CHAPTER 8

ROLLER PATTERNS, CONTROL STRIPS AND TEST SECTIONS

INTRODUCTION

In order to determine if maximum density in the field has been achieved, we must first establish a target density. The actual density tests are taken in the field and compared to that ideal or target density to determine whether the tests pass or fail. The following flow chart demonstrates the appropriate methods used to establish the targets and then the corresponding testing methods used to determine density in place for both soil and aggregate.

This chapter will discuss the establishment of a target density for aggregates by means of a roller pattern and control strip using the nuclear gauge method of testing.

Establishing Target Density

Soil

Proctor
Speedy
+4 correction if needed

Aggregate

Roller Pattern
Control Strip
Direct Transmission
(with+4 correction)

Density Testing

Soil

Direct Transmission with Nuclear Gauge
Or
Sandcone

Aggregate

Backscatter Test with Nuclear Gauge
Or
Sandcone

TESTING PROCEDURES FOR AGGREGATE BASE, SUBBASE, AND SELECT MATERIALS

(Roller Pattern, Control Strip, Direct Transmission, and Acceptance Testing)

Before any acceptance testing can be performed on aggregate base, subbase, or select material, a roller pattern, control strip, and direct transmission test must be established. A roller pattern/control strip is a section of roadway on which the construction technique (placing, compacting, and shaping) of the material to be tested has been closely monitored and evaluated. A direct transmission test (VTM-10 Appendix D) is taken at the end of the control strip to compare its results to the Theoretical Maximum Density as established in accordance with VTM-1.

There are three requirements that must be met by the roller pattern/control strip/ direct transmission test:

1) Roller Pattern--the establishment of a graphical comparison between roller passes and the density achieved; this gives the number of passes needed on the material to achieve the required density.

2) Control Strip--the determination of the average dry density of the control strip, which has been rolled according to the pattern established by the roller pattern; this provides the Control Values, which govern the acceptance of the Test Sections.

3) Direct Transmission Test--the comparison of the results of a direct transmission test to the Theoretical Maximum Density in accordance with VTM-1; this verifies that the Control Strip attained the maximum density achievable and therefore may be used to govern the Acceptance Test Sections.

Before the construction of a control strip, the Inspector and Contractor should be familiar with VDOT Specification Section 304. A copy of this Specification is located in Appendix G. If assistance is needed in setting up the roller pattern and control strip, contact the District Materials' Engineers office.

Initial Requirements:

a) A roller pattern must be established for each control strip. Before establishing these tests, communication with the contractor is fundamental to achieving accurate test results.

b) The results of the roller pattern are recorded on Form TL-53, the control strip on Form TL-54, the direct transmission on Form TL-124 and the test section on Form TL-55.

c) All equipment should remain off the control strip until the material has been placed on the entire area.

d) After the material has been placed, the roller and water truck are the only two pieces of equipment allowed on the control strip until maximum density has been obtained.

I. ROLLER PATTERN CONSTRUCTION

Equipment needed:
Portable Nuclear Moisture-Density Gauge
6 foot charger cord
Reference Standard Block
Leveling Plate/Drill Rod Guide
Drill Rod with Extraction Tool
Hammer
Compaction Equipment (that is typical for the rest of the project)

Material that is typical for the rest of that set of Test Sections. (A change in material requires a new roller pattern.)

For base, subbase and select material, the Backscatter method can be used.

Procedure:

Note: A set of forms at the end of this chapter follows this procedure step by step through the readings and calculations.

1) Establish an area at least 10 feet from any structure and 33 feet from any other radioactive sources to take the Standard Counts. The area should be firm, such as a concrete or asphalt slab, or well compacted soil with a minimum density of 100 lb/ft^3. Allow the 3440 gauge to complete 4 minute count cycle with the gauge on the standard block. Be sure the Standard counts you get have a "P" next to each of them indicating they pass. These readings should be recorded on the top of the TL-53, TL-54, TL-55 and TL-124.

TL-53 **VIRGINIA DEPARTMENT OF TRANSPORTATION**
MATERIALS DIVISION
REPORT OF NUCLEAR ROLLER PATTERN

English **Metric**
Report No. 1-21A Nuclear Gauge Model No. 3440 Serial No. 23456
Date 6-22-99 Route No. 0066 Project No. 0066-029-F19,C501
FHWA No. IM-NH-66-1 County Fairfax
Section No. ____ Station 600+00 ft. (m.) to Station 600+75 ft. (m.)
Type Material Aggr.Base Type I 21A Width 12 ft. (m.)
Optimum Moisture 5.2 Optimum Moisture Range 3.2 - 7.2
Remarks:
Roller pattern #1 (V is for Vibratory and S is for Static)

STANDARD COUNTS

DENSITY 2830 **MOISTURE 701**

Top of the TL-53 showing the standard counts.

2) Select a level and uniform section of roadway that is large enough for the roller pattern (about 75 feet long for the typical application width (an area of at least 100 yd^2). Place the material on this section of roadway at the proper loose depth before any rolling is started. For shoulder material, the Roller Pattern should be sufficient length, so as to have an area of at least 100 square yards. The material must be compacted uniformly from bottom to top and in the same manner as the remainder of the job.

   The moisture content of aggregates should be kept as near optimum as possible throughout the rolling operation. Water must be added when needed to maintain optimum moisture in accordance with Section 308 and 309 of the Road and Bridge Specifications during the compaction process. Section 309.05 states after mixing and shaping each layer shall be compacted at optimum moisture within ±2 percentage points of optimum.

3) Make passes with the roller over the entire surface of the roller pattern. One pass is counted each time the roller crosses the test site. Make sure the previous pass has been completed over the entire surface before the next pass is started. When testing aggregates, take a nuclear test for density and one for moisture in the 15-second mode, using the Backscatter Method. This test should be made at three randomly selected points with good surface conditions. Try to spread the 3 tests over most of the 75 foot section, making sure not to test any closer than 18" to an unsupported edge. Be sure to mark the exact location of each test. If paint is used to mark the test locations, be careful not to paint the gauge (use a template). Record the dry density and percent moisture on TL-53 and obtain the total and average for both moisture and density. Plot the average dry density versus the number of roller passes on the graph. All further tests for the roller pattern must be made in the same 3 locations, with the gauge source rod pointing in the same direction as the first test.

TEST NO.	DRY DENSITY	MOISTURE CONTENT	TEST NO.	DRY DENSITY	MOISTURE CONTENT
Test No. 1 No. of Passes 2V					
Sta. 600+00	137.2	4.4			
Sta. 600+40	131.8	5.3			
Sta. 600+75	123.9	4.4			
Total	392.9	14.1	Total		
Average	130.9	4.7	Average		
Tes No. of			Test No. 7 No. of Passes		
Sta.			ta.		
Sta.			ta.		
Sta.			ta.		
Total			Total		
Average			Average		

Moisture Content from Gauge

Step 1: 4.4 + 5.3 + 4.4 = 14.1

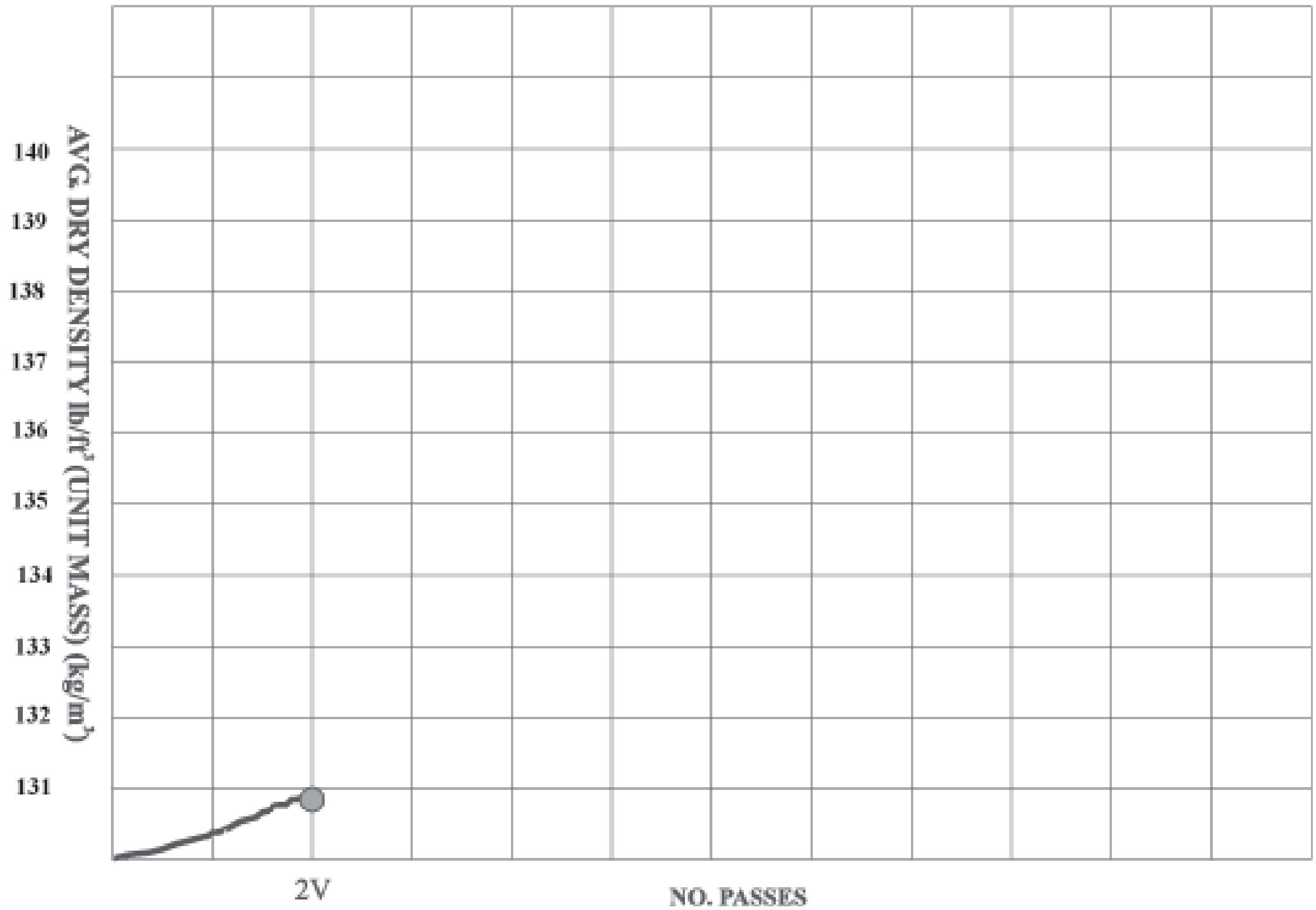
Step 2: $\frac{14.1}{3} = 4.7$

Dry Density from Gauge

Step 1: 137.2 + 131.8 + 123.9 = 392.9

Step 2: $\frac{392.9}{3} = 130.9$

Plot the results on the graph on the back of the Roller Pattern form (TL-53).



Make 2 more passes with the roller over the entire surface of the Roller Pattern, and again take 3 density and moisture readings in the exact same location as the first test. Record these readings under Test No. 2 and plot this second result in the same manner as for Test No. 1.

4) Continue rolling and testing until the roller pattern reaches its maximum density before decreasing or until the graph levels off. To be sure this is a sufficient degree of compaction, make one additional roll over the entire surface and test again.

Note: When the increase in dry density for a Roller Pattern on granular base is less than 1 lb/ft^3 to the maximum dry density, make one additional pass. If the density does not increase by 1 lb/ft^3 with the additional pass, the rolling should be discontinued.

There may be instances where a decrease in density rather than a small increase will occur. This usually is due to a false break where the density levels off well before maximum density is achieved. If this happens, examine the material and if no fracture of the material is visible, continue the rolling process until the maximum density can be obtained. Over-rolling can also cause a decrease in density. Consideration should be given to the number of passes already made and the materials involved, making certain that the break occurring in the Roller Pattern curve is not greater than 1.5 lb/ft^3. If the break is greater than 1.5 lb/ft^3, re-compact the material to its maximum dry density based on the peak of the roller pattern.

TL-53 **VIRGINIA DEPARTMENT OF TRANSPORTATION**

MATERIALS DIVISION

REPORT OF NUCLEAR ROLLER PATTERN

English **Metric**

Report No. 1-21A-1 **Nuclear Gauge Model No.** 3440 **Serial No.** 23456

Date 6-22-99 **Route No.** 0066 **Project No.** 0066-029-F19,C501

FHWA No. IM-NH-66-1 **County** Fairfax

Section No. ______ **Station** 600+00 **ft. (m.) to Station** 600+75 **ft. (m.)**

Type Material Aggr.Base Type I 21A **Width** 12 **ft. (m.)**

Optimum Moisture 5.2 **Optimum Moisture Range** 3.2 - 7.2

Remarks: Roller Pattern #1 (V is for Vibratory and S is for Static)

STANDARD COUNTS

DENSITY 2830 **MOISTURE** 701

TEST NO.	DRY DENSITY	MOISTURE CONTENT	TEST NO.	DRY DENSITY	MOISTURE CONTENT
Test No. 1 No. of Passes 2V			Test No. 6 No. of Passes		
Sta. 600+00	137.2	4.4	Sta.		
Sta. 600+40	131.8	5.3	Sta.		
Sta. 600+75	123.9	4.4	Sta.		
Total	392.9	14.1	Total		
Average	130.9	4.7			
Test No. 2 No. of Passes 4V					
Sta. 600+00	137.4	4.8			
Sta. 600+40	132.4	6.2			
Sta. 600+75	128.9	4.9			
Total	398.7	15.9			
Average	132.9	5.3			
Test No. 3 No. of Passes					
Sta.					
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		
Test No. 4 No. of Passes			Test No. 9 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		
Test No. 5 No. of Passes			Test No. 10 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		

Moisture Content from Gauge

Step 1: 4.8
6.2
+ 4.9
15.9

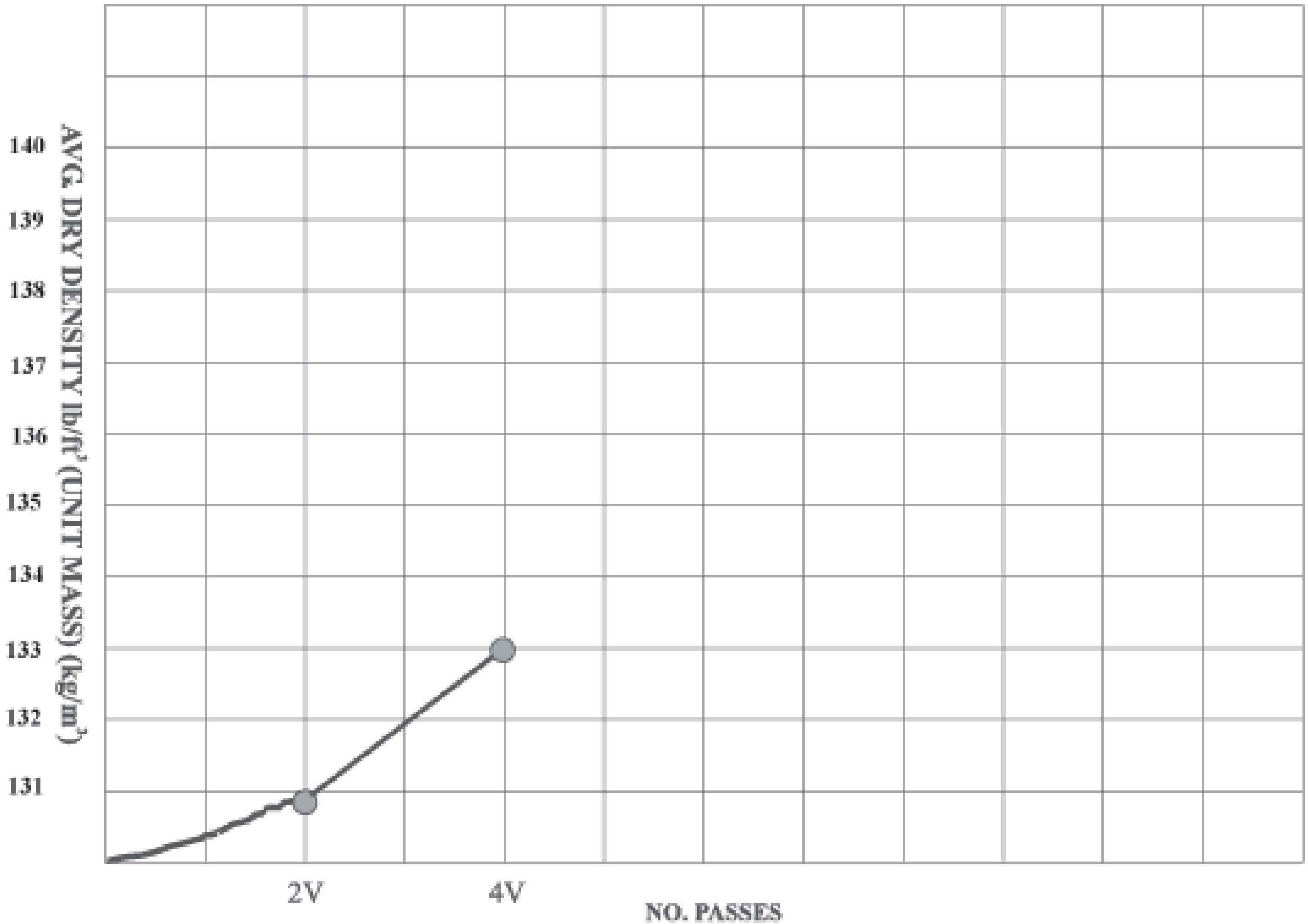
Step 2: $\frac{15.9}{3} = 5.3$

Dry Density from Gauge

Step 1: 137.4
132.4
+ 128.9
398.7

Step 2: $\frac{398.7}{3} = 132.9$

ROLLER PATTERN CURVE



Comments:

By ___________________________________

Title ___________________________________

CC: District Materials Engineer
Project File

TL-53

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR ROLLER PATTERN

English **Metric**

Report No. 1-21A-1 **Nuclear Gauge Model No.** 3440 **Serial No.** 23456

Date 6-22-99 **Route No.** 0066 **Project No.** 0066-029-F19,C501

FHWA No. IM-NH-66-1 **County** Fairfax

Section No. ______ **Station** 600+00 **ft. (m.) to Station** 600+75 **ft. (m.)**

Type Material Aggr.Base Type I 21A **Width** 12 **ft. (m.)**

Optimum Moisture 5.2 **Optimum Moisture Range** 3.2 - 7.2

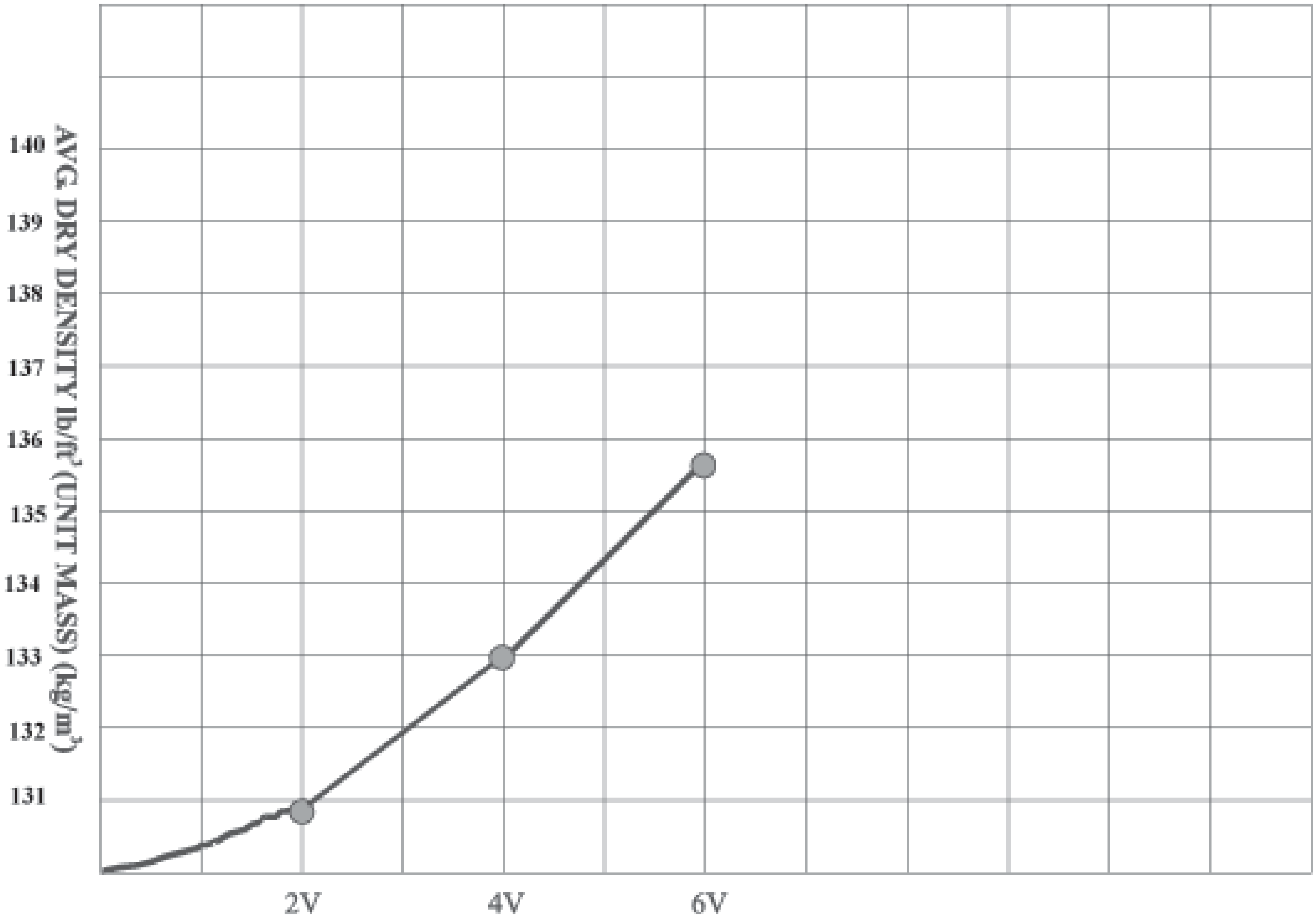
Remarks: Roller Pattern #1 (V is for Vibratory and S is for Static)

STANDARD COUNTS

DENSITY 2830 **MOISTURE** 701

TEST NO.	DRY DENSITY	MOISTURE CONTENT	TEST NO.	DRY DENSITY	MOISTURE CONTENT
Test No. 1 No. of Passes 2V			Test No. 6 No. of Passes		
Sta. 600+00	137.2	4.4	Sta.		
Sta. 600+40	131.8	5.3	Sta.		
Sta. 600+75	123.9	4.4	Sta.		
Total	392.9	14.1	Total		
Average	130.9	4.7	Average		
Test No. 2 No. of Passes 4V			Test No. 7 No. of Passes		
Sta. 600+00	137.4	4.8	Sta.		
Sta. 600+40	132.4	6.2	Sta.		
Sta. 600+75	128.9	4.9	Sta.		
Total	398.7	15.9	Total		
Average	132.9	5.3	Average		
Test No. 3 No. of Passes 6V			Test No. 8 No. of Passes		
Sta. 600+00	137.8	4.2	Sta.		
Sta. 600+40	134.2	5.8	Sta.		
Sta. 600+75	134.5	5.3	Sta.		
Total	406.5	15.3	Total		
Average	135.5	5.1	Average		
Test No. 4 No. of Passes			Test No. 9 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		
Test No. 5 No. of Passes			Test No. 10 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		

ROLLER PATTERN CURVE



Comments:

By ________________________________

Title ________________________________

CC: District Materials Engineer
Project File

TL-53 **VIRGINIA DEPARTMENT OF TRANSPORTATION**

MATERIALS DIVISION

REPORT OF NUCLEAR ROLLER PATTERN

English **Metric**

Report No. 1-21A-1 **Nuclear Gauge Model No.** 3440 **Serial No.** 23456

Date 6-22-99 **Route No.** 0066 **Project No.** 0066-029-F19,C501

FHWA No. IM-NH-66-1 **County** Fairfax

Section No. ______ **Station** 600+00 **ft. (m.) to Station** 600+75 **ft. (m.)**

Type Material Aggr.Base Type I 21A **Width** 12 **ft. (m.)**

Optimum Moisture 5.2 **Optimum Moisture Range** 3.2 - 7.2

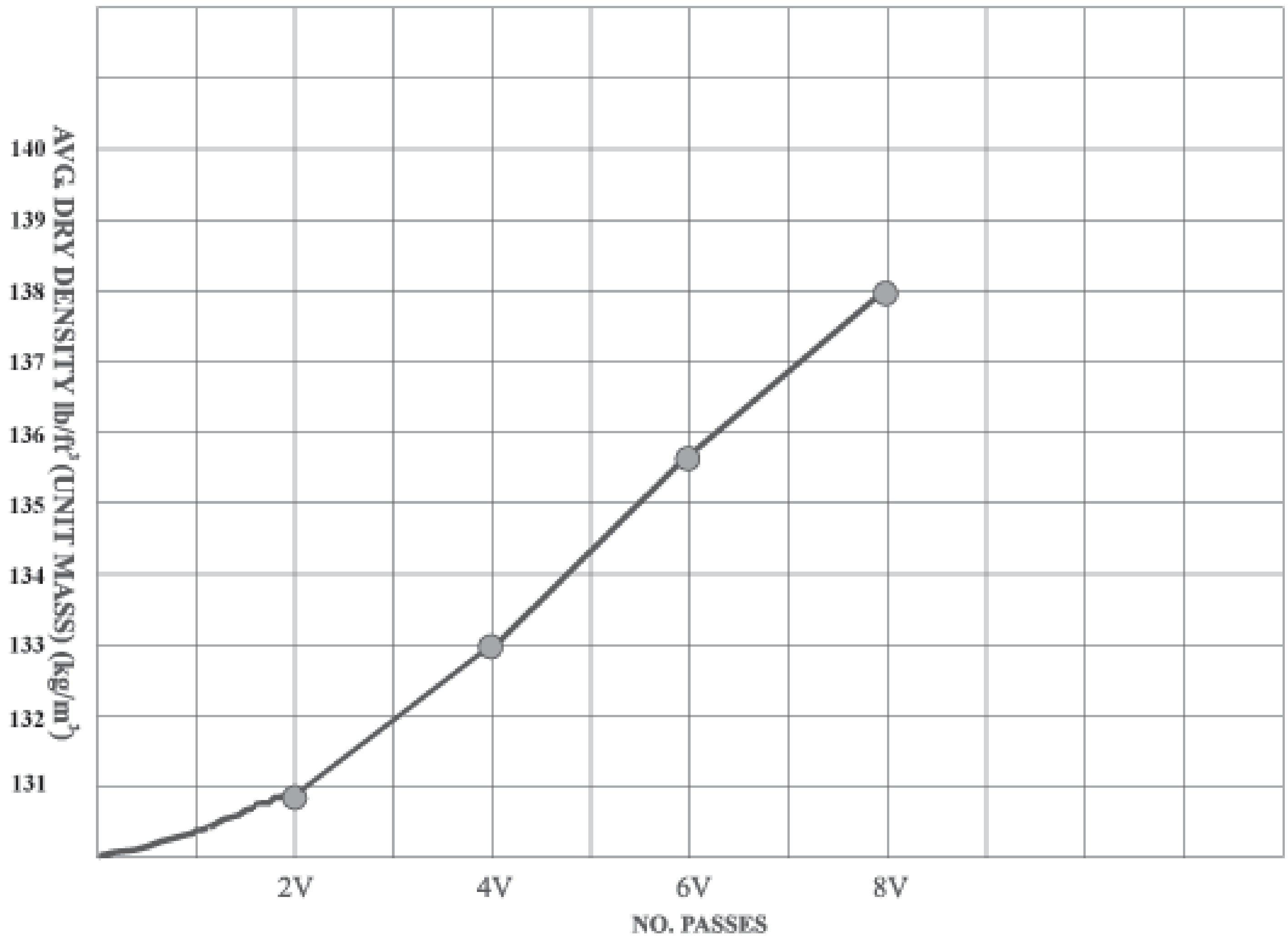
Remarks: Roller Pattern #1 (V is for Vibratory and S is for Static)

STANDARD COUNTS

DENSITY 2830 **MOISTURE** 701

TEST NO.	DRY DENSITY	MOISTURE CONTENT	TEST NO.	DRY DENSITY	MOISTURE CONTENT
Test No. 1 No. of Passes 2V			Test No. 6 No. of Passes		
Sta. 600+00	137.2	4.4	Sta.		
Sta. 600+40	131.8	5.3	Sta.		
Sta. 600+75	123.9	4.4	Sta.		
Total	392.9	14.1	Total		
Average	130.9	4.7	Average		
Test No. 2 No. of Passes 4V			Test No. 7 No. of Passes		
Sta. 600+00	137.4	4.8	Sta.		
Sta. 600+40	132.4	6.2	Sta.		
Sta. 600+75	128.9	4.9	Sta.		
Total	398.7	15.9	Total		
Average	132.9	5.3	Average		
Test No. 3 No. of Passes 6V			Test No. 8 No. of Passes		
Sta. 600+00	137.8	4.2	Sta.		
Sta. 600+40	134.2	5.8	Sta.		
Sta. 600+75	134.5	5.3	Sta.		
Total	406.5	15.3	Total		
Average	135.5	5.1	Average		
Test No. 4 No. of Passes 8V			Test No. 9 No. of Passes		
Sta. 600+00	138.6	4.6	Sta.		
Sta. 600+40	137.2	5.2	Sta.		
Sta. 600+75	138.3	4.6	Sta.		
Total	414.1	14.4	Total		
Average	138.0	4.8	Average		
Test No. 5 No. of Passes			Test No. 10 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		

ROLLER PATTERN CURVE



Comments:

By ___________________________________

Title ___________________________________

CC: District Materials Engineer
Project File

TL-53 **VIRGINIA DEPARTMENT OF TRANSPORTATION**

MATERIALS DIVISION

REPORT OF NUCLEAR ROLLER PATTERN

English **Metric**

Report No. 1-21A-1 **Nuclear Gauge Model No.** 440 **Serial No.** 23456

Date 6-22-99 **Route No.** 0066 **Project No.** 0066-029-F19,C501

FHWA No. M-NH-66-1 **County** Fairfax

Section No. ______ **Station** 600+00 **ft. (m.) to Station** 600+75 **ft. (m.)**

Type Material Aggr.Base Type I 21A **Width** 12 **ft. (m.)**

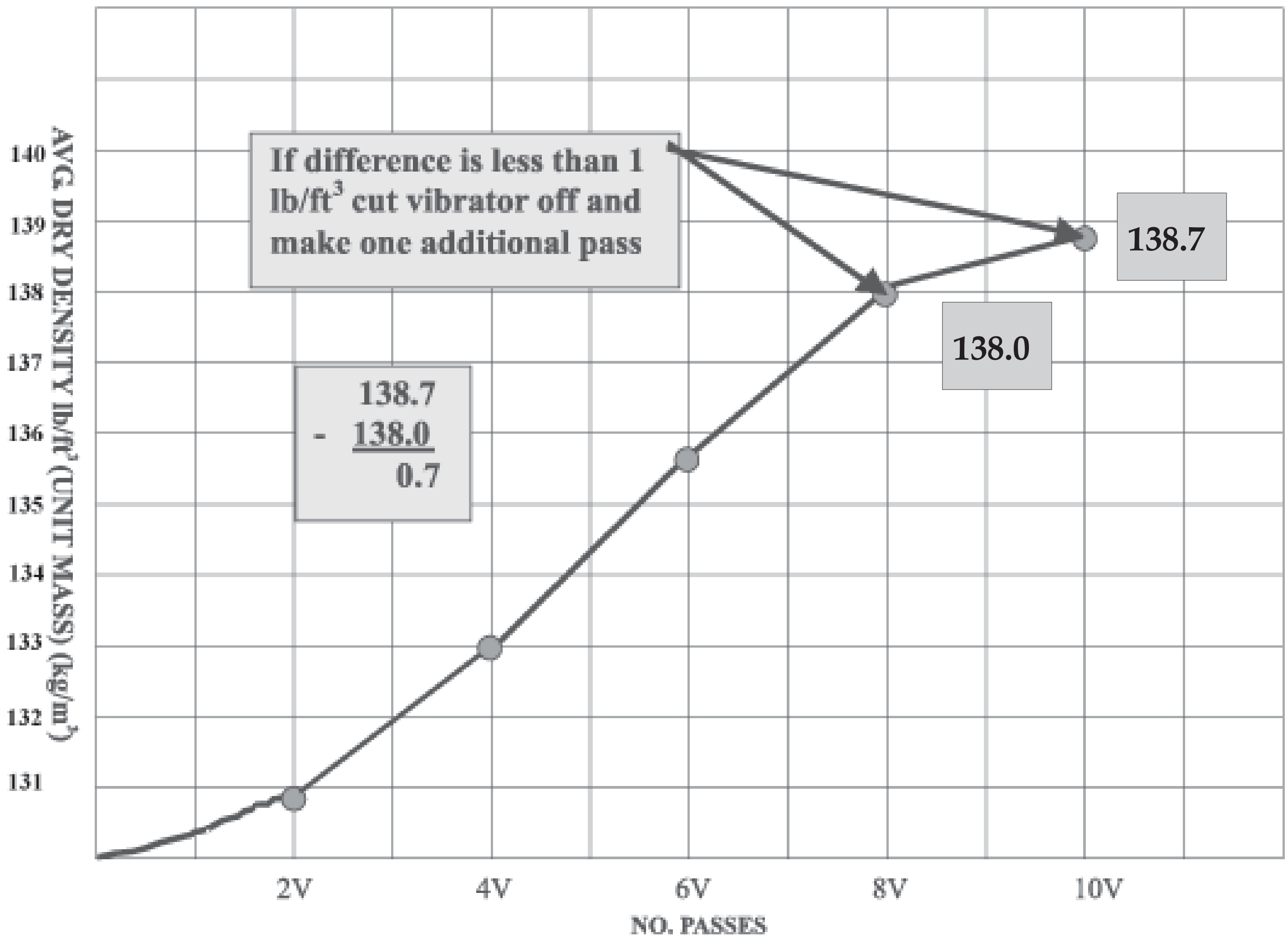
Remarks: Roller Pattern #1 (V is for Vibratory and S is for Static)

STANDARD COUNTS

DENSITY 2830 **MOISTURE** 701

TEST NO.	DRY DENSITY	MOISTURE CONTENT	TEST NO.	DRY DENSITY	MOISTURE CONTENT
Test No. 1 No. of Passes 2V			Test No. 6 No. of Passes		
Sta. 600+00	137.2	4.4	Sta.		
Sta. 600+40	131.8	5.3	Sta.		
Sta. 600+75	123.9	4.4	Sta.		
Total	392.9	14.1	Total		
Average	130.9	4.7	Average		
Test No. 2 No. of Passes 4V			Test No. 7 No. of Passes		
Sta. 600+00	137.4	4.8	Sta.		
Sta. 600+40	132.4	6.2	Sta.		
Sta. 600+75	128.9	4.9	Sta.		
Total	398.7	15.9	Total		
Average	132.9	5.3	Average		
Test No. 3 No. of Passes 6V			Test No. 8 No. of Passes		
Sta. 600+00	137.8	4.2	Sta.		
Sta. 600+40	134.2	5.8	Sta.		
Sta. 600+75	134.5	5.3	Sta.		
Total	406.5	15.3	Total		
Average	135.5	5.1	Average		
Test No. 4 No. of Passes 8V			Test No. 9 No. of Passes		
Sta. 600+00	138.6	4.6	Sta.		
Sta. 600+40	137.2	5.2	Sta.		
Sta. 600+75	138.3	4.6	Sta.		
Total	414.1	14.4	Total		
Average	138.0	4.8	Average		
Test No. 5 No.of Passes 10V			Test No. 10 No. of Passes		
Sta. 600+00	139.3	4.2	Sta.		
Sta. 600+40	137.3	5.0	Sta.		
Sta. 600+75	139.5	5.3	Sta.		
Total	416.1	14.5	Total		
Average	138.7	4.8	Average		

ROLLER PATTERN CURVE



Comments:

By ______________________________

Title ______________________________

CC: District Materials Engineer
Project File

TL-53 **VIRGINIA DEPARTMENT OF TRANSPORTATION**

MATERIALS DIVISION

REPORT OF NUCLEAR ROLLER PATTERN

English **Metric**

Report No. 1-21A-1 Nuclear Gauge Model No. 3440 Serial No. 23456

Date 6-22-99 Route No. 0066 Project No. 0066-029-F19,C501

FHWA No. IM-NH-66-1 County Fairfax

Section No. ________ Station 600+00 ft. (m.) to Station 600+75 ft. (m.)

Type Material Aggr.Base Type I 21A Width 12 ft. (m.)

Optimum Moisture 5.2 Optimum Moisture Range 3.2 - 7.2

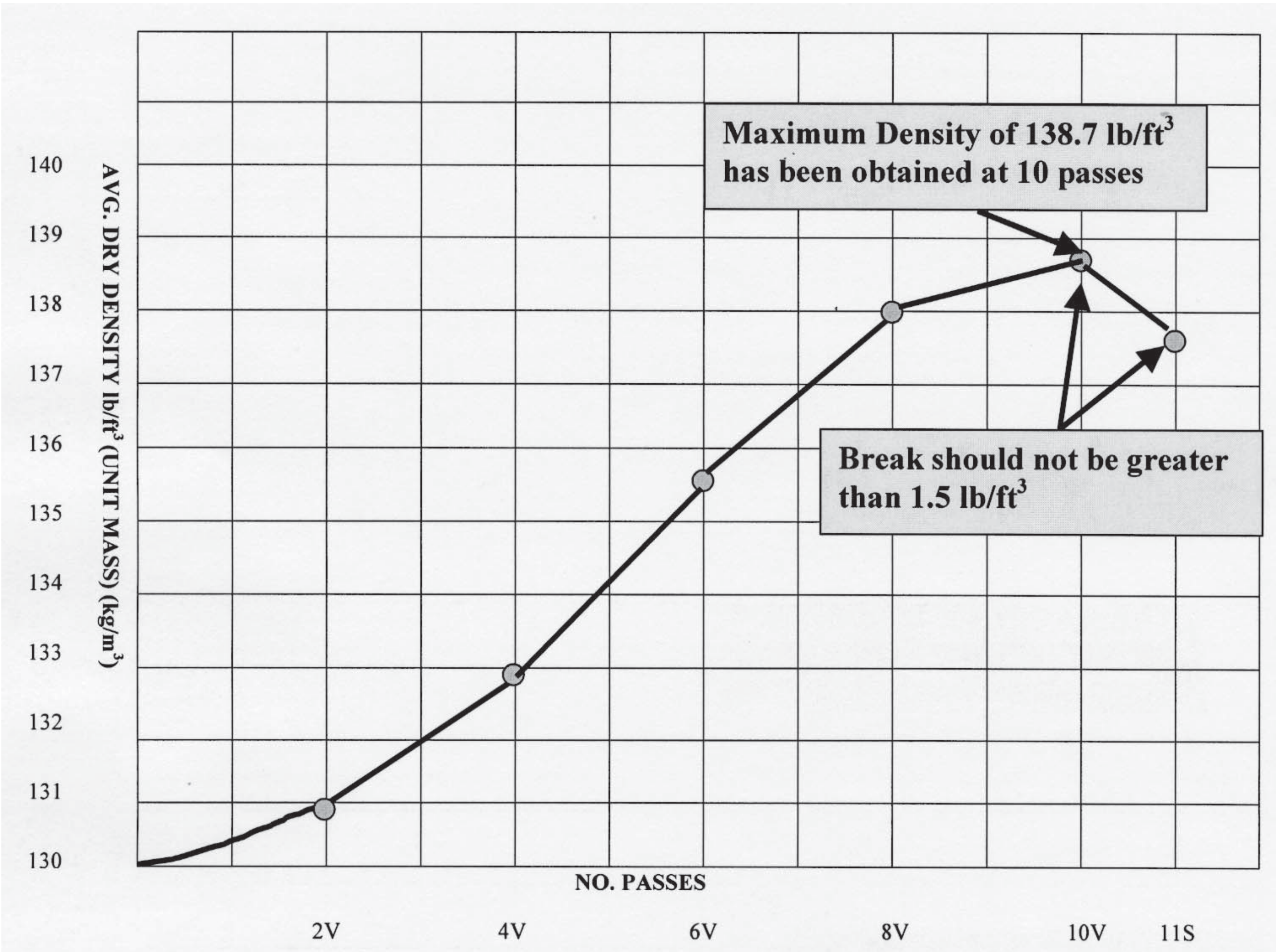
Remarks: Roller Pattern #1 (V is for Vibratory and S is for Static)

STANDARD COUNTS

DENSITY 2830 **MOISTURE 701**

TEST NO.	DRY DENSITY	MOISTURE CONTENT	TEST NO.	DRY DENSITY	MOISTURE CONTENT
Test No. 1 No. of Passes 2V			Test No. 6 No. of Passes 11S		
Sta. 600+00	137.2	4.4	Sta. 600+00	138.5	4.8
Sta. 600+40	131.8	5.3	Sta. 600+40	136.8	5.3
Sta. 600+75	123.9	4.4	Sta. 600+75	137.6	5.5
Total	392.9	14.1	Total	412.9	15.6
Average	130.9	4.7	Average	137.6	5.2
Test No. 2 No. of Passes 4V			Test No. 7 No. of Passes		
Sta. 600+00	137.4	4.8	Sta.		
Sta. 600+40	132.4	6.2	Sta.		
Sta. 600+75	128.9	4.9	Sta.		
Total	398.7	15.9	Total		
Average	132.9	5.3	Average		
Test No. 3 No. of Passes 6V			Test No. 8 No. of Passes		
Sta. 600+00	137.8	4.2	Sta.		
Sta. 600+40	134.2	5.8	Sta.		
Sta. 600+75	134.5	5.3	Sta.		
Total	406.5	15.3	Total		
Average	135.5	5.1	Average		
Test No. 4 No. of Passes 8V			Test No. 9 No. of Passes		
Sta. 600+00	138.6	4.6	Sta.		
Sta. 600+40	137.2	5.2	Sta.		
Sta. 600+75	138.3	4.6	Sta.		
Total	414.1	14.4	Total		
Average	138.0	4.8	Average		
Test No. 5 No. of Passes 10V			Test No. 10 No. of Passes		
Sta. 600+00	139.3	4.2	Sta.		
Sta. 600+40	137.3	5.0	Sta.		
Sta. 600+75	139.5	5.3	Sta.		
Total	416.1	14.5	Total		
Average	138.7	4.8	Average		

ROLLER PATTERN CURVE



Comments:

By ___________________________________

Title ___________________________________

CC: District Materials Engineer
Project File

CRITERIA FOR ESTABLISHING A NEW ROLLER PATTERN:

A new Roller Pattern should be established:

- Whenever there are multiple lifts of material
- Change in Source of material
- Change in compaction equipment
- Visual change in subsurface or subgrade conditions
- Change in gradation or type of material
- Change in depth of lift

II. THE CONTROL STRIP

1) To prepare a Control Strip, place the material under the same conditions as outlined in Step 3 of the Roller Pattern, on an additional section of roadway approximately 300 feet in length and one travel lane in width. After placement, this area is to be rolled the number of passes determined in the Roller Pattern to achieve the peak density.

2) To determine the density of the Control Strip, use the Backscatter Method in the 1 minute mode. Take 10 nuclear readings for moisture and density over the entire section. The results are added and an average is obtained on Form TL-54. This dry density should be within 3.0 lb/ft^3 of the roller pattern peak density. The target values of 98% and 95% of the average dry density can now be determined. These are used to determine the acceptance of the Test Sections.

TL-54 VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR CONTROL STRIP

English Metric
Report No. 1-21A-2 Date 6-22-99
Route 66 Project No. 0066-029-F19,C501
F.H.W.A. No. IM-NH-66-1 County Fairfax
Type Material Aggr.Base Type I 21A Width 12 Feet
Station 601+25 ft. (m.) to Station 604+25 ft. (m.)
Nuclear Gauge Model No. 3440 Serial No. 23456
Remarks

STANDARD COUNT

DENSITY	MOISTURE
2830	701

	STATION	REFERNCE TO CENTER LINE ft. (m)	LANE	DRY DENSITY (lbs/ft^3) DRY UNIT MASS (kg/m^3)	MOISTURE CONTENT
1	601+25	3 Ft. Rt.	EBL	138.0	4.9
2	601+50	9 Ft. Rt.	EBL	139.2	5.3
3	602+00	6 Ft. Rt.	EBL	138.5	4.8
4	602+25	9 Ft. Rt.	EBL	139.3	5.4
5	602+75	3 Ft. Rt.	EBL	138.7	4.9
6	603+00	6 Ft. Rt.	EBL	139.1	5.1
7	603+50	9 Ft. Rt.	EBL	139.0	4.7
8	603+75	6 Ft. Rt.	EBL	139.2	5.2
9	604+00	3 Ft. Rt.	EBL	139.0	4.6
10	604+25	9 Ft. Rt.	EBL	140.5	6.1
				TOTAL: 1390.5	
				AVERAGE: 139.1	

Average Dry Density must be within 3.0 lb/ft^3 of Roller Pattern Peak Density
Roller Pattern Peak Density was 138.7

5.2 OPTIMUM MOISTURE REQUIRED (From Producer or Materials Division)

3.2 – 7.2 OPTIMUM MOISTURE RANGE

(139.1) x 0.95 = 132.1 INDIVIDUAL DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3)
Dens.Avg. REQUIREMENT FOR TEST SECTION

(139.1) x 0.98 = 136.3 AVERAGE DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3)
Dens.Avg. REQUIREMENT FOR TEST SECTION

3) Direct Transmission – The dry density average that has been established from the control strip needs to meet two criteria in order to be acceptable for use with the remaining test sections.

   a. The average dry density from the control strip should be within 3.0 lb/ft^3 of the roller pattern peak density.

   b. At the completion of the control strip, a verification test will be performed when testing aggregates using the direct transmission method with a nuclear moisture density gauge, or other methods approved by the Materials Engineer. At the completion of the test, the density of aggregate material shall be compared to the theoretical maximum density as determined in accordance with the requirements of VTM-1. The density shall conform to the following:

% Retained on No. 4 Sieve	% Minimum Density
0 – 50	95
51 – 60	90
61 – 70	85

   Note: Percentages of material will be reported to the nearest whole number. The requirements for percent density referenced above, apply to the direct transmission method for aggregate only. See Chapter 7 for procedure. Record the results on the TL-124 Form.

4) Once the control strip dry density has been accepted - the remainder of the TL-54 can be completed.

Direct Transmission at End of Control Strip
(See calculations on next page)

TL-124

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)

English Metric
Report No.: 1-21A-3 Date: 6-22-99 Sheet No.: 1 of 1
Route No.: 66 County: Campbell
Project No.: 0066-029-F19,C501
F.H.W.A. No.: IM-NH-66-1
Test For: 21A
Nuclear Gauge Model No.: 3440 Serial No.: 23456 Calibration Date: 2-10-99

STANDARD COUNT	
DENSITY	MOISTURE
2830	701

Test No.		1			
Location of Test: Station ft. (m)		603 + 00			
Ref. to center line ft. (m)		5'Rt. C/L			
Elevation					
Compacted Depth of Lift in. (mm)		6"			
Method of Compaction		Vib. Roller			
A. Wet Density (lbs/ft³), Wet Unit Mass (kg/m³)	=	140.9	Gauge		
B. Moisture Unit Mass (lbs/ft³), Moisture Unit Mass (kg/m³)	=	7.0	Gauge		
C. Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (A - B)	=	133.9	Gauge		
D. Moisture Content (B ÷ C) x 100	=	5.2	Gauge		
E. Maximum Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) Lab Proctor or One Point Proctor	=	132.8	Matls. Div.		
F. Percent Optimum Moisture from Lab or One Point Proctor	=	10.7	Matls. Div.		
G. Percent of plus #4, (plus 4.75mm)	=	58.0	Matls. Div.		
H. Corrected Maximum Dry Density (lbs/ft³) Dry Unit Mass (kg/m³)	=	145.3	See Pg. 19		
I. Corrected Optimum Moisture	=	5.2 3.2 - 7.2	See Pg. 19		
J. Percent Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (C ÷ E) x 100 or (C ÷ H) x 100	=	92.2			
K. Percent Minimum Density Required	=	90.0	Appendix C		

Nuclear Gauge Display Panel

% PR = 100.8%
DD = 133.9
WD = 140.9

M = 7.0 % M = 5.2

Remarks:
Direct Transmission at end of Control Strip

CC: District Materials Engineer
Project File

By: Carolyn Mason

Title: Engr.Tech.

Calculations for Direct Transmission Test taken Within the Control Strip

Information from quarry or Materials Section:

A) Total percent passing the No.4 sieve = 42%
(this is the –4 material)
Therefore: 100 – 42 = 58% (this is the +4 material)

B) Specific Gravity of +4 material = 2.5
Absorption of +4 material = 0.2

C) Lab Proctor Information
Maximum Dry Density of –4 material = 132.8 lb/ft^3
Optimum Moisture of –4 material = 10.7

DENSITY CORRECTION FOR +4 MATERIAL

$$\frac{1}{\dfrac{\%\ +4}{\text{Specific Gravity of } +4 \times 62.4} + \dfrac{\%\ -4}{\text{Maximum Dry Density of } -4}}$$

$$\frac{1}{\dfrac{\%\ +4\ (\text{as a decimal})\ \mathbf{\textit{0.58}}}{\mathbf{\textit{2.50}}\ \text{Sp.Gr.} \times 62.4 = \mathbf{156.0}} + \dfrac{\%\ -4\ (\text{as a decimal})\ \mathbf{\textit{0.42}}}{\text{Max.Dry Density of } -4\ \mathbf{132.8}}}$$

$$\frac{1}{\mathbf{\textit{0.0037179}} + \mathbf{\textit{0.0031626}}}$$

$$\frac{1}{\mathbf{\textit{0.0068805}}} = \mathbf{145.3\ lb/ft^3} = \text{Maximum Density of } \textbf{Total Soil}$$

MOISTURE CORRECTION FOR +4 MATERIAL

[(Absorption +4 Matl. + 1) x % +4 Matl.] + [Opt.Moist. –4 Matl. x % -4 Matl.]

[(0.2 + 1) x 0.58] + [10.7 x 0.42]

[0.696 + 4.494] = 5.19 = 5.2 = Optimum Moisture of **Total Soil**

5) After the direct transmission test passes and the control strip dry density has been accepted – the target values should be transferred to the TL-55 (Test Section).

TL-54 VIRGINIA DEPARTMENTS OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR CONTROL STRIP

English Metric
Report No. 1-21A-2 **Date** 6-22-99
Route 66 **Project No.** 0066-029-F19,C501
F.H.W.A. No. IM-NH-66-1 **County** Fairfax
Type Material Aggr.Base Type I 21A **Width** 12 Feet
Station 601+25 **ft. (m.) to Station** 604+25 **ft. (m.)**
Nuclear Gauge Model No. 3440 **Serial No.** 23456
Remarks ______

STANDARD COUNT

DENSITY	MOISTURE
2830	701

	STATION	REFERNCE TO CENTER LINE ft. (m)	LANE	DRY DENSITY (lbs/ft^3) DRY UNIT MASS (kg/m^3)	MOISTURE CONTENT
1	601+25	3 Ft. Rt.	EBL	138.0	4.9
2	601+50	9 Ft. Rt.	EBL	139.2	5.3
3	602+00	6 Ft. Rt.	EBL	138.5	4.8
4	602+25	9 Ft. Rt.	EBL	139.3	5.4
5	602+75	3 Ft. Rt.	EBL	138.7	4.9
6	603+00	6 Ft. Rt.	EBL	139.1	5.1
7	603+50	9 Ft. Rt.	EBL	139.0	4.7
8	603+75	6 Ft. Rt.	EBL	139.2	5.2
9	604+00	3 Ft. Rt.	EBL	139.0	4.6
10	604+25	9 Ft. Rt.	EBL	140.5	6.1
				TOTAL: 1390.5	
				AVERAGE: 139.1	

5.2 OPTIMUM MOISTURE REQUIRED
(From Producer or Materials Division)

3.2 – 7.2 OPTIMUM MOISTURE RANGE

(139.1) x 0.95 = 132.1 INDIVIDUAL DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3)
Dens.Avg. REQUIREMENT FOR TEST SECTION

(139.1) x 0.98 =136.3 AVERAGE DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3)
Dens.Avg REQUIREMENT FOR TEST SECTION

Since the Direct Transmission Test Passed - the Individual and Average Dry Density target values can be transferred to the TL—55A

Determining the Control Values From the Control Strip Testing:

The Control values for the rest of the density testing for the project are 98% and 95% of the average dry density determined by the control strip.

Using the control values:

98% the average of the five readings on the test section must be greater than 98% of the control strip dry density.

95% each individual reading must be greater than 95% of the control strip dry density.

for shoulders:

the average density must be 95 ± 2 percentage points of the control strip dry density

each individual density must be 95 ± 5 percentage points of the control strip dry density.

III. TEST SECTIONS

1) Next will be the testing of the Test Sections. Each test section for aggregate base, subbase, and select materials will be 0.5 miles in length per application width.

   The length of test sections for shoulders will be the same as the mainline, if possible test alternating sides.

2) The test section is rolled the number of passes determined by the Control Strip. Five (5) readings will be made in the one minute mode on each test section for both density and moisture using the same method of test used on the Roller Pattern and Control Strip. These values are recorded on the TL-55. Each individual reading must be at least 95% of the Control Strip dry density and the average of the five readings must be at least 98% of the Control Strip dry density and the moisture readings must fall within the optimum moisture range.

   For aggregate shoulder material an average density of 95 ± 2 percentage points of the control density, with individual densities within 95 ± 5 percentage points of the control density is required. No other test will be required, unless specified by the Engineer.

   If test section readings are significantly above or below the target values by more than 8 lb/ft^3 another control strip should be established.

TL-55

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR TEST SECTION

English **Metric**

Report No. 1-21A-4 **Date .** 66
Route No. 66 **Project No.** 0066-029-F19,C501
FHWA No. IM-NH-66-1 **County** Fairfax
Type Material Type I 21A **Width** 12 Feet
Section No. ____ **Station** 604+25 **ft (m.) to Station** 630+65 **ft (m.)**
Nuclear Gauge Model No. 3440 **Serial No.** 23456
Remarks ____

STANDARD COUNT	
DENSITY	MOISTURE
2830	701

5.2 **OPTIMUM MOISTURE REQUIRED % (from Producer or Materials Division)**

3.2 - 7.2 **OPTIMUM MOISTURE RANGE**

132.1 **INDIVIDUAL DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED (95% of Control Strip Dry Density from TL-54A)**

136.3 **AVERAGE DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED (98% of Control Strip Dry Density from TL-54)**

TEST NO.	Station ft (m)	Lane	Dry Density (lbs/ft³) Dry Unit Mass kg/m³	Moisture Content	(P) Pass (F) Fail
1	604+25	EBL	138.3	5.3	P
2	610+85	EBL	139.7	5.0	P
3	617+45	EBL	139.0	5.3	P
4	624+05	EBL	138.9	5.2	P
5	630+65	EBL	139.2	5.4	P
Average			139.0		p

TO PASS: The average dry Density must be at least 136.3 AND Each individual dry density reading must be at least 132.1 AND Each moisture must fall within the 3.2 – 7.2 range

Compare the readings taken on the Test Section to the Control Values determined on the Control Strip. This determines if the test section passes or fails for density.

If test section readings are significantly above or below the target values by more than 8 lb/ft³ another control strip should be established.

The following random number procedure is not used in Virginia in soils or aggregate but is used in asphalt. Students should become familiar with this procedure as other states participating in MARTCP use this method and Virginia will in the future.

1.2.7 RANDOM SAMPLING OF CONSTRUCTION MATERIALS, MARTCP METHOD SA-1.4

This section provides guidelines for the selection of random locations or times at which samples or tests of construction materials are to be taken.

Highway construction materials are typically accepted or rejected based on the test results of small representative samples. Consequently, acceptance or rejection of materials is highly dependent on how well a small sample represents a larger quantity of material. If the samples are not truly representative of the larger quantity, acceptable material could be rejected, or substandard material accepted. Correct sampling methods are critical to the validity of the sample test results. Sampling performed incorrectly will lead to test results that do not reflect the true characteristics of the material or product being tested.

The actions required to obtain a good sample (such as how to take the sample, where to take it, what tools to use and the size of sample) are covered in the appropriate materials control program and guidelines specified by the agency for use on the project. Reference should be made to these instructions on sampling requirements.

When a sample is not representative or random, it is said to be biased. Examples of biased sampling that should not be used include sampling an embankment at a given interval, such as every 500 cubic meters (650 yd^3); sampling borrow material at a given frequency, such as every fifth truckload, or taking samples at a given time frequency, such as every hour on the hour. Random sampling is used to eliminate bias in selecting a location or time for sampling. A random sample is any sample which has an equal chance of being selected from a large quantity. In other words, there is an equal chance for all locations and all fractions of a large quantity of material to be sampled.

Random unbiased samples must represent the true nature of the material. Samples should not be obtained on a predetermined basis or based on the quality of the material in a certain area. If sampling is not performed on a random basis, the quality of the sample can be artificially modified causing the sample to no longer be representative of the larger quantity. Specifications will identify lot size, location and frequencies for sampling and testing. A lot is defined as a given quantity of material that is to be sampled. The lot is a predetermined unit which may represent a day’s production, a specified quantity of material, a specified number of truckloads, or an interval of time. Agencies will usually specify the lot size and sampling frequency. Although these frequencies may appear to be a violation of random sampling, they are given as a minimum amount of sampling, not as a specific frequency. Lots are often divided into sublots. The number of sublots used to represent the lot will be determined by the agency and specifications. It may be necessary to take multiple samples and combine them to represent a unit. For example, three samples may be taken from a borrow source and combined to form a composite sample. Several composite samples will then be tested to determine the compliance of a sublot or lot to the specifications. The use of random samples from sublots is referred to as stratified random sampling. Stratified random sampling assures that samples are taken from throughout the entire lot and are not concentrated in one area of the lot (see Figure 1.18).

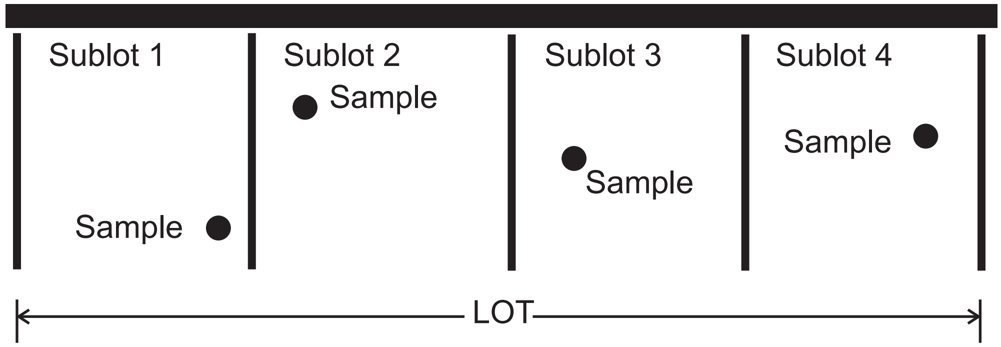


Fig. 1.18 Sublots for stratifield sampling

Quality control/quality assurance specifications are developed based on statistical theory, which is valid only when random sampling is performed. QC/QA specifications are statistically based on a normal distribution (bell curve) of uniform material production. If samples are biased or not random, the test results will not fit in the normal distribution, and the QC/QA specification will no longer be valid.

Random sampling is usually accomplished with the use of random number generators or tables of random numbers. Most calculators and computers contain a random number generator that merely requires the operator to hit a button. The automated random number generators use programmed tables of random numbers similar to the tables included later. A random numbers table is simply a random arrangement of numbers.

ASTM D 3665 is a method for determining random locations or time intervals for sampling and testing. Individual states within the Mid-Atlantic Region have developed various random numbers tables that are much easier to use and less time consuming. The Table on page 8-26 is an example of a table used for selecting test locations on aggregate subbase or base. It is not important which table or method is used as long as random numbers are incorporated into the selection process.

A Test Section for aggregate subbase or base is half a mile per paver width. Each test section is divided into 5 sublots of 528 feet (2640 feet ÷ 5 = 528 feet). One reading is taken in each sublot.

To use the table, select a random starting point on the table by tossing a pencil upon the page or blindly pointing out a location with the finger. Since you will need five sets of numbers, use the location selected and the next four beneath it. The column to the left is used to determine the distance from the beginning of each sublot and the corresponding columns to the right are used to determine the offset distance from the reference line based on the paver width.

Example:

The contractor has applied the dense graded aggregate layer to the right lane of a two lane roadway beginning at Station 65+00 with a paver width of 14 feet. The right side will be used to measure the offset distances. Five sets of numbers are needed to determine where the tests will be performed.

Random numbers from Random Number Table:

Distance from Start of Sublot	Distance from Reference Line
201	8
136	11
78	3
9	11
129	4

Determine the Station Number at the beginning of each sublot. Remember the Test Section is half a mile per paver width and is divided into five sublots of 528 feet in length.

Beginning Station Number of Sublot 1: 65+00

+ 5 28 feet

Beginning Station Number of Sublot 2: 70+28

+ 5 28 feet

Beginning Station Number of Sublot 3: 75+56

+ 5 28 feet

Beginning Station Number of Sublot 4: 80+84

+ 5 28 feet

Beginning Station Number of Sublot 5: 86+12

To determine the test locations, add the Distance from Start of Sublot selected from the Random Number Table to the beginning station number of each sublot. Use the numbers from the Random Number Table under Distance from Reference Line to measure the offset from the right side of the sublot.

Station No.at Beginning of each Sublot	+ Distance from Start of Sublot (ft.)	= Station No. of Test Location	Distance from Reference Line (ft.)
65+00	201	67+01	8
70+28	136	71+64	11
75+56	78	76+34	3
80+84	9	80+93	11
86+12	129	87+41	4

RANDOM NUMBER TABLE

Distance From Start of Sublot (ft.)	Distance From Reference Line						
	Paver Width						
	8 ft.width	9 ft. width	10 ft. width	11 ft. width	12 ft.width	13 ft.width	14 ft.width
137	2	4	5	5	3	9	12
186	4	4	7	8	5	5	8
51	4	6	8	5	7	4	6
96	5	2	5	9	8	4	8
101	5	4	3	9	4	10	12
106	5	3	7	8	8	10	9
27	2	3	7	6	3	4	7
140	2	5	3	8	3	10	2
182	2	2	8	5	10	5	10
156	3	3	7	6	3	6	10
22	5	5	8	2	5	3	7
232	4	3	4	2	7	6	8
57	5	4	3	2	7	8	10
201	2	2	7	5	9	3	8
136	6	5	8	7	7	4	11
78	6	4	2	2	5	5	3
9	3	2	6	3	6	9	11
129	3	5	3	8	3	4	4
244	3	3	3	3	8	2	6
189	2	7	3	9	5	2	5
208	4	5	4	5	10	9	5
128	5	7	8	6	4	4	5
98	3	3	8	8	9	2	10
200	2	4	5	6	10	2	8
78	3	4	8	6	3	6	11
185	4	5	2	6	7	10	3
3	2	4	7	7	3	6	12
96	6	3	7	3	9	8	11
17	4	6	8	9	8	8	8
228	3	7	6	5	2	5	4
230	5	4	8	6	5	10	10
73	2	5	8	6	5	6	9
109	4	4	4	4	6	8	11
181	3	6	6	9	3	9	4
252	4	3	4	3	3	9	11
96	4	4	2	2	2	9	11
43	4	7	5	7	6	3	11
71	4	6	5	6	4	4	12
9	3	3	3	9	6	10	11
157	5	5	7	9	6	9	12

Study Questions

1. True or False. Before a Roller Pattern can be set the subgrade must be approved, compaction equipment must be approved and material to be tested must be placed at uniform depth.

2. ____________________________ compares compactive effort vs. density.

3. When must a new Roller Pattern be set up?

4. _____________________________________ is the testing method in which the gauge is placed on the surface of the material to be tested and the source rod is lowered to the first notch.

5. When taking a nuclear reading near an unsupported edge, _______________ is the minimum distance from the edge that an accurate nuclear reading can be taken.

6. ____ is taken at the end of the control strip to verify the results.

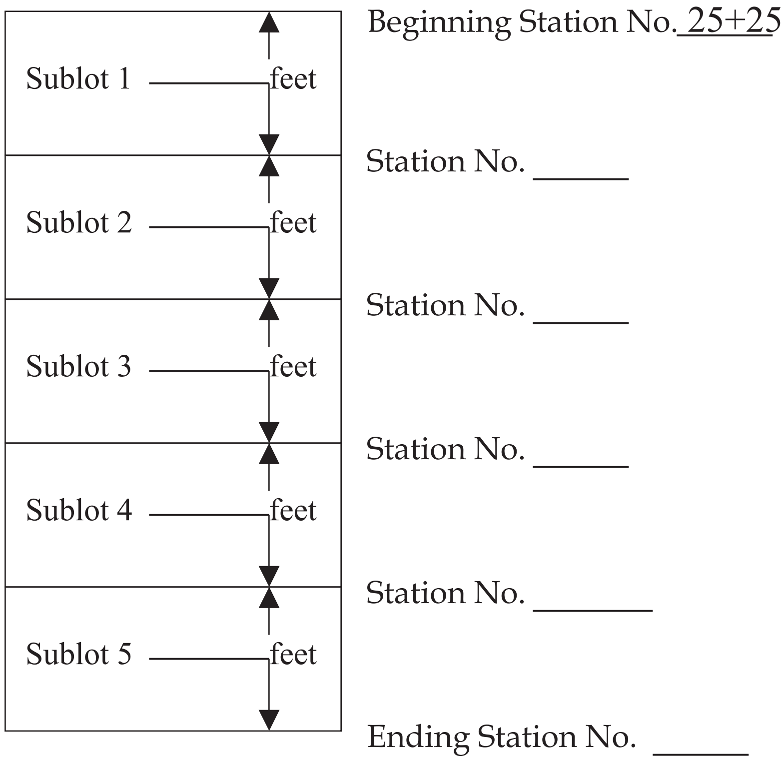
7. The control strip dry density must be within __________________ of roller pattern peak density.

8. A roller pattern on aggregate covers ____________________, a control strip covers ___________________ and a test section covers ________________________ per paver width.

9. The Contractor has applied the dense graded aggregate layer to the right lane of a two-lane roadway beginning at Station 25 + 25. Using the numbers from the Random Number Table given below, calculate and determine the test location for each density and moisture reading for this test section, which is 12 feet wide. Remember not to test any closer than 18 inches to an unsupported edge.

Distance from Start of Sublot	Distance from Reference Line
181 feet	3 feet
252 feet	3 feet
96 feet	2 feet
43 feet	6 feet
71 feet	4 feet

5,280 feet in a mile. A Test Section is ______ mile per paver width or ______ feet.
______ tests will be performed in the test section. _____ ÷ ____ = _____ feet per sublot.



Test No.	**Station No. at Start of Sublot**	**Distance from start of sublot**	**Test at Station No.**	**Distance from reference line**
1				
2				
3				
4				
5				

CHAPTER 8
Practice Problems
NOTE: Each problem contains 4 parts

Practice Problem 1
Nuclear Field Testing of Aggregates
Step #1 - Roller Pattern

A. Given the following information, complete the following worksheet (TL-53).

Optimum Moisture Range: You Calculate

Test 1
2V Passes

Density	Moisture
125.4	5.1
124.9	5.2
125.3	5.6

Test 4
8V Passes

Density	Moisture
134.7	5.5
133.7	4.9
134.8	5.1

Test 2
4V Passes

Density	Moisture
128.4	5.4
127.5	5.1
128.5	4.9

Test 5
?? Passes

Density	Moisture
135.5	5.2
135.0	5.1
135.4	4.9

Test 3
6V Passes

Density	Moisture
131.8	5.1
131.0	5.0
132.1	4.9

Test 6
?? Passes

Density	Moisture
134.0	4.9
133.5	5.0
134.1	5.1

B. How many passes should be made for test 5? Why?

____

____

How many passes should be made for test 6? Why?

____

____

C. Should this be considered an acceptable roller pattern and why?

____

____

TL-53

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR ROLLER PATTERN

English Metric

Report No. 1-21A-1 Nuclear Gauge Model No. 3440 Serial No. 23456

Date Today Route No. 95 Project No. 0095-029-F14,C502

FHWA No. NH(95)-1 County Fairfax

Section No. 1 Station 21+00 ft. (m.) to Station 21+75 ft. (m.)

Type Material Aggregate Subbase or Base Width 12 feet ft. (m.)

Optimum Moisture 5.3 Optimum Moisture Range

Remarks:

1st lift 6” compacted depth, Roller Pattern No. 1, Vibratory Roller

STANDARD COUNTS

DENSITY 2847 MOISTURE 695

TEST NO.	DRY DENSITY	MOISTURE CONTENT	TEST NO.	DRY DENSITY	MOISTURE CONTENT
Test No. 1 No. of Passes 2V			Test No. 6 No. of Passes		
Sta. 21+00	125.4	5.1	Sta. 21+00	134.0	4.9
Sta. 21+35	124.9	5.2	Sta. 21+35	133.5	5.0
Sta. 21+75	125.3	5.6	Sta. 21+75	134.1	5.1
Total			Total		
Average			Average		
Test No. 2 No. of Passes 4V			Test No. 7 No. of Passes		
Sta. 21+00	128.4	5.4	Sta.		
Sta. 21+35	127.5	5.1	Sta.		
Sta. 21+75	128.5	4.9	Sta.		
Total			Total		
Average			Average		
Test No. 3 No. of Passes 6V			Test No. 8 No. of Passes		
Sta. 21+00	131.8	5.1	Sta.		
Sta. 21+35	131.0	5.0	Sta.		
Sta. 21+75	132.1	4.9	Sta.		
Total			Total		
Average			Average		
Test No. 4 No. of Passes 8V			Test No. 9 No. of Passes		
Sta. 21+00	134.7	5.5	Sta.		
Sta. 21+35	133.7	4.9	Sta.		
Sta. 21+75	134.8	5.1	Sta.		
Total			Total		
Average			Average		
Test No. 5 No. of Passes			Test No. 10 No. of Passes		
Sta. 21+00	135.5	5.2	Sta.		
Sta. 21+35	135.0	5.1	Sta.		
Sta. 21+75	135.4	4.9	Sta.		
Total			Total		
Average			Average		

ROLLER PATTERN CURVE

NO. PASSES

Comments:

By ____________________

Title ________________________________

CC: District Materials Engineer
Project File

Step #2 - Control Strip

A. Complete the following worksheet (TL-54) and answer the following questions.

B. How many roller passes were required to attain maximum density on the Control Strip (Use info from Step #1 TL-53)?

____

C. Does test pass the moisture criteria?

____

D. Is Control Strip within tolerance of roller pattern?

____

TL-54

VIRGINIA DEPARTMENTS OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR CONTROL STRIP

English **Metric**

Report No. 1-21A-2 **Date Today**
Route 95 **Project No. 0095-029-F14,C502**
F.H.W.A. No. NH(95)-1 **County Fairfax**
Type Material Aggr.Subbase or Base **Width 12 feet**
Station 22+25 ft. (m.) to Station 25+25 ft. (m.)
Nuclear Gauge Model No. 3440 **Serial No. 23456**
Remarks 1st Lift 6" compacted depth, roller pattern No. 1

STANDARD COUNT

DENSITY 2847 **MOISTURE** 695

	STATION	REFERNCE TO CENTER LINE ft. (m)	LANE	DRY DENSITY (lbs/ft³) DRY UNIT MASS (kg/m³)	MOISTURE CONTENT
1	22+25	3' Rt.	WBL	134.8	5.4
2	22+65	9' Rt.	WBL	135.2	5.3
3	23+00	6' Rt.	WBL	135.6	5.4
4	23+35	9' Rt.	WBL	135.5	5.4
5	23+70	3' Rt.	WBL	135.3	5.4
6	24+00	9' Rt.	WBL	135.3	5.1
7	24+35	6' Rt.	WBL	135.2	5.5
8	24+70	9' Rt.	WBL	135.8	5.4
9	25+00	6' Rt.	WBL	135.3	5.1
10	25+25	3' Rt.	WBL	134.7	5.0
			TOTAL:		
			AVG. :		

________ **OPTIMUM MOISTURE REQUIRED (From Producer or Materials Division)**

________ **OPTIMUM MOISTURE RANGE**

(________) x 0.95 = ________ **INDIVIDUAL DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIREMENT FOR TEST SECTION**
Dens.Avg.

(________) x 0.98 = ________ **AVERAGE DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIREMENT FOR TEST SECTION**
Dens.Avg

By ________________________
Title ________________________

Cc: District Materials Engineer
Project File

Step #3 – Direct Transmission

A. Using the information below complete the TL-124 and then answer the questions.

Information from Quarry or Materials Lab

Percent Passing No. 4 sieve = 46%
Therefore Percent of +4 material = _______
Specific Gravity +4 material = 2.4
Absorption +4 material = 0.2
Max.Dry Density from Lab Proctor on –4 material = 133.0 lb/ft^3
Optimum Moisture from Lab Proctor on –4 material = 10.1

Gauge Display Panel

% PR = 91.9 WD = 137.1 DD = 130.2 M = 6.9 %M = 5.3

B. What is the minimum density required?

____

C. Does this test pass?

____

D. Does this test validate the control strip?

____

TL-124

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)

English Metric

Report No.: ______________________Date: ________________ Sheet No.: _______of ________________

Route No.: ____County: ___________________________

Project No.: ____

F.H.W.A. No.: ____

Test For: ____

Nuclear Gauge Model No.: _________________________Serial No.: ______________________________

	STANDARD COUNT	
DENSITY		MOISTURE
______		_______

Test No.				
Location of Test	Station ft. (m)	22 + 35		
	Ref. to center line ft. (m)	2' Rt.		
	Elevation			
Compacted Depth of Lift in. (mm)				
Method of Compaction				
A. Wet Density (lbs/ft^3), Wet Unit Mass (kg/m^3)	=			
B. Moisture Unit Mass (lbs/ft^3), Moisture Unit Mass (kg/m^3)	=			
C. Dry Density (lbs/ft^3), Dry Unit Mass (kg/m^3) (A - B)	=			
D. Moisture Content (B ÷ C) x 100	=			
E. Maximum Dry Density (lbs/ft^3), Dry Unit Mass (kg/m^3) Lab Proctor or One Point Proctor	=			
F. Percent Optimum Moisture	=			
G. Percent of plus #4, (plus 4.75mm)	=			
H. Corrected Maximum Dry Density (lbs/ft^3) Dry Unit Mass (kg/m^3)	=			
I. Corrected Optimum Moisture	=			
J. Percent Dry Density (lbs/ft^3), Dry Unit Mass (kg/m^3) (C ÷ E) x 100 or (C ÷ H) x 100	=			
K. Percent Minimum Density Required	=			

Remarks:

Direct Transmission at end of Control Strip

CC: District Materials Engineer
Project File

By: ______________________________________

Title: _____________________________________

Step #4 – Test Section

A. Transfer the OPTIMUM MOISTURE, OPTIMUM MOISTURE RANGE, INDIVIDUAL DRY DENSITY REQUIREMENT AND AVERAGE DRY DENSITY REQUIREMENT from the control strip to the proper location on the TL-55.

B. Given the following information , complete the TL-55.

Test No. 1

%PR

WD = 144.1
DD = 136.4

M = 7.7 %M = 5.1

Test No. 2

%PR

WD = 142.3
DD = 135.0

M = 7.3 %M = 5.4

Test No. 3

%PR

WD = 143.8
DD = 136.5

M = 7.3 %M = 5.0

Test No. 4

%PR

WD = 140.2
DD = 133.2

M = 7.0 %M = 5.3

Test No. 5

%PR

WD = 142.9
DD = 136.0

M = 6.9 %M = 5.1

C. Does this test pass? ______________ Why?

____

____

D. If the test does not pass, what corrective action should be taken?

____

____

E. What are the beginning and ending station numbers of your 1st acceptance testing test section?

____

TL-55

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR TEST SECTION

English **Metric**

Report No. 1-21A-4 **Date** Today
Route No. 95 **Project No.** 0095-029-F14,C502
FHWA No. NH(95)-1 **County** Fairfax
Type Material 21-A **Width** 12 feet
Section No. 1 **Station** 25+25 **ft (m.) to Station** 51+65 **ft (m.)**
Nuclear Gauge Model No. 3440 **Serial No.** 23456
Remarks 1st lift 6"compacted depth, roller pattern No. 1

STANDARD COUNT

DENSITY 2847

MOISTURE 695

____________________ **OPTIMUM MOISTURE REQUIRED %**
(from Producer or Materials Division)

____________________ **OPTIMUM MOISTURE RANGE**

____________________ **INDIVIDUAL DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3) REQUIRED**
(95% of Control Strip Dry Density from TL-54)

____________________ **AVERAGE DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3) REQUIRED**
(98% of Control Strip Dry Density from TL-54)

TEST NO.	Station ft (m)	Lane	Dry Density (lbs/ft^3) Dry Unit Mass kg/m^3	Moisture Content	(P) Pass (F) Fail
1	25+25	WBL	136.4	5.1	
2	29+25	WBL	135.0	5.4	
3	35+50	WBL	136.5	5.0	
4	43+00	WBL	133.2	5.3	
5	51+65	WBL	136.0	5.1	
Average					

Comments:

CC: District Materials Engineer
Project File

By ____________________
Title ____________________

Practice Problem 2
Nuclear Field Testing of Aggregates
Step #1 - Roller Pattern

A. Given the following information, complete the following worksheet (TL-53).

Report No.: 3-21A**CTA**-1
Nuclear Gauge Model No.: 3440
Serial No.: 23456
Date: Today
Route: 0007
Project No.: 0007-053-121,C501
FHWA No.: None
County: Loudoun
Section No. 1

Station 900+00 to Station 900+75
Type Material: **Aggregate Subbase or Base Type 1 21-A with 4% cement**
Width: 12 feet
Optimum Moisture: 5.1
Optimum Moisture Range: You Calculate
Remarks: 1st Lift 6” compacted depth, roller pattern #3, Vibratory Roller

Standard Counts: Density 2864 Moisture 709
Station Nos.: 900+00, 900+35, 900+75 (use same station #s on all tests).

Test 1
2V Passes

Density	Moisture
115.4	5.3
114.6	5.1
116.1	4.9

Test 2
4V Passes

Density	Moisture
118.9	5.3
118.6	5.2
119.1	5.3

Test 3
6V Passes

Density	Moisture
121.9	5.1
121.0	4.9
122.9	5.3

Test 4
8V Passes

Density	Moisture
129.2	5.5
128.1	4.8
130.2	5.0

Test 5
10V Passes

Density	Moisture
132.1	5.3
131.6	4.3
132.6	5.9

Test 6
?? Passes

Density	Moisture
132.2	5.2
131.7	5.0
132.7	5.2

Test 7
?? Passes

Density	Moisture
131.8	4.4
131.7	5.2
131.8	5.8

B. Should this be considered an acceptable roller pattern and why?

TL-53

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR ROLLER PATTERN

English **Metric**

Report No. ________________ **Nuclear Gauge Model No.** _______ **Serial No.** ________________

Date ________________ **Route No.** ________________ **Project No.** ________________

FHWA No. ________________ **County** ________________

Section No. ________________ **Station** ________________ **ft. (m.) to Station** ____________ **ft. (m.)**

Type Material ________________ **Width** ________________ **ft. (m.)**

Optimum Moisture ________________ **Optimum Moisture Range** ________________

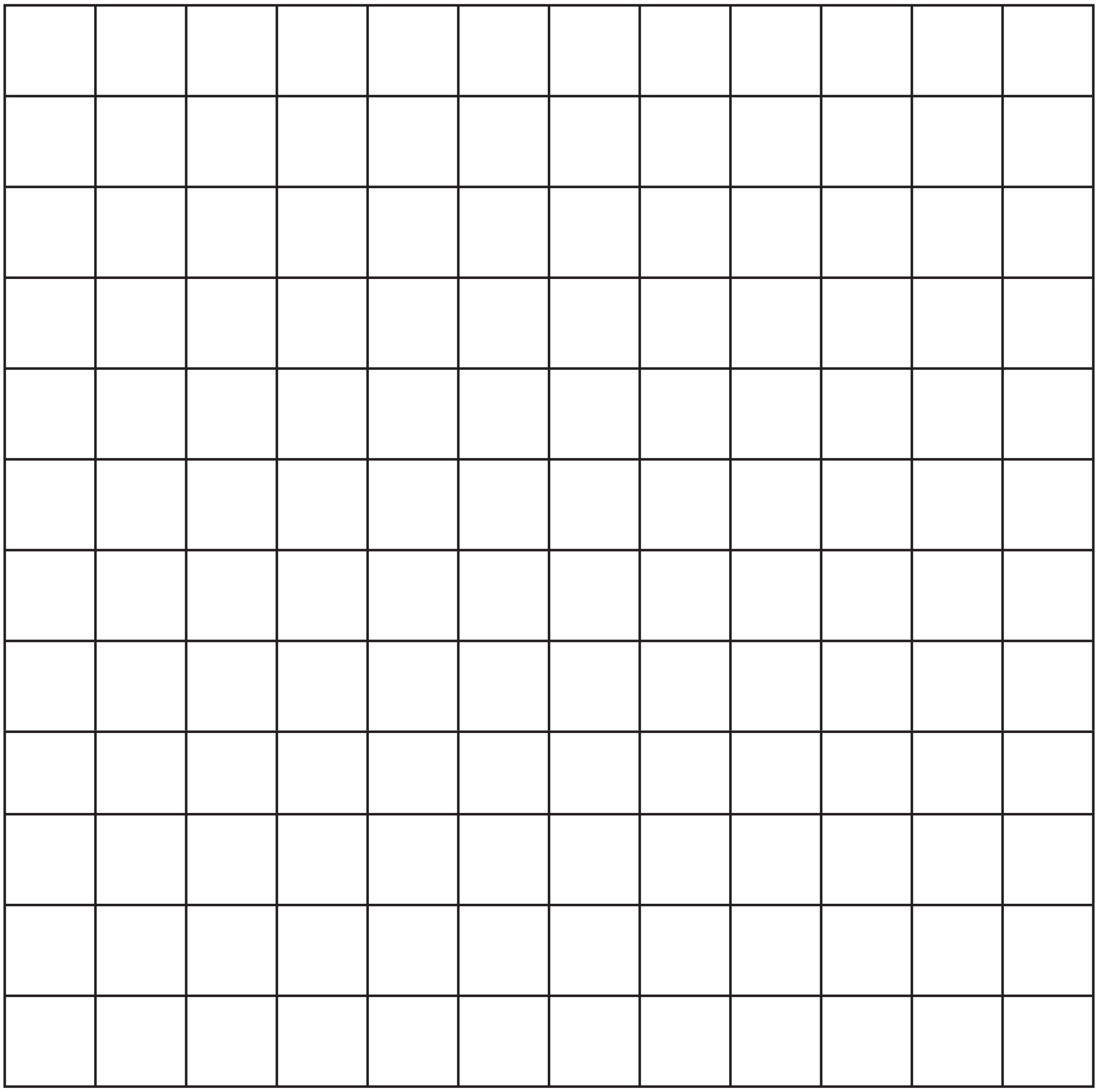
Remarks:

STANDARD COUNTS

DENSITY __________ **MOISTURE** ____________

TEST NO.	DRY DENSITY	MOISTURE CONTENT	TEST NO.	DRY DENSITY	MOISTURE CONTENT
Test No. 1 No. of Passes			Test No. 6 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		
Test No. 2 No. of Passes			Test No. 7 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		
Test No. 3 No. of Passes			Test No. 8 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		
Test No. 4 No. of Passes			Test No. 9 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		
Test No. 5 No. of Passes			Test No. 10 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total			Total		
Average			Average		

ROLLER PATTERN CURVE



NO. PASSES

Comments:

By ____________________________________

Title ____________________________________

CC: District Materials Engineer
Project File

Step #2 - Control Strip

A. Using the same "Header" information in Step #1 plus the information given below, complete the following worksheet (TL-54).

Report No.: 1-21A-2
Station 901+25 to Station 904+25
Standard Count Density: 2864
Standard Count Moisture: 709

Test No.	Station	Ref. To C/L	Lane	Dry Density	Moisture Content
1	901+25	3 ft. Lt.	WBL.	132.8	5.6
2	901+75	9 ft. Lt.	WBL	132.7	5.7
3	902+00	6 ft. Lt.	WBL	132.9	5.6
4	902+30	3 ft. Lt.	WBL	132.6	5.8
5	902+70	6 ft. Lt.	WBL	133.0	5.2
6	903+00	9 ft. Lt.	WBL	132.5	5.7
7	903+35	9 ft. Lt.	WBL	132.7	5.1
8	903+70	3 ft. Lt.	WBL	132.7	5.8
9	904+00	6 ft. Lt.	WBL	132.5	5.2
10	904+25	9 ft. Lt.	WBL	132.8	5.5

B. How many roller passes were required to attain maximum density on the Control Strip? (use info from Step #1 TL-53)?

____

C. Does test pass the moisture criteria?

____

D. Is Control Strip within tolerance of roller pattern? ________________________

E. Does Direct Transmission Test validate Control Strip dry density? (See Page 8-47)

____

TL-54

VIRGINIA DEPARTMENTS OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR CONTROL STRIP

English **Metric**

Report No.____________________ **Date** ____________________

Route ____________________ **Project No.** ____________________

F.H.W.A. No. ____________________ **County** ____________________

Type Material ____________________ **Width** ____________________

Station ____________________ **ft. (m.)** **to Station** ____________________ **ft. (m.)**

Nuclear Gauge Model No. ____________________ **Serial No.** ____________________

Remarks ____

STANDARD COUNT

DENSITY _______ **MOISTURE** _______

	STATION	REFERNCE TO CENTER LINE ft. (m)	LANE	DRY DENSITY (lbs/ft^3) DRY UNIT MASS (kg/m^3)	MOISTURE CONTENT
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
			TOTAL:		
			AVG. :		

__________ **OPTIMUM MOISTURE REQUIRED (From Producer or Matls.Division)**

__________ **OPTIMUM MOISTURE RANGE**

(_______) x 0.95 = __________ **INDIVIDUAL DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3)**
Dens.Avg. **REQUIREMENT FOR TEST SECTION**

(_______) x 0.98 = __________ **AVERAGE DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3)**
Dens.Avg **REQUIREMENT FOR TEST SECTION**

By ____________________

Title ____________________

Cc: District Materials Engineer
Project File

Step #3 – Direct Transmission

TL-124

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)

English Metric

Report No.: **3-21ACTA-1** Date: ________ Sheet No.: **1** of **1**

Route No.: **7** County: **Loudoun**

Project No.: **0007-053-121,C501**

F.H.W.A. No.: **None**

Test For: **Direct Transmission on 21A at end of Control Strip**

Nuclear Gauge Model No.: **3440** Serial No.: **23456**

STANDARD COUNT

DENSITY	MOISTURE
2864	**709**

Test No.		**1**
Location / of / Test	Station ft. (m)	**901+35**
	Ref. to center line ft. (m)	**2' Rt.**
	Elevation	
Compacted Depth of Lift in. (mm)		**6"**
Method of Compaction		**Vib.Roller**
A. Wet Density (lbs/ft³), Wet Unit Mass (kg/m³)	=	**140.8**
B. Moisture Unit Mass (lbs/ft³), Moisture Unit Mass (kg/m³)	=	**7.2**
C. Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (A - B)	=	**133.6**
D. Moisture Content (B ÷ C) x 100	=	**5.4**
E. Maximum Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) Lab Proctor or One Point Proctor	=	**133.0**
F. Percent Optimum Moisture	=	**10.1**
G. Percent of plus #4, (plus 4.75mm)	=	**57**
H. Corrected Maximum Dry Density (lbs/ft³) Dry Unit Mass (kg/m³)	=	**145.3**
I. Corrected Optimum Moisture	=	**5.1** **5.1 - 7.1**
J. Percent Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (C ÷ E) x 100 or (C ÷ H) x 100	=	**92**
K. Percent Minimum Density Required	=	**90**

Calculations for Corrected Maximum Density

$$\frac{1}{\frac{0.57}{2.5 \times 62.4 = 156.0} + \frac{0.43}{133.0}} =$$

$$\frac{1}{.00365 + .00323} =$$

$$\frac{1}{.00688} =$$

145.3 lb/ft³

Calculations for Corrected Optimum Moisture

[(0.3 + 1) x 0.57] + [10.1 + 0.43]

0.741 + 4.343

5.084 = 5.1

Remarks:

CC: District Materials Engineer
Project File

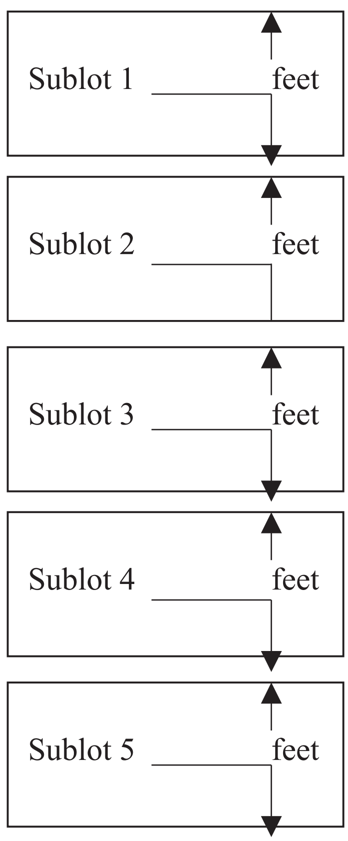
By: ____________________
Title: ____________________

Step #4 – Test Section

A. Testing at the minimum frequency: With the Test Section beginning at Sta 904+25 and 12 feet wide, choose 5 random sites to complete your test stations using the following random numbers.

Distance from Start of Sublot	Distance from Reference Line
101	4
106	8
27	3
140	3
182	10

5,280 feet in a mile. A Test Section is ______ mile per paver width or ______ feet.
_____ tests will be performed in the test section. _____ ÷ ____ = _____ feet per sublot.



Beginning Station No. 904+25

Station No. ________________

Station No. ________________

Station No. ________________

Station No. ________________

Ending Station No. ______________

Test No.	Station No. at start of sublot	Distance from start of sublot	Test at Station No.	Distance from reference line
1				
2				
3				
4				
5				

B. Transfer the OPTIMUM MOISTURE, OPTIMUM MOISTURE RANGE, INDIVIDUAL DRY DENSITY REQUIREMENT AND AVERAGE DRY DENSITY REQUIREMENT from the control strip to the proper location on the TL-55.

C. Given the following information, complete the TL-55 using the same header information as the preceding problems (except use correct report number).

Test No. 1

%PR	
WD = 139.8	
DD = 132.3	
M = 7.5	%M = 5.7

Test No. 4

%PR	
WD = 138.0	
DD = 131.3	
M = 6.7	%M = 5.1

Test No. 2

%PR	
WD = 138.4	
DD = 131.2	
M = 7.2	%M = 5.5

Test No. 5

%PR	
WD = 137.4	
DD = 129.6	
M = 7.8	%M = 6.0

Test No. 3

%PR	
WD = 137.4	
DD = 130.6	
M = 6.8	%M = 5.2

D. Does this test pass? ___________________Why?_________________________________

____

____

____

E. At what Station Number is Test No. 4 to be taken?___________________________

F. At what Station Number does Sublot 2 begin? ______________________________

G. How many feet from the reference line is Test No. 5 to be taken? _______________

TL-55

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR TEST SECTION

English **Metric**
Report No. ________________________________ **Date**_
Route No. ________________________________ **Project No.** ________________________________
FHWA No. ________________________________ **County** ________________________________
Type Material ______________________________ **Width**
Section No. ________________________ **Station** ________________ **ft (m.) to Station** ____________ **ft (m.)**
Nuclear Gauge Model No. ____________________ **Serial No.** ____________________________________
Remarks ____

DENSITY	**STANDARD COUNT**	**MOISTURE**
________________		___________

______________________ **OPTIMUM MOISTURE REQUIRED %**
(from Producer or Materials Division)

______________________ **OPTIMUM MOISTURE RANGE**

______________________ **INDIVIDUAL DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3) REQUIRED (95% of Control Strip Dry Density from TL-54)**

______________________ **AVERAGE DRY DENSITY (lbs/ft^3), DRY UNIT MASS (kg/m^3) REQUIRED (98% of Control Strip Dry Density from TL-54)**

TEST NO.	Station ft (m)	Lane	Dry Density (lbs/ft^3) Dry Unit Mass kg/m^3	Moisture Content	(P) Pass (F) Fail
1					
2					
3					
4					
5					
Average					

Comments:

CC: District Materials Engineer **By** ________________________________

Project File **Title** ________________________________