB Module in ASN.1 format containing any and all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros. A MIB containing any other objects supported by the device.

The DMS manufacturer shall allow the use of any and all of this documentation by any party authorized by the Department for systems integration purposes at any time, initially or in the future, regardless of what parties are involved in the systems integration effort.

(q) **DMS Structures**

DMS sign structure designs shall be in conformance with the requirements of Section 700. Structures for walk-in signs shall be designed to include landings with toe stops adjacent to entry doors, handrails, harness clip-ons, and other design features to provide OSHA compliant access to the entry of the walk-in sign cabinet from the edge of pavement.

Furnish and install DMS span (length as indicated on the Plans) and butterfly structures with concrete foundations in accordance with these Specifications, Standard Drawings, and the Contract. Foundations shall be constructed from the minimum class of concrete required to support the sign structure per structural calculations and these Specifications. Span structures shall be constructed to the appropriate width to span across all travel lanes and shoulders of a single direction of travel, or to span across all travel lanes and shoulders of both directions of travel. Span structures or Butterfly-type structures shall be used to support a Type 1 DMS or Type 2/2A DMS, unless otherwise noted in the Plans.

The Contractor shall ensure that all structures are placed outside of the clear zone or install guardrail as required. All testing and documentation shall be included and no separate payment will be made. Furnish complete sign structure details including, but not limited to, loads imposed on the structure and connecting details for Engineer approval prior to fabrication and erection. Structural design is to be signed and sealed by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia.

(r) **DMS Retrofit**

The work required for a DMS retrofit includes removing the existing DMS from the existing structure, replacing components of the DMS, and reinstalling the DMS on the existing structure, unless otherwise noted in the Plans. The Contractor performing the retrofit shall use DMS equipment approved by the Engineer, and listed by the manufacturers or vendors for use in the proposed application and shall meet these specifications.

- DMS Retrofit, Type 1 shall be for all walk-in signs and Type 2 shall be for all non-walk-in signs.
- DMS Retrofit, Type 2A will be for 18" character heights, per NEMA TS-4.
- DMS Retrofit, Type 2B will be for 12" character heights, per NEMA TS-4.

Where DMS retrofit activities are to follow DMS removal, the Contractor shall install a pull rope during the removal of existing communication and power cables between the ground cabinet and the DMS structure.

The signs are of varying makes and models, varying sign housings, varying character sizes, etc. The equipment, materials and related services to be provided for DMS retrofit shall be in conformance with the respective sections of the specification for complete DMS installations. The retrofitted DMS is to be brought up to the same technical and performance levels as a new DMS after an existing CMS, VMS, or DMS is subjected to the retrofitting process. The DMS sign case painting process shall follow a four-step method of primer, paint, initial clear coat, and final clear coat. Paint products shall contain Kynar 500 polyvinylidene fluoride (PVDF) or approved equal.

The existing sign structure and controller cabinet are typically within 100 feet of one another. Actual distances for each site shall be field verified by the Contractor during the survey stage of the retrofit activities. Controller cabinets are separated from the structure behind sound walls in some locations.

Locations identified for Auxiliary UPS Power shall utilize the existing controller cabinet, unless otherwise approved by the Engineer.

Proposed components shall be compatible with the existing sign housing, unless otherwise approved by the Engineer.

Prior to removing the sign from the structure, the contractor shall conduct a field survey to determine the necessary DMS components that will be required for the retrofit. Once the field survey is completed the Contractor shall submit the following for approval from the Engineer:

1. **Shop Drawings (per sign type):**

    - Revised Ground Cabinet Layout (including UPS equipment, where applicable)
    - DMS Enclosure Layout
    - DMS Attachment Details

- Power and Communications Connection Details

2. **Retrofit approach, procedures and certifications:**

- Letter from vendor with requirements compliance matrix
- DMS Removal Plan (including sign lighting)
- Paint system installation certification
- Welding Certifications
- Sign window refurbish or replacement procedure
- NTCIP Compatibility Exerciser Test Certification
- Factory Proof of Performance Testing Certification
- NEMA TS-4 Environmental Testing Certification

3. **Testing Procedures:**

- Pre-Installation Testing
- Field Acceptance Testing
- TOC Integration Testing
- 30-Day System Acceptance Testing

The Contractor shall request approval from the Engineer to remove the sign a minimum of 7 days prior to the removal. The Contractor shall not remove the DMS from the structure until the retrofit materials for the DMS have been received. The Contractor shall remove, perform the retrofit and reinstall the sign within 45 days of the date of removal. Liquidated damages shall apply as is indicated in the project contract.

DMS removal for retrofit includes removal of the sign from the structure, removal of existing communications cabling between the ground cabinet and the sign, and removal of the power cabling from the sign to a disconnect point. The Contractor shall submit a proposed disconnect point to the Engineer for approval. DMS removal shall also include the removal of the sign lighting, where present, located in front of the existing DMS.

The Contractor shall weigh the existing sign prior to removing the components to enable comparing the weight of the existing sign with the sign retrofit. The retrofitted sign weight shall be equal to or less than the existing sign weight. The retrofitted sign shall be weighed on-site before reinstallation.

Following the removal of the DMS, the Contractor shall transport the sign to a selected facility where the retrofit work will be performed. Retrofit work shall be performed at an indoor facility. The Contractor shall remove all components from the sign and deliver them to a designated Department facility or dispose of the materials in accordance with Section 106.04 of the

Specifications. Refinish the sign housing using materials in accordance with these Specifications. Notify the Engineer to inspect the refinished sign housing upon completion and prior to installing the retrofit materials. If the retrofitting facility is more than a two hour drive from the associated regional TOC, the Contractor shall be responsible for all travel expenses associated with the Engineer's inspection visit.

The DMS retrofit will include replacement of existing DMS components within the housing, as applicable. All materials shall meet the material and installation requirements defined herein:

- LED panels;
- LED panel mounting brackets and hardware;
- Controllers;
- Power supplies;
- Surge Protection Devices (SPD) for communications and power;
- Light, temperature and humidity sensors;
- Heaters;
- Fans;
- Filters;
- Polycarbonate sheeting or approved Acrylic / Polycarbonate composite sheeting;
- Miscellaneous materials for the installation of these components; and
- All cabling assemblies, connectors, fittings, brackets, etc. for a fully operational sign assembly.

DMS retrofit shall include replacing the existing DMS controller with a new controller in the existing ground cabinet. Some existing sites currently rely on serial RS-232 communications. Replacement controllers shall support two communication ports (one Ethernet, and one serial) or the Contractor shall supply the standard Ethernet port with a compatible media converter to integrate with the existing system communications.

DMS retrofit work shall be performed by individuals certified by the retrofit equipment manufacturer or vendor to perform the retrofit activities. Upon completion of the sign retrofit work at the retrofit facility, follow the factory testing procedures, completing them successfully prior to scheduling reinstallation.

A Professional Electrical Engineer, holding a valid license to practice engineering in the Commonwealth of Virginia, shall conduct a field review of the existing power service for the sign. The Contractor shall submit the recommendations and new design (if applicable) from the Professional Electrical Engineer to provide appropriate power to the retrofitted DMS. This shall be submitted to the Engineer for approval.

Furnish and install a new communications and power cable from the DMS controller to the sign housing. Make all necessary connections for a fully functional DMS. The Contractor shall proof the existing conduits where new conductors and/or cabling is being placed and demonstrate that a continuous path exists by passing a mandrel through the conduit.

The proofing test shall consist of the following:

- Blow air through the existing conduit to remove debris and water.
- Mandrel test conduit path by pulling a mandrel through the conduit.

The mandrel shall have a diameter no less than 70% of the inside diameter of the conduit and shall have a length of at least 2 inches. If the conduit does not allow the mandrel to be pulled through, the conduit run shall be cleaned and repaired to permit passage of the mandrel.

Repairs. If conduit obstructions still exist, repair conduit where needed by installing a new conduit section connecting to the existing conduits using a mechanical splice approved by the Engineer.

The Contractor shall coordinate with and receive approval from the Engineer prior to the repair of any conduit. The Contractor shall provide to the Engineer a final construction quantity and shall be paid for the total length for all repaired conduit as approved by the Engineer.

Cleaning. After the mandrel test, clean and swab the existing conduit run before cables are installed.

The Contractor shall furnish and install new attachment hardware to install the sign onto the existing or new sign structure. The attachment hardware shall meet ASTM standards.

Following installation of the sign onto the existing or new sign structure, make all necessary connections for a fully functional DMS. Perform field, TOC Integration, and 30-day system acceptance tests as defined within these Specifications.

804.05—Procedures

Securely mount the sign on the sign support structure in accordance with Section 700 and the design of the structure; DMS sign case, and attachment hardware. All signs shall be mounted with a minimum clearance of 20 feet between the crown of the roadway surface and any portions of the signs or associated structure.

Lift and install the DMS housing and display in place on the overhead structure only with prior approval of, and in the presence of the Engineer. Do not lift and install the DMS housing and display until all equipment, materials, and labor are available so that the DMS can be operated with messages from the local DMS controller within 72 hours of installation on the overhead structure.

When lane closures are required for DMS installation, attach and secure all mechanical hardware for initial attachment prior to the reopening of lanes to traffic. Complete the attachment of hardware prior releasing the lift cables. Install and connect the DMS sign wiring and communications cables to the field device cabinet only after attaching and securing the sign to the sign structure.

Furnish and install DMS communications cables between the DMS housing and ground cabinet. Install all equipment necessary to operate the dynamic message signs. Furnish and install any conduit required on the device structure for installation of any power conductors and communications cabling to the DMS assembly. All wiring between assemblies within the sign case and the ITS controller cabinet shall be installed in conduit. Feed all cable connections from the DMS assembly leaving a minimum of 25 feet of slack in the cable for normal movement and maintenance of the assembly. At vertical transitions, support the cable by integral hooks or other methods that assure that the stress placed on the wiring or fiber optic cable is minimized and in no case violates the cable or wire manufacturer's maximum static, pulling, or dynamic tension, or bend radius. Install the wiring in continuous, unspliced lengths between the sign housing and the field device cabinet. Coil sufficient slack neatly in the base of the field device cabinet to ensure that the connections to the housing and the power source will be possible without the need to add or splice any cables.

Route all other wiring within the sign case and ITS controller cabinet in properly supported cable trays.

Furnish and install all necessary power and communications cabling and terminations in the ITS controller cabinet for a fully functional system including operability at the cabinet, at the DMS, between the cabinet and the DMS, and between the cabinet and any upstream and downstream cabinets. This shall include any fiber jumpers, Cat5e jumpers, etc. that may be required for complete functionality of this ITS project.

Perform all connector crimping using a ratchet installation tool with a compatible crimp jaw sized for the connector used. Strip wire in accordance with the connector manufacturer's recommendations. Make all connections to terminal boards or screw-type equipment terminals with insulated fork-tongue compression connectors using stranded cable. Make all wiring to bulkhead connectors on equipment housings with MS bayonet-type or other connectors. Solder connector joints for use with extra-low voltage (less that 30 Volts) systems, with the joint metals preheated to the flow temperature of the solder or crimped using ratchet-type positive crimp tools and a double crimp (conductor and jacket) connector.

Make all harnesses neat and firm, and route them to minimize cross talk and electrical interference. Separately bundle or shield wiring containing AC from all DC logic control circuits. Route wiring to prevent conductors from being in contact with metal edges. Arrange wiring so that any removable assembly may be removed without disturbing conductors not associated with that assembly.

After installation and cable termination, perform an initial test to confirm that the DMS has been installed in accordance with the manufacturer's recommendations. This initial test is not a replacement of or substitute for any acceptance test. Perform the DMS assembly manufacturer's initial power-on test in accordance with the manufacturer's recommendation. Ensure that the DMS assembly receives all telemetry settings by exercising the DMS from the DMS controller in the cabinet or other recommended procedure(s) to confirm that the initial functionality is operational. The Engineer will program message displays on the DMS at the point in time that the power and communication circuits are fully operational. Visually confirm that the DMS display is properly aligned to provide maximum legibility. Make sight alignment adjustments to the DMS housing and display to ensure the greatest viewing angle is achieved as directed by the Engineer.

The Contractor may submit a request for approval by the Engineer to mount power supplies in a Contractor-provided 336S cabinet pole-mounted as specified in these Specifications for ITS Infrastructure near the base of the sign structure where voltage drop distances and/or non-ventilated cabinets warrant. Upon approval by the Engineer of the Contractor's request, non-ventilated cabinets being retrofitted will not require upgrading with new ventilation, cooling fans, and temperature sensors unless required by the DMS manufacturer. If the DMS manufacturer requires new ventilation, cooling fans, and

temperature sensors, the Contractor shall furnish and install a power supply cabinet at no additional cost.

Remove and dispose of any existing sign up-lights located immediately in front of proposed DMS panel locations. The Contractor shall maintain existing lighting and lane control signals and associated electrical circuitry for remaining sign lights on structure. Existing static sign panels (e.g. Shoulder Lane, HOV, Restricted Lane) and lane control signals may remain in place if the Contractor's operations do not require removal, otherwise the static sign panels and lane control signals shall be salvaged and re-used at the existing locations.

(a) **Testing**

Testing shall be completed to demonstrate that all DMS functions and features are operational and shall be documented at the conclusion of each test procedure for each DMS provided under this contract. The Contractor shall meet the requirements of the Department's NEMA TS-4 tests, LED pixel tests, factory acceptance tests, pre-installation tests, system compatibility (NTCIP) tests, field acceptance tests, TOC Integration tests, and system acceptance tests. The test plans can be found on the Department's website.

The Contractor shall provide environmental testing certifications for compliance with NEMA TS-4.

The Engineer will be present at the testing and will confirm the results of any testing that is to be reported to the Department for acceptance purposes. The Engineer will certify successful testing of individual DMS as the tests are successfully completed.

Testing requirements for DMS equipment accepted as pre-approved are not waived but the Contractor may request a waiver of some or all of the testing of pre-approved products at the approval of the Engineer.

(b) **Training**

Upon completion of the work and at a time approved by the Engineer, the Contractor shall provide training by a qualified instructor to Department personnel in the proper operation and maintenance of the equipment. Department personnel shall receive training comparable to the equipment manufacturer's factory training for each new type of DMS equipment that has not previously been installed in the region. The minimum training shall be one 2 hour session for instruction of device operation and one 2 hour session for instruction on device maintenance.

(c) **System Documentation**

The Contractor shall supply all working and as-built documentation necessary for proper identification, scheduling, installation, operation and maintenance of the Dynamic Message Signs provided under this contract.

The Contractor shall provide 2 copies of descriptive manuals or brochures for each type of equipment proposed and used for this Contract. No equipment shall be accepted for delivery or any payment made without written approval of the corresponding submittal by the Engineer. These documents shall contain sufficient technical data for the Engineer to evaluate the system proposed by the Contractor as meeting the Contract requirements.

The quality, function, and capability of each deliverable item shall be described. Manuals, brochures and certifications shall be originals or professional grade legible copies equal to originals. Documentation, catalog cuts and shop drawings submitted for review of DMS and cabinets shall be submitted to the Engineer as one complete package.

Six copies of shop drawings shall also be required for each type of fabricated item. These drawings shall contain all information required for complete fabrication in accordance with the Specifications, such as: materials, welds, finish, mounting details, weight, overall dimensions and position of doors and control cabinet foundation detail. DMS shop drawings shall be on sheets 11 inches in height and 17 inches long. Shop drawings shall be submitted within 60 days after award of bid.

Submittals shall clearly document meeting the DMS requirements herein and shall be provided in the same order for review as the specifications are written.

The Contractor shall submit an installation summary for each DMS prior to the conducting of any Pre-Installation Testing. This summary shall include the following information:

- Equipment complement
- A complete wiring diagram for each cabinet, covering every cable entering the cabinet.
- DMS software control manuals including:
    - Six copies of all instructions and installation manuals. All relevant manuals available from the manufacturer shall be provided. The manuals shall contain sufficient information to operate and maintain the equipment including schematic, wiring, and interconnection diagrams; complete instructions for proper installation including equipment outlines, mounting, weight, power, and cooling requirements; a complete parts list and a list of recommended spares.
    - Provide and attach to the inside of each dynamic message field controller cabinet a printed set of wiring diagrams. Drawings shall be attached to the door with stainless steel fasteners and protected from weather with a waterproof enclosure. An electronic version of all wiring diagrams shall be provided to the Engineer. The electronic format will be confirmed with the Engineer prior to delivery.

The documentation shall be in English.

(d) **Warranty**

Ensure that Dynamic Message Signs and retrofits, DMS communication cables and all associated components defined herein furnished, assembled, and installed have a manufacturer's warranty covering defects in assembly, fabrication, and materials for a minimum of five years from the date of final acceptance, except as specified otherwise herein. If the manufacturer's warranties for the components are for a longer period, those longer period warranties will apply.

The manufacturer's warranties on Dynamic Message Signs, DMS communication cables, and associated components shall be fully transferable from the Contractor to the Department. Ensure that these warranties require the manufacturer to furnish replacements for any part or

equipment found to be defective during the warranty period at no cost to the Department within 10 calendar days of notification by the Department.

Warranty periods shall begin on the date of final acceptance by the Department.

804.06—Measurement and Payment

Dynamic Message Sign (Type/(Amber/Full-Color)) will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing, installing, testing, personnel training, providing operational software packages and firmware, supplies, shop drawings, documentation; and all labor, tools, materials and equipment and incidentals necessary to complete the work. DMS UPS and associated batteries shall be considered incidental to the DMS. Fifty percent (50%) of the unit price bid for this item will be paid upon delivery of the DMS unit and all equipment for each individual location to the Contractor's staging area.

Thirty percent (30%) of the unit price bid for this item will be paid upon successful completion of the Field Acceptance Test. Twenty Percent (20%) of the unit price bid for this item will be paid upon successful completion of the 30-Day System Acceptance Test.

DMS Sign Structure (Type/Length) will be measured in units of each and will be paid for at the contract unit price per each. This price shall include designing, fabricating, furnishing and installing the complete structure, grounding electrodes, grounding conductors, grounding lugs, identification tags, galvanization, field drilling and all materials, labor, tools, equipment, and incidentals necessary to complete the work. Eighty percent (80%) of the unit price will be paid upon completion of the structure. The remaining 20% of the unit price will be paid upon completion of the field acceptance test for the DMS.

Concrete foundations for sign structures including maintenance pad, vented rodent barrier, clearing and grubbing, and incidentals necessary to complete the work will be measured and paid for in accordance with Section 700.

Conduit and electrical conductor cables between the controller cabinet and DMS structure will be measured and paid in accordance with Section 700.

Test bores will be measured and paid separately in accordance with Section 700.

DMS Communication Cable will be measured in units of length and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing single mode and terminating fiber optic cable or other approved cable for connection between the DMS and controller. This price shall be full compensation for all labor, materials, tools, and equipment necessary to complete the work.

DMS Retrofit (Type/(Amber/Full-Color)) will be measured in units of each and will be paid for at the contract unit price per each. This price shall include assessing sites; providing DMS controller, cabinet accessories, auxiliary UPS power, operational software packages and firmware, and working drawings for electrical and communications (including sign case modification drawings, attachment details, and written approach of the retrofit process); removing the DMS; transporting to and from site; refurbishing sign case; disposal of unsuitable surplus materials; testing, training, re-installing; and all labor, tools, materials, equipment, and incidentals necessary to complete the work. Ten percent (10%) of the unit price will be paid upon completion of Electrical and Communication Working Drawings. Seventy percent (70%) of the unit price will be paid upon completion of the re-installation of the DMS and successful

field acceptance testing. The remaining 20% of the unit price will be paid for upon completion of the 30-Day system acceptance testing and delivery and acceptance of the as-built drawings.

DMS Support Equipment will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing a set of support materials for each type of DMS.

Conduit Repair will be measured in units of linear feet and will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing conduits and couplings, excavating trench, backfilling, clearing and grubbing, seeding/restoration and all labor, tools, materials and equipment necessary to complete the work of repairing 4" conduit or smaller.

Payment for removal of DMS structures will be in accordance with Section 510.

Payment will be made under:

Pay Item	Pay Unit
Dynamic Message Sign (Type) (Amber/Full-Color)	Each
DMS Span Structure (Length)	Each
DMS Butterfly Structure (Type)	Each
DMS Communication Cable	Linear Foot
Dynamic Message Sign Retrofit (Type) (Amber/Full-Color))	Each
DMS Support Materials Package	Each
Conduit Repair	Linear Foot

SECTION 805 – VEHICLE DETECTION AND DATA COLLECTION

805.01—Description

This work shall consist of furnishing and installing nonintrusive high definition (HD) microwave radar vehicle detector system (VDS), with Transient Voltage Surge Suppression (TVSS) in accordance with these specifications and as shown on the plans or as directed by the Engineer. The VDS shall be capable of vehicle presence detection and traffic data collection meeting the requirements defined herein.

805.02—Materials

All components of the vehicle detection system shall be fully compatible and operational with VDOT's Traffic Operations Center (TOC) central system software for the respective region where the VDS are being installed.

All materials furnished shall be new products. Reconditioned equipment or system components shall not be used. The materials, equipment, and components shall be commercial off-the shelf products.

The VDS assembly shall consist of microwave radar sensor(s) in enclosed housing(s) (i.e., the detectors). The Contractor shall furnish an installation kit with mounting brackets; horizontal extension arm (length as recommend by the manufacturer); VDS composite cable for the transmission and receipt of data and communications between the field detector and the communication system hardware in the ITS field controller cabinet; and all required power and data cables.

(a) **Mechanical Specifications**

The vehicle detection system shall, at a minimum, produce vehicle presence, volume, speed, and occupancy data for each detected lane. The vehicle detection system detector shall use a Federal Communications Commission (FCC)-certified, low-power microwave radar beam to detect vehicle presence and generate volume, occupancy, and speed data as defined herein.

The VDS shall be a true-presence microwave radar that uses the frequency modulated continuous wave (FMCW) principle. The detector shall transmit a low-power, frequency modulated microwave signal in a fixed beam. Any non-background targets detected shall reflect the signal back to the microwave radar detector and their range shall be measured.

The vehicle detector shall determine vehicle presence by the return or reflection of radar output waves and, upon this return the VDS, shall generate data and/or a contact closure signal that corresponds to vehicle presence.

The detector shall accumulate and transmit short-term statistical data on each zone using a serial communication port or an IP connection.

The detector shall be capable of resolving closely spaced vehicles. The VDS setup program shall enable the operator to select whether the data is output as contact closures emulating standard loop detector outputs, and/or as accumulated statistical data using detector serial ports. The VDS sensor shall have a minimum 250-foot detection range with a viewing angle that is 65 degrees or greater vertical and seven degrees or less horizontal, and detection capability starting within 6 feet horizontally from the sensor pole. The VDS sensor shall have a minimum operating frequency of 24.0 GHz (K-band). The VDS sensor shall have the capability of collecting and providing speed data for single vehicles. Speed trap algorithm shall utilize a dual radar beam detection method that detects individual vehicles speeds. The VDS sensor shall have the capability of detecting and displaying individual single vehicle speeds while monitoring sensor performance.

The assembly shall be manufactured in such a way as to prevent reversed or improper installation. The VDS design shall provide high-voltage exposure protection to personnel during equipment operation, adjustments, and maintenance.

The VDS shall provide speed-trap emulation and have the ability to automatically detect sensor settings, baud rates, loop spacing, and communication port settings to select an operational mode.

The detector shall have the ability to self-tune and allow manual calibration via supplied vendor software. The VDS shall be capable of auto-calibration and auto-configuration, and shall not transmit any signals outside its FCC-approved frequency. Provide a setup program that allows the operator to define detection zones within the detector's field of view. The detector shall automatically configure zones, requiring minimal external tuning. The unit shall not be adversely affected by varied weather conditions, such as rain, fog, heat, or wind.

The VDS shall have the capacity to compute, store, and provide all required traffic parameter measurements per detection zone in user-selected time intervals from 0 to 60 minutes, including, but not limited to, 10 seconds, 20 seconds, 30 seconds, 60 seconds, 5 minutes, 10 minutes, 15 minutes, 30 minutes, and 60 minutes. The VDS shall log and store vehicle volume, occu-

pancy, and speed data locally in flash nonvolatile memory for all programmed detection zones for a minimum of seven days regardless of collection interval. Data storage within the VDS shall utilize a first in/first out architecture such that the oldest stored data record is overwritten with the newest data record when the storage device is at full capacity.

Transient Voltage Surge Suppression (TVSS) shall meet the requirements of Section 802. The remote cabinet shall be of sufficient size to install the TVSS and terminate the data and power cabling.

(b) **Electrical Specifications**

The vehicle detection system shall operate using a nominal input voltage at the field cabinet of 120 volts of alternating current (VAC). The system's power supply shall operate with an input voltage ranging from 89 to 135 VAC. For any device requiring a source input other than the standard 120 VAC, supply the appropriate means of conversion.

The power and communication cables shall comply with NEC sizing requirements as presented in NEC Article 210-19(a), Fine Print Note (FPN) No. 4, and meet all other applicable standards, specifications, and local code requirements. The VDS composite cable shall be a polyurethane-jacketed cable approved by the Engineer, with polyvinyl chloride (PVC) insulated conductors. The VDS composite cable shall have a 300-volt rating and a temperature rating of 200°F. The cable shall be equipped with #20 or #22 American Wire Gauge (AWG) conductors, at a minimum.

Power conductors from the power source to the assembly input shall be sized so that no more than a 3.0 percent voltage drop is experienced. All connections to the VDS shall be protected, including power and Ethernet connections to ensure the continued operation of the VDS in the presence of electrical surges.

The vehicle detection system or subcomponents shall automatically recover from power disruptions after power is restored. All programmable system settings shall return to their previous configurations and the system resumes proper operation.

(c) **Environmental Specifications**

The detection systems shall meet all specifications during and after being subjected to an ambient operating temperature range of 30°F to 165°F with a maximum non-condensing relative humidity as defined in the environmental requirements section of the NEMA TS 2 standard.

The detection system manufacturer shall certify that its device has successfully completed environmental testing as defined in the NEMA TS 2 standard (latest edition). Vibration and shock resistance shall meet the requirements of Sections 2.1.9 and 2.1.10, respectively, of NEMA ,TS 2 (latest edition).

No item, component, or subassembly shall emit a noise level exceeding the peak level of 55 decibels adjusted (dBa) when measured at a distance of 3.3 feet away from its surface.

System components shall comply with the environmental requirements detailed in the NEMA TS 2 standard. The Contractor shall provide third party enclosure test results for NEMA TS 2 testing.

(d) **Physical Specifications**

Any sensor detector assembly exposed to the elements shall be housed in an environmentally resistant and tamper-proof sensor detector enclosure. The enclosure shall be environmentally sealed upon installation and shall be light in color. The VDS shall:

- weigh no more than 5 pounds
- be no larger than 14" x 12" x 6" (L/W/D)
- be mounted in a NEMA 4X polycarbonate box, whereby the electrical/communication connections are located on the bottom of the box, unless otherwise approved.

The remote cabinet, where applicable, shall meet or exceed NEMA 3X requirements.

The VDS, associated mounting hardware, and horizontal extension arms shall be designed in accordance with the edition of *AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals* specified in the VDOT Structure & Bridge Division's S&B-IIM-90 Memorandum (VDOT Modifications to AASHTO's Standard Specifications) in effect at the time of project advertisement.

(e) **Communication Standards**

The VDS field hardware shall meet the requirements in the FCC's 2005 Code of Federal Regulations (CFR), Title 47, Part 15. The detector shall not interfere with any known equipment. The detector shall be FCC certified and the FCC's identification number shall be displayed on an external label. The detector shall transmit within a frequency band of 24 - 24.25 gigahertz, or another FCC approved spectral band.

The vehicle detection system shall generate and transmit traffic data in serial format using an Electronic Industries Alliance (EIA) standard EIA-232 communication port and an Ethernet Internet Protocol (IP) interface. The Contractor shall verify that the detection system is IP addressable. All device communication addresses shall be user programmable. The communications interface in the cabinet shall provide EIA-232 and TCP/IP Ethernet connections. The serial interface shall be equipped with an EIA-232 DB-9 communication port for calibration and maintenance laptop connection. An Ethernet communication port shall be provided. All devices for converting the data communications protocol to Ethernet format shall be provided with each VDS detector.

The interface ports shall support the following baud rates: 9600, 19200, 38400, 57600, and 115200. The EIA-232 port shall be full duplex and shall support true RTS/CTS hardware handshaking for interfacing to various communications devices. The serial port's data format shall be standard binary non-return to zero (NRZ) modulation with 8-bit data, a 1-stop bit, and no parity. The detection system shall support Point-to-Point Protocol (PPP), Point to Multi-Point Protocol (PMPP) (i.e., polled protocols), and Ethernet protocols. The setup program shall assign an IP address to the detection unit. The vehicle detection system shall respond to a polling request from the VDOT TOC for traffic data. The Contractor shall verify that the detection unit responds with the accumulated traffic parameter measurements from the period since the last polling request was issued.

(f) **Management Capability**

The vehicle detection system shall include computer software that allows an operator to program, operate, and read current status of all system features and functions using a laptop computer or remote TOC workstation. The vehicle detection system shall use protocols and device drivers compatible with VDOT TOC software for querying/polling the field devices. Any software-based applications shall not interfere with TOC software when the two are installed and used together on a shared hardware platform. The software application shall provide PC desktop display of the detection zones and control of any vehicle detector connected to the network.

Any software licenses that may be needed for communication with the Department's TOC central system software and for field communications shall be provided. The detection system software shall offer an open API and software development kit available to the Department at no cost for integration with third party software and systems.

An operator using a locally connected laptop computer shall be able to conduct system setup, calibration, diagnosis, and data retrieval operations. The detection system shall be capable of having its configuration data saved to a laptop computer or TOC operator workstation, which can later transfer the data back to the detection system for reloading.

The detection system operator shall be able to use a laptop computer or TOC workstation to edit previously defined detection configurations to permit adjustments to the detection zone's size, placement, and sensitivity, and to reprogram the detector's parameters.

The VDS shall support the configuring of lanes or detection zones in 1 foot increments or better.

The laptop computer and the detection system shall have the capacity to communicate when connected directly by an EIA-232 cable. The laptop computer and detection system shall be able to communicate across the ITS system's communication network. The software shall support communication between multiple users and multiple field devices concurrently across the same communication network.

The vehicle detection system's time clock shall be synchronized each time the device is polled.

Once programmed, no periodic adjustments shall be required to the detection zones unless physical roadway conditions change, such as lane shifts or closures.

(g) **Performance**

1. **Detection Accuracy**

The vehicle detection system shall meet minimum total roadway segment accuracy levels of 95% for volume, 90% for occupancy, and 90% for speed for all lanes, up to the maximum number of lanes that the device can monitor as specified by the manufacturer. The Contractor shall conduct performance validation on a sampling of 10% (rounded up to the nearest integer) of the project quantities on the Plans.

2. **Calculation of Volume, Occupancy, and Speed Accuracy**

Perform evaluations by comparing sample data collected from the vehicle detection system with ground truth data collected during the same time by human observation or by another method approved by the Engineer to verify conformance with the accuracy

requirements in this section. Base the vehicle detection system's performance evaluation on sample data taken over several time periods under a variety of traffic conditions. Weight each data sample to represent the predominant conditions over the course of a 24-hour period. Samples will consist of 15- and 30 minute data sets collected at various times of the day. Representative data periods and their assigned weights are provided in Table VIII-7.

TABLE VIII-7
Data Collection Periods

Period	Intended To Represent	Duration	Weight
Early morning (predawn) [EM]	12:30 AM – 6:30 AM	15 minutes	24
Dawn [DA]	6:30 AM – 7:00 AM	30 minutes	2
AM Peak [AMP]	7:00 AM – 8:00 AM	15 minutes	4
Late AM Off-Peak [LAOP]	8:00 AM – Noon	15 minutes	16
Noon [NO]	Noon – 1:00 PM	15 minutes	4
Afternoon Off Peak [AOP]	1:00 PM – 5:00 PM	15 minutes	16
PM Peak [PMP]	5:00 PM – 6:00 PM	15 minutes	4
Dusk [DU]	6:00 PM - 6:30 PM	30 minutes	2
Night [NI]	6:30 PM - 12:30 AM	15 minutes	24
		Total Sum of Weights	96

For instance, the sample gathered for the Late AM Off-Peak period is intended to represent typical traffic conditions between 8:00 AM and noon. Since the sample period's duration is 15 minutes and the actual period of time represented is 4 hours, the multiplication factor or weight assigned is 16, the number of 15 minute intervals in a 4 hour period.

3. **Calculation of Volume Accuracy**

The Contractor shall compute volume accuracy as described in this subsection.

Determine individual lane volume accuracy per period by calculating the percentage of absolute difference of the total volume measured by the detection system and the true volume computed, divided by the true volume for the period under consideration.

In Equation 1, EM represents the early morning period. The variable i represents a lane in a roadway and could vary from 1,…, N, where N is the maximum number of lanes on the roadway segment. Substitute other lane numbers and periods as necessary to determine the accuracy for each lane during each period (i.e., dawn, AM peak, late AM off peak, etc.).

Variables used in the following calculations are identified as follows:

VT = Total volume

VD = Vehicle detection data (in this case, count data)

GT = Ground truth measurement utilizing a reliable method approved by the Engineer

VA = Volume accuracy

a. **Equation 1 – Early Morning Lane Volume Accuracy Expressed In Percentage**

$$VA_{EM,ln_i} = 100 - \frac{\left|VT_{EM,VD,ln_i} - VT_{EM,GT,ln_i}\right|}{VT_{EM,GT,ln_i}} x100$$

where:

VA_{EM,ln_i} = Volume accuracy for early morning traffic conditions in the ith lane.

VT_{EM,VD,ln_i} = Total volume for the 15-minute early morning period using the vehicle detector in the ith lane.

VT_{EM,GT,ln_i} = Total volume for the 15-minute early morning period in the ith lane using human observation or another method approved by the Engineer.

The period volume accuracy will be the arithmetic mean of the lane volume accuracy over all lanes.

In Equation 2, EM represents the early morning period and N is the maximum number of lanes in the roadway segment under test. Substitute other periods as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM off-peak, etc.).

b. **Equation 2 - Early Morning Period Volume Accuracy Expressed in Percentage**

$$VA_{EM} = \left(\frac{\sum_{i=1}^{N} VA_{EM,ln_i}}{N}\right)$$

where:

VA_{EM} = Average volume accuracy for early morning traffic conditions for all lanes on the roadway segment.

VA_{EM,ln_i} = Volume accuracy for early morning traffic conditions in the ith lane.

Calculate the roadway segment accuracy over all periods using Equation 3. Calculate the volume accuracy using Equation 2 for each individual period, multiplied by its corresponding weight, as shown in Table 1. Next, add the products for all periods and divide the sum by 96 to obtain the overall system accuracy.

c. **Equation 3 – Total Roadway Segment Accuracy Expressed in Percentage**

$$VA_{Total} = \frac{[VA_{EM}x24+VA_{DA}x2+VA_{AMP}x4+VA_{LAOP}x16+VA_{NO}x4+VA_{AOP}x16+VA_{PMP}x4+VA_{DU}x2+VA_{NI}x24]}{96}$$

where:

VA_{Total} = Volume accuracy for all lanes for all periods discussed in Table 1
VA_{EM} = Volume accuracy for early morning traffic conditions
VA_{DA} = Volume accuracy for dawn traffic conditions
VA_{AMP} = Volume accuracy for AM peak traffic conditions
VA_{LAOP} = Volume accuracy for late AM off-peak traffic conditions
VA_{NO} = Volume accuracy for noon traffic conditions
VA_{AOP} = Volume accuracy for afternoon off-peak traffic conditions
VA_{PMP} = Volume accuracy for PM peak traffic conditions
VA_{DU} = Volume accuracy for dusk traffic conditions
VA_{NI} = Volume accuracy for night traffic conditions

Position the detector and configure the detection zones so that a vehicle is detected when 70% or more of the vehicle width is inside a lane, and not detected when 15% or less of the vehicle width is in the lane. Use the detection zone configuration to minimize the occurrence of a double count for the same vehicle, while ensuring that it will be counted at least once.

4. **Calculation of Speed and Occupancy Accuracy**

Calculate speed accuracy as discussed in this subsection. Calculate occupancy in a manner similar to the speed computation methodology described below.

The difference between the volume accuracy and speed accuracy computation is that the volume of a particular lane can be aggregated over a period of time, while speed cannot. For computing the accuracy of the detector speed measurement, the average speed readings obtained from the detection system are compared to ground truth values on a particular roadway segment.

Equation 4 represents the ground truth average speed computation procedure for a particular lane during a specific time period. Equation 5 represents the average speed computation procedure for a particular lane during a specific time period using data gathered from the detection system.

In Equations 4 and 5, the time period described is the early morning period, represented by EM, and the variable k represents a vehicle traveling on the roadway and could vary from 1,…, K, where K is the maximum number of vehicles in lane i during the time period under consideration. The variable i represents a lane in a roadway and could vary from 1,…, N, where N is the maximum number of lanes on the roadway segment. Substitute other lanes and periods as necessary and compute the accuracy for each lane for all time periods.

Variables used in the following calculations are identified as follows:

SA = Speed accuracy
S = Speed of an individual vehicle
veh = Vehicle

a. **Equation 4 – Early Morning Average Ground Truth Vehicle Speed**

$$S_{Avg,\,EM,\,GT,\,ln_i} = \frac{1}{K}\sum_{k=1}^{K} S_{EM,\,GT,\,ln_i,\,veh_k}$$

where:

$S_{Avg,\,EM,\,GT,\,ln_i}$ represents the average ground truth vehicle speed for the ith lane during the early morning period.

$S_{EM,\,GT,\,ln_i,\,veh_k}$ represents the true speed for the kth vehicle in the ith lane during the early morning period using human observation or another method approved by the Engineer.

b. **Equation 5 - Early Morning Average Vehicle Detector Speed Measurement**

$$S_{Avg,\,EM,\,VD,\,ln_i} = \frac{1}{K}\sum_{k=1}^{K} S_{EM,\,VD,\,ln_i,\,veh_k}$$

where:

$S_{Avg,\,EM,\,VD,\,ln_i}$ represents the average ground truth vehicle speed for the ith lane during the early morning period.

$S_{EM,\,VD,\,ln_i,\,veh_k}$ represents the true speed for the kth vehicle in the ith lane during the early morning period using human observation or another method approved by the Engineer.

The lane speed period accuracy is computed as a percentage of the absolute difference of the average lane speed calculated using detection system data and the average lane true speed calculated in Equation 4 (or using another method approved by the Engineer), divided by average ground truth lane speed for the period.

In Equation 6, EM represents the early morning period. The variable i represents a lane on a roadway and could vary from 1,…,N, where N is the maximum number of lanes on the roadway segment. Substitute other lanes as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM off peak, etc.).

c. **Equation 6 - Early Morning Lane Speed Accuracy Expressed in Percentage**

$$SA_{Avg,\,EM,\,ln_i} = 100 - \frac{\left|S_{Avg,\,EM,\,VD,\,ln_i} - S_{Avg,\,EM,\,GT,\,ln_i}\right|}{S_{Avg,\,EM,\,GT,\,ln_i}}\,x100$$

where:

$SA_{Avg,\,EM,\,ln_i}$ = represents the average speed accuracy during early morning traffic conditions for all vehicles that traveled in lane i of the roadway segment.

The period speed accuracy will be the arithmetic mean of the lane speed accuracy, computed using Equation 6, over all lanes.

In Equation 7, EM represents the early morning period. The variable i represents a lane on a roadway and could vary from 1,…, N, where N is the maximum number of lanes on the roadway segment. Substitute data as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM off peak, etc.).

d. **Equation 7 – Early Morning Speed Accuracy Expressed in Percentage**

$$SA_{EM} = \left(\frac{\sum_{i=1}^{N} SA_{EM,ln_i}}{N} \right)$$

where:

SA_{EM} = represents the average speed accuracy during early morning traffic conditions for all lanes on the roadway segment.

Calculate the roadway segment accuracy over all periods using the following equation. This equation is a weighted average to account for variations in each of the sample detection periods over the course of a 24-hour period. First, calculate the speed accuracy for each individual period using Equation 7. Next, multiply the individual period by its corresponding weight as shown in Table 1. Add the products for all periods and divide the sum by 96 to obtain the overall system accuracy.

e. **Equation 8 – Total Roadway Segment Accuracy Expressed in Percentage**

$$SA_{Total} = \frac{[SA_{EM}x24+SA_{DA}x2+SA_{AMP}x4+SA_{LAOP}x16+SA_{NO}x4+SA_{AOP}x16+SA_{PMP}x4+SA_{DU}x2+SA_{NI}x24]}{96}$$

where:

SA_{Total} = Speed accuracy for all lanes for all periods discussed in Table 1
SA_{EM} = Speed accuracy for early morning traffic conditions
SA_{DA} = Speed accuracy for dawn traffic conditions
SA_{AMP} = Speed accuracy for AM peak traffic conditions
SA_{LAOP} = Speed accuracy for late AM off-peak traffic conditions
SA_{NO} = Speed accuracy for noon traffic conditions
SA_{AOP} = Speed accuracy for afternoon off-peak traffic conditions
SA_{PMP} = Speed accuracy for PM peak traffic conditions
SA_{DU} = Speed accuracy for dusk traffic conditions
SA_{NI} = Speed accuracy for night traffic conditions

805.03—Procedures

The Contractor shall install, configure, and demonstrate a fully functional vehicle detection system to the Engineer. Furnish all equipment with the appropriate power and communication cables. Install the power cable and the communication cables according to the manufacturer's instructions. Neatly install and organize all cabinet accessories, connectors, surge suppression and communications

connections for the VDS assembly on a 19" EIA rack mounted shelf in the closest ITS Controller Cabinet identified in the Plans. The Engineer must approve the layout and design of all connections and accessories mounted on the shelf for acceptance. Connect all field hardware and TOC components to the existing communication network, and provide all materials as specified in the Contract. Install all equipment according to the manufacturer's recommendations or as directed by the Engineer.

Install the detector in a side-fire configuration, and mount the detector level from side to side. Verify that all detection zones are contained within the specified elevation angle according to the manufacturer's recommendations and that the VDS is capable of fully detecting all vehicles in up to 10 lanes. The configuration shall provide accurate collection of all data types as detailed in this specification.

For VDS installations on a single pole, refer to the 45 foot steel pole requirements in Section 803.

For VDS installations on a DMS structure or CCTV pole with lowering device, each VDS unit shall be installed with a universal mounting bracket and with a minimum 10 foot horizontal extension arm. Mount VDS so that it does not obstruct lowering devices on CCTV poles. The universal mounting bracket provided by the VDS manufacturer shall be adjustable on two axes for optimum alignment. The horizontal extension arm shall be constructed of galvanized steel; extension arms constructed of alternate materials may be submitted to the Engineer for consideration. The Contractor shall submit details of the horizontal extension arm to the Engineer for approval.

The Contractor shall determine the appropriate mounting angle and mounting height for each VDS installation location. Mounting locations shall be in accordance with manufacturer's recommendations unless otherwise approved by the Engineer. Submit records of the final mounting angles and heights to the Engineer.

When installing a detector near metal structures, such as buildings, bridges, or sign supports, the Contractor shall mount and aim the sensor to ensure the detection zone is not under and does not pass through any structure to avoid distortion and reflection. The detection quality of the VDS shall not be degraded due to assembly movement and vibration after mounting and installation. The detector shall be factory calibrated to ensure compliance with all applicable standards, specifications, and requirements. The detector shall not require further adjustment after initial setup and calibration to ensure that no periodic calibration is required.

Provide an interface to external equipment with a single connector. The connector shall provide power to the unit and allow generation of contact closure output pairs for interface with traffic controller inputs. The connector shall include serial communication lines for programming, testing, and interfacing with the modem at a minimum 9,600-baud rate. The serial port's data format shall be standard binary non-return to zero (NRZ) modulation with 8-bit data, 1-stop bit, and no parity.

The Contractor shall supply a test cable and converter to connect the detector to a laptop computer for testing and configuration. Verify that the test cable and converter are compliant with current EIA-232 and Universal Serial Bus specification standards for protocol converters. The male DB-9 and USB connectors for laptop computers equipped with only a USB port shall support the automatic handshake mode, transmission rates of 230 kilobits per second (kbps), and remote wakeup and power management features. Verify that the test cable and converter are compatible with the operating systems recommended for the TOC central system software, and are USB powered.

Crimp or solder the detector connector pins to the cable conductors. Assemble and test the cable prior to onsite installation and pulling. Provide service loops at all connections.

Perform continuity tests on the detector's stranded conductors using a meter having a minimum input resistance of 20,000 Ω per volt and show that each conductor has a resistance of not more than 16 Ω per 985 feet of conductor.

Measure the insulation resistance between isolated conductors and between each conductor, ground, and shield using a meter designed for measuring insulation resistance. The resistance must be infinity. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronic or field devices.

Furnish and install all necessary power and communications cabling and terminations in the ITS controller cabinet for a fully functional system including operability at the cabinet, at the VDS detector, between the cabinet and the VDS detector, and between the cabinet and any upstream and downstream cabinets. This shall include any fiber jumpers, Cat5e jumpers, etc. that may be required for complete functionality of the ITS system.

Where a remote cabinet with TVSS is required, attach the cabinet to the pole with banding at a height of approximately 4 feet from the ground. All cabling from the main ITS controller cabinet to the remote cabinet and from the remote cabinet to the VDS shall be run inside the pole.

The Contractor shall furnish and install a remote cabinet with Transient Voltage Surge Suppression (TVSS) on the VDS pole when the VDS is installed more than 100 feet from an ITS controller cabinet, or in accordance with the manufacturer recommendations, whichever is more stringent. Furnish and install TVSS to connect all data and power cabling for the VDS.

(a) **Testing**

Subject the equipment covered by these specifications to design approval tests (DATs), field acceptance tests (FATs), VDOT TOC Integration tests (TOCITs), and system acceptance testing (SAT). The Contractor shall meet the requirements of the Department's test plan. The test plan can be found on the Department's website.

(b) **Training**

Upon completion of the work and at a time approved by the Engineer, the Contractor shall provide training by a qualified instructor to Department personnel in the proper operation and maintenance of the equipment. Department personnel shall receive training comparable to the equipment manufacturer's factory training for each new type of VDS equipment that has not previously been installed within the region. The minimum training shall be one 2 hour session for instruction of device operation and maintenance.

(c) **Warranty**

The VDS detectors, VDS cables and associated equipment and materials furnished, assembled, and installed shall have a manufacturer's warranty covering defects in assembly, fabrication and materials for a minimum of three (3) years from the date of final acceptance by the Engineer of all work to be performed under the Contract. If the manufacturers' warranties for the components are for longer periods, then those longer period warranties shall apply.

The manufacturer's warranties on VDS detectors and cables shall be fully transferable from the Contractor to the Department. These warranties shall require the manufacturer to furnish

replacements for any part or equipment found to be defective during the warranty period at no cost to the Department within 10 calendar days of notification by the Department.

Warranty periods shall begin on the date of final acceptance of the project by the Department.

805.04—Measurement and Payment

VDS Detectors will be measured in units of each and paid for at the contract unit price per each. This price shall include video detectors, installation kit with mounting brackets; horizontal extension arm, all required power and data cables. This price shall also include providing all operational software package(s) and firmware(s), supplies, support, personnel training, shop drawings, documentation, testing, and incidentals necessary for a complete VDS system. The cost for furnishing and installing any required remote cabinets with TVSS shall be included in the per each unit price for VDS detector.

VDS Composite Cable will be measured in units of linear feet and paid for at the contract unit price per linear foot. This price shall include composite cable, any operational software package(s) and firmware(s).

Payment will be made under:

Pay Item	Pay Unit
VDS Detector	Each
VDS Composite Cable	Linear Foot

SECTION 806 - ENVIRONMENTAL SENSOR STATIONS

806.01—Description

This work shall consist of furnishing and installing environmental sensor stations (ESS) that are fully compatible with the most recently installed ESS equipment within the respective Traffic Operations Center Region and as directed by the Engineer and according to these specifications.

806.02—Materials

(a) **Concrete** shall conform to Section 217.

(b) **Reinforcing steel** shall conform to Section 223.

(c) **Aluminum** shall conform to Section 229 and shall be fabricated, welded, and inspected according to Section 407.

(d) **Electrical items** shall conform to Section 238 and the specification requirements herein.

806.03—Equipment

The Contractor shall furnish and install an environmental sensor station (ESS) to include environmental sensors mounted on an aluminum tripod tower or metal pole; other sensors mounted in the roadway and in the soil; and a remote processing unit (RPU) at the tower or pole's base, if required for the location as specified on the plans. The remote processing unit shall have the capacity to collect, store, and process sensor data to document current weather conditions. Furnish any ancillary equipment or incidental items required, including mounting hardware, power supplies, grounding, surge suppression devices, and communication equipment at each specified location to assemble and construct a complete and fully operational environmental sensor station. The system, once installed and operational, shall provide real-time, accurate, reliable data on all system parameters to the degree of precision defined herein.

(a) **ESS sensors** shall collect, store, and transmit the following data

1. **Roadway sensors** (located in, above, or under the pavement):

   - Temperature
   - Subsurface temperature
   - Precipitation data that includes precipitation type, percent of ice, and precipitation depth/amount.

2. **Atmospheric sensors** (mounted on towers or poles that are installed along the roadway or on bridges):

   - Temperature
   - Relative humidity
   - Barometric pressure
   - Precipitation data including type and intensity
   - Visibility as affected by fog, smoke, or a combination thereof
   - Wind data, including direction and average speed
   - Solar radiation (optional, unless specified on the plans)

3. **Subsoil data,** including:

   - Temperature
   - Moisture (optional)

4. **High water data** (optional, unless specified on the plans)

   - Water level

(b) **Sensor Types** - The ESS shall have the capacity to collect and store data from various sensors that are divided into the following four categories:

- **Roadway sensors** located in, above, or under the pavement.
- **Atmospheric sensors** mounted on towers or poles that are installed along the roadway or on bridges.
- **Subsoil sensors** located in soil adjacent to the ESS.
- **High water sensors** located in or near low-lying areas (e.g. drainage basins, etc.) adjacent to the ESS.

1. **Mechanical Specifications**

Each environmental sensor and its associated transducers shall record the following attributes to the listed degree of accuracy:

a. **Roadway Data**

- Surface Temperature ±0.36°F between -40°F and 140°F
- Subsurface Temperature ±0.36°F between -40°F and 140°F
- Precipitation
- Type: Dry, wet at >32°F; wet at <32°F; frozen, frost, and dew
- Percent of Ice: From 0 to 100%
- Depth/Amount: From 0 to 0.5 inch

Pavement sensors shall function as specified above when installed up to 2,000 feet from the RPU.

b. **Atmospheric Data**

- Temperature ± 1°F between -40°F and 140°F; resolution of 0.1 degree
- Relative Humidity at 70°F ± 5% between 10 and 100%
- Barometric Pressure Accurate from ±0.3 to 1.5 hPa between 500 and 1100 hPa; resolution of 0.1 hPa.
- Precipitation:
  - o Type: Light rain, rain, and ice
  - o Intensity: ± 20% between 0.02 to 200 inches per hour
  - o Visibility: ± 10% from 0.005 to 1 mile
- Wind
  - o Direction: ± 3 degrees between 0 and 360 degrees

- o Speed: ± 2% between 0 and 165 mph
- o Solar Radiation < 10% between 0 and 2,000 watts per square meter

c. **Subsoil Data**

- Temperature: ± 0.36°F between -40°F and 140°F
- Moisture: ± 5% water moisture content between 0 and 100%

d. **High water Data**

- Water level with resolution accuracy within 0.05 feet

2. **Electrical Specifications**

Sensor equipment and components installed at the ESS shall operate at 110 to 120 VAC from a commercial utility company or, alternatively, 12 VDC from a solar-powered or battery-powered system. The manufacturer shall provide design and calculations for locations requiring solar power as shown in the Plans.

3. **Environmental Specifications**

All ESS and other field equipment shall be made of materials able to withstand wet, corrosive, dusty and humid weather conditions characteristic of the Virginia climate.

4. **Physical Specifications**

Ultrasonic anemometers and other sensors shall be electronic devices that do not rely on moving parts to create electrical signals for processing. Hardware and fasteners shall conform to Section 700 of these Specifications, and Section 1300 of the Standard Drawings.

5. **Communication Standards**

ESS installations utilizing wireless communications shall conform to IEEE standard 802.15.4, Wireless Media Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs).

(c) **Remote Processing Unit (RPU)**

Where required, the Contractor shall supply and install a remote processing unit (RPU) meeting the following requirements:

1. **Mechanical Specifications**

Furnish an RPU that supports a minimum of four pavement sensors, four subsoil sensors, and eight atmospheric sensors.

The RPU shall be capable of collecting, storing, and transmitting single-frame, H.264 digital color images from a fixed position closed-circuit television (CCTV) camera that

meets the sensor and networking requirements outlined for the digital cameras within Section 803 CCTV Video Equipment. The camera shall be mounted on the ESS tower/pole.

The RPU unit's minimum mean time between failures (MTBF) shall be 15,000 hours or 625 days.

2. **Electrical Specifications**

The RPU shall operate using a nominal input voltage at the cabinet of 110 to 120 VAC, and also be capable of operating on 12 VDC of solar or battery power. The RPU shall issue an alarm to the jurisdictional Traffic Operations Center and Statewide Road Weather Information System (RWIS) contractor if the AC power supply is low or if there has been a complete power loss. The RPU shall send a message when the unit returns to normal conditions.

Each ESS installation shall be equipped with provisions for emergency backup power in the event of primary power loss. Ensure that backup power is capable of continuing the ESS's full operations for a minimum of 12 hours.

Solar and battery powered units shall be capable of 14 days of continuous operation without requiring battery recharge. The Contractor shall provide an appropriate means of conversion for any device that requires a different power source.

3. **Environmental Specifications**

Furnish a NEMA Type 4-rated RPU enclosure that is designed specifically for ESS applications. All components within the RPU shall operate throughout an ambient operating temperature range of 0°F to 140°F, with a maximum relative humidity of 90%.

4. **Physical Specifications**

Attach the RPU control cabinet/enclosure to the tower/pole according to the manufacturer's instructions.

5. **Networking Standards**

The RPU shall be capable of transmitting all collected data to any one of VDOT's Transportation Operations Centers (TOC) and the Statewide RWIS contractor using the National Transportation Communications for ITS Protocol (NTCIP) over any of the following media:

- Microwave communications infrastructure.
- Ethernet communications over single-mode fiber optic cable that transfers data at a minimum rate of 10 megabits per second (Mbps).
- Twisted-pair copper wire capable of transferring data at a rate of up to 128 kilobits per second (kbps).
- Cellular mobile telephone service with data transmission rates of up to 56 kbps.

6. **Communication Standards**

- All communications, including those between sensors, the RPU, and central software shall be nonproprietary and compliant with NTCIP 1204 – Environmental Sensor Station (ESS) Interface Standard.

- The RPU shall be capable of or adaptable to providing peer-to-peer wireless communication at a maximum distance of 5 miles when designated in the Plans.

- The RPU shall support EIA 232/485 serial protocols, as well as TCP/IP output. The RPU shall be programmable and based on an open architecture. Provide a unit having a minimum of 16 digital inputs, 8 analog inputs, and 2 EIA-232/485 serial ports. The RPU shall provide serial data transmission rates up to and including 128 kbps.

7. **Management Capability**

The RPU shall issue and communicate an alarm whenever a user-defined threshold is exceeded. The RPU shall also be capable of producing an output through contact closure or a digital output that imitates a contact closure. At a minimum, the RPU shall be able to store internally 75,000 readings over 10 minutes.

(d) **ESS Software**

1. **Networking Standards**

When the software supplied with the ESS is installed on a laptop computer or a remote workstation, the operator shall be able to access, either remotely through a workstation or at the site with the laptop computer, all user-defined parameters and stored data within the RPU and view, download, and delete stored data.

2. **Communication Standards**

The ESS shall comply with the latest revisions of all applicable NTCIP standards, including NTCIP-1201 and NTCIP-1204, as well as all applicable standards from the National Weather Service. The ESS software package shall provide viewing of H.264 video streams.

3. **Management Capability**

The ESS system shall provide the system operator the ability to display environmental measurements, such as the dew point, wind chill, and heat index, from sensor data received. The ESS software shall have the capacity to report minimums, maximums, averages, cumulative values, and standard deviations for all data recorded over a minimum of a one year time period.

The ESS software shall provide Imperial-to-metric unit conversions, when applicable, and let the operator choose which unit of measurement to report if more than one unit is common for a particular measurement.

When identified in the plans, the Contractor shall ensure that all data is provided directly by the vendor to the Department.

(e) **Foundation and Tower/Pole Specifications**

The Contractor shall furnish and install foundations and towers\poles meeting the following requirements:

1. **Mechanical Specifications**

Furnish a supporting tower or pole as shown in the Plans that provides a mounting platform for atmospheric sensors free of influences from topography, buildings, and vehicles. The tower/pole shall also support any lightning protection devices (e.g., air terminal) for the site(s) shown on the Plans. Lightning protection shall be as furnished by the manufacturer.

2. **Physical Specifications**

Mount the atmospheric sensors on an 18-foot tower or pole. Furnish a support structure that is self-supporting without guy wires, using a 50-year design life, and in accordance with Section 1300 of the Standard Drawings and Section 700 of these Specifications. The Contractor shall perform a soil boring at the location of each tower or pole for use in the foundation design. Tower, pole, and foundation designs (including all calculations) shall be signed and sealed by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia and shall be submitted to the Engineer for approval. Tower structures shall be made of 6061-T6 corrosion-resistant aluminum or an approved equivalent. Pole structures shall be made of corrosion-resistant galvanized steel or an approved equivalent. All hardware and fasteners shall be stainless steel.

If the field site is solar powered, the structure shall include a mounting platform for the solar array and the control cabinet that houses the battery bank and charger. The Contractor shall provide a concrete technician pad measuring 4 feet wide by 3 feet long by 4 inches deep in front of the RPU control cabinet.

806.04—Procedures

All equipment and materials furnished, assembled, fabricated, or installed shall be commercial off-the-shelf products. Unless detailed otherwise in the Plans, mount all atmospheric sensors except anemometers at cabinet-top height, approximately 10 feet above grade. Mount anemometers at the top of the tower/pole. If local restrictions prevent installing the anemometers at the top, install the anemometers no less than 16 feet above the ground. Locate pavement and subsoil sensors as specified on the Plans.

The Contractor shall install all wiring internal to a pole in conduit attached to truss members or in underground conduit.

Install all buried lead-in cable in conduit at subsoil elevation in unpaved locations (i.e. from tower/pole to roadway edge of pavement). Install roadway pavement sensors lead in cable in the pavement according to the manufacturer's instructions or as directed by the Engineer. Mount all roadway surface mount sensors flush with the roadway surface.

(a) **Testing**

Use a testing procedure that includes a remote field sensor and RPU test, a remote-to-central communication test, and a systems operational test. Perform the following procedures and submit the results to the Department:

- Document laboratory tests verifying proper sensor calibration.
- Calibrate instrument alignment with true north.
- Furnish sensor calibration protocols and adjustment procedures.
- Verify and ensure that sensors are reporting proper field data.
- Detail regular site maintenance procedures and calibration training.
- Provide block diagrams, schematics, catalogs, and line drawings.
- Program source codes in both printed and digital form.
- Verify proper orientation of wiring and cabling.
- Ensure that the conduit is straight, neat, and properly secured.
- Verify that the grounding component is installed to produce a voltage standing wave ratio (VSWR) of 1.5 or less. The Contractor shall subject the environmental sensor station to a 30-day observation period, during which time the Contractor shall perform any and all maintenance, recalibration, and data verification required by the Engineer.

The Contractor shall ensure all anemometers are certified to transmit correct wind conditions by wind tunnel tests. Submit test results to the Engineer for review and approval. Upon request, furnish independent laboratory testing documentation certifying adherence to the stated wind force criteria using a minimum effective projected area (EPA), the actual EPA, or an EPA greater than that of the device to be attached.

Perform local field operational testing at each ESS field site according to the test plans in this section. After the environmental sensors and RPUs, and other ESS hardware, power supplies, and connecting cables have been installed, the Contractor shall perform the following:

- Verify that physical construction has been completed as per the manufacturer's instructions
- Inspect the quality and tightness of ground and surge protector connections.
- Check power supply voltages and outputs.
- Connect devices to the power sources.
- Verify installation of specified cables and connections between the environmental sensor and RPUs, and the control cabinet.
- Test local operation of all environmental sensor and RPU components.

Within five (5) days of successful tests completion, the Contractor shall deliver to the Engineer a written completion notice and a copy of all test results. Include in the completion notice the documentation of any discrepancies found during testing along with associated environmental sensor and RPU serial numbers and any corrective measures taken to ensure compliance with specification requirements. Include ESS assembly installation locations and successful test completion dates.

The Engineer will provide the Contractor written notice of either acceptance or rejection of the work within ten (10) days of receipt of the completion notice and all test results. If rejected; the Engineer will specify the defect or failure in the work.

If the Engineer rejects the work, the Contractor shall promptly correct the defect or failure specified in the Department's notice. Upon completion of the correction, the Contractor shall again provide the Engineer with a completion notice for the Engineer's determination of acceptance.

(b) **Documentation**

The Contractor shall provide ESS components and software documentation to the Engineer that is accessible via web browser, and shall be capable of being printed. The documentation shall not be web-based and shall be locally accessible. Documentation shall provide all the information on the Environmental Sensor Station necessary to install, configure, troubleshoot, replace, and verify the proper functioning of the Environmental Sensor Station. The documentation shall be in English.

(c) **Warranty**

The ESS equipment and components furnished shall have a manufacturer's warranty covering defects in assembly, fabrication, and materials for 3 years from the date of final acceptance of the work in the contract according to Section 108.09(c).

If the manufacturer's warranty for the ESS system and components is for a longer period, the longer period warranty shall apply. The manufacturer's warranty on ESS components shall be fully transferable from the Contractor to the Department. The warranty shall require the manufacturer to furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department within 10 calendar days of notification by the Department.

Warranty periods shall begin on the date of final acceptance by the Department.

806.05—Measurement and Payment

Environmental Sensor Station (ESS), electrical service will be measured in units of each and paid for at the contract unit price per each. This price shall include furnishing and installing the Environmental Sensor Station system including all sensors, remote processing unit (RPU), tower/pole structure, anemometers, structural and foundation designs, soil boring, foundation, electrical equipment, central system/software integration, mounting hardware, power supplies, grounding, surge suppression devices, and communication equipment, wiring, cables, conduit, operational software package(s) and firmware(s), excavation, trenching, backfill, compaction, technical support, personnel training, shop drawings, testing, documentation, and warranty(ies).

Environmental Sensor Station (ESS), solar/battery powered will be measured in units of each and paid for at the contract unit price per each. This price shall include ESS system including all sensors, remote

processing unit (RPU), tower/pole structure, anemometers, structural and foundation designs, soil borings, foundation, solar or battery power designs and equipment, central system/software integration, mounting hardware, power supplies, cables, conduit, excavation, trenching, backfill, compaction grounding, surge suppression devices, and communication equipment, operational software package(s) and firmware(s), technical support, personnel training, shop drawings, testing, documentation, and warranty(ies).

Payment will be made under:

Pay Item	Pay Unit
ESS, Electric Service	Each
ESS, Solar/battery Powered	Each

SECTION 807 – WIRELESS TRANSCEIVERS

807.01—Description

This work shall consist of, installing and fully integrating wireless transceivers (to include cellular/PCS wireless modems, a 900 MHz wireless Ethernet radio transceivers, or 5.8 GHz wireless broadband radio transceivers) including all necessary hardware and software in accordance with these specifications and as shown the plans or as directed by the Engineer.

This specification covers technical specifications for wireless transceivers used to provide communication using leased cellular/PCS services or a license free (ISM) communication frequency band.

807.02—Materials

Equipment shall conform to the National Electrical Code (NEC), the National Electrical Safety Code (NESC), Underwriter's Laboratories (UL), and all local safety codes in effect on the date of advertisement. If equipment is installed on utility poles, comply with all regulations and codes imposed by the owner of the affected utility poles. The Contractor shall install wireless transceivers in accordance with these Specifications except when otherwise indicated on the Plans or elsewhere in the Contract.

(a) **Cellular/PCS Wireless Modem**

The wireless/cellular modem (herein wireless modem) shall be Restriction of Hazardous Substance directive (ROHS) compliant and FCC approved. The wireless modem shall be certified by the PCS Type Certification Review Board (PTCRB). The wireless modem shall support at a minimum the following host interfaces: one Ethernet 10/100 Mbps RJ-45, one USB 2.0 (Mini-B5), and one I/O port. The wireless modem shall also support the following antenna connections: Primary 50 Ohm SMA, and Rx Diversity: 50 Ohm SMA. The wireless modem shall be Class I, Div. 2 Certified. The wireless modem shall provide IPsecVPN features. The wireless modem shall include an external "rubber-duck" style antenna. All equipment supplied shall be identical, from same manufacturer, and shall be completely interchangeable.

1. **Electrical Specifications**

The wireless modem shall support a DC power source compatible with solar powered battery charging systems. A manufacturer recommended AC power adapter shall be furnished where AC power sources are used at locations shown in the Plans. A fuse (1-2 Amps) shall be furnished and installed on the line closest to a DC power source to protect power source from possible surges due to shorts or other line issues.

2. **Environmental Specifications**

Wireless modem equipment shall be hardened for field cabinet conditions. Wireless modem shall have a minimum operating temperature range -30 degrees° to 165° Fahrenheit (F) with a maximum non-condensing relative humidity as defined in the environmental requirements section of the NEMA TS 2 standard. The unit shall have thermoelectric cooling (i.e. no fans or moving parts).

3. **Physical Specifications**

The unit shall be DIN-rail or shelf mountable. A rubber-duck style ruggedized antenna compatible with the wireless modem shall be provided for external mounting to the associated ITS controller cabinet or pole.

4. **Network Specifications**

The wireless modem shall support the following application interfaces: TCP/IP, UDP/IP, DHCP, HTTP, SNMP, SMTP, SMS, and MSCI.

5. **Communications Standards:**

The modem shall support the following network technologies:

- HSUPA (7.2 Mbps) with fallback to: HSDPA, UMTS, EDGE, GPRS (MS-12) North America SKUs: Tri-Band UMTS/HSDPA/HSUPA, 850/1900/2100 MHz, Quad-Band GPRS/EDGE, 850/900/1800/1900 MHz.

- ROW SKU: Quad-Band UMTS/HSDPA/HSUPA, 850/900/1900/2100 MHz, Quad-Band GPRS/EDGE, 850/900/1800/1900 MHz.

- EV-DO Rev A With fallback to: CDMA 1x, CDMA IS-95, 800 MHz Cellular, 1900 MHz PCS.

6. **Management Capability:**

The wireless modem shall feature remote management and configuration.

7. **Leased Wireless Services:**

The Contractor shall include one (1) year of wireless service with each wireless modem from a Department/State-contract approved wireless provider. The Contractor will be provided a list by the Engineer. The Contractor shall submit a copy of the wireless service contract to VDOT for approval prior to purchase.

(b) **900 MHz Wireless Ethernet Distribution Radio**

Furnish, install, and integrate license free 902 – 928 MHz Ethernet distribution radios with antennas, coaxial cable, mounting hardware, and configuration software. Ethernet distribution radios shall be capable of point-to-point and point-to-multipoint configurations. All equipment supplied shall be identical, from the same manufacturer and shall be completely interchangeable. The wireless Ethernet distribution radio system shall operate on a license free (ISM) Spread Spectrum radio band (902 – 928 MHz). The wireless Ethernet radio shall feature 32 Bit encryption.

1. **Mechanical Specifications**

The wireless Ethernet radio system shall feature:

- 10/100 BaseT Ethernet interface that complies with IEEE 802.3 and is capable of operating at a rate of 1.0 Mbps or better
- RJ-45 connector for Ethernet port
- Maximum of 8 mSec. end-to-end latency
- 16 bit Cyclic Redundancy Check (CRC) error checking with auto re-transmit
- Built-in store-and-forward (single radio repeater – the use of back to back radio set-ups are not allowed to accomplish this function)
- Receiver Sensitivity of –110 dBm @ 10-6 BER
- Antenna port: Reverse Polarity - Threaded Normalized Connector-Female (RP TNC-F) antenna connector
- Front Panel LED indicators for: power, transmit data, receive data, data port indicator

2. **Electrical Specifications**

The wireless Ethernet distribution radio system shall feature:

- Wall adapter (120 VAC UL/CSA wall cube plug-in module with 12 VDC, 1 Amp, nominal output).
- Typical current draw of no greater than 355 mA when powered with 12 VDC input, and transmitting 1 Watt of RF output power.
- Radio Sleep mode with a maximum current draw of <1 milliAmp.

3. **Environmental Specifications**

The wireless Ethernet distribution radio shall have an operating temperature of –40 to +176 degrees F at 0 to 95% humidity.

4. **Physical Specifications**

The wireless Ethernet distribution radio system shall feature cabinet equipment capable of being DIN-rail or shelf mounted and shall not exceed 9” long x 2” wide x 5” high.

5. **Communications Standards:**

The wireless Ethernet distribution radio system shall feature:

- Frequency hopping technology (direct sequence spread spectrum technology is not acceptable).
- Bi-directional, full duplex
- Programmable Radio Frequency (RF) output levels of 1 mW, 10 mW, 100 mW, or 1 Watt
- User-selectable channels, and a minimum of 50 hopping patterns

6. **Management Capability**

The wireless Ethernet distribution radio shall feature remote management and configuration capabilities. Furnish units with a web-based software program that uses a GUI (Graphical User Interface) to provide remote programming, radio configuration, remote maintenance, diagnostics, and spectrum analyzer features. Provide software that is designed to function with the approved wireless Ethernet distribution radio. Provide configuration software that can be upgraded in the future at no additional charge. The radio shall be SNMPv2/SNMPv3 compatible for monitoring of remote alerts/alarms. The Contractor shall coordinate with the Department for configuration of standard traps for relay to network management system(s).

The Ethernet distribution radio shall be configurable from a single location (i.e. master radio location) via web-based software interface at no extra cost.

7. **Antenna**

Furnish a directional antenna or omni-directional antenna as specified in the plans that will allow the system to function as designed. Furnish mounting hardware to secure the antenna to the metal pole or wood pole, as recommended by the manufacturer of the antenna and as approved by the Engineer.

a. **Directional Antenna (Yagi)**

8.5 dB Gain, 13 dB Gain antenna, or an approved equivalent antenna meeting the following minimum specifications at locations shown in the Plans:

Property	**8.5 dB Gain Antenna**	**13 dB Gain Antenna**
Frequency Range	896 – 940MHz	902 – 928 MHz
Nominal Gain	8.5 dB	13 dB
Front to Back Ratio	18 dB	20 dB
Horizontal Beam width (at half power points)	65 degree	40 degree
Vertical Beam width (at half power points)	55 degree	35 degree
Power Rating, UHF Frequency	200 Watts	200 Watts

Lightning Protection	DC Ground	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector	Coaxial pigtail with a Standard N-Type Female Connector
Impedance	50 ohms	50 ohms
Length	24”	53” (1346 mm)
Rated Wind Velocity	125 mph	125 mph
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.26 ftsq.	0.46 ftsq.
Number Elements	6	13
Allows for Vertical or Horizontal polarization	Yes	Yes
Minimum separation distance from persons installing and using an active device	9” (230 mm)	9”
Minimum separation distance from other RF sources including radios and antennas	6.5’ (2 m)	6.5’
Welded construction	Yes	Yes

NOTE: Ethernet distribution radios equipped with an integrated panel antenna with comparable RF gains are an acceptable alternate for external Yagi antenna locations shown on the Plans. Antenna coaxial cables shall be substituted with outdoor-rated Cat6 shield twisted pair cabling from the cabinet to the integrated radio/antenna.

b. **Omni Directional Antenna**

3 dBi or 6 dBi omni antenna or an approved equivalent antenna meeting the following minimum specifications:

Frequency Range	902 – 928 MHz
Nominal Gain	Typical gains of 3 or 6 dB (dependent upon gain needed for application)
Termination	Standard N-Type Female Connector
Impedance	50 ohms
VSWR	1.5:1
Vertical Beam Width	3 dB – 33 degrees; 6 dB – 17 degrees
Lightening Protection	DC Ground
Power Rating, UHF Frequency	100 Watts
Length	3 dB – 25”; 6 dB – 65”
Rated Wind Velocity	125 mph
Solid, single piece construction	
Minimum separation distance from persons installing and using an active device	9”
Minimum separation distance from other RF sources including radios and antennas	6.5
Mount in a vertical direction and limit to vertically polarized RF systems	

8. **Coaxial Cable:**

Furnish a 400 series braided cable, or equivalent antenna coaxial cable to provide a link between the antenna and the lightning arrestor that meets the following minimum specifications:

Attenuation (dB per 100 feet) @ 900MHz	3.9 dB
Power Rating @ 900MHz	0.58 kW
Center Conductor	0.108” Copper Clad Aluminum
Dielectric: Cellular PE	0.285”
Shield	Aluminum Tape – 0.291” Tinned Copper Braid – 0.320”
Jacket	Black UV protected polyethylene
Bend Radius	1” with less than 1 ohm impedance change at bend
Impedance	50 ohms
Capacitance per foot	23.9 pf/ft
End Connectors	Standard N-Type Male Connectors on both ends

Furnish Standard N-Type male connector(s) of proper sizing to mate with the 400 series coaxial cable and utilize a crimping method to secure the connector to the coaxial cable.

Furnish a connector that meets the following minimum specifications:

- Center Contact: Gold Plated Beryllium Copper-(spring loaded – Non-solder)
- Outer Contact: Silver Plated Brass
- Body: Silver Plated Brass
- Crimp Sleeve: Silver Plated Copper
- Dielectric: Teflon PTFE
- Water Proofing Sleeve: Adhesive Lined Polyolefin – Heat Shrink
- Attachment Size: Crimp Size 0.429” (minimum) hex
- Electrical Properties:
    - o Impedance: 50 ohms
    - o Working Voltage: 1000 vrms (max)
    - o Insertion loss: 0.1 x √ Fghz
    - o VSWR: 1.25:1 (max) up to 3GHz
    - o Provide instructions on properly installing the connector

The Contractor shall provide a coaxial cable shield grounding kit containing components that will adequately bond and ground the cable shield to the pole ground. The grounding kit shall comply with MIL-STD-188-124A Specifications "Military Standard for Grounding, Bonding, and Shielding" for coaxial cable and protect the cable from lightning currents in excess of 200kA. Each kit shall be supplied, as a minimum, with the following:

- Preformed Strap: 24 Gauge copper strap that is a minimum of 1 5/8 inch long and is sized to mate with the 400 series coaxial cable
- Tensioning Hardware: Copper nuts and lock washers
- Grounding Lead Cable: #6 AWG, stranded, insulated copper wire
- Instructions on properly installing the shield grounding system

The Contractor shall furnish and install a weatherproofing kit containing components that will protect the coaxial cable shield grounding system against the ingress of moisture and prevent vibrations from loosening the connections. The weatherproofing kit shall be supplied, as a minimum, with the following:

- Butyl Mastic Tape: 3 3/4 inches wide by 24 inches long (approximately)
- Electrical Tape: 2 inches wide by 20 inches long (approximately)
- Instructions on properly installing the weatherproofing system

9. **Lightning Arrestor**

The Contractor shall furnish and install an in-line lightning arrestor between each antenna and its designated radio modem inside the equipment cabinet. The lightning arrestor shall meet the following minimum requirements:

- Surge:
  - o 20kA, 800MHz to 2.0 GHz < 1.1 : 1 VSWR
  - o 18kA, 800MHz to 2.3 GHz < 1.1 : 1 VSWR
  - o 18kA, 700MHz to 2.7 GHz < 1.2 : 1 VSWR
- Insertion Loss: ≤ 0.1 dB over frequency range
- Max Power: 500 w @ 920MHz (750 W @ 122°F)
- RF Power: 300 Watts
- Let Through Voltage: ≤ +/- 3 Volts for 3kA @ 8/20 μs Waveform
- Throughput energy: ≤ 0.5 μJ for 3 kA @ 8/20 μs Waveform
- Temperature: -40 to 185°F Storage/Operating 122°F

- Vibration: 1G at 5 Hz up to 100 Hz
- Unit Impedance: 50 Ω
- VSWR: 1.1:1
- Frequency Range: 800 MHz to 2200 MHz
- Multi-strike capability
- Low strike throughput energy
- Flange mount and bulkhead mount options
- Standard N-Type Female Connector on both the surge side and protected side connectors

10. **Managed Field Ethernet Switch**

The Contractor shall install a Managed Field Ethernet Switch (MFES) at each site where a wireless radio system is shown in the Plans. The MFES shall meet all specifications in Section 809 - Managed Field Ethernet Switch, except that optical modules/small-form pluggable (SFP) ports are not required with such applications. The wireless Ethernet distribution radio shall be compatible with the MFES. The MFES shall be considered incidental to the installation of each wireless Ethernet distribution radio.

(c) **5.8 GHz Wireless Broadband Radio**

The Contractor shall furnish license-free 5.8 GHz broadband radios with antennae, cables, mounting hardware, and configuration software. The radio systems shall be capable of point-to-point and point-to-multipoint configurations. All equipment supplied shall be identical, from same manufacturer, and shall be completely interchangeable. The equipment shall conform to all applicable IEEE 802 standards. The wireless broadband radio system shall operate on an unlicensed frequency (5.725 – 5.850 GHz).

1. **Mechanical Specifications:**

The wireless broadband radio system shall feature the following interfaces:

- Wired Ethernet: 10/100 or 10/100/1000 Base-TX Ethernet (RJ-45 connector)

2. **Electrical Specifications:**

The wireless broadband radio system shall support Power over Ethernet (PoE) with or without electrical distribution.

3. **Environmental Specifications**

The wireless broadband radio system shall meet or exceed the following environmental specifications:

- Equipment must operate in a minimum temperature range of -28 degrees F to 140 degrees F

- 100% Humidity, condensing

- Rated Wind Velocity: 100 mph

Furnish and install a manufacturer recommended in-line lightning arrestor between each radio/antenna and its network device inside the equipment cabinet. The lightning arrestor shall have multi-strike capability, and low strike throughput energy.

4. **Physical Specifications**

- Maximum dimensions for antenna are 15” x 15” x 10” (W x H x D).

- Maximum weight excluding mounting hardware is 20 lbs.

5. **Network Specifications**

- System shall feature MAC address/IP filtering.

- System shall provide SNMP and MIB II support.

6. **Antenna and Communications Standards:**

The integrated antenna shall be a directional type panel antenna featuring dual polarity and shall be between 14 dBi to 28 dBi. Outdoor-rated Cat6 shield twisted pair cabling shall be used to provide communications and power from the cabinet to the integrated radio/antenna.

Furnish a weatherproofing kit containing components that will protect the cable against the ingress of moisture and prevent vibrations from loosening the connections. The weatherproofing kit shall be supplied with instructions on properly installing the weatherproofing system.

The wireless broadband radio system shall be capable of speeds of 54 to 200 Mbps, minimum, over a minimum distance of 10 miles with line-of-sight.

7. **Management Capability**

The wireless broadband radio shall feature remote management and configuration capabilities. Furnish units with a web-based software program that uses a GUI (Graphical User Interface) to provide remote programming, radio configuration, remote maintenance and diagnostics features. Provide software that is designed to function with the approved wireless broadband radio. Minor updates to configuration software shall be provided to the Department for the duration of the warranty period described herein at no additional charge. The wireless broadband radio shall feature remote management using Telnet and should be compatible with SNMPv2/SNMPv3. The Contractor shall coordinate with the Department for configuration of standard traps for relay to network management system(s).

8. **Managed Field Ethernet Switch:**

A managed field Ethernet switch (MFES) shall be installed at each site where a wireless broadband radio is shown in the Plans. The MFES shall meet all specifications for the Managed Field Ethernet Switch in Section 809, except that optical modules/SFPs are not required with these applications. The wireless broadband radio shall be compatible with the MFES. The MFES will be considered incidental to the furnishing and installation of each wireless broadband radio.

807.03—Procedures

The Contractor shall install all equipment according to the latest version of the manufacturer's installation procedures and industry accepted installation standards, codes, and practices, or as directed by the Engineer. All materials and installation practices shall be in accordance with the applicable OSHA requirements as found in 29 Code of Federal Regulations (CFR) Part 1926, Safety and Health Standards for Construction.

(a) **Cellular/PCS Wireless Modem**

The wireless cellular modem shall be installed in a cabinet and located for easy accessibility for maintenance purposes. If the antenna must be mounted to the exterior surface of a cabinet, the Contractor shall use manufacturer-approved grommets and sealants that are listed and rated for this type of installation. The Contractor shall submit the method of attachment to the Engineer for approval prior to installation. A copy of all manufacturer equipment specifications and instructions and maintenance manuals shall be placed in the equipment cabinet.

(b) **900 MHz Wireless Ethernet Radio and 5.8 GHz Wireless Broadband Radio**

The Contractor shall perform a radio path site survey test before installing any equipment. The test shall evaluate the Signal Strength (dBm), Fade Margin (dB), Signal-to-Noise Ratio, Data Integrity (poll test), and a complete frequency spectrum scan. The radio path site survey test shall be performed using the supplied brand and model of radio equipment to be deployed. During the initial radio path signal strength test it may be determined that one or more repeater stations will be necessary to complete the intended link. Repeater stations installed in excess of those shown on the Plans or Working Drawings as authorized by the Engineer will be paid according to Section 109.05. The Contractor shall provide the test results to the Engineer for review and approval. Submit copies of the test results and colored copies of the frequency spectrum scan along with an electronic copy of this information. The Engineer will approve final locations of antennae. Install an antenna splitter cable at locations where it is determined that a dual antenna configuration is necessary to accommodate communications in multiple directions.

Install the antenna in a manner that avoids conflicts with other utilities (separation distances shall be in accordance with the guidelines of the National Electrical Safety Code and the affected utilities) and as specified in the antenna manufacturer's recommendations. Secure the antenna mounting hardware to the pole and route the coaxial cable so that no strain is placed on the coaxial connectors. On wood pole installations, bond the antenna mounting hardware to the pole ground using # 6 AWG bare copper wire using split bolt or compression type fitting. The Contractor shall use the latest version of manufacturer-provided mounting hardware.

Install the cable shield grounding system by removing the outer jacket of the cable without damaging the cable shield. Install the shield grounding system following the cable manufacturer's instructions. Install and make weatherproof the connection using the appropriate weatherproofing materials and following the manufacturer's instructions. On wood poles, secure the #6 AWG grounding lead cable to the pole ground using split bolt or compression type fitting or a Department approved method. On metal poles, secure the #6 AWG grounding lead cable to the pole using a Department approved method.

Do not exceed the manufacturer recommended bend radius of the coaxial cable as it traverses from the cabinet to the antenna assembly. Connect the lightning arrestor to the cable (or shielded twisted pair alternate cables) in the equipment cabinet. Properly ground and secure the arrestor in the cabinet. Permanently label all cables entering the cabinet. Ensure that the power supply for the radio system is not connected to the GFCI receptacle circuit located in the cabinet. Place a copy of all manufacturer equipment specifications, instructions, and maintenance manuals in the equipment cabinet.

(c) **Acceptance Testing**

The wireless transceivers shall be subjected to Field Acceptance tests (FATs), VDOT Traffic Operations Center Integration (TOCIT) testing, and System Acceptance testing (SAT). The Contractor shall meet the requirements of the Department's test plan. The test plan can be found on the Department's website.

(d) **Warranty**

Provide a minimum two (2) year warranty with each wireless transceiver installation on all equipment to ensure that all products are free of manufacturing, design, material, and workmanship defects. The warranty period shall begin on the date of final acceptance of the work as defined in Section 108.09.

807.04—Measurement and Payment

Cellular/PCS Wireless Modem will be measured in units of each and will be paid for at the contract unit price per each. This price shall include providing wireless modem, mounting arms, antenna, fittings, miscellaneous cabling, installation and testing, operational software and firmware, supplies, technical support, personnel training, shop drawings, documentation, 1 year of leased services required to complete the work. Seventy percent (70%) of the unit bid price will be paid upon delivery of materials, software protocols, and documentation, installation of the wireless modem and all wiring for a fully operational wireless modem, and successful completion of the field acceptance tests. Thirty Percent (30%) of the unit bid price will be paid upon successful integration with the VDOT Traffic Operations Center (TOCIT) and successful completion of the subsequent 30-day System Acceptance Test (SAT).

900 MHz Wireless Ethernet Distribution Radio will be measured in units of each and will be paid for at the contract unit bid price per each. This price shall include furnishing, installing and testing the appropriate antennae, transceiver radio including: splitter cables, cable shield grounding system with weatherproofing, lightning arrestors, wireless Ethernet switch, labeling, repeater stations known to be required before setup, and any integration between a wireless Ethernet distribution radio, a fiber optic network or other State owned or leased communication node as indicated on the Plans as necessary to complete the work. All power supplies, power cords, adapters, antenna mounting hardware, connectors,

cables, signs, decals, installation materials and configuration software necessary to complete this work, including the radio path site survey tests and warranties will be considered incidental to the cost the radio distribution system. Riser assemblies will be incidental to the cost of each installation. Seventy percent (70%) of the unit bid price will be paid upon delivery of materials, software protocols and documentation, installation of the wireless Ethernet radio and all wiring for a fully operational wireless Ethernet distribution radio, and successful completion of the field acceptance test. The remaining thirty percent (30%) of the unit bid price will be paid upon successful integration with the VDOT Traffic Operations Center (TOCIT) and successful completion of the subsequent 30-day Acceptance Test.

5.8 GHz Wireless Broadband Radio will be measured in units of each and will be paid for at the contract unit bid price per each. This price shall item include furnishing, installing and testing the appropriate antennae, transceiver radio, splitter cables, cable shield grounding system with weatherproofing, lightning arrestors, wireless Ethernet switch, labeling and any integration between a wireless broadband radio, a fiber optic network or other State owned or leased communication node as indicated on the Plans necessary to complete the work. All power supplies, power cords, adapters, antenna mounting hardware, connectors, serial cables, signs, decals, installation materials and configuration software necessary to complete this work, including the radio path site survey tests and warranties will be considered incidental to the price bid for the broadband radio system . Riser assemblies will be considered incidental to the cost of each installation. Seventy percent (70%) of the unit bid price will be paid upon delivery of materials, software protocols, and documentation, installation of the wireless broadband radio and all wiring for a fully operational wireless broadband radio, and successful completion of the Field Acceptance test (FAT). The remaining thirty percent (30%) of the unit bid price will be paid upon successful integration with the VDOT Traffic Operations Center and successful completion of the subsequent 30-day System Acceptance Test.

No separate payment will be made for coordinating with the utility companies or installing and integrating wireless transceivers but the cost thereof will be considered incidental to other appropriate items of work. No separate payment will be made for line of sight analysis which will be considered incidental to the integration of the wireless transceiver system.

Payment will be made under:

Pay Item	Pay Unit
Cellular/PCS Wireless Modem	Each
900 MHz Wireless Ethernet Distribution Radio	Each
5.8 GHz Wireless Broadband Radio	Each

SECTION 808 - FIBER OPTIC CABLE AND INTERCONNECT

808.01—Description

This work shall consist of furnishing and installing a fiber optic cable system in accordance with these specifications and as shown on the plans or as directed by the Engineer. All backbone fiber optic cable shall be a minimum of 96 strand single mode, unless otherwise noted in the plans. All fiber optic drop cable between cabinets and backbone cable shall be no less than 12 strand single mode, and shall be sized as shown on the plans. All underground fiber optic cable shall be installed in new or existing conduit; direct buried fiber shall not be permitted. Fiber optic cable shall not be installed with power conductors in pull boxes, vaults, or conduit.

808.02—Materials

(a) **Fiber Optic Cable**

The fiber optic cable shall be all-dielectric, dry-filled, loose-tube, dispersion-unshifted, single-mode fiber (SMF) with low water peak, gel free, and suitable for underground (i.e., in conduit) and aerial outside plant installation. All fiber optic cable shall be splice-compatible with the Department's existing dispersion-unshifted single-mode fiber and require no electronic equipment for dispersion compensation between new and existing fiber. All components that comprise a single length of cable shall be continuous and shall be of the same material. Only commercial off the shelf materials, equipment and components shall be furnished. The Contractor shall furnish a fiber optic cable system meeting the following requirements:

1. **Mechanical Specifications**

a. **Strength Member**

The fiber optic cable shall contain a dielectric central strength member and dielectric outside strength member to prevent buckling of the cable and provide tensile strength. The fiber optic cable shall be capable of withstanding a pulling tension of 600 pounds during installation without increasing the fiber attenuation more than 0.8 decibel per mile, without changing other optical fiber characteristics after the tensile load is removed, and without damage to any components of the fiber optic cable.

b. **Water Blocking Compound**

The fiber optic cable shall contain a dry water blocking material to prevent the ingress of water within the outer cable jacket. The water blocking tapes and yarns shall be non-nutritive, dielectric, resistant to mold/fungus, homogeneous, and free from dirt and foreign matter. A dry water blocking material for fiber optic cables shall be used for either aerial or underground installations. A dry water blocking compound shall be longitudinally applied around the outside of the central buffer tubes. All cables with water blocking tape shall be constructed in accordance with the Electronic Industries Alliance/Telecommunication Industry Association EIA/TIA-455-81B standard and have been subjected to water penetration tests as defined in the EIA/TIA-455-82B standard.

c. **Ripcord**

The cable shall contain at least one ripcord under the sheath. The ripcord shall permit the removal of the sheath by hand or with pliers.

2. **Environmental Specifications**

a. **Water infiltration**

The fiber optic cable shall be capable of withstanding the tests for water penetration as defined in the TIA/EIA-455-82 standard. A one meter length of cable shall be capable of withstanding a one-meter static head of water applied at one end for 24 hours without water leaking through the other open cable end.

b. **Operating Temperature**

The shipping and the operating temperature range of fiber optic cable shall meet or exceed -30º to 158ºF as defined in the environmental requirements section of the National Electrical Manufacturers Association NEMA, TS 2 standard. The installation temperature range of fiber optic cable shall meet or exceed -22º to 140ºF.

3. **Physical Specifications**

a. **Color Coding**

The marking and color coding of the fibers and buffer tubes shall conform to telecommunication industry requirements as detailed in the TIA/EIA-598-D standard.

The colors shall be permanent and stable during temperature cycling, and not subject to fading or smearing onto each other or into the water blocking material. The fibers shall be colored with UV curable inks that permanently remain clearly distinguishable as the intended color.

b. **Filler**

Fillers or rods may be included in the cable core to lend symmetry to the cable cross section.

c. **Outer Jacket**

The fiber optic cable shall be jacketed with medium density polyethylene (MDPE) that is free of blisters, cracks, holes, and other deformities. The nominal jacket thickness shall be a minimum of 0.03 inch. The jacketing material shall be directly applied over the tensile strength members and water-blocking material. The MDPE shall contain carbon black to provide ultraviolet (UV) protection and shall not promote the growth of fungus.

The jacket shall be continuously marked, at no less than 5 foot intervals, with the cable manufacturer's name, fiber type, fiber count, date of manufacture, the words "VDOT FIBER OPTIC CABLE," and the sequential marked cable lengths marked in feet. The actual length of the cable shall be within 1% of the length indicated by the marking. The markings shall be legible and of contrasting color to that of the cable jacket.

d. **Buffer Tubes**

The fiber optic cable shall include loose buffer tubes that isolate internal optical fibers from outside forces and provide protection from physical damage as well as water ingress and migration. The buffer tubes shall provide freedom of movement for internal optical fibers. The buffer tubes shall allow for expansion and contraction of the cable without damage to internal optical fiber. The fibers shall not adhere to the inside of the tube. The buffer tubes shall permit intentional scoring and breakout without damage to the fiber. Each fiber optic cable buffer tube shall contain 12 fibers per tube.

e. **Optical Fiber**

The optical fibers used in the cable shall meet or exceed the TIA-492 CAAB specification, the U.S. Department of Agriculture Rural Utilities Service (RUS) 7 CFR 1755.900 Telcordia GR-20 standards, International Electrotechnical Commission (IEC) 60793-2-50 Type B1.3, and International Telecommunication Union ITU-T G.652.E requirements. Use only optical fibers meeting the following additional requirements:

Geometry
Cladding Diameter: 125µm, ±0.7 µm Core-to Cladding Concentricity: ≤0.5 µm Zero Dispersion: 1310nm

Optical
Cabled Fiber Attenuation: 1,310 nm, ≤0.4 dB/km; 1,550 nm, ≤0.3 dB/km Point Discontinuity: 1,310 nm, ≤0.05 dB/km; 1,550 nm, ≤0.05 dB/km Total Dispersion: 1,625 nm ≤23.0 ps/(nm•km) Macrobend Attenuation: Turns – 100; Outer diameter (OD) of the mandrel – 60 mm, ±2 mm; ≤0.05 dB at 1,550 nm

Each optical fiber shall be glass and consist of a germania-doped silica core surrounded by concentric silica cladding. All fiber in the buffer tube shall be usable fiber that complies with attenuation requirements. Fibers shall not adhere to each other. The fiber shall be free of surface imperfections and inclusions. All fiber optic core glass shall be from the same manufacturer.

f. **Cable Strength**

The fiber optic cable shall be capable of withstanding a pulling tension of 600 pounds during installation without increasing the fiber attenuation more than 0.8 decibels per mile and without changing other optical fiber characteristics after the tensile load is removed. The optical fiber shall be proof-tested by the fiber manufacturer at a minimum of 100 kilo pounds per square inch. The cable shall withstand 25 impact cycles and the change in attenuation shall not exceed 0.2 decibel at 1,550 nanometers when tested according to the requirements as detailed in the TIA/EIA-455-25C standard. The fiber optic cable shall be capable of withstanding a minimum compression load of 125 pounds per square inch when applied uniformly over the length of the sample at the rate of 0.15 to 0.8 inch per minute and maintained for 10 minutes as defined in the TIA/EIA-455-41A standard. The change in attenuation shall not exceed 0.15 decibel during loading at 1,550 nanometers, and no fiber shall display a measurable change in attenuation after load removal.

g. **Bend Radius**

The fiber optic cable shall be capable of withstanding a minimum unloaded bend radius of 10 times the cable diameter and a minimum loaded bend radius of 20 times

the cable diameter when loaded to pulling tension of 600 pounds. The cable shall be tested as required in the EIATIA-4550-33B standard. The optical characteristics of the fiber shall not be affected when the cable is subjected to the minimum bending radius.

(b) **Splicing Materials**

All splice enclosures, organizers, cable end preparation tools, and procedures shall be compatible with the fiber optic cable, and approved by the Engineer. All optical fiber splices shall be contained within a splice enclosure. The enclosures shall provide storage for fiber splices, non-spliced fiber, and buffer tubes. The splice enclosures shall ensure and maintain the mechanical and environmental integrity of the fiber optic cable, encase the sheath opening in the cable, and organize and store optical fiber.

Fiber optic splice enclosures shall meet the following requirements:

1. **Mechanical Specifications**

Mechanical
Resist compression deformation to a maximum of 400 lbs. Withstand an impact energy to a maximum of 40 ft. lbs. at 0°F Axial Tension: 100 lbs. for 30 minutes Cable Torsion: (10) ten 90° rotations Cable Flexing: (10) ten 90° bends

2. **Environmental Specifications**

Environmental
Hydrostatic Pressure Head: up to 20 ft. lbs. (-9 lbs per square inch) Withstand 40 freeze/thaw temperature cycles Ultraviolet resistant during a maximum 30 day exposure in compliance with the requirements detailed in ASTM B117

Chemical
Withstand a 90 day exposure to solutions of 3% sulfuric acid, 0.2 normal of sodium hydroxide, 10% Igepal®, kerosene, and be fungus-resistant as required in ASTM G21

3. **Physical Specifications**

All splice enclosure hinges and latching devices shall be stainless steel. The enclosure shall be airtight and prevent water intrusion. The splice enclosure shall be capable of accommodating pressurization. The enclosure shall provide fiber and splice organizers, including splice trays and strain relief.

The splice enclosures shall allow for re-entry without requiring specialized tools or equipment and be hermetically sealed when closed to protect internal components from environmental hazards such as moisture, insects, and UV light. Fiber optic splice enclosures shall also:

- Comply with the Telcordia Technologies' GR-771-CORE standard and all applicable NEC requirements.

- Provide space for future expansion equal to 100% of the initial utilization.

Fiber optic cable penetration end caps shall be of a size to adequately accommodate a minimum installation of two trunk fiber optic cables and two fiber optic drop cables (minimum of four round ports and one oval port). The enclosure end caps shall be factory drilled to the proper diameter to accept and seal the fiber optic cable entries. The cable entry locations shall accommodate an assortment of cables with outer diameters ranging from 0.45 to 0.55 inch, +10% without jeopardizing the waterproof characteristics of the enclosure.

All splice trays shall be securely attached, accessible, and provide adequate storage for the fiber cable. The splice trays shall provide access to individual fibers without disrupting other fibers in the tray. The splice trays shall hold the buffer tubes rigidly in place and provide protection for fusion splices. The raceway shall accommodate the minimum bend radius of the fiber. The splice trays shall allow visible inspection of the fiber. The splice trays shall include a cover with a locking mechanism to hold it in firmly place.

(c) **Cable Reel Packaging Requirements and Terminations**

1. **Mechanical Specifications**

The fiber optic cable ends shall be capped or sealed to prevent the entry of moisture during shipping, handling, storage, and installation. One end of the fiber optic cable shall be equipped with flexible pulling eyes.

The fiber optic cable shall be shipped and stored with a protective wrap or other approved mechanical reel protection device over the outer turns of the fiber optic cable on each reel. Wrap shall be weather resistant and shall protect the cable reel from environmental hazards. The cable reel shall remain thoroughly wrapped until the cable is to be installed.

The packaging and delivery of fiber optic cable reels shall comply with the following minimum requirements:

- Cable shall be shipped on reels of marked continuous length.

- Each cable shall be shipped on a separate, strongly constructed reel designed to prevent damage to the cable during shipment and installation.

- Each reel shall have a minimum of 6 feet on each end of the cable available for testing.

- All fiber optic cable shall be continuous and free from damage.

- There shall be no point discontinuities greater than 0.1 decibel per reel.

- All cable delivered shall have been manufactured within 6 months of the delivery date to the project.

- A copy of the transmission loss test results as required by the EIA/TIA-455-78 standard, as well as results from factory tests performed prior to shipping, shall be provided to the Engineer upon delivery

- The manufacturer shall provide the date of manufacture; product and serial numbers; cable data, including the reel length; refraction index; the project name and location; type of fiber and quantity of strands used; technical product data sheet(s); and reel number(s).

2. **Environmental Specifications**

Standard Connector (SC) - type connectors shall have an operating and storage temperate range of -30° to 165°F as per the NEMA TS 2 standard.

3. **Physical Specifications**

Only SC type connectors shall be used unless otherwise approved by the Engineer. The optical fiber within the body of all connectors shall be mechanically isolated from cable tension, bending, and twisting.

All connectors shall be compliant with the TIA/EIA-568-C and TIA/EIA-604 standards, as applicable, and shall be tested according to the Telcordia/Bellcore GR-326-CORE standard. When tested according to the TIA and EIA's Fiber Optic Test Procedure (FOTP)-171 (TIA/EIA-455-171), the connectors shall test to an average insertion loss of ≤0.4 decibel and a maximum loss of ≤0.75 decibel. The connectors shall be tested as detailed in FOTP-107 (TIA/EIA-455-107) to reflectance values of ≤ -50 decibels.

(d) **Pre-terminated Fiber Patch Panel**

The pre-terminated fiber patch panel shall be a termination panel that includes a factory installed all-dielectric SMF cable stub of sufficient length for installation to the splice point with the fiber optic trunk cable. The panel shall include factory-installed and terminated SC - type panel connectors. The cable stub shall be of an adequate length to splice the stub and provide a fiber connection between the panel and the backbone fiber cable or be a length as directed by the Engineer. The patch panel shall be compatible with the fiber optic cable and color coded to match the optical fiber color scheme. The patch panel shall have SC type panel connectors. The quantity of connectors shall be equal to the number of fibers in the SMF cable stub. The patch panel shall be suitable for mounting within the ITS controller cabinet at the field device location(s).

Molded/sealed patch panels shall not be used.

(e) **Fiber Distribution Center (FDC)**

The fiber distribution center (FDC) shall be a drop cable, 19 inch EIA rack-mount fiber distribution center, unless otherwise noted in the Plans. The rack-mount FDC shall be of metallic construction with fixed-mounted front-facing fiber termination couplers accessible behind a hinged and removable transparent plastic dust cover. A separate FDC splice housing that is integral to the overall FDC enclosure shall be included with each FDC, but contained in a separated compartment either above or below the termination couplers. The Contractor shall include the appropriate quantity of couplers, panels, splice trays, organizers, FDC interconnect cables, and ancillary materials necessary to terminate each drop cable in the FDC.

Only manufacturer recommended single-mode FDC couplers shall be used. SC connectors shall be used, unless otherwise directed by the Engineer. Dust caps shall be included on all couplers. All FDC couplers shall be labeled in numerical order based on EIA/TIA color coding.

Each drop cable FDC shall include drop cable FDC interconnect cables that consist of factory pre-connectorized "pigtails." The FDC interconnect cables shall be constructed of 900 micron tight buffered fiber (single mode optical fiber) surrounded with U.S. manufactured aramid fibers and jacketed with flame retardant jacket material. The optical fiber shall be proof tested to 100 kpsi and shall meet all of the optical fiber requirements of these specifications. The factory-installed connectorization shall meet all requirements of these specifications. The FDC interconnect cable fibers shall be individually color-coded for ease of identification and the termination order shall be based on EIA/TIA color coding.

808.03—Procedures

All equipment shall be installed according to the latest version of the manufacturer's installation procedures and applicable industry accepted installation standards, codes, and practices, or as directed by the Engineer. All materials and installation practices shall be in accordance with the applicable OSHA requirements as found in 29 Code of Federal Regulations (CFR) Part 1926, Safety and Health Standards for Construction.

In addition, the following shall be performed:

- Ensure conduit is clean and free from damage prior to installing fiber optic cable.
- Document the sequential cable length markings at each splice box and pull box wall that the cable passes through, and include the information with the as-built documentation.

The Contractor shall provide all incidental parts necessary for a complete and properly operating system.

The Contractor is required to submit reel tests prior to installation of cable.

Required documentation shall be in English.

(a) **Fiber Optic Cable Installation**

Nomenclature shall be developed for identification of the fiber optic cable. Nomenclature shall be "VDOT FIBER OPTIC CABLE" and shall be used to create cable identification tags. The approved cable identification tags shall be used on all test results and fiber related documents that are submitted to the Engineer.

Cable tags shall be installed within 1 foot of each splice and/or termination point indicating the cable type, fiber count, and each fiber optic cable origination and termination point in addition to the permanent markings on the cable. The cable tags shall be permanent labels suitable for outside plant application and shall be affixed to all fiber optic cables. The lettering shall be permanent ink and display the label "VDOT FIBER OPTIC CABLE".

1. **Pulling**

The fiber optic cable shall be installed by hand or by using a mechanical pulling machine when the pulling method is utilized. If a mechanical pulling machine is used, the machine shall be equipped with a tension meter that monitors or records the tension being applied to the cable. At no time shall the manufacturer's recommended maximum pulling tension be exceeded. The central strength member and aramid yarn shall be attached directly to the pulling eye during the cable pulling operation. Pulling attachments, such as "basket grip" or "Chinese finger" type, shall be used to ensure that the optical and mechanical characteristics are not degraded during the fiber optic cable installation.

Excess cable shall be coiled in a figure eight configuration and fed manually when pulling through pull boxes and splice boxes by hand. If pulleys and sheaves are to be used to mechanically pull through pull boxes and splice boxes, a drawing of the proposed layout shall be provided to the Engineer prior to the start of installation showing that the cable shall never be pulled through a radius less than the manufacturer's minimum bend radius. Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the appropriate bend radius. Tension monitoring shall be provided at all times during the pulling operation. A cable pulling lubricant, recommended by the optical fiber cable manufacturer, shall be used during the installation process.

2. **Blowing**

Either the high-airspeed blowing (HASB) method or the piston method shall be used for blowing operations. When using the HASB method, the volume of air passing through the conduit shall not exceed 600 cubic feet per minute or the conduit manufacturer's recommended air volume, whichever is more restrictive. When using the piston method, the volume of air passing through the conduit shall not exceed 300 cubic feet per minute or the conduit manufacturer's recommended air volume, whichever is more restrictive.

3. **Slack Cable Storage**

Additional fiber optic cable shall be provided and stored at each pull box and splice box to allow for future splices, additions, or repairs to the fiber network. The additional fiber optic cable shall be stored without twisting or bending the cable below the minimum bend radius.

A total of 200 feet of fiber optic trunk cable shall be stored in splice boxes, with 100 feet of cable on each side of the cable splice point.

A total of 50 feet of spare fiber optic trunk cable shall be stored in pull boxes.

A total of 50 feet of spare fiber optic drop cable shall be stored in the base of each cabinet or the adjacent splice pull box.

(b) **Splicing**

All optical fiber splicing shall be performed using the fusion splicing technique, and in accordance with the latest version of the manufacturer's cable installation procedures, industry accepted installation standards, codes, and practices; or as directed by the Engineer. For trunk to trunk splicing, all splices shall match fiber and buffer tube colors. Where a fiber cable is to be accessed for lateral or drop signal insertion, only open the buffer tube containing the fiber

to be accessed and only cut the actual fiber to be accessed. If a fiber end is not intended for use, cut the fiber to a length equal to that of the fiber to be used and neatly lay it into the splice tray. Treat any fibers exposed during splicing with a protective coating and place in a protective sleeve or housing to protect the fiber from damage or contaminants. No mechanical splicing will be allowed.

The Contractor shall document each splice location and identify the source and destination of each fiber in each splice tray. Document all fiber colors and buffer jacket colors used during installation, and develop a sequential fiber numbering plan as required in the TIA/EIA-598-D standard for color - coding in the documentation.

Fiber optic drop cables shall be spliced to the backbone cable in a splice enclosure located in a splice box/vault within close proximity to the cabinet.

All splice enclosures within a splice box/vault shall be neatly stored. The splice enclosure shall be attached to the splice box/vault interior wall to prevent the enclosure from lying on the bottom of the splice box.

The splice loss for a fusion splice shall not exceed a maximum bidirectional average of 0.1 dB per splice. The Contractor shall repair or replace splices that exceed allowable attenuation at no cost to the Department.

The attenuation in the connector at each termination panel and its associated splice shall not exceed 0.5 dB. The Contractor shall repair or replace connectors exceeding allowable attenuation at no cost to the Department.

Splice Equipment Specifications

A fusion splice machine shall be used to splice all optical fiber. The unit shall be portable and capable of 120 VAC and internal battery powered operation. The unit shall be capable of splicing fibers with a 250 micrometer coating. The fusion splice machine shall have the following capabilities:

- Splice loss measurement.
- Splice protection sleeve heater.
- Battery with charging unit and power cable.
- Spare electrodes, fuses, and lamps.
- Power meter/light source with carrying case.

The power meter/light source shall be a calibrated pair that is portable and battery operated. The power meter/light source shall operate at selectable wavelengths of 850/1,310/1,550 nanometers. The power meter shall have a decibel milliwatt measurement scale with a range of +3 to -45 decibel milliwatts for SMF operation and an accuracy of 0.5 decibel or better.

The splice machine shall be new from the factory or serviced and certified by the factory or its authorized representative within the previous 6 months from the commencement of its use on the project. A letter of certification from the manufacturer or authorized

representative shall be provided to the Engineer certifying compliance. All splicing equipment shall be cleaned and calibrated according to the manufacturer's recommendations prior to each splicing session at each location.

(c) **Pre-terminated Fiber Patch Panel Installation**

Patch panels shall be neatly installed and secured in a weather proof enclosure. All patch panel connectors shall be clearly and permanently labeled. All installed patch panels shall include documentation regarding the identification, route, and function of each patch panel connector at that location. At least one copy of this information shall be placed with the installed equipment.

(d) **Fiber Distribution Centers (FDC)**

This work shall consist of furnishing and installing drop cable rack-mount Fiber Distribution Centers in 19 inch EIA equipment racks at positions specified by the Engineer. A FDC interconnect cable shall be furnished and installed with each FDC installed at the communications hub. All FDC interconnect cable fibers shall be spliced to all trunk cable fibers in appropriate order based on EIA/TIA color coding. Route the interconnect cable within the FDC and its splice cabinet and connect it to the termination panels of the FDC. Label FDC interconnect cables exactly as for the drop cable when the FDC interconnect cable must be routed to the exterior of the FDC and its splice cabinet.

(e) **Testing**

The equipment covered by these specifications shall be subjected to reel test and installation testing. The Contractor shall meet the requirements of the Department's test plan for reel and Field Acceptance testing (FAT). The test plan can be found on the Department's website.

(f) **Training**

Upon completion of the work and at a time approved by the Engineer, the Contractor shall provide training by a qualified instructor to Department personnel in the proper operation and maintenance of the cable and cable installation equipment. Department personnel shall receive training comparable to the equipment manufacturer's factory training for each new type of fiber optic infrastructure equipment that has not previously been installed within the region. The minimum training shall be one 2 hour instruction session for device operation and maintenance.

(g) **Warranty**

Unless otherwise required herein, provide manufacturer's warranty(ies) covering defects in materials, fabrication, and workmanship on cable, drop cable, patch panels, splice enclosures, and incidentals required for installation that are customarily issued by the equipment manufacturer and that are at least one (1) year in length from the date of final acceptance of the work as defined in Section 108.09 (c) by the Department. Include replacement or coverage for all parts and labor necessary to repair defective material, equipment, or workmanship that arises during the warranty period.

The warranty period shall begin on the date of final acceptance of the work as defined in Section 108.09.

808.04—Measurement and Payment

Fiber optic cable (Strands) will be measured in units of linear feet and will be paid for at the contract unit price per linear foot for the number of strands specified. This price shall include furnishing and installing fiber optic cable, organizers, cable end protection, labeling, and testing of all cable materials, ancillary components, and equipment.

Fiber optic drop cable (Strands) will be measured in units of linear feet and will be paid for at the contract unit price per linear foot for the number of strands specified. This price shall include furnishing, and installing fiber optic cable, organizers, cable end protection, labeling, and testing of all cable materials, ancillary components, and equipment.

Pre-terminated fiber patch panel will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing fiber patch panel, cable stub, and panel connectors, splicing, and testing all materials and equipment. Pre-terminated patch panels and cable stubs shall be provided as a single assembly,

Underground splice enclosure will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing, installing, splicing, and testing all materials and equipment.

Fiber distribution center will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing fiber distribution center, splicing, housing, couplers, panels, splice trays and testing all materials and equipment.

Splicing, furnishing and installing splice trays, cable storage trays, pigtails, jumpers, cable hooks, connector panels, documentation, shop drawings, testing and training will not be measured for separate payment but shall be considered incidental to furnishing and installing fiber optic cable, fiber distribution centers, fiber patch panels, and fiber splice enclosures.

Payment will be made under:

Pay Item	Pay Unit
Fiber optic cable (Strands)	Linear Foot
Fiber optic drop cable (Strands)	Linear Foot
Pre-terminated fiber patch panel	Each
Underground splice enclosure	Each
Fiber distribution center	Each

SECTION 809 – MANAGED FIELD ETHERNET SWITCH

809.01—Description

This work shall consist of furnishing and installing an environmentally hardened, device-level Managed Field Ethernet Switch (MFES). The MFES shall provide wire-speed fast Ethernet connectivity at transmission rates of 100 megabits per second or 1 gigabit per second from a remote device installation location to the network trunk interconnection point, as shown on the plans. The MFES shall support a minimum combination of 10 fiber optic and copper Ethernet ports.

809.02—Equipment

The Contractor shall furnish and identify all equipment and appurtenances by name, model number, serial number, technical support, and warranty telephone numbers, and any other pertinent information required to facilitate equipment verification, installation, troubleshooting, and maintenance.

The MFES shall have minimum management intelligence typical of most current industrial Ethernet deployments. The MFES shall include Layer 2 capability providing architecture standardization, open connectivity (i.e., interoperability), bandwidth management, rate limiting, security filtering, and general integration management of an advanced Ethernet switching architecture.

The MFES shall be fully compatible and interoperable with the existing trunk Ethernet network interface, and shall support half and full duplex Ethernet communications. The MFES shall feature non-blocking on all ports, and the full-duplex operation shall have no collisions. The MFES shall have non-blocking, store and forward switching at a minimum. The MFES shall provide a selectable, self healing feature that redirects the fiber connectivity in cases where the fiber link from the head end is severed and the data to and from the MFES has an alternate fiber route path to maintain communications.

The MFES shall have a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

The Contractor shall furnish a managed field Ethernet switch meeting the following requirements:

(a) **Mechanical Specifications**

All wiring shall comply with NEC requirements and standards.

All conductive contact surfaces or pins shall be gold-plated or made of a non-corrosive, non-rusting, non-reactive, durable conductive metal.

All external screws, nuts, and locking washers shall be stainless steel. Self-tapping screws shall not be used unless approved in advance by the Engineer.

All parts shall be made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

(b) **Electrical Specifications**

The MFES shall be supplied by 115 volts of alternating current (VAC) and shall have a minimum operating input of 85 VAC and a maximum operating input of 265 VAC. If the device requires operating voltages other than 120 VAC, the Contractor shall supply the required voltage converter at no additional cost. The maximum power consumption shall not exceed 50 watts.

The MFES shall have diagnostic light emitting diodes (LEDs) including link, TX, RX, speed (for Category 5E ports only), and power LEDs.

(c) **Environmental Specifications**

The MFES shall perform all of the required functions during and after being subjected to an ambient operating temperature range of -30°F to 165°F as defined in the environmental

requirements section of the NEMA TS 2 standard, with a non-condensing humidity of 0 to 95%. The MFES shall meet these temperature requirements without the use of fans.

The MFES manufacturer shall certify that their device has successfully completed environmental testing as defined in the environmental requirements section of the NEMA TS 2 standard. Vibration and shock resistance shall meet the requirements of Sections 2.1.9 and 2.1.10, respectively, of the NEMA TS 2 standard. The MFES shall comply with the operating voltage, operating frequency, power interruption, and power service transient requirements in the NEMA TS 2 standard.

The MFES shall be protected from rain, dust, corrosive elements, and typical conditions found in a roadside environment.

(d) **Physical Specifications**

Each MFES shall have a non-corrosive metal enclosure and shall be shelf, DIN rail, or rack mountable in a standard 19" EIA rack. Each MFES shall be provided with the necessary hardware for installation by any of the three mounting methods. Maximum dimensions of each MFES shall be 6" x 19" x 10" (H x W x D).

1. **Managed Field Ethernet Switch Optical Ports**

All fiber optic link ports shall operate at 1,310 nanometers (nm) and/or 1,550 nm in single mode. The optical ports shall be Type ST, SC, LC, or FC. Mechanical transfer registered jack (MTRJ) type connectors shall not be used.

The Contractor shall provide a MFES equipped with a minimum of three optical 1000 Base-X small-form pluggable (SFP) ports capable of transmitting data at dual speed, auto-negotiable between 100 megabits per second and 1 gigabit per second. Each optical port shall consist of a pair of fibers; one fiber shall transmit (TX) data and one fiber shall receive (RX) data. The Contractor shall furnish attenuators at no additional cost if required to service the optical uplink without saturating receiving optics.

Distribution small-form pluggable (SFP) ports shall be furnished in two types, Short Haul or Medium Haul as described herein, in Section 810 Primary Network and L3 Aggregation, where noted in the Plans.

Short haul SFP optical port shall transmit and receive Ethernet data at a distance of 15 to 20 km on 0.3 dB/km signal loss SM fiber. All short haul ports supplied shall be identical.

Medium haul SFP optical port shall transmit and receive Ethernet data at a distance of 40 to 50 km on 0.3 dB/km signal loss SM fiber. All medium haul ports supplied shall be identical.

Each MFES shall be provided with optical distribution SFP modules as indicated on the Plans. Distribution SFPs in the forms of short haul and medium haul types shall be compatible with existing distribution SFPs in adjacent switches including primary network switches and L3 field aggregation switches.

2. **Copper Ports**

MFES shall include a minimum of seven copper ports. All copper ports shall be Type RJ-45 and shall auto-negotiate speed (i.e., 10/100 Base) and duplex (i.e., full or half). All 10/100 Base TX ports shall meet the specifications detailed in this section and shall be compliant with the IEEE 802.3 standard pinouts, power, and signaling levels.

All Category 5E unshielded twisted pair/shielded twisted pair network cables shall be compliant with the EIA/TIA-568-A standard.

(e) **Networking Standards**

The MFES shall comply with all applicable IEEE networking standards for Ethernet communications, including but not limited to:

- IEEE 802.1D standard for media access control (MAC) bridges used with the Spanning Tree Protocol (STP).
- IEEE 802.1Q standard for port-based virtual local area networks (VLANs).
- IEEE 802.1P standard for Quality of Service (QoS).
- IEEE 802.1w standard for MAC bridges used with the Rapid Spanning Tree Protocol (RSTP).
- IEEE 802.1s standard for MAC bridges used with the Multiple Spanning Tree Protocol.
- IEEE 802.3 standard for local area network (LAN) and metropolitan area network (MAN) access and physical layer specifications.
- IEEE 802.3u supplemental standard regarding 100 Base TX/100 Base FX.
- IEEE 802.3x standard regarding flow control with full duplex operation.

(f) **Communications Standards**

The Contractor shall furnish MFESs that provide 99.999% error-free operation, and shall comply with the Electronic Industries Alliance (EIA) Ethernet data communication requirements using single-mode fiber optic transmission medium and Category 5E copper transmission medium. The MFESs shall provide a switched Ethernet connection for each remote field device.

(g) **Management Capability**

TOC network administrators shall be able to manage each MFES individually or as a group/cluster for switch configuration, performance monitoring, and troubleshooting.

The MFES shall support all Layer 2 management features and features related to multicast snooping. These features shall include, but not be limited to:

- An STP healing rate that meets or exceeds specifications published in the IEEE 802.1 D standard.

- An RSTP healing rate that meets or exceeds specifications published in the IEEE 802.1w standard (no greater than 20 millisecond healing rate).
- A port-based VLAN and supports VLAN tagging that meets or exceeds specifications as published in the IEEE 802.1Q standard, and has a minimum 4 kilobit VLAN address table.
- A minimum 8 kilobit MAC address table.
- Internet Group Management Protocol (IGMP) Snooping (v1 & v2) and multicast pruning for limiting traffic to those ports that need to participate in the multicast; provide IGMP snooping on a per VLAN basis. IGMP shall be configurable to either active or passive participation. A minimum of 256 IGMP groups shall be supported.
- Remote accessibility via telecommunications network (Telnet) and HTTP web browser for configuration and monitoring.
- CLI (command line interface) based management.
- Support Simple Network Management Protocol (SNMP) v1 and v2 manageable. SNMP shall have email (i.e. SMTP) capabilities.
- Accessibility using the resident EIA 232, USB or RJ-45 management port.
- Support File Transfer Protocol (FTP) or Trivial File Transfer Protocol (TFTP) for software and configuration parameter uploads from a remote location.
- Port security through controlling access by the users. The capability to generate an alarm and shut down ports when an unauthorized user accesses the network.
- Enable remote monitoring (RMON) of the Ethernet agent including statistics, history, alarms, and events, and the ability to be upgraded to switch monitoring (SMON), if necessary. Each MFES unit's statistics, history, alarms, and events shall also be stored on the unit itself with sufficient storage capacity for a minimum of 24 hrs of records.
- Use network time protocol (NTP) or simple network time protocol (SNTP) to provide an accurate and consistent timestamp to all MFES units. The timestamp shall be configurable to any U.S. time zone. The timestamp shall be automatically updated a minimum of once per hour.
- Support port mirroring for troubleshooting purposes when combined with a network analyzer.

Units shall be immediately serviceable or replaceable when defective or damaged.

809.03—Procedures

The MFES shall be mounted securely inside a field site cabinet, connected to a communication system and shall be fully accessible by field technicians. The MFES shall be resistant to all electromagnetic interference (EMI).

The Contractor shall furnish only MFES units that can be serviced or replaced immediately when defective. Damaged units must be removed and replaced. The Department will return defective units to the manufacturer for warranty repair or replacement.

(a) **Documentation**

Documentation provided shall be accessible via web browser, and capable of being printed. The documentation shall not be web-based and shall be locally accessible. Documentation shall provide all the information on the Field Ethernet Switch necessary to install, configure, verify the proper functioning, troubleshoot, and replace (if required) the MFES. The documentation shall be in English.

(b) **Testing**

All equipment and materials furnished shall be tested and certified by the manufacturer prior to shipment to the delivery site. Documentation shall be provided by the manufacturer to the Contractor, who in turn shall submit it to the Engineer, verifying and certifying compliance with the specifications and demonstrating operational status of the equipment and software. The MFES manufacturer shall use test procedures that demonstrate equipment, software performance, and operation in conformance with the Contract requirements.

The MFES installed under the Contract shall be subjected to field acceptance tests (FATs), Traffic Operations Center Integration (TOCIT) testing, and 30-day system acceptance testing (SAT). The Contractor shall meet the requirements of the Department's test plan. The test plan can be found on the Department's website.

(c) **Training**

Upon completion of the work and at a time approved by the Engineer, the Contractor shall provide training by a qualified instructor to Department personnel in the proper operation and maintenance of the equipment. Department personnel shall receive training comparable to the equipment manufacturer's factory training for each new type of MFES equipment that has not previously been installed within the jurisdictional VDOT Traffic Operations region. The minimum training shall be one 2 hour instruction session for device operation and maintenance.

(d) **Warranty**

The manufacturers of the MFES equipment shall furnish at least a 5 year warranty that is fully transferable from the Contractor to the Department. If the manufacturers' warranties noted below are for a longer period, those longer period warranties shall apply.

The Contractor shall provide a MFES having a manufacturer's warranty on furnished equipment and parts to be free from defects in fabrication, assembly, and materials for at period of least five (5) years from the date of final acceptance by the Engineer of the work to be performed under the Contract according to Section 108.09. The MFES warranty shall also include technical support for product hardware and its software.

The Department will return defective units to the manufacturer for warranty repair or replacement.

(e) **Support Agreement**

Clearly identify, in writing, the designated contact person and alternate contact responsible for equipment support and equipment warranty work. Provide full technical support and materials from the Contractor's vendor for the duration of the warranty period for hardware and software.

The support shall cover maintenance and software and firmware upgrades including any upgrades available to the general public and provide such at no additional cost during the warranty/support period. Coverage shall also include repair or replacement for any defects in materials, equipment, and workmanship for all system components including all labor, tools, equipment, system components, and other materials and incidentals necessary to perform repairs or replacement. The vendor support shall encompass all system components notwithstanding any manufacturer's warranties whether written or implied. Software patches and firmware packages are included in the warranty period.

809.04—Measurement and Payment

Managed field Ethernet switch (Speed) will be measured in units of each and paid for at the contract unit price per each for the speed designated. This price shall include furnishing, installing, integrating, testing, training, cabling, jumper cables, fiber distribution centers, configuration, and manufacturer's warranty required to complete the work. The Contractor will be paid seventy percent (70%) of the unit bid price following successful completion of the Field Acceptance Test. The remaining thirty percent (30%) of the unit bid price will be paid following the successful completion of the 30-day System Acceptance Test.

Distribution SFP module (Speed, Type, Haul) will be measured in units of each and paid for at the contract unit price per each for the speed, type, and haul designated. This price shall include furnishing, installing, integrating, configuring, and testing of optics module, fiber patch cables, and attenuators required to complete the work. The Contractor will be paid seventy percent (70%) of the unit bid price following successful completion of the Field Acceptance Test. The remaining thirty percent (30%) of the unit bid price will be paid following the successful completion of the 30-day System Acceptance Test.

Payment will be made under:

Pay Item	Pay Unit
Managed field Ethernet switch (Speed)	Each
Distribution SFP module (Speed, Type, and Haul)	Each

SECTION 810 - PRIMARY NETWORK SWITCH AND LAYER 3 FIELD AGGREGATION ETHERNET SWITCH

810.01—Description

This work shall consist of furnishing and installing Primary Network Switches (PNSWs) and/or environmentally hardened Layer 3 (L3) Field Aggregation Ethernet Switches for intelligent transportation system projects. The Primary Network Switches and L3 Field Aggregation Ethernet Switches shall provide Ethernet connectivity and shall distribute digitally encoded video, network traffic, and ITS device control data at the communications hub and within the appropriate Traffic Operations Center (TOC) for the Contract. The PNSWs and L3 Field Aggregation Ethernet Switches shall be connected to field devices by way of Managed Field Ethernet Switches (MFES) and shall be connected to L3 Field Aggregation Ethernet Switches and PNSWs, respectively. These connections shall be through Ethernet links over fiber optic cable.

810.02—Equipment

Primary Network Switches and L3 Field Aggregation Ethernet Switches shall be compatible with the existing communication devices and those communication devices provided by the Contractor for the Contract. PNSWs shall be placed in designated centers as shown on the Plans or directed by the Engineer. L3 Field Aggregation Ethernet Switches shall be placed in designated field cabinet locations as shown on the Plans. The Contractor shall provide PNSWs and L3 Field Aggregation Ethernet Switches meeting the following requirements:

(a) **Primary Network Switch Equipment**

1. **Mechanical Specifications**

Each PNSW chassis shall be of a modular design capable of adding modules to allow for future system expansion. Each PNSW shall have no fewer than 4 interface slots and shall meet the following requirements:

- Minimum of twenty-four Small Form-Factor Pluggable (SFP) Gig-E ports and twenty-four 10/100/1000 Base-TX copper Ethernet ports; these ports shall be present on two separate interface slots unless otherwise approved by the Engineer

- Combination of up to 24 short-haul, medium haul, long-haul, and very long-haul SFP-based ports: LC fiber connectors (single-mode) as needed to meet distance requirements for connection with other PNSWs and be compatible with matched Field MFES and Aggregation Switches provided under the Contract. Furnish attenuators, if required, to service link without saturating receiving optics.

- Fiber jumper cables with appropriate connectors for switch and adjacent drop cable connectors

- Minimum of 24x 10/100/1000 Base-TX copper RJ-45 connectors

- Ethernet management port: RJ-45 connectors, 2-pair Cat-5 UTP cabling

- Management console port: RJ-45-to-DB9 cable for PC connections

- Dynamic Host Configuration Protocol (DHCP)

- Autonegotiation on all ports for auto selection of speed and duplexing modes

- Link Aggregation Control Protocol (LACP)

- Automatic media-dependent interface crossover (MDIX)

- Switching fabric of 1,000 Gbps at a minimum; N+1 switch fabric redundancy, or approved equal

- Management module redundancy (1:1, or approved equal)

- Packet routing greater than 500 million packets per second (pps)

- Support 10 GbE and 100GbE interface modules/ports

- At least 1000 VLANs
- At least 4000 VLAN IDs
- 1000 Switched Virtual Interfaces (SVIs)
- Support 1000 IGMP groups and multicast routes
- Support automatic address learning of up to 12,000 MAC addresses

2. **Electrical Specifications**

Each PNSW shall come with redundant (1+1) auto-switching power supplies rated for operation between 100-220 VAC. A fully loaded chassis shall consume no greater than 2,100 watts, including redundant power supplies when functionally configured per this application.

The power cable shall be designed to meet NEC standards for the Primary Network Switch volt-ampere loads.

The PNSW shall contain all power conversion and regulation necessary to support electronics operations in compliance with this specification.

Over and under voltage conditions shall be considered a power failure and the PNSW shall automatically recover from an over or under voltage condition when primary power has returned to values defined herein.

The PNSW shall not require reprogramming or any manual adjustments upon return to primary power. The chassis shall be bonded to the rack in which it is installed.

The PNSW shall be reliable and shall provide circuit redundancy with the ability to mix AC and DC within the same system. The power supplies (i.e., AC-to-DC converters) shall be fault tolerant and shall be hot-swappable.

3. **Environmental Specifications**

The Primary Network Switch shall perform to specification when operated within an ambient temperature range from 5°C to +40°C (41°F to 104°F) with relative humidity from 5% to 80%, non-condensing.

4. **Physical Specifications**

A standard back-plane data and address bus shall be provided. The Primary Network Switch shall be of modular construction with interchangeable electronics modules. The PNSW data and address bus shall facilitate “mix and match” of modules, preventing damage from a module not “plugged into” a specific chassis slot.

The chassis shall be constructed from metal, unless otherwise approved by the Engineer. The PNSW shall not be constructed of dissimilar metals to inhibit cathodic action and corrosion. Materials used shall not support fungal growth. Unit construction shall facilitate EIA “19-inch” equipment rack mounting and shall not exceed a 5U panel height. Depth of the Primary Network Switch shall not exceed 25 inches with connectors. The

PNSW shall be supplied with locking chassis slides. Fully loaded, the PNSW shall not exceed 120 pounds. The chassis shall be provided with handling (carrying/mounting/dismounting) provisions to support safe handling, installation, and removal.

The chassis shall include any required cooling provisions such as fans. Where fans are used, acoustic noise shall not exceed 50 dBa, as measured 9 feet from the chassis, and shall be provided with redundancy (auto-switchover).

All Primary Network Switch connectors including fiber ports and copper ports shall be provided on the front panel of the unit. Power connectors shall be provided on the rear panel. Front connectors shall not interfere with the front installed cable and associated cabinet door closure. Connector placement shall facilitate ease of equipment cable connection. Modular unit replacement shall be from the front panel. Each module shall contain appropriate status indicators to prompt, facilitate, and support maintenance.

The Primary Network Switch shall contain a permanently attached identification plate on the chassis including:

- Product Name
- Product Model Number
- Serial Number
- Manufacturer's Name
- Manufacturer's Address

Each removable module shall, as a minimum, include a permanently attached (e.g., stamped, etched, etc.) part number. Each removable module shall include a permanently attached serial number to assist in maintenance management.

All components identifications shall correctly correspond to schematics, parts lists, and written narratives included in maintenance manuals. The unit shall include a permanently attached plate or markings specifying type and maximum amount of power. Switches, indicators, and jacks shall be uniquely marked. Modules shall include part number. All interconnect cables shall be uniquely marked to identify the cable and the specific jack/connector mates.

All data and drawings supplied with the equipment shall represent the "as delivered/as installed" hardware and cabling. The Primary Network Switch shall include protective covers over connectors during shipment. Modules not installed in the chassis during shipment shall include electrostatic discharge protection as well as protection against physical damage.

Full management capabilities shall be available via a management module and require no additional software or hardware for management. All required management software shall be included in the Primary Network Switch. Fail-over of the primary management module to the second module shall be automatic. The RJ-45 TX ports in the backup module shall fully function while the backup module is in either backup or primary mode.

5. **Networking Standards**

Primary Network Switches shall meet the following Layer 2 and Layer 3 standards:

- IEEE 802.1q VLAN tagging
- IEEE 802.1p bit priority tagging
- Support port mirroring and monitoring
- IEEE 802.1d spanning tree protocol
- IEEE 802.1w rapid spanning tree protocol
- Support 4096 IEEE 802.1q addressable VLANS with 2048 being active
- Support IGMP snooping both passive and active (ability to perform IGMP queries)
- Support RIP version 1 and 2 (RFC 1058 and 1723)
- Support OSPF version 2 (RFC 1583 and 2328)
- Support PIM (SM/DM)
- Support IGMP version 1 and 2 (RFC 1112 and 2236)
- Support DVMRP
- Support VRRP (RFC 2338)
- Support 802.1p mapping to priority queue
- IP Forwarding
- Multicasting

6. **Communication Standards**

Optical Small Form-Factor Pluggable (SFP) modules shall meet the following minimum requirements:

- Fully support the 1 Gbps (1GbE) data transmission needs over single mode fiber operating at nominal wave lengths of 1310 and/or 1550 nm
- 100% compatibility with the network equipment and be a standard product of the manufacturer
- Dual (Tx-Rx) LC fiber connectors with 9 micron cable core diameter
- SFP slot compatible
- Hot swappable

- IEEE 802.3z compliant

Each PNSW shall be provided with optical distribution and backbone SFP modules. Distribution SFPs shall come in the forms of short haul (SH), and medium haul (MH) where specified and shall be compatible with the MFES distribution SFPs. Backbone SFP modules shall come in the forms of short haul (SH), medium haul (MH), long haul (LH), and very long haul (VLH) where specified, and shall be compatible with those provided with other PNSWs and L3 Field Aggregation Switches.

The short haul SFP optical port shall transmit and receive Ethernet data at a distance of 15 to 20 km on 0.3 dB/km signal loss Single Mode (SM) fiber. Short haul ports shall be identical.

The medium haul SFP optical port shall transmit and receive Ethernet data at a distance of 40 to 50 km on 0.3 dB/km signal loss SM fiber. Medium haul ports shall be identical.

The long haul SFP optical port shall transmit and receive Ethernet data at a distance of 70 to 90 km on 0.3 dB/km signal loss SM fiber. Long haul ports shall be identical.

The very long haul SFP optical port shall transmit and receive Ethernet data at a distance of 150 km on 0.3 dB/km signal loss SM fiber. Very long haul ports shall be identical.

7. **Management Capability**

The Contractor shall provide a Primary Network Switch that meets the following maintenance interface requirements:

- The PNSW shall be centrally managed from an interface tool to enable central station (TOC) software control and configuration updates. The Contractor shall provide all control software and licensing for use of the management software.

- Command Line Interface (CLI) shall be industry standard configuration interface.

- Optional Graphical User Interface (GUI) for system configuration from standard web browsers.

- Wire-speed network monitoring and accounting, without network performance impact, for gathering a variety of sophisticated network statistics and information for real-time network monitoring and capacity planning.

- SNMP - All versions.

- Remote monitoring supporting network monitoring and multiple mirror ports for network tracing and troubleshooting.

- Built-in hardware and firmware testing and diagnostic functions. Built-in test shall detect a fault, prevent its propagation throughout the network, and be capable of reporting the failure to the network user/operator. Built-in test shall isolate a failure to a single module or to any two modules.

- Indicators on the front edge of each module to support fault isolation, operational verification, and isolating failed modules. Indicators shall be marked for easy identification. Front panel shall include status indicators.

- User-friendly provisions to support applications software development and maintenance.

- Each Ethernet port programmed to be active shall have periodic tests to validate communications. Built-in test function shall be automatic and run concurrently with normal operation.

- Electronics shall be modular in design. Electronics modules shall be replaceable between Primary Network Switch units. Built-in test features shall be provided with failure reporting via the maintenance communications serial interface. The Primary Network Switch Mean-Time To-Repair (MTTR) at the interchangeable unit level shall not exceed 15 minutes after fault diagnostics by a qualified technician. MTTR of a failed electronic module shall not exceed 60 minutes.

- Modular, fault tolerant design with built-in test and failure reporting which shall include power supplies, switch management and supervisory engines (i.e., at least two shall be provided).

- All interfaces shall comply with open architecture standards.

Units shall be immediately serviceable or replaceable when defective or damaged.

(b) **Layer 3 Field Aggregation Ethernet Switch Equipment**

The Contractor shall furnish equipment that meets the following requirements:

1. **Mechanical Specifications**

- Minimum of twelve SFP Gig-E ports and eight 10/100/1000 Base-TX copper Ethernet ports

- Combination of up to 12 1000BASE-SX, -LX/LH, -ZX SFP-based ports: LC fiber connectors (single-mode) as needed to meet distance requirements at each Aggregation Switch and be compatible with matched Field and Primary Switches provided for the project. Furnish attenuators, if required, to service link without saturating receiving optics.

- Fiber jumper cables with appropriate connectors to connect with switch and adjacent drop cable connectors and/or other switches.

- Ethernet management port: RJ-45 connectors, 2-pair Cat-5 UTP cabling

- Management console port: RJ-45-to-DB9 cable for PC connections

- Minimum of eight 10/100/1000 Base-TX copper RJ-45 connectors

- Dynamic Host Configuration Protocol (DHCP)

- QoS

- Autonegotiation on all ports for auto selection of speed and duplexing modes

- Link Aggregation Control Protocol (LACP)
- Automatic media-dependent interface crossover (MDIX)
- Switching Fabric of 48 Gbps
- 128 MB DRAM or greater
- 16MB FLASH or greater
- 256 VLANs
- 4000 VLAN IDs
- 256 Switched Virtual Interfaces (SVIs)
- 9216 Byte Jumbo Frames or greater
- 35 Mpps Forwarding Rate or greater
- Support 1000 IGMP groups and multicast routes
- Support automatic address learning of up to 12,000 MAC addresses

2. **Electrical Specifications**

- Rated to handle input power of 115 VAC/60Hz (± 10%)
- Power supply shall have two stage isolation accomplished via two transformers step down from primary AC/DC to VDC

3. **Environmental Specifications**

- meet or exceed NEMA TS-2 requirements for temperature, shock, humidity, and vibration for use in traffic signal controller cabinets.
- compliant with ISO 7779 or ISO 7296 for acoustic noise.

4. **Physical Specifications**

Furnish L3 Field Aggregation Ethernet Switches with a Mean Time Between Failures (MTBF) exceeding 80,000 hours.

- Shelf-mounted with optional DIN-rail/rack mounting
- 500 cubic inches maximum
- Per-port status through SNMP or switch software
- System-status LEDs: system and power supplies

5. **Networking Standards**

L3 Field Aggregation Ethernet Switches shall meet the following standards:

- IEEE 802.1s Multiple Spanning Tree Protocol
- IEEE 802.1w Rapid Reconfiguration Spanning Tree Protocol
- IEEE 802.1x
- IEEE 802.3ad
- IEEE 802.3x full duplex on 10BASE-T, 100BASE-TX, and 1000BASE-T ports
- IEEE 802.1D Spanning Tree Protocol
- IEEE 802.1p CoS Prioritization
- IEEE 802.1Q VLAN
- IEEE 802.3 10BASE-T specification
- IEEE 802.3u 100BASE-TX specification
- IEEE 802.3ab 1000BASE-T specification
- IEEE 802.3z 1000BASE-X specification
- RFC 2338 Virtual Router Redundancy Protocol (VRRP)
- OSPFv2 and v3: RFC 2328 for IPv4 and RFC 2740 for IPv6
- L3 features required for compatibility with the L3 Core Switches

6. **Communication Standards**

Optical Small Form-Factor Pluggable (SFP) modules shall meet the following minimum requirements:

- Fully support the 1 Gbps (1GbE) data transmission needs over single mode fiber operating at a nominal wave length of 1310 and/or 1550 nm
- 100% compatibility with the network equipment and be a standard product of the manufacturer
- Dual (Tx-Rx) LC fiber connectors with 9 micron cable core diameter
- SFP slot compatible
- Hot swappable
- IEEE 802.3z compliant

Each L3 Field Aggregation Switch shall be provided with optical distribution and backbone SFP modules as indicated on the Plans. Distribution SFPs shall come in the forms of short haul, and medium haul where noted in the Plans shall be compatible with the MFES distribution SFPs. Backbone SFP modules shall come in the forms of short haul, medium haul, long haul, and very long haul and shall be compatible with those provided with other L3 Field Aggregation Switches and PNSWs.

7. **Management Capability**

L3 Field Aggregation Ethernet Switches shall meet the following requirements for maintenance interface:

- DHCP Snooping
- Dynamic ARP Inspection (DAI)
- Secure Shell (SSH) Protocol, and Simple Network Management Protocol Version 3 (SNMPv3), Network Time Protocol
- Port Mirroring
- TACACS+
- MAC Address Notification
- Port Security
- Bridge protocol data unit (BPDU) protection and filtering
- IGMP snooping
- Dynamic VLAN assignment

8. **Safety Requirements**

FL3 Field Aggregation Ethernet Switches shall meet the following:

- UL 60950 or CSA C22.2 No. 60950
- FCC Part 15 Class A for EMI emissions

Units shall be immediately serviceable or replaceable when defective or damaged.

810.03—Procedures

(a) **PNSW Installation Procedures**

The Contractor shall mount the PNSW in a 19” rack at the Traffic Operations Center and communications hub as specified on the Plans or as directed by the Engineer. The PNSW shall be resistant to all electromagnetic interference (EMI). The PNSW shall be mounted securely in the equipment rack and be fully accessible by maintenance staff.

Furnish and install all mounting brackets and hardware necessary to install the PNSW in existing equipment racks in the hub and at the TOC.

Furnish and install all power supplies, cables, etc. required to properly power on the PNSW at each location.

Furnish and install all communications cabling, such as single mode fiber jumpers, Cat6 cables, etc. that are required for communication from the PNSW to the trunk fiber terminations in the hub and at the TOC and from the PNSW to any video decoders, servers, etc. at the TOC.

The Contractor shall provide and install any software and firmware that is needed in order to provide a fully functional PNSW. Any associated licenses shall be provided to the Department.

(b) **L3 Field Aggregation Ethernet Switch Procedures**

The L3 Field Aggregation Ethernet Switches shall be securely mounted inside a field ITS controller cabinet and be fully accessible by field technicians. The L3 Field Aggregation Ethernet Switch shall be resistant to all electromagnetic interference (EMI).

Furnish and install all mounting brackets and hardware necessary to install the L3 Field Aggregation Ethernet Switch.

Furnish and install all power supplies, cables, etc. that are required to properly power on the L3 Field Aggregation Ethernet Switch at each location.

Furnish and install all communications cabling, such as single mode fiber jumpers, Cat6 cables, etc. that are required for communication from the L3 Field Aggregation Ethernet Switch to the trunk fiber terminations and devices.

The Contractor shall provide and install any software and firmware needed to provide a fully functional L3 Field Aggregation Ethernet Switch. Any associated licenses shall be provided to the Department.

(c) **Documentation**

Documentation provided shall be accessible via web browser, and capable of being printed. The documentation shall not be web-based and shall be locally accessible. Documentation shall provide all the information on the PNSW and/or L3 Field Aggregation Ethernet Switch necessary to install, configure, troubleshoot, replace, and verify the proper functioning of the switch. The documentation shall be in English.

(d) **Testing**

All equipment, materials, and software shall be tested by the manufacturer for conformance with the specifications and to demonstrate operational status of the equipment and software and firmware provided prior to shipment. The manufacturer shall use test procedures that will demonstrate equipment and software performance and operation in conformance with the Contract.

The switches installed under the Contract shall be subjected to Field acceptance testing (FAT), TOC Integration testing (TOCIT), and system acceptance testing (SAT). The Contractor shall meet the requirements of the Department's test plan for Primary Network Switches and

Layer 3 Field Aggregation Ethernet Switches. The test plan can be found on the Department's website.

The switch manufacturer(s) shall provide technical support during additional testing phases conducted by the Department, including: post-installation testing, conditional acceptance testing, system acceptance testing, and 30 day operational testing. Testing support shall be in the form of toll free telephone support and, if issues raised during the toll free telephone support are not resolved within one business day after notice, the manufacturer shall provide on-site technical support to resolve the particular issue(s) or condition(s) preventing successful completion of the specific test(s) conducted.

(e) **Training**

Training shall be performed by the switch manufacturer's qualified personnel endorsed as a trainer and factory support specialist familiar with the equipment and software. Training will be provided for up to 10 people as determined by the Department.

Training shall provide at least the following:

- Internal operating system of the switch/router to include but not limited to:
  - o Configuration commands necessary to configure each interface in the switch/router and the global parameters
  - o Commands to obtain statistics on the operational status of the switch/router
  - o Commands necessary to troubleshoot the hardware
  - o Commands to upgrade IOS of the router/switch
- Hardware training to include but not limited to:
  - o Installation of all hardware
  - o Replacement of all hardware

Department personnel shall receive training comparable to the equipment manufacturer's factory training for each new type of Switch equipment that has not previously been installed within the jurisdictional Traffic Operations region. The minimum training shall be one 4 hour session for instruction of device operation and maintenance.

(f) **Warranty**

The manufacturer's warranty on the installed equipment and associated software and firmware shall be fully transferable from the Contractor to the Department. If the manufacturer's warranty(ies) noted below are for a longer period, those longer period warranties will apply.

The Contractor shall provide switches having a manufacturer's warranty for equipment and parts to be free from defects in fabrication, assembly, and materials for five (5) years from the date of final acceptance by the Engineer of all work performed under the Contract in accordance with Section 108.09.

The Department will return defective units to the manufacturer for repair or replacement under the warranty agreement.

Support Agreement

The manufacturer shall clearly identify, in writing, the designated contact person or persons and alternate(s) responsible for equipment and associated software support under the warranty agreement. Provide full support from the Contractor's vendor (parts and labor) for the duration of the warranty period for hardware and software. The support shall cover maintenance, software and firmware upgrades, any upgrades available to the public shall also be included and provided at no additional charge during the warranty support period. Any defects in materials and workmanship for all system components shall provide repair or replacement, including labor, testing, integration, materials, and incidentals. The vendor support shall encompass all system components notwithstanding any manufacturer's warranties whether written or implied. Software patches and firmware packages shall be included in the warranty period.

810.04—Measurement and Payment

Primary Network Switches will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing, installing, configuring, integrating, testing all equipment and materials, including but not limited to, the PNSW, SFP Gigabit Optical Module slots, operational software package(s) and firmware(s), attenuators (if required), training, all tools, labor, hardware, supplies, support, shop drawings, documentation, and incidentals necessary to complete the work. The Contractor will be paid seventy percent (70%) of the unit bid price following successful completion of the Field Acceptance Test (FAT). The Contractor will be paid the remaining thirty percent (30%) of the unit bid price following the successful completion of the 30-day System Acceptance Test (SAT).

L3 Field Aggregation Ethernet Switches will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing, installing, configuring, integrating, training, testing of all equipment and materials, including but not limited to, the L3 Field Aggregation Ethernet switch, SFP Gigabit Optical Module slots, operational software package(s) and firmware(s), supplies, support, shop drawings, documentation, attenuators, if required, all tools, labor, hardware, and incidentals necessary to complete the work. The Contractor will be paid seventy percent (70%) of the unit bid price following successful completion of the Field Acceptance Test (FAT) for that item. The Contractor will be paid the remaining thirty percent (30%) of the unit bid price following the successful completion of the 30-day System Acceptance Test (SAT).

SFP modules (Type, Speed, Haul) will be measured in units of each and will be paid for at the contract unit price per each for the type, speed and haul specified. This price shall include fiber patch cables, attenuators, configuration, testing, and other labor or materials required to install and integrate the SFP module with Ethernet Switch will be considered incidental and not be paid for separately. The Contractor will be paid seventy percent (70%) of the unit bid price following successful completion of the Field Acceptance Test (FAT). The Contractor will be paid the remaining thirty percent (30%) of the unit bid price following the successful completion of the 30-day System Acceptance Test (SAT).

Mounting brackets and necessary hardware, communications cabling, including but not limited to ,single mode fiber jumpers and Cat6 cables, power supplies and cables, and manufacturers' equipment, software and firmware including upgrades , testing; training; software and licenses, and warranty shall be considered incidental and shall be included in the contract unit price of the equipment.

Payment will be made under:

Pay Item	Pay Unit
Primary Network Switch	Each
L3 Field Aggregation Ethernet Switch	Each
SFP Module (Type, Speed, Haul)	Each

SECTION 811 – ETHERNET TERMINAL SERVER

811.01—Description

This work shall consist of furnishing and installing an environmentally hardened Ethernet Terminal Server for Intelligent Transportation System (ITS) applications. The Terminal Server device, also commonly referred to as a Port Server device, shall communicate bi-directionally between IP-based Ethernet network systems and existing field devices that communicate or are controlled via a full-duplex serial interface.

811.02—Materials

The Contractor shall furnish an Ethernet Terminal Server meeting the following requirements:

(a) **Mechanical Specifications**

The minimum mechanical requirements shall include:

- 10/100 Base-TX Ethernet port connection
- RS-232/485/422 selectable or programmable serial connections
- Baud rates up to 230 Kbps
- All terminal servers shall be mechanically and electrically interchangeable within the existing or proposed network.

(b) **Electrical Specifications**

The minimum electrical/power requirements shall include:

- 120 VAC input power.
- An external power supply unit is acceptable.

(c) **Environmental Specifications**

The minimum environmental requirements shall include:

- Compliance with environmental requirements for NEMA TS-2 Standards

- Provision to operate in a temperature range of -35 degrees F (-35 degrees C) to 165 degrees F (74 degrees C).

- Provision to operate in relative humidity of 5% to 95% (Non-condensing).

(d) **Physical Specifications**

The minimum physical requirements shall include:

- Each Terminal Server shall have the following ports:

  - o Network Ethernet Port: Minimum one (1) 10/100 Mbps RJ-45.

  - o Serial Data Interfaces: Two (2) RJ-45 or DB-9 ports.

- Maximum Dimensions: 8”W x 6”D x 3”H.

- LED status for link and power

- All connectors, indicators, and replaceable components shall be permanently marked and traceable to the supplied documentation, including schematics and parts list. The external markings shall include the product function name, model number, serial number and manufacturer’s name.

- Terminal Servers shall be shelf mountable or DIN-rail mountable. Other mounting options may be submitted for the Engineer’s review and approval prior to ordering

- Adapter cables/connectors shall be provided for compatibility with the serial devices to be integrated.

(e) **Networking Standards**

The minimum networking requirements shall include the following:

- TCP/IP protocol

- SNMP protocol

- HTTP protocol

- Remote TELNET connection

- ARP-Ping for IP address assignment

(f) **Communications Standards**

The minimum communication requirements shall include the following:

- Support a minimum of two (2) bi-directional serial communication channels over an Ethernet 10/100 Base-TX uplink.

- A minimum of two (2) EIA-232/485/422 Serial interface ports. These ports shall be individually and independently configurable, directly by switching or over the network to EIA-232/485/422 mode of operation as defined by the EIA for data format, data rate, and data structure (e.g., the number of bits, parity, stop bits, etc.). Each serial port shall support up to 230 Kbps.

- Each serial port shall support IP addressing, and shall not use proprietary encapsulation methods.

- The capability to establish an IP connection directly from a workstation to any device IP address.

- Each Terminal Server shall have an Ethernet Interface (10/100Base-TX protocol, Full/Half-Duplex, Auto Sense (802.3), RJ-45).

(g) **Management Capability**

The minimum management system requirements shall include:

- Remote Management and Port Configurable

- SNMP compatible

- Local Configuration Port

- Port Configurable via Telnet

Units shall be immediately serviceable or replaceable when defective or damaged.

811.03—Procedures

The Contractor shall furnish and install power supplies, cables, etc., required to power on the Ethernet Terminal Server at each location.

Furnish and install all communications cabling such as serial cables, Cat6 cables, etc., required for communication from the Ethernet Terminal Server to the Managed Field Ethernet Switches (MFESs), Primary Network Switches (PNSs), or L3 Field Aggregation Switches at locations shown in the Plans.

Furnish and install all software and firmware needed to configure and provide a fully functional Ethernet Terminal Server.

Provide documentation that is accessible via web browser, and capable of being printed if necessary. The documentation shall not be web-based and must be locally accessible. Documentation shall provide all the information on the Ethernet Terminal Server necessary to install, configure, troubleshoot, replace, and verify the proper functioning of the Ethernet Terminal Server. The documentation shall be in English.

(a) **Testing and Training**

1. **General**

All equipment and materials to be provided by the Contractor shall be tested by the manufacturer prior to shipment for conformance with these specifications and to demonstrate operational status of the equipment and software provided by the manufacturer. The manufacturer shall use test procedures that demonstrate equipment, software performance, and operation are in conformance with the Contract.

The testing shall include pre-installation and acceptance testing. The manufacturer shall also provide support during additional testing phases conducted by the Department, including: post-installation testing, conditional acceptance testing, system acceptance testing, and 30 day operational testing. The technical support during testing provided by the manufacturer shall be in the form of toll free telephone support and, if an issue or condition that arises during the toll free telephone support is not resolved within one business day of the date of phone contact, the manufacturer shall provide on-site technical support within 48 hours to resolve the issue or condition preventing successful completion of the specific test being conducted.

2. **Field Acceptance Testing**

The Ethernet Terminal Server shall be subjected to Field Scceptance Tests (FATs). The Contractor shall be responsible for developing and submitting a FAT plan to the Engineer for review and approval. The Contractor shall conduct local FATs on installed Ethernet Terminal Servers according to the Engineer approved test plan. The Engineer reserves the right to witness all FATs. The Contractor shall notify the Engineer at least 14 days prior to the start of the FATs, and shall submit the results of the FATs to the Engineer within one week of performing the testing.

At a minimum, the Contractor shall perform the following for the FATs:

- Verify that physical construction has been correctly and successfully completed and is in compliance with server manufacturer's instructions
- Verify proper voltages for all power supplies and related power circuits
- Connect devices to the power sources
- Verify all connections are properly installed, including correct installation of communication and power cables

3. **System Acceptance Testing**

Upon successful completion of the Field Acceptance Tests (FATs), the terminal servers shall undergo a 30-day System Acceptance Tests (SATs) to verify proper operations of the terminal servers and control of associated devices from the appropriate Traffic Operations Center (TOC).

4. **Training**

The Contractor shall arrange for training of Department personnel to be performed by the Ethernet Terminal Server equipment manufacturer's qualified personnel endorsed as a

trainer and factory support specialist who is thoroughly familiar with the equipment and software. Training shall be provided for up to 10 people as determined by the Department.

Department personnel shall receive training comparable to the equipment manufacturer's factory training for each new type of Ethernet Terminal Server equipment not previously installed in the jurisdictional TOC region. The minimum training shall be one 4 hour session for instruction of device operation, troubleshooting, and maintenance.

(b) **Warranty**

The Contractor shall provide an Ethernet Terminal Server having a manufacturer's warranty for equipment and parts furnished to be free from defects in fabrication, assembly, and materials for a period of five (5) years from the date of final acceptance of all work performed under the Contract by the Engineer according to Section 108.09. The warranty period shall begin on the date of final acceptance of the Contract by the Department.

The manufacturer's warranty shall be fully transferable from the Contractor to the Department. If the manufacturer's warranty is for a longer period of time, that longer period warranty shall apply.

The Department will return defective units to the Contractor's vendor or manufacturer for repair or replacement under the warranty agreement. The warranty agreement shall also cover technical support as detailed below.

(c) **Support Agreement**

The Contractor shall clearly identify, in writing, the designated contact person and alternate contact responsible for technical support of the equipment and equipment warranty. The Contractor shall arrange to provide full support from the Contractor's vendor (for parts and labor) for the duration of the warranty period for hardware, software, and firmware. Technical support shall cover maintenance, software upgrades (any upgrades available to the public shall be included and provided at no additional charge during the warranty/support period). Coverage shall also include repair or replacement of any defects equipment, materials, and workmanship for all system components. The vendor support shall encompass all system components notwithstanding any manufacturer's warranties whether written or implied. Software patches and firmware packages are to be included in the warranty period.

811.04—Measurement and Payment

Ethernet Terminal Server will be measured in units of each and will be paid for at the contract price per each. This price shall include furnishing and installing the Ethernet terminal server, configuring, testing, training, providing documentation, software, firmware, and licenses, and technical support necessary to complete and support the work. The price bid shall also include mounting hardware, Cat-6 patch cords, serial port cables or connectors, power cable, power adapters, user manuals, warranty, and any and all other equipment or incidentals required for complete installation and integration of the unit.

Payment will be made under:

Pay Item	Pay Unit
Ethernet Terminal Server	Each

SECTION 812 - ITS CONDUIT

812.01—Description

This work shall consist of furnishing and installing conduit for ITS systems in accordance with these Specifications and as shown on the Plans or as directed by the Engineer.

812.02—Materials

ITS Conduit shall be Polyethylene (PE) or High-density (heavy-wall) Polyethylene (HDPE) conforming to Section 238 and as amended below.

(a) **Conduit**

PE conduits shall be SDR 11 meeting ASTM D 3035. The Contractor shall provide one orange conduit for fiber optic or ITS communications cable installations, where shown in the Plans. Where additional conduits are required along the same path, subsequent conduits shall be color-striped or solid-colored to distinguish each one separately. Colors or conduit stripe colors shall be submitted to the Engineer for review and approval prior to use. The conduit shall include all required fittings and incidentals necessary to construct a complete installation.

(b) **Conduit Transitions**

Only conduit couplings and fittings specifically listed for transition between designated conduit types shall be used.

(c) **Utility RFID Marker Balls and Pegs**

Utility ball markers shall conform to APWA uniform color coding for marking underground utility lines and industry standard frequency for detection. Communications (orange) 101.4 kHz marker balls shall be able to be detected at a depth of 5 feet below grade and shall be between 4 to 4.5 inches in diameter. Peg markers shall be detectable at a depth of 2 feet below grade and 3 to 4 inches in length. Marker balls and pegs shall have a passive antenna circuit and; therefore, not need an internal power source to be functional. Markers and pegs shall be a polyethylene, weather resistant enclosure, or an Engineer approved equivalent. The Contractor shall preprogram markers and pegs, and the Department will verify the contents for detection capability at least 30 days prior to the installation.

812.03—Procedures

(a) **Fiber Conduit Installation Requirements**

The Contractor shall install conduits in continuous unspliced runs between enclosures and junction boxes, unless otherwise approved by the Engineer. The installation of the fiber optic backbone conduit shall be placed in front of the tree line as far from the travel lane as possible (maintaining as straight an alignment as possible) and outside of any ditches or stormwater retention areas. A minimum distance of 10 feet shall be maintained from the edge of pavement unless

otherwise approved by the Engineer. Install conduit a minimum of 30 inches below grade, except where bedrock is encountered in which case an installation depth of at least 18" may be permitted with the Engineer's approval. All conduit installations shall be within the right of way.

The Contractor shall prevent water and debris from entering a conduit riser above ground during construction by sealing the conduit with tape or any other approved temporary protective measure.

The conduit system shall not exceed the fiber optic cable manufacturer's allowable bending radius after installation. Fiber optic cable manufacturer's installation instructions shall be provided to the Engineer upon request.

Fiber shall be installed in the orange conduit and mule tape, or an approved equal, shall be installed in all spare and empty conduits.

HDPE or PE conduit may be installed by trenching, boring, or plowing and/or as indicated on the Plans. Submit a conduit installation plan to the Engineer for approval prior to the start of construction that details where each method of installation is planned for use. Conduits shall be installed by directional boring for any locations where the conduit will cross existing pavement or other existing facilities unless otherwise shown on the plans or approved by the Engineer.

Conduit shall terminate horizontally into pull boxes at a maximum depth of 18 inches. All conduit terminations in pull boxes, junction boxes, cabinets, etc. shall be sealed using a method and materials approved by the Engineer.

(b) **Conduit Transitions**

Transitions between conduit types shall occur in junction boxes unless otherwise approved by the Engineer.

Where transitions are approved outside of a junction box, the Contractor shall install couplings specifically listed by the manufacturers for such purpose for the conduit materials being joined.

(c) **RFID Marker Ball/Peg Installation Requirements**

Locator tape shall be installed 6 to 8 inches below finished grade. The Contractor shall furnish and install non-detectable underground locator tape with the wording "WARNING – Fiber Optic Cable."

RFID markers balls shall be placed in open trench operations below the locator tape, 12 inches below finished grade. RFID marker pegs shall be placed in pilot holes 18" below finished grade and above conduits that are installed by directional boring operations.

The Contractor shall use orange colored RFID markers to designate communication and telephone installations for ITS or fiber conduits.

RFID marker balls shall be placed every 100 feet in instances where minimum utility conflict is involved and where route deviation is minimal.

Standard placement of RFID marker balls is at 25 foot increments for open trench operations. RFID near surface markers are to be installed in pilot holes above the conduits at 20 foot

increments or at every other rod length with directional boring applications. In areas where conduit routing significantly changes and where higher utility conflicts are potentially involved (such as at traffic intersections and interchanges), marker balls shall be placed every 25 feet unless otherwise directed by the Engineer.

RFID marker balls shall be placed at every change in direction of the conduit/cable and with 5 foot offsets to boxes and vaults. RFID near surface marker pegs may be substituted for RFID marker balls when permitted by the Engineer

The Contractor shall install a minimum of two marker balls per each utility trench.

The Contractor shall program the following data on the RFIDs: unique 10-digit serial number, utility owner designation, item description, item details, placement depth below grade, placement date, orientation, elevation, and information about item (for example, a pipe or cable lies below).

The data will be input into a standardized format as shown below:

Label	Description
Company	
Description	
Depth	
Date	
Size	
Cable #	

Similar technology may be used in lieu of marker balls or pegs only when preapproved by the Engineer.

(d) **GPS Mapping**

The Contractor shall use a handheld GPS device to provide a data base of electronic markers and matched GPS coordinates for each RFID marker with sub-foot accuracy. The handheld GPS devices shall have integrated software to facilitate mapping the marker template information in DGN format as an overlay to the MicroStation Plans, and KML using Google Earth/Map as the base mapping, then copied as a PDF or other approved format as required by the Engineer. This electronic as-built information shall be provided to the Department within 10 days of successful completion of the installed ITS utility system. The handheld GPS device mapping shall include all the components as required for documenting a complete as-built installation.

(e) **Testing**

The Contractor shall perform a mandrel test on each conduit to ensure no conduit was damaged during installation. The mandrel test shall be performed after the installation of conduits and after completion of tamping and backfilling the installation. The Contractor shall furnish a non-metallic mandrel having a diameter of approximately 80% of the inside diameter of the conduit through which it is to be pulled. If damage has occurred to the conduit, the

Contractor shall replace the entire length of conduit between the corresponding junction boxes or enclosures. Ensure pull tape, locator tape, and marker balls and pegs are re-installed with the replacement conduit installation.

812.04—Measurement and Payment

Bored ITS Conduit (Size) will be measured in linear feet and will be paid for at the contract unit price per linear foot for the size specified. This price shall include directional bore installation of conduit, providing conduit, fittings, couplings conduit bodies, pull tapes, locator tape, RFID markers and pegs, mule tape, testing, and disposal of surplus and unusable material. This price shall also include electronic as-built information of conduit routes.

ITS Conduit (Size) will be measured in linear feet and will be paid for at the contract unit price per linear foot for the size specified. This price shall include providing and installing conduit, fittings, couplings, pull ropes, pull tapes, locator tape, RFID markers and pegs, testing, and electronic as-built information of conduit routes.

Trench excavation will be paid for separately in accordance with Section 700.05.

Payment will be made under:

Pay Item	Pay Unit
Bored ITS Conduit (Size)	Linear Foot
ITS Conduit (Size)	Linear Foot

INDEX

Abbreviation definitions, 3
Acceptance of work, 124
Acronym definitions, 3
Admixtures used in hydraulic cement concrete, 199
Advertisement, Notice of, 5
Aggregates,
acceptance procedures, 146
certification, 146
base course, 385
base material, 159
coarse, 150
crusher run, 153
fine, 148
handling & storing, 147
lightweight, 154
nonpolishing, 146, 270, 415, 464
penetration surface courses, 39
subbase, 383
Aggregate material, maintenance of traffic, 707
Air pollution, 93
Allaying dust, 687
Alteration of character of work, 32, 130, 134
Alteration of quantities, 31, 129, 134
Aluminum alloy, 234
Anchor bolts
installation procedures, 531, 795-798, 811-814
materials, 230
Anchorage assemblies, intermediate, 671
Anchors, 514
fabrication (Materials and Fabrication), 515
see Bearing devices & anchors
Antennas, 983, 984
Archeological findings, 96
Arches, filled spandrel, 439
Arrows, electronic, 694
Asphalt concrete (SUPERPAVE)
acceptance, 183
adjustment system, 184
aggregates, 171
binders, 167
handling (Handling and Storing Aggregates), 186
inspection plant, 183
job-mix formula, 175
materials, 171
mixture prepartion, 189
mixtures, 180
payment adjustment system, 184
plant requirements (Asphalt Concrete Mixing Plant), 186
production initial, 190
referee system, 185
storage system, 190
tests, testing, 181, 182
Asphalt concrete curbs
construction procedures, 661
materials, 180
Asphalt concrete pavement
base, 402
density requirements, compacting, 406
equipment, 400
finishing, 403
materials, 180, 399
mixtures, 180
pavement samples, 313, 394, 412
pavement tolerances, 412
paving limitations, cold weather, 401
paving technician, 147, 404
placement limitations, 401
placement procedures (Placing and Finishing), 403
plant (Asphalt Concrete Mixing Plant), 186
plant technician, 147
priming, 402
procedures, 402
rumble strips, 411
sidewalks, 668
tolerances, 412
Asphalt materials, 164
cement, 165
coating ability, 164
curb backup material, 400
cutback curing asphalts, 164
emulsions, 165
liquid asphalt materials, 164
non tracking tack, 165
shipping, storing 170
VAAP requirements, 165
pay adjustments, 170
test reports, 167
used in hydraulic cement stabilization, 377
Attenuators, impact, 698
Authority
Engineer, 36
Inspector, 36
Contractor, 37
Contractor's Superintendent, 44

Award cancellation, 26, 29
Award of contract, 26
Backfill
culverts/storm drains, 331
flowable fill, 320
porous, 153, 438
replacing undercut excavation, 352
structures, 352, 437
Baled straw, 347
Bar chair supports, 495
Bar mats, 227
Barricades, 55, 696, 708
responsibility to public (Barricades and warning Signs), 55
Barrier
delineators, 662, 697, 823
service, traffic, 697
silt, 326, 347
sound walls, 734
steel median, 670
traffic barrier service, 697
see also Median barriers
Base course, 385
Basements, demolition, 724
Batcher, certification of, 147
Beads, glass, 247
Bearing areas, bridge seats, 480, 531
Bearing devices & anchors
materials, 251
placement procedures, 531
Bearing pads, 251, 515
Bearing piles, 442
Bearing plates, 514
Bedding material, 254, 330
culverts/pipes, 330
box culverts, 336
drop inlets, manholes, spring boxes, junction boxes, etc., 336
sidewalk, 667
Bidding
bid consideration, 25
bid letting, 24
bidder disqualification, 22
bidder prequalification, 16
bid preparation, 19
combination or conditional proposals, 17
debarred suppliers, 20
design options, 19
eVa. registration, 24
E-Verify, 25
general information, 19
irregular bids, 21
material, 17
proposal content, 17
proposal guaranty, 22
proposal quantities (Interpretation of Quantities in Proposal), 17
public opening (Public Opening of Bids), 24
requirements (Bidding Requirements and Conditions), 16
submission of bid, 24
standard, 17
withdrawal, 24
worksite/proposal examination (Examination of Site of Work and Proposal), 17
Bolts, 230-232
Bond requirements
bid, 22
performance/payment, 27
contract, 27
Borrow, subgrade & shoulders, 370, 373
Box culverts, 326, 335
Breakaway support systems, 795, 804
Brick, 226
Bridge
approach slabs, 415
asphalt overlay removal, 639
asphalt plug joints, 608
concrete surface penetrant sealers, 634
conduit systems, 601
construction over navigable waters, 112
cover depth survey, 478
deck construction, 476
deck grooving, 482
deck overlays (Repairs), 611
deck repair (Widening, Repairing, and Reconstructing Existing Structures), 563
drainage aprons & chutes, 656
elastomer expansion joint sealing system, 601
epoxy overlay, 647
expansion joints, 479
finishing concrete, 480
guardrail attachments, 557
high early/very high early strength concrete, 611
joints, 472, 479, 601
joint sealants, 632
latex concrete, 611
lighting systems, 601
median barriers, 534
NBIS inspection, 646
opening to traffic, 467

repairing existing steel structures, 619
seat bearing areas, 480
silica fume concrete, 611
deck waterproofing membrane systems, 635
widening, 557
Bronze alloy, 235
Buildings
demolition, 724
use by Contractor, 724
Bull nose barrier, 677
Bulletin boards and posting official notices, 84
Burning, 70, 93, 94
Cable
aerial, 804
barricades, 671
color coding, 806
conductor, 804
guardrail, 671
interconnect, 805, 808, 858
lighting conductor, 806
lighting systems, 804
loop detector lead in, 855
materials, 254
signal, 804
splicing, 805
Caissons, 437, 736
Calcium chloride, 261
Cameras, (CCTV), 856, 907-911
Camera poles, 798, 917, 922
Carrier rates, common, 137
Casing pipe, 243, 751
Casting frames & covers, drainage structures, 343
Castings, 229
Catch basin, masonry unit, 226
CCTV (ITS)
analogue, 910
digital, 911
encoder/decoder, 913
equipment, 907
poles, 917
procedures, 921
retrofit, 923
Cement, hydraulic, 198
admixtures, 199
Cement, hydraulic stabilization, 377
types, 199
Cement-stabilized select borrow, 378, 380
Central mix aggregate technician, 147
Certificates, permits, licenses, 74
Certifications
batcher, technician, 147
herbicide/pesticide applicator, 770
SSPC, 538
welder, 446
Channel
diversion, 329
preservation of, 435
Channelizing devices, 695
Check dams, erosion control, 347, 364
Cisterns, 350, 725
Cited specs, material , 71
Claims
certification, 63
compensation, 64, 130, 131, 133-137
content, 62
disposition of, 61
extension of time, 62, 118
Notice of Intent, 61
responsibility for damage, 81
review, 64
submission, 61
time limit to file, 62
Class I backfill material, 331
Cleanup, 60
Clearing & grubbing, 325
area connecting substructure units, 439, 440
Clearing of parcels, 125
Closing wells, 724
Cofferdams, 437
Cold weather paving limitations, 404
Combining pipe of one size, 328, 755
Combustibles, disposal of, 93, 325
Common carrier rates, 137
Communication/decision making, 37
Communications hub (ITS), 890, 896, 898
Compaction, *see* Density
Compensation for altered quantities, 31, 130, 134
Completion date, 118
Completion, failure to on time, 120
Concrete
corrugated metal bridge deck forms, 464, 465
curing box (storage chamber), 215
curing materials, 220
cylinders, 215, 216, 242, 333, 438, 439, 474, 476, 485, 490, 558, 574
encasement, 751
field technician, 147, 209
foundations, 330, 350, 352, 435, 725, 741, 796, 798, 801, 821, 895, 902
prestressed (Tolerances), 492

slope protection, 592
steps, 666
testing, 213
see Asphalt concrete
see Hydraulic cement
Concrete pavement
see Asphalt concrete pavement
see Hydraulic cement concrete pavement
Conductor cables, 804-808, 958
Conduit systems
bridges, 601
traffic control, 808
ITS, 1026
Construction
joints hydraulic cement concrete, 419-421, 472
over/or adjacent navigable waters, 112
safety & health standards, 101
signs, 689, 698
surveying (Construction Stakes, Lines & Grades), 50, 726
Contract
alteration in work, 31
audit, 29
award, 26
bond requirements, 27
cancellation of award, 26, 29
concurrent (Cooperation Among Contractors), 45
contract time (Determination and Extension of Contract Time Limit), 118
default of, 120
documents, 27
eliminated items, 138
execution & approval, 30
extension of contract time, 64, 118
failure to execute, 29
failure to complete on time, 120
failure to furnish bonds/insurance, 29
fixed date, 118
liquidated damages, 120
Notice to Proceed, 34
provisions, 49
quantities, 17
ranking of elements, 49
subcontracting, 43
termination, 122, 123
time limit, 118
unbonded, 30
Contract documents, 27
affidavits & documents, 27
ambiguity in, 18
bonds, contract, 27
definition (see Contract), 7
hierarchy/coordination, 49
insurance, liability, 28
insurance, workers comp, 28-30, 106, 132
progress schedule, 28, 115
Contract Engineer, authority of, 14, 18, 20
Contract intent, 31
Contract requirements, 27
Contractor
character of workers, work methods, & equipment, 42
cooperation among contractors, 45
cooperation of, 44
critical materials, 73
failure to complete on time, 120
gratuities, 42
insurance, 28, 103(RR)
limitation of operations, 115
liquidated damages, 120
Notice to Proceed, 34
progress schedule, 115
prosecution of work, 114
responsibility for utility property & services, 79
responsibility for Work, 124
separate contracts, 105
subcontracting, 43
suspension of work ordered by the Engineer, 119
termination of responsibilities, 125
time limit determination, 118
time limit extension, 118
work responsibility, 124
Contractor companies, payment of, 138
Control centers, lighting systems, 878
Control strips, density, 368
Controllers, traffic signals, 826-828
Convenience & safety, public, 55
Copper alloy, 235
Corps of Engineers permits, 74, 77, 93
Crack repair, 478, 564
Crib walls, 600
Crushed gravel, 150
Crushed hydraulic cement concrete, 150, 153
Culverts
see Box culverts
see Pipe
Curb & gutter, 657
Curb-cut ramps, 662

Curing materials, 223
Cut, *see* Excavation
Damages, liquidated, 120
Damp-proofing/waterproofing materials, 198
Debarred suppliers, 20
Default of contract, 120
Definitions
abbreviations & acronyms, 3
terms, 4
Delineators
materials, 247
installation procedures, 824, 825
Delivery of bid, 24
Demolition
basements, 724
buildings, 724
foundations, 350, 352
pavement, 683
structures, 584
Density
aggregate base course, 386
asphalt concrete pavement, 406
cement-stabilized courses, 377
control strips, 368
embankments, 353
hydraulic embankments, 357
lime-stabilized courses, 374
pipe backfill, 331
shoulders, 372
subbase courses, 383
subgrade, 380
Density control strip construction
constructing, 368
equipment, 368
materials, 368
procedures, 370, 384, 368
Density requirements, aggregate base course, 386
Density requirements, aggregate subbase course, 384
Department furnished
construction signs, 689, 691
materials, 73
Department/railway provisions, 102
Detectors, *see* traffic signals
Determination of bearing piles
capacities, 455
lengths, 446
Detours
during construction, 55, 78, 115
temporary, 55, 691
Direct tension indicators, 231, 508, 509
Directional island curbs, 663
Disinfecting water mains, 755
Dismantling existing structure, 585
Disposal areas, 68
Contractor furnished, 68
material, coal & valuable, 70
material, organic/inorganic, 70
material, surplus, 69
material, unsuitable, 69
rock, excavated, 70
site plan, 68
Disposal of material, bridge painting, 554
Disposal of structure & obstruction, 439
Disqualification of bidder, 22
Documents, contract, 27
Drainage aprons & chutes, bridge, 662
Drainage structures, 326
materials, 327
procedures, 327
Drawings, working (general) 46
Drop inlets, 336
Drop inlet sediment trap, 349
Dry riprap, 586
Dumped riprap, 587, 589
Dust, allaying, 687
Dynamic Message Signs (DMS)
equipment, general, 928
equipment, DMS, 929
retrofit, 951
sign structure , 950
software, 942, 944
testing, 952
Earth berms, 346, 364
Earthwork, 345
construction procedures, 350
erosion & siltation control, 346
hydraulic, 357
materials, 345
shrinkage/swell, 363
slopes, 357
surplus material, 353, 358
tolerances, 359
Easements, 78
Elastomeric expansion dams, 605
Elastomeric pads
bridges, 531
materials, 251
sound barrier walls, 739
Electrical components, 254
Electrical service

bridge lighting systems, 601
roadway traffic controls, 802
temporary signalization, 699, 802
traffic control devices, 802
Electronic arrows, 694
Eliminated items, 138
Embankments, *see* Earthwork
Encasement pipe, 243, 751
End sections
installation procedures, 327
materials, 327
Endwalls, 336
Energy dissipators, 663
Engineer
definition, 9
duties & authority (Authority of Engineer), 36
Entrance gutter, 659, 662
Environmental protection
air pollution, 93
erosion/siltation control, 91
forest fires, 96
noise pollution, 95
stipulations, 90
water pollution, 92
Environmental sensor stations, 971
data collection, 972
remote processor, 974
software, 976
testing, 978
warranty, 978
Epoxy mastic coating, 239
Epoxy-coated reinforcing steel, 228
Epoxy-mortar patching, 564
Epoxy-resin systems, 267
Equal Employment Opportunity, 83
Equipment
aggregate base course, 385
asphalt concrete pavement, 440
character of, 42
constructing density control strips, 407
hydraulic cement concrete pavement, 415
hydraulic cement concrete, 201
mowing, 789
penetration surface courses, 396
rental, 132
retained in signal modifications, 853
seal coat, 392
stabilized open-graded material, 394
traffic signals, 826
warranties, guaranties, 65
Eradication of
exist. pavement markings, 706, 875
pavement markings & markers, 875
Erosion & Siltation control, 91, 346
Department certified person, 92
inspection, 98
items, 346
part of SWPPP, 98
Etherner Terminal server, 1021
equipment, 1021
installation procedures, 1023
testing, 1024
warranty, 1025
eVA, 24
Excavation
borrow, 345, 351
drilled-in caisson, 437
minor structure, 352
overhaul, 358
presplitting, 351
regular, 350
retaining walls, 678
rock, 351
slopes, 359
structure, 435
undercut, 352
within limits of curb/gutter/
combination/median barrier, 657
see also Earthwork
Expansion dams, elastomeric, 605
Explosives use, 80
Extra work, 31, 130
Fabric, geotextile drainage, 348
installation procedures, 346
materials, 288
Falsework
installation procedures, 467, 511
working drawings, 46, 511
Fastening devices, to keep reinforcing bars in position, 495
Federal aid provisions, 78
Fences
construction procedures, 681
materials, 263
Fertilizer
application procedures, 764, 768, 777, 787
materials, 274
Fiber optic cable
material, 922
distribution center, 997
installation, 998
splicing, 995

testing, 1001
warranty, 1001
Fiber Reinforced Polymer Wrap System, 559, 577
Field offices, 716
Fill
procedures, 353
see also Embankment
Filter cloth, *see* **Fabric, geotextile**
Final acceptance, 125
Final payment, 141
Fire hydrants, 757
Fires, forests, 96
Fixed Completion Date, 118
Fixed object attachments (FOA), 672, 675, 676, 697, 712
Flaggers, 54
automated (AFAD), 693
to protect new concrete pavement, 426
measurement & payment, 711
railway, 102
service, 54, 691, 694
Floors
plank, 600
steel grid, 532
Flowable fill, 320
Flumes, paved, 659
Fly ash
used in concrete, 263
used in lime stabilization, 263
Force account work, 131
Forest fires, 96
Forgings, steel, 230
Forms
concrete, 464
corrugated metal bridge deck, 465
prestressed deck panel, 485
removal, 473
Foundations
retaining walls, 678
seals, 440
sound barrier walls, 734
structures, 436
traffic control devices, 796
Frames & covers
installation procedures, 751, 752
materials, 229
Furnishing & erecting precast structures, 333
Furnishing & placing backfill, 435
Furshing right of way, 78
Gabions, 790
Galvanized surfaces, painting, 549
Galvanizing, 246
Geosynthetics
installation procedures, 347
materials, 288
Geotextile bedding, 289
bedding material, 588
drainage fabric, 666, 667
drainage fabric, underdrains, 653
fabric, erosion control, 345
materials, 289
Girders
concrete, 471
steel, 497
Glass beads, for pavement marking, 247
Grades, lines, & stakes, 50, 726
Grading operations, DTMs, 51, 53, 727
Gratuities, 42
Gravel, crushed, 150
Grid floors, steel, 532
Group 1& 2 channelizing devices, 695
Grout/Grouted
hydraulic cement material, 222
riprap, 587
rubble gutters, paved ditches, paved flumes, street connection pavement & bridge drainage aprons/chutes, 659, 661, 669
Grubbing, 325
Guaranty
forfeiture of proposal guaranty, 26
material, 65
plants, 783
proposal, 22
Guardrail, 255, 670
certified installer, 672
delineators, 671, 823
installation procedures, 672, 824
materials, 225, 247, 248
Guardrail & steel median barriers, 670
Gutters, 659
Handling, storing, & shipping materials, 72, 73
epoxy-resin systems, 267
hydraulic cement concrete, 203
steel structures, 505
Handrails, 669
Hauling
overhaul, 358
public roads, 57
rates, 157
route, 57
size/weight limits, 125
Health standards, 101, 102

Herbicides
applicators, 770
materials, 272
High-mast luminaire assemblies, 796
Historic sites, 96
Holidays, 115
Hydraulic cement
mortar & grout, 222
Hydraulic cement concrete
acceptance, 213
admixtures, 199
batcher, 147
consolidation, 468
construction joint bonding, 472
construction joint exposure to tidal waters, 112
curing, 423
equipment, 205
finishing surfaces, 480
forms, 464, 485
handling, 203
latex modified, 204, 611
materials, 201
materials, measurement of, 204
mixing, 217
mixture classification, 208
mixture proportion, 209
placement limitations, 219
placement procedures, 468
pneumatic placement, 471
prestressed, 483
protection, 475
sidewalks, 667
silicone treatment, 476
storing, 203
tremie, 435, 471
widening & repair, 557
Hydraulic cement concrete operations
bridge deck construction, 476
bridge seat bearing areas, 480
expansion & fixed joints, 479
finishing concrete surfaces, 480
materials, 464
procedures, 464
Hydraulic cement concrete pavement
cold weather protection, 424
consolidation, 421
curing, 423
depth, 427
dowels, 421
equipment, 415
finishing, 421
forms, 416
form removal, 424
grade preparation, 417
joints, 419
materials, 415
opening to traffic, 426
placement procedures, 417
reinforcing steel, placement, 417
slipforming, 417
straightedging, 423
test, beam, 419
texturing, 423
tolerances, 427
Hydraulic cement concrete
conformance with, 145
joints, 191
technician, 147
waterproofing, 198
Hydraulic cement stabilization, 377
field laboratory, 378
Hydroseeding, 763, 765
Impact attenuators
temporary, 708
permanent, 698
attenuator service, 698
Incidental concrete items
materials, 656
procedures, 657
Inspection
authority/duties of inspector, 36
by others, 60
for project acceptance, 124, 125
RR right to Contractor's insurance, 108
storage of materials, 141
SWPPP, 98, 99
materials, 146
material technicians, 147
work, 60
Insurance
bodily injury, liability, property damage, 28
failure to furnish, 29
force account cost of, 132
home office overhead (HOOH), 136
railroad, 103
required for contract execution, 30
workers' compensation, 28
Intake boxes, 343
Items, eliminated, 138
ITS conduit
installation procedures, 1026

materials, 1026
RFID ball/pegs, 1027
testing, 1028
Jacked pipe, 328
Jacking & blocking of beams, 569
Joint sealer, preformed elastomeric, 601
Joints
see Asphalt concrete pavement
see Bridges
see Construction joints
see Hydraulic cement concrete pavement
materials, 191
Junction boxes
drainage, 326
electrical, 254
removal of, 853
traffic control devices, 811
Jute twine, 282
Labor & wages, 82
Landscape, protection of, 79
Latex modified concrete, 615
Latex modifier, 204
Laws to be observed, 74
Legal relations
certificates, 74
claims, damage responsibility, 81
contractor work, utility property/service responsibility, 79
Corps of Engineers permits, 74
Environmental stipulations, 90
erosion & siltation control, 91, 96
laws observed, 74
licenses, 74
nationwide federal permits, 74
other, 75
restoration work performed by others, 80
Legal rights
construct method approval (RR), 103
construct on R.O.W., 103
construction, beginning, 112
contractor's insurance, 103
contractor's property damage, 103
insurance policy copies, 112
Insurance, property damage, 103
legal rights, no waiver of, 78
liability, public insurance, 103
no waiver of, 78
patented devices, materials, & processes, 78
protection of property & landscape, 79
public officials' personal liability, 78
railroad insurance, 103
railway-highway provisions, 102
Licenses, 74
Lighting structures (poles), 796
steel for, 221
Lighting systems, 876
bridge, 601
Lights, navigation, 606
Lime
stabilization, 374
types, 262
seeding, 274
use in asphalt concrete, 173
Limestone, 262
Limitation of operations, 114
Lines, grades, & stakes, 50, 726
Liquid asphalt, 164
Liquidated damages, 120
Local material sources, 65
Lumber, structural, 249
Luminaires, 877
arms, 798
poles, 796
Mailboxes, 59
Maintaining traffic, 688
Maintenance during construction, 54
connections, 56
delays, 56
detours, 55
entrances, 57
flagging, 54
grading operations, 59
haul route, 59
patching operations, 57
signs, 55
structure & obstruction removal/disposal, 59
structures, failure to maintain, 59
structures, temp, 57
work suspension, 56
Major contract items, 32
Manhole, masonry units, 226
Manholes
drainage, 336
materials, 226
Manipulation, 374, 378
Managed field ethernet switches, 1002
installation procedures, 1006
ports, 1004, 1005
testing, 1007
warranty, 1007
Markers, pavement, 247, 866
Markings, pavement, 292, 866

glass beads for, 247
materials, 292
procedures, 867
Masonry units, 226
catch basins, 226
manholes, 226
Materials
acceptance, 146
cited specs, 71
control of, 64
critical, 73
delivery, 65
found on project, 70
furnished by Contractor, 67
furnished by Department, 67, 73
handling, 73
local sources, 65
cited specs, 71
patented, 78
payment, on hand, 140
quality requirements, 64
rights & uses, 70
sampling, 71, 145
source of supply, 64
storage, 72
testing, 71, 145
unacceptable, 73
warranties, 62
Measurement (units), 125
cubic yard, 127
lump sum, 127
weight, 126
Measurement
asphalt, 128
borrow, 128
compensation for altered quantities, 31, 32, 133
compensation, 133
concrete, 127
cubic yard, 127
eliminated items, 138
embankment, 128
equipment rental, 132
equipment, 132
excavation, 128
extra & force account work, 130
final payment, 141
insurance, 132
items, excluded, 138, 141
labor, 131
lump sum, 127
materials, 132
materials, inventory, 141
materials, other, 140
measurement & payment, 129
miscellaneous, 133
partial payment, 138
payment for material on hand, 140
payment, 138
plan quantities, 128
quantities measurement, 125
scope of payment, 129
specific items, 127
statements, 133
storage, 141
subcontractor, 139
tax, 132
timber, 128
weight, 126
Median barriers
bridge, 536
concrete, 662
steel, 670
Median strips, 656, 663, 664
Milling, Type A, 611
Mineral filler, 148, 172, 188, 270
Mineralogical findings, 96
Minimum wage, 82
Minor structure excavation
drainage structures, 342
earthwork, 352, 361
gabions, 790
Mobilization, 715
Modifying exist. misc. items, 686
Mortar, 222
pneumatically applied, 583
Mortared riprap, 589
Mowing, 782, 789
Mulch
application procedures, 765, 777, 781, 785
materials, 275, 285
Nationwide federal permit, 75
Navigable waters, 75
construction over or adjacent to, 112
Navigation lights, 606
NBIS inspection, 646
Newspaper boxes, 59
Noise pollution, 95
Notice
of Advertisement, 12, 24
of Intent to File Claim, 61
to Proceed, 34
posting official, 85

Nuclear gage, 331, 355, 369, 371, 384, 386, 401, 718
Obscuring roadway, 684
Obstruction removal/disposal, 59
Office, field, 716
Offsetting existing pipe, 755
Open graded shoulder material, 163
Opening section of project to traffic, 58
Organic
compounds, emissions of, 93
material, 70
Outlet pipe, 654
Overhaul, 358
Overhead sign structures, 796
Overhead, field office (FOOH), 135
Overhead, home office(HOOH), 136
Overlay exist. panels, traffic signs, 821, 823
Overruns, 32
Overseeding, 765, 767
Paint, 235, 294
Painting, 446, 515, 534, 535, 540
of metal, *see* Protective coating of metal
timber structures, 596
Paleontological findings, 96
Parapets, 534, 601
Parcel, clearing, 125
Partial payment, 138
Patching, bridges, 557, 563, 564, 580
Patents devices, materials, & processes, 78, 129
Paved ditches & flumes, 659
Pavement
demolition, 683
patching during construction, 57
planing, 720
see also Asphalt concrete pavement
see also Hydraulic cement concrete pavement
Pavement markers
installation procedures, 689, 705, 706
materials, 247, 248
Pavement markings
eradicating, 706
installation procedures, 703
materials, 292
Pavement message markings, 707
construction, 703
material, 292
Payment
accepted quantities changes, 130
bonds, 27
escrow account, 139
final, 141
materials on hand, 140
partial, 138
retainage, 140
scope, 129
withholding, 139, 140
Pedestrian fences, 682
Penetration surface courses, 396
Performance bond, 27
Permits, 74
Piles
bearing, 442
bearing capacity determination, 455
cast in place, 444
driving, 447, 461
length determination, 446
loading tests, 455
materials, 442
order list, 462
penetration, 453
pile types, 442
points, 447
preboring, 453
procedures, 447
protection, 446
restrike, 458
retaining walls, 678, 680
sheet, 441
splicing, 443
steel piles or pile shells, 445
timber, 449
tip elevation, 448, 449, 452, 462
tolerances, 454
Pilot vehicle, 694
Pipe
combining pipe of one size, 756
elbows, reducers & tees, 327, 341
endwalls, 336, 342
extended pipelines not specified, 342
grate, 327, 343
post installation inspection, 337
structural plate, 330
temp stream, relocation, 343
tunneling, 332
types of, 241
underdrains, 653
Pipe arch, 331
installation procedures, 327
materials, 240
structural plate, 330
Pipe culvert, 327
jacked methods, 328

Pipe installation
drainage, 327
underdrains, 654
water & sewer, 746
Pipe types, 241
Pipe spillouts, 342
Pit materials, 65
Placement limitations
asphalt concrete pavement, 401
hydraulic cement concrete, 417
stabilized open-graded material, 395
Placing latex & silica fume hydraulic cement concrete, 615
Plan quantities, 128
earthwork, 364
Planing
flexible pavement, 721
ridgid pavement, 721
Plans, 46
specifications conformity with, 49
working drawings, 46
Plant inspection, material, 71
Planting
acceptance criteria, 779, 783
care and maintenance of plants, 777
Establishment Period, 779
installation procedures, 774
guarantee, 783
herbicide application, 775-777, 779, 781, 782
payment schedule, 784
personnel qualifications, 770
pruning, 774
procedures, 770
substituted/deleted by Engineer from Contract, 772
unacceptable plant criteria, 778
vegetation control, 781
watering, 780
Plants for roadside development
materials, 272
planting, 769
Pneumatic placement of concrete, 471
Poles, 796-798
Pollution, 92
Posting official notices, 84
Posts
fence, 680
guardrail, 670
sign, 796, 803
Precast
drainage structures, 333
structures, furnishing & erecting, 333
Pre-Construction conference, 35
Preformed elastomeric joint sealer, 601
Prequalification of bidders, 16
Preservatives, wood, 249
Prestressed concrete
concrete controls, 485
materials, 484
piles, 493
plant review, 484
procedures, 485
structural units, 494
Prestressing tendons, 228
Primary network/Layer 3 Aggregation switches
equipment, 1009, 1014
installation procedures, 1017
testing, 1018
warranty, 1019
Prime coat, asphalt, 390
Progress of work, 114
Progress schedule, 115
Property, protection of, 79
Proposal
combination or conditional, 17
content, 17
contractor value engineering, 32
examination of, 17
forfeiture of guaranty, 26
guaranty, 22
quantities interpretation, 17
Prosecution & progress of work, 114
Protection & restoration of property & landscape, 79
Protective coating of metal in structures, 537
certifications, 538
coating galvanized surfaces, 549
environmental protection, 551
existing structures, 546
galvanized surfaces, 549
general surface preparation and application standards, 539
health and safety, worker, 555
materials, 538
new structures, 548
zone coating of existing structure, 547
Protective coverings, soil retention coverings, 786
Pruning, 761, 770, 774
Establishment Period, 779
guarantee, 783
materials, 769
Public

convenience & safety, 55
officials personal liability, 78
use of roads, open/not open, 113
Quantities
alteration, 31
compensation for altered (in scope), 130
measurement of, 125
plan quantities, 128
proposal, 17
Quarry materials, 65
Railing, 534
Railway
contractor's insurance, 103
construction method approval on R.O.W., 103
flagger/watchperson services, 102
highway tests, 112
railroad protective, 104
railway-highway provisions, 102
railroad tests, 112
restoration of property & landscape, 79
starting construction, 112
warning signs, 55
watchperson, 102
Rank of contract documents, 49
Reconstruct
existing structures, 557
manholes, 337, 343
Recycled materials
asphalt pavement, 173
asphalt shingles, 174
crushed glass, 147
fly ash, 263
hydraulic cement concrete, 150
Reflective sheeting, 309
Regular excavation, 350
Reinforced concrete crib walls, 680
Reinforcing steel
installation procedures, 494
materials, 227
Reinstalled pipe, 342
Relocating or modifying exist. misc. items, 686
Removal
asphalt concrete overlay, 611
unacceptable & unauthorized work, 61
portion of an existing structure, 584
Removal & disposal of structures & obstructions, 59
Removing, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating existing items, 686
Repairing existing structures, 557
Restoration
property, 79
Retainage, 140
Retaining walls, concrete, 678
Retroreflectors, 247, 824
Reuse guardrail & terminal, 674, 686
Right of way
construction method approval on railway, 103
furnishing, 78
Right-of-way monuments
installation procedures, 53, 664
materials, 223
Riprap
materials, 153, 587
placement procedures, 588
Road edge delineators, 824
Roadside development
construction, 762, 764, 771, 786, 788
materials, 769
Rolled Erosion Control Products (RECP), 786
Rootmat, 13, 70
Route map, 55
Rubble gutter, grouted, 661
Safety & health standards
during construction, 55
public, 55, 101
Salt, (sodium chloride & calcium chloride), 261
Samples, tests, cited material specs, 71
Sanitary
provisions, 101
Sanitary sewer, 746
facilities, 686, 746
Scales, 126
Scope of payment, 129
Seal coat, 392
Sediment basins, 349
Seed
application procedures, 763
materials, 273
Seeding materials, erosion control, 273, 765
Select material, 155
Selective tree removal, trimming, & cleanup, 761
Septic tanks, 350, 725
Settlement plates
embankments, 356
Sewer brick, masonry units, 226
Sewer facilities, sanitary, 746
testing, 752
Sheet piles
temporary, 441
Sheeting, 309

warranty requirements, 822
reflective, 308, 817
Shop drawings, *see* **Working drawings**
Shotcrete, 569
Shoulder material, open-graded
materials, 163
procedures, 370
Shoulders, 369
Sidewalk, 666
Signal components, 254
Signal poles, traffic control devices, 796
Signalization, temporary, 698, 700
Signals
traffic, 826
traffic equipment, 826
traffic procedures, 852
see Traffic Signals
Signs
erection, 820
fabrication, 817
islands, 663
overlayment, 817
panels, 817
posts, 803
sheeting, protecting, 819
storage & transportation, 819, 820
structures, 803, 820
temporary, 707
traffic, 817
transporting, 820
Silt barriers, 31
Siltation control, 346
Site conditions, differing, 34
Site of work examination, 17
Size & weight limitations, 113
Slag, 150
aggregates, 153, 159
use in hydraulic cement concrete, 200, 201
Slides, removal, 350
Slope drains, 366
Slope protection, 765, 766
Sod
materials, 278
placement procedures, 767
Sodium chloride, 261
Soil retention coverings, 275
Soil stabilization mats, 283
installation procedures, 786
materials, 283, 284
Sound barrier walls, 734
Source of supply, 64
Special provision copied notes, 49
Special provisions, 49
Specialty items, 16, 43
Specifications
coordination with contract documents, 49
contract rank, 49
highway, 112
materials, conformance with, 64, 145
cited specs, 71
railroad, 112
supplemental, 49
Spraying, herbicide, 788
Spring boxes, 326
Stabilization
hydraulic cement, 377
lime, 374
materials, 378
procedures, 378
weather limitations, 378
Stabilized open-graded material
acceptance, 395
equipment, 396
materials, 394
placing limitations, 395
procedures, 396
proportioning, 394
Stakeout, 50-52, 726-730
Stakes, lines, & grades, 50, 726, 729, 730, 731
Standard combination curb & gutter, 659
Standard drawings, 49
Standard retaining walls, 678
Steel
corrosion-resistant, 228
forgings, 229
grid flooring, 233
grid floors, 532
median barriers, 670
piles, 233
reinforcement, 227
reinforcing materials, 227, 494
reinforcing procedures, 494
shafting, 229
structural, 230
Steel structures
bolt holes, 502
bolt tension, 507
erection of, 506
expansion joints, 480
fabrication procedures, 498
falsework, 511
handling, storing, & shipping materials, 505

materials, 230, 498
painting, 542-547
pedestals, 513, 531
shear connectors, 504
straightening & curving, 500
structures, girders, 499-502
welding, 499, 500
working drawings, 498
Steps, 666
Stone, 153
bedding, 150, 153
Storage of materials, 72
Storm drains, 326
Structural plate, 244
Structural steel, 230
working drawings, 498
Structure excavation, 435
Structures, existing
dismantling, 584
reconstructing, 557
removal/disposal, 584
repairing, 557
timber, 596
widening, 557
Stud shear connectors, 231
Stumps, 70, 761
Subbase
acceptance, 384
grading, 159
materials, 159
placement procedures, 383
Subcontracting, 43, 86
Subgrade, 370
Subsurface data, 18
Suppliers, debarred, 20
Supply source/quality material requirements, 64
Surcharge, 356
Surface course, penetration, 396
aggregates, 397
cover material, 397
equipment, 397
liquid asphalt, 164, 397
materials, 397
procedures, 398
weather limitations, 397
Surplus material, disposal of, 60, 68, 69, 358
Surveying, construction, 726
Surveying, state forces, 50
Suspension of work, 119
SWaM, 87
Switches
Layer 3, aggregation, 1014
Managed Field Ethernet, 1002
Primary network, 1009
Tack coat, 387
Technicians certification & classification, 147
Temporary structures, 57
Termination of contract, 121
Termination of Contractor's responsibilities, 125
Terms, definitions, 4
Tests of material (general) 71
Tests, Testing (Systems/Operations)
Field Acceptance Test (FAT), 924, 952, 956, 970, 990, 1001, 1018, 1024
System Operations Test (SAT), 924, 952, 956, 970, 990, 1018, 1024
Traffic Operations Center Intergration Test (TOCIT), 924, 952, 956, 970, 990, 1018, 1024
local intersection , 860
traffic signal equipment, 858-860
Testing, (Specific material)
adhesive joint sealant systems, 603
anchor bolts, 814
anodes, 567
bearings, 527
conduit, 809
FRP systems, 578
grounding electrodes, 799, 800
piles, loading, 455, 458
silicone joint sealants, 633
structure coatings, 545
welds, 505, 619
Timber
disposition, 325
merchantable, 70
preservatives, 266
structures, 596
Time limit, contract, 118
Topsoil
application procedures, 762
materials, 272
stockpile, 351
Traffic barrier service
guardrail terminal, 697
Traffic control devices
construction of, 795, 799
delineators, 823
materials, 795
pavement markings & markers, 866
signs, 817
temporary, 703

working drawings, 798
see also Traffic signals
Traffic opening, project sections, 58
Traffic signals
controllers & cabinets, 826
detectors, magnetic, inductive loop, 840
flashers, 839
signal heads, 839
testing & demonstration, 858-860
Traffic, maintaining, 688
materials, 688
procedures, 55, 689
Traffic signs
materials, 817
erection, 820
fabrication, 817
transporting & storing, 819
warranty, 822
Trainees on construction projects, 732
Transplanting, 777
Tree
cleanup, 761
herbicide, 769, 770
planting, transplanting, 769
removal, 761
replacement, 777
selective cutting/disposal, 761
trimming/ pruning, 761, 774
walls/wells, 789
Truck mounted attenuators, 708
Unacceptable & unauthorized work, 61
Unacceptable materials, 73
Undercut excavation, 352
Underdrains
installation procedures, 653
materials, 653
post construction inspection, 654
Outlet pipe, 654
Underruns, 32
Unions, 86
Unsuitable material, 352
material, removal of, 68, 69, 352
Uninterruptible Power Supply (Traffic Engineering), 846
batteries, 849
cabinet, 849
warranty, 852
Uninterruptible Power Supply (ITS)
batteries, 905
equipment, 903
testing, 906
warranty, 906
Utilities
adjustment, 18, 44, 746
Contractor's responsibility, 79
cooperation regarding, 44
Value engineering proposals, Contractor (VECP), 32
Vehicle Detection System (ITS)
detector, 959
performance, 963
testing, 970
warranty, 970
Video Detectors (Traffic Engineering)
loop detectors, 855
pedestrian detectors, 857
video cameras, 856
wireless, 857
Virginia Asphalt Acceptance Program, 165
compliance requirements, 165
binder testing, 167
cutback testing, 168
emulsified asphalts testing, 168
non-tracking tack, 169
non-compliance pay adjustment, 170
Virginia Test Methods, 145
VOC emission areas, 93
Wages, 43, 82, 85
Walls
retaining, 678
sound barrier, 734
tree, 788
Warning lights, 694
Warning signs, responsibility to public, 55, 691
Warranties
general, 65
CCTV, 924
Dynamic Message Signs, 957
environmental sensor stations, 979
fiber optic cable (ITS), 1001
ITS components, 898
L3 Aggregation switches, 1019
managed field ethernet switches, 1007
pavement markings, 294, 870
primary network switches, 1019
traffic control devices, 312, 822
Uninterruptible Power Supply (UPS), 852, 906
video detection system, 842, 970
Watchperson, railway, 102
Water
cement use, 200
gate, 682

lime use, 200
pollution, 92
supply, protection of, 748
Water & sanitary sewer facilities
disinfecting water mains, 755
materials, 746
placement, 748
procedures, 747
testing, 752
Watering, 779, 780, 785, 787
Waterproofing, 594, 635
installation procedures, 463, 480, 483
materials, 198, 636
procedures, 594
Water stops, 463, 483
Weather limitations
penetration surface courses, 397
prime coat, 391
seal coat, 392
stabilized open-graded material, 395
stone matrix asphalt, 429
tack coat, 388
Weed killer (herbicides)
applicators, 770
materials, 272
spraying procedures, 779, 781, 785
Weight & size limitations, 113
Welded wire fabric, 227
Welder certification, 498
Welds
reinforcing steel, 497
structural steel, 499
Wells, 724
Widen, repair, & reconstruct existing structures, 557
Wire mesh, 227
Wireless transceivers, 980
antennas, 983
broadband radio, 987
ethernet radio, 982
leased services, 981
modem, 980
Work
alteration of character, 32, 134
authority to begin, 35
conditions for, 121
default of contract, 120
examination of site, 17
extra, 130
failure to complete on time, 120
fixed completion date, 118
force account, 130
gratuities, 42
inspection of, 60
limitation of operations, 114
liquidated damages, 120
materials, critical, 73
methods, character of, 42
Notice to Proceed, 34
progress schedule, 115
prosecution of, 114
removal of unacceptable & unauthorized, 61, 81
responsibility, Contractor's, 124
subcontracting, 43
suspension, 56
suspension ordered by Engineer, 119
termination of contract, 121
termination of Contractor's responsibilities, 125
time limit, extension of contract, 118
Work, control of
claims submission/disposition, 61
construction surveying, 726
construction, 34
D.T.M., 51, 727
final acceptance, 125
partial acceptance, 124
R.O.W. monumenting, 53, 664, 731
Work, scope of, 31
character of, 32
cleanup, 60
contract intent, 31
Workers' compensation insurance
certificate, 27
Working drawings
falsework, 467, 511
general, 46
steel structures, 48, 498
traffic control devices, 48, 798
Work zone
alternate plans (Contractor), 699
alternate timing(Contractor), 700
M.O.T., 54-57, 689
temporary signals, 702
temporary signs, 691
traffic signals, 701, 702