Report on the Use of High RAP Asphalt Concrete Mixes for the 2007 Lynchburg District Plant Mix Contracts

By

Robert A. Reid, P.E.

Virginia Department of Transportation

Lynchburg District Materials Section

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LYNCHBURG DISTRICT HIGH RAP REPORT

As part of the Evaluation Plan for High RAP mixes (Reclaimed Asphalt Pavement which make-up more than 20% of the asphalt mix), this report documents the Lynchburg District's experience with these mixes during the 2007 paving season. While a special provision was developed for High RAP mixes, this was not a part of any of the Lynchburg District paving schedules. Instead of the special provision, these mixes were permitted based on the contractor submitting a value engineering proposal. Based on a memorandum from Mal Kerley, P.E., VDOT Chief Engineer, an approach to assessing value engineering proposals (VEP) for High RAP mixes was developed utilizing a spreadsheet that analyzed the Department's computed unit price versus the unit price submitted by the contractor. Once the adjusted VEP unit price was computed by the Department, it was compared to the unit price submitted by the contractor in the VEP. If the Department's computed unit price was equal to or greater than the unit price submitted by the contractor, then the Department would accept the VEP at the contractor's lower unit price. If the computed unit price was less than the unit price submitted by the contractor, then further analysis and evaluation would be performed prior to accepting or rejecting the VEP.

The Lynchburg District received a total of three value engineering proposals for three separate paving contracts by two different asphalt paving contractors. Following is a summary of the three paving schedules that utilized high RAP mixes in 2007, including contractor and plant information and field operations.

MARVIN V. TEMPLETON & SONS, MT. ATHOS PLANT
CONTRACT : PM-3B-07 (APPOMATTOX RESIDENCY)

Schedule Information

The contract awarded to Marvin V. Templeton and Sons consisted of approximately 24,841 tons of SM-9.5D in Appomattox and Campbell Counties. The unit price on the awarded contract was $51.95/ton. The unit price for the value engineering proposal

(VEP), which increased the RAP percentage from 15 to 25, was $49.87/ton. This VEP was accepted by the Department. The majority of the placement occurred on Rte. 24 in Campbell and Appomattox Counties, with some additional paving on Route 691 in Appomattox County.

Schedule Quantities for Appomattox County

Route	Pavement Description	From (MP)	To (MP)	Length (mi)	Width (ft)	Tonnage
24 Both	Mainline Pavement	8.64	8.83	0.19	65	598
	Connections					175
24 Both	Mainline Pavement	8.83	16.60	7.77	25	9,402
	Connections					875
691 Both	Mainline Pavement	0.00	0.46	0.46	20	445
	Connections					50
691 Both	Mainline Pavement	0.00	2.29	2.29	22	2,438
	Connections					150

Schedule Quantities for Campbell County

Route	Pavement Description	From (MP)	To (MP)	Length (mi)	Width (ft)	Tonnage
24 Both	Mainline Pavement	14.59	22.39	7.80	25	9,438
	Connections					650

Plant Background

The Mt. Athos plant for Marvin V. Templeton and Sons is located just east of Lynchburg on the site of a Boxley aggregates quarry and predominately serves Campbell and Appomattox Counties. The plant at this location is a CMI plant with a Counter flow drum (See Figure 1). The production rate is approximately 400 tons of Hot Mix Asphalt (HMA) per hour with a typical operating temperature of 300 degrees F. The plant has a Gencor single Silo that holds about 200 tons of HMA.

Figure 1 – Marvin V. Templeton's Mt. Athos Plant

The Mt. Athos plant normally uses between 15 to 20% RAP in their HMA mixes. The estimated maximum RAP capacity of this plant is 30%. For the Appomattox Residency Schedule, the RAP percentage used was 25%. Gradations and asphalt content testing of the RAP stockpiles were checked once per week as part of the plants' quality control. The percent moisture from the RAP stockpiles was performed on a daily basis during production. The stockpiles in general were not protected with any special covering. The source of the RAP for this plant came from milling operations on various routes within the Lynchburg District.

The RAP processing consisted of utilizing a Proto Grind 1200 Tub Grinder to perform the crushing operation from stockpiles at the plant, shown in Figures 2 and 3. The processed RAP stockpiles are shown in Figures 4 and 5. Note the dime in Figure 5. Before introduction into the plant, the RAP was passed over a 2 inch scalping screen (see Figure 6). The RAP enters the drum approximately 16 feet from the exit end of the drum. The maximum size aggregate from the RAP used in this SM-9.5D mix was 1/2 inch.

Figure 2 – RAP Grinder used for initial processing by MVT

Figure 3 – RAP Grinder used for initial processing by MVT

Figure 4 – RAP after Processing at Mt. Athos Plant

Figure 5 – RAP after processing at Mt. Athos Plant

Figure 6 – RAP Scalping Screen (left) and Conveyer (right) at Mt. Athos Plant

Job Mix Formula

The initial job mix formula for the SM-9.5D mix with 25% RAP was as follows:

Material/ Mix Property	**Design Value**
#8 Aggregate (Boxley, Mt. Athos)	43%
Natural "B" Sand (Otter River)	22%
Manuf. "B" Sand (Boxley, Mt. Athos)	10%
RAP (Various Rtes.)	25%
Design AC Content (PG64-22, Citgo, Hopewell Va)	5.5%
Design VTM	3.9%
Design G_{mm}	2.598

A slight adjustment was made to the job mix formula during production by decreasing the percentage passing the #200 sieve from 5.6 to 4.8 after approximately 14,000 tons had been produced and after two lots were assessed a penalty. No further adjustments to the job mix formula were made during production.

The normal mix design for SM-9.5D produced by the Mt. Athos plant consisted of 15% RAP with a higher asphalt content of 5.6% and stiffer binder, PG 70-22. The percentage

of #8 virgin aggregate used in the 15% RAP mix was 12% higher, while the "B" sand was 2% lower than the High RAP mix. According to Marvin V. Templeton and Sons, the predominant savings were in using the softer binder grade, PG64-22, at $300/ton, over the stiffer binder grade, PG70-22, at $315/ton and using less #8 aggregate. They report their costs for handling, hauling, and processing RAP average $9.45/ton.

Laboratory Test Results

The total tonnage of 24,841 was produced in 13 lots. Of the 13 lots, two lots were assessed a penalty or an adjustment. VDOT assesses a penalty of one adjustment point for each 1.0% above or below the acceptance range for gradation on a lot of material on the #200 sieve. The total adjustment was 1.8 points, which was 0.9 points per lot. In this case the unit price of the asphalt mix was reduced (adjusted) by 0.9% on each of the two lots in which the #200 sieve was outside the acceptance range.

The following tables summarize the gradation and asphalt content data and volumetric test data, acceptance ranges, and statistical comparisons between the producer and VDOT. Note there are two separate job mixes reflecting the change in the #200 material. The initial job mix #3014-2007-12 represented the first 7 lots produced while the revised job mix #3014-2007-15 represented the final 6 lots.

Gradation and Asphalt Content Test Data (Job Mix #3014-2007-12)

Test Item	Mix Design	Accept Range	Producer Results			VDOT Monitor Results			Non-Matched Statistical Comparison			
			N	X	s	N	X	s	F	$F_{(99)}$	|Xm-Xc|	μ
1/2"	100	100	28	99.1	0.37	11	98.5	0.7	2.90	4.47	0.31	0.69
3/8"	94	90-98		93.5	1.27		92.5	2.11	3.69	4.47	0.52	3.45
#4	58	54-62		58.7	2.33		56.7	3.13	2.06	4.47	1.96	4.76
#8	44	40-48		41.3	1.22		40.7	1.42	1.21	4.47	0.56	1.98
#200	5.6	4.6-6.6		4.8	0.58		4.1	0.81	1.94	9.59	0.49	0.64
AC	5.5	5.2-5.8		5.67	0.12		5.7	0.13	1.66	4.47	0.02	0.21

Volumetric Test Data(Job Mix #3014-2007-12)

Test Item	Mix Design	Accept Range	Producer Results			VDOT Monitor Results			Statistical Comparison (All Samples)			
			N	X	s	N	X	s	F	$F_{(99)}$	|Xm-Xc|	μ
VTM	3.9	2.0-5.0	20	3.14	0.60	11	2.7	0.56	1.15	5.23	0.44	0.60
VMA	15.7	15 min.		16.65	0.24		15.59	0.67	7.79	3.93	1.06	0.64
VFA	75.2	68-84		81.15	3.43		82.79	2.95	1.35	5.23	1.64	3.26
F/A	1.02	0.6-1.2		0.86	0.09		0.72	0.15	2.77	3.93	0.14	0.15

Gradation and Asphalt Content Test Data (Job Mix #3014-2007-15)

Test Item	Mix Design	Accept Range	Producer Results			VDOT Monitor Results			Non-Matched Statistical Comparison			
			N	X	s	N	X	s	F	$F_{(99)}$	|Xm-Xc|	μ
1/2"	100	100	22	99.8	0.28	6	98.5	0.84	10.55	6.16	1.54	2.83
3/8"	94	90-98		93.7	1.07		92.7	1.03	1.37	6.16	1.37	2.81
#4	58	54-62		60.4	1.40		59.5	1.87	2.17	6.16	1.22	5.36
#8	44	40-48		42.4	1.07		42.7	1.75	2.18	6.16	0.47	3.95
#200	4.8	3.8-5.8		4.4	0.42		4.1	0.24	2.61	42.94	0.41	0.55
AC	5.5	5.2-5.8		5.68	0.10		5.7	0.17	10.39	6.16	0.13	0.46

Volumetric Test Data(Job Mix #3014-2007-15)

Test Item	Mix Design	Accept Range	Producer Results			VDOT Monitor Results			Statistical Comparison (All Samples)			
			N	X	s	N	X	s	F	$F_{(99)}$	|Xm-Xc|	μ
VTM	3.9	2.0-5.0	10	2.92	0.61	6	2.98	0.62	1.03	7.47	0.06	0.97
VMA	15.7	15 min.		15.79	0.53		15.82	0.19	7.78	13.77	0.03	0.56
VFA	75.2	68-84		81.59	3.49		81.05	3.82	1.20	7.47	0.54	5.84
F/A	0.87	0.6-1.2		0.73	0.06		0.71	0.05	1.44	13.77	0.02	0.08

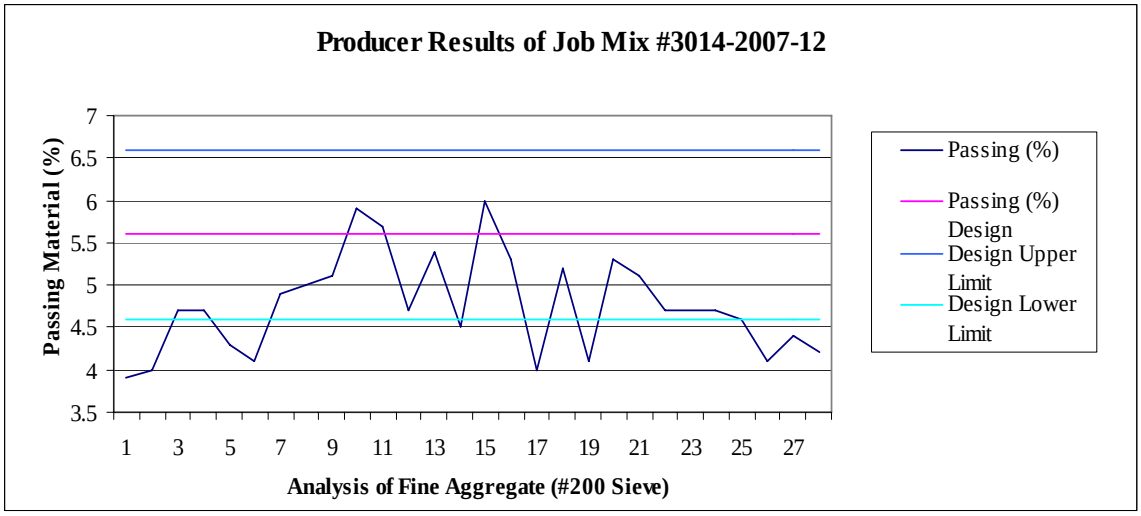
N = number of samples
X = mean or average value
s = standard deviation

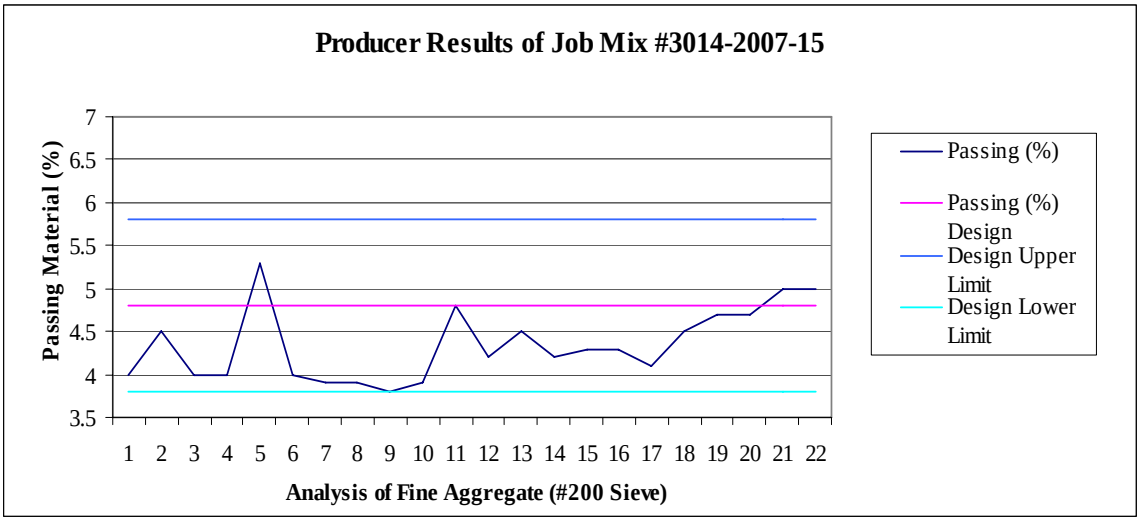
F = calculated value of F (test statistic of variability)
$\mathbf{F_{(99)}}$ = critical value of F (rejection region)
|Xm-Xc| = difference of monitor/contractor mean test values (test statistic)
μ = critical value of t (rejection region)

Notes: The non-matched statistical method (utilized for both aggregate gradation and asphalt content) is a comparison of the producer lot acceptance sample population to the VDOT monitor sample population, in which matched split sample results are excluded from the analysis, as specified in Virginia Test Method 59. As such, the analysis compared 21 producer samples to 7 VDOT monitor samples for job mix #3014-2007-12 and 18 producer samples to 4 VDOT monitor

samples for job mix #3014-2007-15. For job mix #3014-2007-12, the non-matched statistical comparison demonstrated that the producer and monitor results agreed for the High RAP mix produced by the contractor and, therefore, verified that all specifications were met for both aggregate gradation and asphalt content. For job mix #3014-2007-15, the non-matched statistical comparison did not meet the VTM-59 comparison criteria for the percent passing the ½" sieve and asphalt content. After review of the data, it was determined that the sample populations did not compare on the ½" sieve because VDOT monitor samples in lot 8 sample 3 and lot 10 sample 2 retained 2% and 3% more aggregate particles than the contractors samples. This was probably due to the retention of one or two aggregate particles on a sieve where most all of the aggregate particles pass. A review of the asphalt content data showed that the matched or IA split sample data on VDOT and contractor samples compared but were 0.2% to 0.3% higher than the overall population average. In the non-matched statistical comparison, the contractors' split samples are eliminated from the data set. The non-matched comparison then showed a statistical difference in populations with VDOT monitor samples 0.3% higher than the Job Mix Formula and the contractors' data 0.1% higher than the JMF.

In addition, it should be noted that statistical comparisons of the volumetric test data were performed for informational purposes only and included all 20 producer samples and all 11 VDOT monitor samples for Job mix #3014-2007-12 and all 10 producer samples to 6 VDOT monitor samples for Job mix #3014-2007-15. All of the volumetrics for both job mix #'s 3014-2007-12 and 3014-2007-15 compared using F and T test comparison criteria, with the single exception of Voids in Mineral Aggregate (VMA) for job mix #3014-2007-12. In examining the data, it appears that the VDOT monitor sample results were 1% lower on VMA than the contractor sample results. After the mix design was revised, the mix volumetrics met all of the comparison criteria.





From review of the graphical data, it is evident that the adjustment on the #200 sieve from 5.6 percent passing to 4.8 percent passing produced no deviations below the lower acceptance limit and the variability was reduced for both producer and monitor results.

Field Operations and Monitoring Issues

The first placement utilizing the initial job mix formula (#3014-2007-12) occurred on Route 691 in Appomattox County between May 22 and May 24, 2007 during the daytime hours. No night paving was performed during the duration of this schedule. Subsequent paving was completed on SR 24 in Appomattox County between May 31 and June 19, 2007. On June 19, the change was made to the revised job mix formula (#3014-2007-15). The remainder of the paving occurred on SR 24 in Campbell County between August 8 and August 18, 2007.

Transport temperatures at the plant ranged from 285º F to 350º F, with an average temperature of 320º F. Haul distances from the plant ranged from a minimum of 13 miles on SR 24 in Campbell County to a maximum of 21 miles on SR 24 in Appomattox County. Haul times ranged from 20 to 30 minutes for all of the routes on the schedule. No issues were observed regarding failing temperatures on the project.

A total of three control strips were evaluated for this schedule. The densities of the plugs averaged 94.2% of G_{mm}, validating the target nuclear density by meeting the minimum

requirement of 92.2% for an SM-9.5D mix. All VDOT QA test results of the plugs were within the acceptable tolerance of +/- 0.01 of G_{mb}.

A total of 37 lots or test sections were evaluated by the contractor with an average nuclear density of 99.0%. None of the test sections were reported as failing or outside of the acceptance range (98%-102% of the target nuclear density). No Q.A. or I.A. nuclear density testing was performed by the Department for this schedule.

MARVIN V. TEMPLETON & SONS, PINEY RIVER PLANT

CONTRACT : PM03-062-241,N501 (NELSON COUNTY)

Schedule Information

The contract awarded to Marvin V. Templeton and Sons consisted of approximately 24,898 tons of SM-12.5D in Nelson County. This project was the first plant mix contract in the Lynchburg District using federal dollars and included a substantial amount of guardrail and shoulder work. All of the paving work consisted of milling the existing pavement surface and replacing with 1.5 inches of SM-12.5D. The unit price on the awarded contract was $51.95/ton, while the value engineering proposal price was $49.93/ton. This VEP increased the RAP percentage from 20 to 25 and was accepted by the Department. All of the placement occurred on US 29 in Nelson County. Approximately 4,500 tons were eliminated from the original schedule when some additional milling was needed to remove a layer of latex microsurfacing below the previous surface layer. The northernmost section of US 29NB was cut short as a result of the extra work.

Schedule Quantities for Nelson County

Route	Pavement Description	From (MP)	To (MP)	Length (mi)	Width (ft)	Tonnage
29 SBL	Mainline Pavement	0.00	7.67	7.67	30	12,149
29 NBL	Mainline Pavement	0.00	1.95	1.95	26	2,677
29 NBL	Mainline Pavement	15.32	19.23	3.91	26	5,368
29 NBL	Mainline Pavement	10.76	12.14	1.38	26	1,894
29 NBL	Mainline Pavement	5.56	8.67	3.11	26	4,269

Plant Background

The Piney River plant for Marvin V. Templeton and Sons, is located in Amherst County on Rte. 665 approximately 1 mile from SR151 on a Boxley aggregates quarry site and predominately serves Amherst and Nelson Counties. The plant at this location is a Gencor plant with a Counter flow drum. The production rate is approximately 300 tons of Hot Mix Asphalt (HMA) per hour with a typical operating temperature of 300 degrees F. The plant has a Gencor single Silo that holds about 200 tons of HMA. (See Figure 7)

Figure 7 – Marvin V. Templeton's Piney River Plant

The Piney River plant normally uses between 15 to 20% RAP in their HMA mixes. The estimated maximum RAP capacity for this plant is 40%. For the Nelson County Schedule the RAP percentage used was 25%. Gradations and asphalt content testing of the RAP stockpiles were checked once per week as part of the plants' quality control. The percent moisture from the RAP stockpiles was performed on a daily basis during production. The stockpiles in general were not protected with any special covering. The source of the RAP for this plant came from milling operations on this contract, US 29 in Nelson County.

RAP processing at the Piney River plant normally consists of utilizing a Proto Grind 1200 Tub Grinder to perform the crushing operation from stockpiles at the plant, shown previously for the Mt. Athos Plant in Figures 2 and 3. For this project, the millings on US 29 were not processed through the tub grinder but introduced directly into the plant. The unprocessed RAP stockpiles are shown in Figure 8, while the processed RAP stockpiles are shown in Figures 9 and 10. Note the quarter in Figure 10. Before introduction into the plant, the RAP was passed over a 2 inch scalping screen (see Figure 11). The RAP enters the drum approximately 16 feet from the exit end of the drum. The maximum size aggregate from the RAP used in this SM-12.5D mix was ¾ inch.

Figure 8 – Unprocessed RAP at Piney River plant

Figure 9 – Processed RAP at Piney River plant

Figure 10 – Processed RAP at Piney River plant

Figure 11 – RAP Scalping Screen and Conveyer

Job Mix Formula

The initial job mix formula for the SM-12.5D mix with 25% RAP was as follows:

Material/ Mix Property	**Design Value**
#78 Aggregate (Boxley, Piney R.)	30%
Manuf. "B" Sand (Boxley, Piney R.)	30%
#8 Aggregate (Boxley, Piney R.)	15%
RAP (US 29, Nelson Co.)	25%
Design AC Content (PG64-22, Assoc. Asphalt, Roanoke Va)	5.7%
Design VTM	4.0%
Design G_{mm}	2.558

The normal mix design for SM-12.5D produced by the Piney River plant consisted of 15% RAP with a higher asphalt content of 5.8% and stiffer binder, PG 70-22. The percentage of #78 virgin aggregate used in the 15% RAP mix was 10% higher and the "B" sand was 5% higher, while the #8 aggregate percentage was 5% lower. According to Marvin V. Templeton and Sons, the predominant savings were in using the softer binder

grade, PG64-22, at $300/ton, over the stiffer binder grade, PG70-22, at $315/ton and using less #78 aggregate. They report their costs for handling, hauling, and processing RAP average $9.45/ton.

Laboratory Test Results

The total tonnage of 24,898 consisted of 13 complete lots and 1 partial lot. No adjustment points were applied to any of the lots.

The following tables summarize the gradation and asphalt content data and volumetric test data, acceptance ranges, and statistical comparisons between the producer and VDOT.

Gradation and Asphalt Content Test Data (Job Mix #3005-2007-06)

Test Item	Mix Design	Accept Range	Producer Results			VDOT Monitor Results			Non-Matched Statistical Comparison			
			N	X	s	N	X	s	F	$F_{(99)}$	|Xm-Xc|	μ
3/4"	100	100	53	100	0.00	17	100	0.00				
1/2"	96	92-100		96.8	1.26		97.7	1.21	1.21	4.24	0.99	1.14
3/8"	86	82-90		86.4	2.52		86.8	2.79	1.32	2.97	0.27	2.67
#8	44	40-48		42.8	2.28		42.6	3.39	2.62	2.97	0.51	2.98
#200	5.1	4.1-6.1		5.4	0.42		5.5	0.51	1.09	4.24	0.09	0.39
AC	5.7	5.4-6.0		5.72	0.19		5.7	0.22	2.28	2.97	0.03	0.21

Volumetric Test Data (Job Mix #3005-2007-06)

Test Item	Mix Design	Accept Range	Producer Results			VDOT Monitor Results			Statistical Comparison (All Samples)			
			N	X	s	N	X	s	F	$F_{(99)}$	|Xm-Xc|	μ
VTM	4.0	2.0-5.0	32	3.48	1.03	17	3.57	1.11	1.15	2.94	0.09	0.89
VMA	16.1	14 min.		15.43	0.82		15.51	0.94	1.31	2.94	0.08	0.74
VFA	75.0	65-83		77.67	5.71		75.24	9.22	2.61	2.94	2.43	6.86
F/A	1.0	0.6-1.2		1.08	0.10		1.09	0.09	1.23	3.53	0.01	0.08

N = number of samples
X = mean or average value
s = standard deviation

F = calculated value of F (test statistic of variability)
$\mathbf{F_{(99)}}$ = critical value of F (rejection region)
|Xm-Xc| = difference of monitor/contractor mean test values (test statistic)
μ = critical value of t (rejection region)

Notes: The non-matched statistical method (utilized for both aggregate gradation and asphalt content) is a comparison of the producer lot acceptance sample population to the VDOT monitor sample

population, in which matched split sample results are excluded from the analysis, as specified in Virginia Test Method 59. As such, the analysis compared 40 producer samples to 13 VDOT monitor samples. The non-matched statistical comparison demonstrated that the producer and monitor results agreed for the High Rap mix produced by the contractor and, therefore, verified that all specifications were met for both aggregate gradation and asphalt content.

In addition, it should be noted that statistical comparisons of the volumetric test data were performed for informational purposes only and included all 32 producer samples and all 17 VDOT monitor samples.

Field Operations and Monitoring Issues

All of the schedule work consisted of milling and replacing the existing mainline pavement on US 29 in Nelson County. One problem that surfaced during milling was the need to mill deeper on a section located North of Lovingston beginning at Milepost 10.76 after a layer of microsurfacing was discovered under the existing 1.5 inch surface layer. Unfortunately this was not discovered until approximately one lane mile of mix had already been placed. The construction project manager noticed the new lane was heaving and moving during coring operations. Subsequent investigation revealed that the microsurfacing layer had very little bond strength to the underlying layer, which required that the new lane be milled deeper, up to 2.0 inches, and replaced.

The additional work necessitated that one of the pavement sections be cut short. It was decided that the northernmost northbound section would be ended approximately 2.0 miles short. There are plans to complete this section under the 2008 schedule.

The paving on US 29 took place over the duration of 7 weeks between August 27 and October 10 of 2007. All of the paving was performed during the daytime hours. Transport temperatures at the plant ranged from 292º F to 320º F, with an average temperature of 310º F. Haul distances from the plant ranged from a minimum of 7 miles to a maximum of 22 miles. Haul times ranged from 10 to 30 minutes depending on the proximity to the plant for sections on the schedule. No issues were observed regarding temperatures on the project.

One control strip was evaluated for this schedule. The densities of the plugs averaged 93.5% of G_{mm}, validating the target nuclear density by meeting the minimum requirement of 92.2% for an SM-12.5D mix. All six of the plugs tested by VDOT for Quality

Assurance were within the +/- 0.01 tolerance of G_{mb} for comparison with the contractor results.

A total of 39 lots or test sections were evaluated by the contractor with an average nuclear density of 99.6%. None of the test sections were reported as failing or outside of the acceptance range (98%-102% of the target nuclear density).

Independent Assurance and Quality Assurance density testing were performed by VDOT on the control strip and 8 test sections, representing 20% of the total paved lane miles. The average nuclear density for Q.A. testing was 99.9% with all lots within the acceptance range of 98% to 102%.

All of the sections on this contract had the rideability special provision applied. All of the lanes received an incentive. The following Table shows the International Roughness Index (IRI) numbers before and after paving, the percent change or improvement and the incentive paid to the contractor on each section.

Rideability Results for US 29, Nelson County

Lane	MP From	MP To	Before IRI	After IRI	% Change	$ Incentive/Disincentive
SB-1	0.00	7.67	58	56	3	22,208.95
SB-2	0.00	7.67	62	51	18	28,517.58
NB-1	0.00	1.95	93	58	38	4,216.48
NB-2	0.00	1.95	87	53	39	6,002.85
NB-1	5.56	8.67	84	57	32	8,046.72
NB-2	5.56	8.67	80	51	36	11,490.72
NB-1	10.76	12.41	91	65	29	1,094.35
NB-2	10.76	12.41	101	58	43	3,250.88
NB-1	15.32	19.20	64	59	8	7,692.67
NB-2	15.32	19.20	58	55	5	11,844.77
SB-1	0.00	7.67	58	56	3	22,208.95

W-L CONSTRUCTION AND PAVING, SHELTON PLANT

CONTRACT: PM-3E-07

Schedule Information

The contract awarded to W-L Construction and Paving consisted of approximately 31,940 tons of SM-9.5D in Pittsylvania County. The unit price on the awarded contract was $46.73/ton, while the value engineering proposal price was $45.65/ton, which increased the RAP percentage from 15 to 21 and was accepted by the Department. The majority of the savings occurred when the contractor was able to "bump" down one grade to a softer binder, PG64-22, from PG70-22. The majority of the placement occurred on US 29 with some additional paving on SR 57, Rte. 729, Rte. 640 and Rte. 988.

Schedule Quantities for Pittsylvania County

Route	Pavement Description	From (MP)	To (MP)	Length (mi)	Width (ft)	Tonnage
29 SBL	Mainline Pavement Ramps	9.24	7.57	1.67	25	2,021 66
29 NBL	Mainline Pavement Connections	27.49	29.18	1.69	30	2,454 896
29 NBL	Mainline Pavement Connections	37.93	43.10	4.98	30	7,231 581
29 NBL	Mainline Pavement Connections	44.93	47.51	2.58	32	4,015 151
29 NBL	Mainline Pavement Connections	0.37	4.17	3.80	28	5,150 1125
57 Both	Mainline Pavement Connections	18.82	21.79	2.75 0.10	24 24	3,194 116
640 Both	Mainline Pavement Connections	0.00	3.84	3.84 0.04	21 21	3,903 43
729 Both	Mainline Pavement Connections	0.00	2.21	2.21 0.05	24 28	2,567 68
988 Both	Mainline Pavement Connections	0.00	1.00	1.00	24	1,162 182

Plant Background

The Shelton plant for W-L Construction and Paving is located just south of Danville on the site of a Vulcan Materials aggregates quarry in Pelham North Carolina and predominately serves Pittsylvania County. The plant at this location is an Astec Double Barrel counter flow drum. The production rate is approximately 400 tons of Hot Mix Asphalt (HMA) per hour with a typical operating temperature of 300 degrees F. The plant has three Astec silos, two that hold 200 tons each and one that holds 50 tons of HMA (See Figure 12).

Figure 12 – W-L Construction's Shelton Plant

The Danville plant normally uses between 10 to 20% RAP in their HMA mixes. The estimated maximum RAP capacity for this plant is 30%. For the Pittsylvania County Schedule the RAP percentage used was 21%. Gradations and asphalt content testing of the RAP stockpiles were checked once per week when RAP was being crushed as part of the plants' quality control. The percent moisture from the RAP stockpiles was performed on a daily basis during production. The stockpiles in general were not protected with any special covering. The source of the RAP for this plant came from milling operations on various routes in the District and neighboring counties in North Carolina.

The RAP processing consisted of an off-site central storage location by an outside contractor that crushed RAP over 5/8 inches in size using an International Aggregates Impact Crusher. This was then blended with uncrushed -5/8 inch RAP, hauled to the Shelton plant and stored in a separate stockpile, that was sloped and well draining. The processed RAP stockpiles are shown in Figures 13 and 14. The RAP enters the drum approximately 3 feet from the end of the double barrel drum. The maximum size aggregate from the RAP used in this SM-9.5D was 1/2 inch.

Figure 13 – RAP after Processing at Shelton Plant

Figure 14 – RAP after Processing at Shelton Plant

Job Mix Formula

The initial job mix formula for the SM-9.5D mix with 21% RAP was as follows:

Material/ Mix Property	**Design Value**
#8 Aggregate (Vulcan, Shelton)	40%
#10 Screenings (Vulcan, Shelton)	27%
RAP (Various Rtes.)	21%
Sand (W-L, Dan River/Halifax)	12%
Design AC Content (PG64-22, Citgo, Hopewell Va)	5.9%
Design VTM	3.8%
Design G_{mm}	2.436

The normal mix design for SM-9.5D produced by the Shelton plant consisted of 15% RAP with a higher asphalt content of 6.0% and stiffer binder, PG 70-22. The percentage of sand and #10 screenings used in the 15% RAP mix were both 3% lower. According to Doug Dawson of W-L Construction and Paving, Inc., the predominant savings were in using the softer binder grade, PG64-22, at $290/ton, over the stiffer binder grade, PG70-

22, at $305/ton and using less sand and #10 screenings. They report their costs for handling, hauling, and processing RAP average $5/ton.

Laboratory Test Results

The total tonnage of 31,940 consisted of 15 complete lots and 1 partial lot. No adjustment points were applied to any of lots.

The following tables summarize the gradation and asphalt content data and volumetric test data, acceptance ranges, and statistical comparisons between the producer and VDOT.

Gradation and Asphalt Content Test Data (Job Mix #3007-2007-18)

Test Item	Mix Design	Accept Range	Producer Results			VDOT Monitor Results			Non-Matched Statistical Comparison			
			N	X	s	N	X	s	F	$F_{(99)}$	|Xm-Xc|	μ
1/2"	100	100	64	99.6	0.34	22	99.6	0.58	1.98	2.72	0.18	0.36
3/8"	94	90-98		94.0	1.05		93.8	1.14	1.06	3.71	0.09	0.90
#4	63	59-67		62.7	2.12		62.0	2.08	1.47	3.71	0.57	1.52
#8	46	42-50		46.0	1.84		46.3	1.96	1.44	3.71	0.16	1.37
#200	5.8	4.8-6.8		6.1	0.27		6.2	0.30	1.57	3.71	0.18	0.20
AC	5.9	5.6-6.2		5.91	0.20		5.8	0.18	1.23	3.71	0.07	0.15

Volumetric Test Data (Job Mix #3007-2007-18)

Test Item	Mix Design	Accept Range	Producer Results			VDOT Monitor Results			Statistical Comparison (All Samples)			
			N	X	s	N	X	s	F	$F_{(99)}$	|Xm-Xc|	μ
VTM	3.8	2.0-5.0	60	3.05	0.74	22	3.20	0.58	1.63	2.83	0.15	0.41
VMA	15.8	15 min.		15.65	0.45		15.60	0.42	1.15	2.83	0.05	0.29
VFA	74.6	68-84		80.70	4.15		79.64	3.39	1.50	2.83	1.06	2.41
F/A	1.1	0.6-1.2		1.11	0.06		1.18	0.06	1.20	2.37	0.07	0.04

N = number of samples
X = mean or average value
s = standard deviation

F = calculated value of F (test statistic of variability)
$\mathbf{F_{(99)}}$ = critical value of F (rejection region)
|Xm-Xc| = difference of monitor/contractor mean test values (test statistic)
μ = critical value of t (rejection region)

Notes: The non-matched statistical method (utilized for both aggregate gradation and asphalt content) is a comparison of the producer lot acceptance sample population to the VDOT monitor sample population, in which matched split sample results are excluded from the analysis, as specified in

Virginia Test Method 59. As such, the analysis compared 49 producer samples to 15 VDOT monitor samples. The non-matched statistical comparison demonstrated that the producer and monitor results agreed for the High Rap mix produced by the contractor and, therefore, verified that all specifications were met for both aggregate gradation and asphalt content.

In addition, it should be noted that statistical comparisons of the volumetric test data were performed for informational purposes only and included all 60 producer samples and all 22 VDOT monitor samples. All of the volumetrics compared using F and T test comparison criteria, with the single exception being Fines/Asphalt (F/A) ratio. In examining the data, it appears that the VDOT monitor results for F/A ran consistently higher than the contractor results, thus contributing to the results not comparing using the T test comparison criteria.

Field Operations and Monitoring Issues

The first paving in Pittsylvania County utilizing job mix formula #3007-2007-18 took place on Rte. 729 between September 4 and September 6, 2007 during the daytime hours. No night paving was performed during the duration of this schedule. Between September 11 and September 20, 2007 paving was completed on US 29 Northbound nearest the plant near the N.C. border. From there, paving was completed on SR 57 and Rte. 988 between September 21 and September 28, 2007. The remainder of the paving on US 29 was completed between October 3 and November 9, 2007. The final route, 640, was completed between November 13 and November 17, 2007.

Transport temperatures at the plant ranged from 285º F to 350º F, with an average temperature of 320º F. Haul distances from the plant ranged from a minimum of 5 miles on US 29 to a maximum of 50 miles on US 29 and Rte. 988 near the Campbell County line. Haul times ranged from 10 minutes to 60 minutes depending on the route and proximity to the plant. No issues were observed regarding temperatures on the project.

A total of five control strips were evaluated for this schedule. The initial control strip placed on Rte. 729 failed with an average plug density of 91.3% of G_{mm}, or less than the minimum requirement of 92.2% for an SM-9.5D mix. The remaining four control strip plug densities averaged 92.5% of G_{mm}, with each exceeding the minimum requirement. One of six plugs tested by VDOT for Quality Assurance was not within the +/- 0.01 tolerance of G_{mb} but was within 0.015 of the contractor results and was not deemed significant as the remainder of the cores were within the comparison criteria.

A total of 49 lots or test sections were evaluated by the contractor with an average nuclear density of 99.4%. One test section was reported as failing with an average density of 97.4%, representing 671 tons. All of the remaining test sections were reported within the acceptance range (98%-102% of the target nuclear density). No Q.A. or I.A. nuclear density testing was performed by the Department for this schedule.

Three of the sections on US 29 in this contract had the rideability special provision applied. Five of the six lanes received an incentive. The following Table shows the International Roughness Index (IRI) numbers before and after paving, the percent change or improvement and the incentive paid to the contractor on each section.

Rideability Results for Pittsylvania County

Lane	MP From	MP To	Before IRI	After IRI	% Change	$ Incentive/Disincentive
NB-1	27.49	29.18	92	70	24	0.00
NB-2	27.49	29.18	80	57	29	2,863.35
NB-1	37.93	43.10	77	65	16	4,233.96
NB-2	37.93	43.10	73	64	12	5,265.31
NB-1	44.93	47.51	82	67	18	1,967.71
NB-2	44.93	47.51	96	69	28	705.66

Form TL-127 (Rev. 11/05)

Ron

VIRGINIA DEPARTMENT OF TRANSPORTATION

MATERIALS DIVISION

STATEMENT OF ASPHALT CONCRETE OR CENTRAL-MIX AGGREGATE JOB-MIX FORMULA

Submit to the District Administrator, Virginia Department of Transportation. Approval must be received by the contractor from the Materials Division before work is begun. This job-mix design is approved for all projects of the Department for the type of mix and the calendar year shown below.

Contractor Design Mix No. _____ Design Lab No. L-2

Date 4/3/2007 Job Mix ID No. 3014-2007-12 Calendar Yr. 2007 TSR Test No. _____

Type Mix / Size Aggregate SM-9.5D RAP (25%)

Producer Name & Plant Location Marvin V. Templeton & Sons, Inc. - Mt. Athos Phone 434-845-3606

Materials					Kind	Source
Approval Phase	A	B*	C			
Aggregate	43	43		%	#8s	Boxley Aggregates - Mt. Athos
Aggregate				%		
Rap	25	25		%	RAP	Various Routes - Lynchburg District
Sand	22	22		%	"B" Grade Natural	Otter River - Evington, VA
Screening	10	10		%	"B" Grade Manufactured	Boxley Aggregates - Mt. Athos
Lime				%		
Asphalt Cement					PG 64-22	Citgo Oil Co. - Hopewell, VA
Asphalt Prime/Tack						
Additives:						
ARRMAZ	0.5	0.5			Ad-Here 62-40	ARRMAZ - Mulberry, FL

Job-Mix Sieves	Total % Passing		Tolerance % + or -	Acceptance Range Average of 4 Test(s)		End of Year Average	Design/Spec. Range
	Lab JMF	Production JMF					
Approval Phase	A	B*		A	B	C	
1/2"	100	100	-	100	100		100
3/8"	94	94	+/-4	90-98	90-98		90-100
#4	58	58	+/-4	54-62	54-62		80 max
#8	44	44	+/-4	~~36-44~~	40-48		38-67
#200	5.6	5.6	+/-1	~~3.8-5.8~~	4.6-6.6		2-10
Asphalt (%)	5.5	5.5	+/-0.3	5.2-5.8	5.2-5.8		

Lay Down Temperatures	270-350 °F(°C)	Muffle Furnace Correction Factor:	0.11
		Field Correction Factor ($G_{se} - G_{sb}$):	0.040
Lab Compaction Temperatures	295-300 °F (°C)	Pill Weight:	5150
		SMA Mixes	
		VCA_{DRC}:	
Producer Technician's Certification Number	Ken Arthur	G_{CA}:	

MATERIALS DIVISION USE ONLY

Remarks

Nominal Max. Size Aggregate	3/8"	Application Rates:	Min.	110 lb/yd³ (~~kg/m³~~)	Max.	175 lb/yd³ (~~kg/m³~~)	
Mix Properties at the Job-Mix Asphalt Content:	Compacted Unit Weight	155.8 lb/ft³ (~~kg/m³~~)	VTM:	3.9%	G_{mm}:	2.598	

Checked By: TNK

Approved tentatively subject to the production of material meeting all other applicable requirements of the specification.

* Note: Part B 'Production JMF' and corresponding Material percentages will be filled out by the DME upon receipt of the additional requirements of the HMA producer within the first three lots under Section 502.01(b)

Copies:	Approvals				
State Materials Engineer			Part A:	H.D. Ford	Date: 5/11/07
District Materials Engineer			Part B:	H.D. Ford	Date: 7/13/07
Project Inspector			Part C:		Date:
Sub-Contractor and/or Producer					

Form TL-127 (Rev. 11/05)

Ron

VIRGINIA DEPARTMENT OF TRANSPORTATION

MATERIALS DIVISION

STATEMENT OF ASPHALT CONCRETE OR CENTRAL-MIX AGGREGATE JOB-MIX FORMULA

Submit to the District Administrator, Virginia Department of Transportation. Approval must be received by the contractor from the Materials Division before work is begun. This job-mix design is approved for all projects of the Department for the type of mix and the calendar year shown below.

Contractor Design Mix No. _____ Design Lab No. L-2

Date 4/3/2007 Job Mix ID No. 3014-2007-15 Calendar Yr. 2007 TSR Test No. _____

Type Mix / Size Aggregate SM-9.5D RAP (25%)

Producer Name & Plant Location Marvin V. Templeton & Sons, Inc. - Mt. Athos Phone 434-845-3606

Materials					Kind	Source
Approval Phase	A	B*	C			
Aggregate	43	43		%	#8s	Boxley Aggregates - Mt. Athos
Aggregate				%		
Rap	25	25		%	RAP	Various Routes - Lynchburg District
Sand	22	22		%	"B" Grade Natural	Otter River - Evington, VA
Screening	10	10		%	"B" Grade Manufactured	Boxley Aggregates - Mt. Athos
Lime				%		
Asphalt Cement					PG 64-22	Citgo Oil Co. - Hopewell, VA
Asphalt Prime/Tack						
Additives:						
ARRMAZ	0.5	0.5			Ad-Here 62-40	ARRMAZ - Mulberry, FL

Job-Mix Sieves	Total % Passing		Tolerance % + or -	Acceptance Range Average of 4 Test(s)		End of Year Average	Design/Spec. Range
	Lab JMF	Production JMF					
Approval Phase	A	B*		A	B	C	
1/2"	100	100	-	100	100		100
3/8"	94	94	+/-4	90-98	90-98		90-100
#4	58	58	+/-4	54-62	54-62		80 max
#8	44	44	+/-4	~~36-44~~	40-48		38-67
#200	5.6	4.8	+/-1	~~3.8-5.8~~	3.8-5.8		2-10
Asphalt (%)	5.5	5.5	+/-0.3	5.2-5.8	5.2-5.8		

Lay Down Temperatures	270-350 °F(°C)	Muffle Furnace Correction Factor:	0.11
		Field Correction Factor ($G_{se} - G_{sb}$):	0.040
Lab Compaction Temperatures	295-300 °F (°C)	Pill Weight:	5150
		SMA Mixes	
		VCA_{DRC}:	
Producer Technician's Certification Number	Ken Arthur	G_{CA}:	

MATERIALS DIVISION USE ONLY

Remarks							
Nominal Max. Size Aggregate	3/8"	Application Rates:	Min.	110 lb/yd² (~~kg/m²~~)	Max.	175 lb/yd² (~~kg/m²~~)	
Mix Properties at the Job-Mix Asphalt Content:	Compacted Unit Weight	155.8 lb/ft³ (~~kg/m³~~)	VTM:	3.9%	G_{mm}:	2.598	
Checked By: TNK							

Approved tentatively subject to the production of material meeting all other applicable requirements of the specification.

* Note: Part B 'Production JMF' and corresponding Material percentages will be filled out by the DME upon receipt of the additional requirements of the HMA producer within the first three lots under Section 502.01(b)

Copies:	Approvals				
State Materials Engineer District Materials Engineer Project Inspector Sub-Contractor and/or Producer			Part A:	H.D. Bird	Date: 5/11/07
			Part B:	H.D. Bird	Date: 7/13/07
			Part C:		Date:

EFFECTIVE LOT # 8
REFER TO JM 3014-2007-12

Form TL-127 (Rev. 11/03)

VIRGINIA DEPARTMENT OF TRANSPORTATION

MATERIALS DIVISION

STATEMENT OF ASPHALT CONCRETE OR CENTRAL-MIX AGGREGATE JOB-MIX FORMULA

Submit to the District Administrator, Virginia Department of Transportation. Approval must be received by the contractor from the Materials Division before work is begun. This job-mix design is approved for all projects of the Department for the type of mix and the calendar year shown below.

Contractor Design Mix No. _____ Design Lab No. L-2

Date 6/13/2007 Job Mix ID No. 3005-2007-06 Calendar Yr. 2007 TSR Test No. _____

Type Mix / Size Aggregate SM-12.5D RAP (25%)

Producer Name & Plant Location Marvin V. Templeton & Sons, Inc. - Piney River Plant Phone 434-277-5977

Materials					Kind	Source
Approval Phase	A	B*	C			
Aggregate	30	30		%	#78s	Boxley Aggregates - Piney River
Aggregate	15	15		%	#8s	Boxley Aggregates - Piney River
Rap	25	25		%	Recycled Asphalt Millings	Rt. 29 Nelson County
Sand	20	20		%	"A" Grade Manufactured Sand	Boxley Aggregates - Piney River
Screening	10	10		%	"B" Grade Manufactured Sand	Boxley Aggregates - Piney River
Lime				%		
Asphalt Cement					PG 64-22	Associated Asphalt - Roanoke,VA
Asphalt Prime/Tack						
Additives:						
ARRMAZ	0.50	0.5			Ad-Here 62-40	ARRMAZ - Mulberry, FL

Job-Mix Sieves	Total % Passing		Tolerance % + or -	Acceptance Range Average of 4 Test(s)		End of Year Average	Design/Spec. Range
	Lab JMF	Production JMF					
Approval Phase	A	B*		A	B	C	
3/4"	100	100	-	100	100		100
1/2"	96	96	+/-4	92-100	92-100		95-100
3/8"	83	86	+/-4	79-87	82-90		90 max
#8	41	44	+/-4	37-45	40-48		34-50
#200	5.1	5.1	+/-1	4.1-6.1	4.1-6.1		2-10
Asphalt (%)	5.7	5.7	+/-0.3	5.4-6.0	5.4-6.0		

Lay Down Temperatures	250-350 °F(°C)	Muffle Furnace Correction Factor:	0.08
		Field Correction Factor ($G_{se} - G_{sb}$):	0.051
Lab Compaction Temperatures	290-295 °F (°C)	Pill Weight:	4870
		SMA Mixes	
		VCA_{DRC}:	
Producer Technician's Certification Number	Ken Arthur	G_{CA}:	

MATERIALS DIVISION USE ONLY

Remarks

Nominal Max. Size Aggregate	1/2"	Application Rates:	Min.	144 lb/yd² (kg/m²)	Max.	230 lb/yd² (kg/m²)	
Mix Properties at the Job-Mix Asphalt Content:	Compacted Unit Weight	153.3 lb/ft³ (kg/m³)	VTM:	4.0 %	G_{mm}:	2.558	

Checked By: TNK

Approved tentatively subject to the production of material meeting all other applicable requirements of the specification.

* Note: Part B 'Production JMF' and corresponding Material percentages will be filled out by the DME upon receipt of the additional requirements of the HMA producer within the first three lots under Section 502.01(b)

Copies:	Approvals				
State Materials Engineer		X	Part A:	[signature]	Date: 7/19/07
District Materials Engineer			Part B:	[signature]	Date: 11/26/07
Project Inspector			Part C:		Date:
Sub-Contractor and/or Producer					

Form TL-127 (Rev. 11/05)

VIRGINIA DEPARTMENT OF TRANSPORTATION

MATERIALS DIVISION

STATEMENT OF ASPHALT CONCRETE OR CENTRAL-MIX AGGREGATE JOB-MIX FORMULA

Submit to the District Administrator, Virginia Department of Transportation. Approval must be received by the contractor from the Materials Division before work is begun. This job-mix design is approved for all projects of the Department for the type of mix and the calendar year shown below.

Contractor Design Mix No. 04318 Design Lab No. T-1

Date 8-24-07 Job Mix ID No. 3007-2007-18 Calendar Yr. 2007 TSR Test No.

Type Mix / Size Aggregate SM-9.5 DR 21.0% Rap

Producer Name & Plant Location W-L Construction & Paving, Inc. – Shelton Phone (336)388-9582

Materials					Kind	Source
Approval Phase	A	B*	C			
Aggregate	40	40		%	#8	Vulcan Materials – Shelton
Screenings	10	10		%	Washed	Vulcan Materials – Shelton
Rap	21	21		%	FINE RAP	APAC-Atlantic- Shelton
Sand	12	12		%	SAND	APAC-Atlantic – Dan River
Screening	17	17		%	# 10	Vulcan Materials – Shelton
Lime				%		
Asphalt Cement	5.7	5.9		%	PG 64-22	Citgo – Hopewell Va.
Asphalt Prime/Tack						
Additives:	0.5	0.5		%	LOF 65-00	ARR MAZ Products – Vanceboro NC.

Job-Mix Sieves	Total % Passing Lab JMF	Total % Passing Production JMF	Tolerance % + or -	Acceptance Range Average of __ Test(s) A	Acceptance Range Average of __ Test(s) B	End of Year Average	Design/Spec. Range
Approval Phase	A	B*		A	B	C	
½	100	100	0	100	100		100
3/8	94	94	4	90-98	90-98		90-100
4	61	63	4	57-65	59-67		90 max
8	44	46	4	40-48	42-50		38-67
200	5.8	5.8	1	4.8-6.8	4.8-6.8		2-10
Asphalt (%)	5.7	5.9	0.3	5.4-6.0	5.6-6.2		

Lay Down Temperatures	275-350 °F(°C)	Muffle Furnace Correction Factor:	-0.07
		Field Correction Factor ($G_{se} - G_{sb}$):	0.029
Lab Compaction Temperatures	295-300°F (°C)	Pill Weight:	4725
		SMA Mixes	
		VCA_{DRC}:	
		G_{CA}:	

Producer Technician's Certification Number Brian M. Jones

MATERIALS DIVISION USE ONLY

Remarks

Nominal Max. Size Aggregate	3/8"	Application Rate:	Min.	103 lb/yd² (~~kg/m²~~)	Max.	165 lb/yd² (~~kg/m²~~)	
Mix Properties at the Job-Mix Asphalt Content:	Compacted Unit Weight	146.2 lb/ft³ (~~kg/m³~~)	VTM:	3.8%	G_{mm}:	2.436	
Checked By: TNK							

Approved tentatively subject to the production of material meeting all other applicable requirements of the specification.

* Note: Part B 'Production JMF' and corresponding Material percentages will be filled out by the DME upon receipt of the additional requirements of the producer within the first three lots under Section 502.01(b)

Copies: State Materials Engineer
District Materials Engineer
Project Inspector
Sub-Contractor and/or Producer

Approvals			
	☒	Part A: H. D. Greenlee P.E.	Date: 8/30/07
	X	Part B: H. D. Greenlee P.E.	Date: 11/6/07
		Part C:	Date: