Report on the Use of High RAP Asphalt Cement Concrete for the 2007 Salem District Plant Mix Schedule

By

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Virginia Department of Transportation

Salem District Pavement Management Division
Salem District Materials Division

March 28, 2008

Report on the Use of High RAP Asphalt Cement Concrete – Salem District

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Schedule Information

As part of the ongoing evaluation process, the use of High RAP Asphalt Cement Concrete was incorporated into Plant Mix Schedule PM-2A-07 and, in turn, required on four sections of Route 58 in Carroll County and one section of Route 221 in Floyd County. The combined estimated quantity (surface mix only) for these five sections was determined to be 18,280 tons with 10,398 tons (56.9%) being placed on Route 58 and the remaining 7,882 tons (43.1%) being placed on Route 221. The following table details the schedule breakdown:

Schedule Quantities for Carroll County

Route	Pavement Description	From (MP)	To (MP)	Length (Mi)	Width (Ft)	Tonnage
58 WBL	Mainline Pavement	1.50	2.95	1.45	24	1684
	Shoulder Pavement			1.45	6	421
	Connections & Crossovers					450
58 Both	Mainline Pavement	8.66	9.84	1.18	36	2056
	Connections & Crossovers					270
58 Both	Mainline Pavement	16.55	17.36	0.81	24	941
	Shoulder Pavement			0.49	8	190
	Connections & Crossovers					50
58 EBL	Mainline Pavement	19.54	22.92	3.38	24	3926
	Connections & Crossovers					410

Schedule Quantities for Floyd County

Route	Pavement Description	From (MP)	To (MP)	Length (Mi)	Width (Ft)	Tonnage
221 Both	Mainline Pavement	16.80	23.37	6.57	24	7632
	Connections & Crossovers					250

The actual tonnages placed, however, deviated slightly from the initial estimates for both routes. In fact, upon schedule completion, the reported quantities indicated that 17,586 tons of asphalt material was allocated to the above sections with 10,042 tons (57.1%) going to Route 58 and 7,544 tons (42.9%) to Route 221. These figures represent a 694 ton (3.8%) reduction in combined quantity when compared against the initial schedule estimates. The following table details the actual placement dates and quantities utilized on both routes:

Route	Date	Tonnage
221	6/14/07	518.63
	6/15/07	631.46
	6/18/07	981.87
	6/22/07	365.20
	6/25/07	1024.03
	6/26/07	1051.87
	6/27/07	1032.48
	6/28/07	819.52
	6/29/07	1119.21

Route	Date	Tonnage	Date	Tonnage
58	9/21/07	1056.47	10/10/07	975.04
	9/24/07	611.72	10/11/07	913.20
	9/25/07	1422.92	10/12/07	241.64
	9/26/07	1453.41	10/15/07	497.67
	9/27/07	750.43		
	10/1/07	784.19		
	10/2/07	585.48		
	10/3/07	676.89		
	10/4/07	71.84		

Production and Plant Operations

The prime contractor for Plant Mix Schedule PM-2A-07 was Adams Construction Company, which operates a number of asphalt production plants throughout and adjacent to the Salem District. However, with regard to the sections discussed above, the sole production facility for all required high RAP asphalt mixtures was the Adams Sylvatus Plant (VDOT No. 2065) in Sylvatus, Virginia. This particular plant has two 150-ton storage silos and utilizes the Astec Double Barrel Drum Mixer, which is a counter-flow, continuous type unit with a production rate of approximately 200 tons per hour or 2,000 to 2,400 tons per day under optimal conditions. The plant normally produces asphalt mixtures with a 15% RAP component; however, it has the capability to increase RAP proportioning to 50% of the total aggregate matrix. The Astec Double Barrel Drum Mixer permits the direct addition of RAP materials within the insulated mixing chamber through a top-side insulated flop gate (recycled material entry point), which is located at the lower end (burner end) of the angled drum.

Handling and Processing RAP Materials

The unprocessed RAP material is stored at the quarry site adjacent to the Sylvatus Plant and is generally not restricted to source- or type-specific asphalt mixtures; thus the unprocessed material may contain a variety of binder systems and aggregate grading to include surface, intermediate, and base courses. These stockpiles are generally not subject to quality control testing, although visual observations or inspections are conducted to identify the presence of soil contaminants and other deleterious matter. Prior to utilization however, the material is processed via crushing operation, which reduces the variable RAP fragments to uniform size (generally < 1/2") in order to promote final blend consistency. To accomplish this task, the plant employs an Eagle Crusher Unit with a RAP processing/screening capacity of 1000 tons per day. Once processed, the RAP material is then stored for use in well-maintained conical stockpiles (not covered) and, in turn, subjected to comprehensive, quality control testing. The initial testing regime (single cycle) examines representative samples for asphalt content, gradation, absorption, and moisture levels. However, during actual production stages, test procedures for asphalt content and aggregate gradations are revisited and maintained at a frequency of one test per week, while moisture contents are generally monitored on a daily basis.

Job Mix Formula and High RAP Asphalt Production Issues

The job mix formula (type SM-9.5D HR, see Attachment 1) was submitted by Adams Construction Company on April 24, 2007 and granted initial approval (Mix Design No. 2065-2007-04) by Clyde Landreth of the Salem District Materials Division on April 25, 2007, as well as verbal production approval by Jeff Henderson of the Salem District Materials Division on June 28, 2007. Upon confirmation of subsequent production data, the job mix formula was granted full production approval by Henderson on October 3, 2007. The following table details the final mix proportions, as well as the material source data:

Material	Amount (%)	Kind	Source
NP Stone	40	#8 Quartzite	Salem Stone – Sylvatus, Virginia
RAP Material	30	Processed RAP	Adams Construction Company – Variable
Natural Sand	17	Natural Sand	Wythe Sand – Wytheville, Virginia
Screenings	13	#10 Quartzite	Salem Stone – Sylvatus, Virginia
Asphalt Cement	5.5	PG 64-22	Associated Asphalt – Roanoke, Virginia
Additives	0.5	Adhere HP+	Arr Maz Products – Winter Haven, Florida

The job mix formula specified RAP portioning at 30% of the total aggregate matrix and therefore required a virgin asphalt binder with a 64-22 performance grade designation. This binder adjustment corresponded with existing standards for designing high RAP mixtures (> 20% RAP material) and helped ensure that the final composite mix met the 70-22 performance grade specification for standard SM-9.5D mixes. The final composite mixture was evaluated (extracted and recovered by Abson Method) for such properties by Todd Withrow of the Central Office Materials Division on June 22, 2007 and consequently determined to meet this requirement.

In addition to binder analysis, the mixture also underwent significant quality control/quality assurance testing for aggregate gradation, asphalt content and volumetric properties. The following tables provide a summation of those test results for both producer and VDOT samples, as well as statistical comparisons between the sample populations:

Gradation and Asphalt Content Test Data

Test Item	Mix Design	Accept Range	Producer Results N	Producer Results X	Producer Results s	VDOT Monitor Results N	VDOT Monitor Results X	VDOT Monitor Results s	Non-Matched Statistical Data F	Non-Matched Statistical Data $F_{(99)}$	Non-Matched Statistical Data M-C	Non-Matched Statistical Data μ
1/2”	100	99-100	36	99.8	0.32	8	99.8	0.22	2.14	12.67	0.08	0.34
3/8”	94	90-98		93.1	1.48		92.9	1.62	1.11	12.67	0.63	2.20
#4	58	54-62		58.1	2.83		58.8	4.11	1.10	12.67	0.08	4.19
#8	42	38-46		42.5	2.40		42.3	3.63	1.14	4.26	0.63	3.89
#200	6	5-7		6.4	0.77		6.1	0.74	3.81	12.67	0.54	0.62
AC	5.5	5.2-5.8		5.7	0.22		5.6	0.18	1.45	12.67	0.13	0.29

Volumetric Test Data

Test Item	Mix Design	Accept Range	Producer Results N	Producer Results X	Producer Results s	VDOT Monitor Results N	VDOT Monitor Results X	VDOT Monitor Results s	Statistical Data (All Samples) F	Statistical Data (All Samples) $F_{(99)}$	Statistical Data (All Samples) M-C	Statistical Data (All Samples) μ
VTM	3.4	2-5	19	3.15	0.80	7	4.20	1.17	2.12	4.66	1.05	1.55
VMA	16.0	15 Min.		16.47	0.59		16.77	0.84	2.06	4.66	0.30	1.12
VFA	78.9	68-84		80.66	4.65		75.29	5.91	1.61	4.66	5.38	7.84
F/A	1.09	0.6-1.2		1.13	0.15		1.08	0.16	1.08	4.66	0.05	0.21

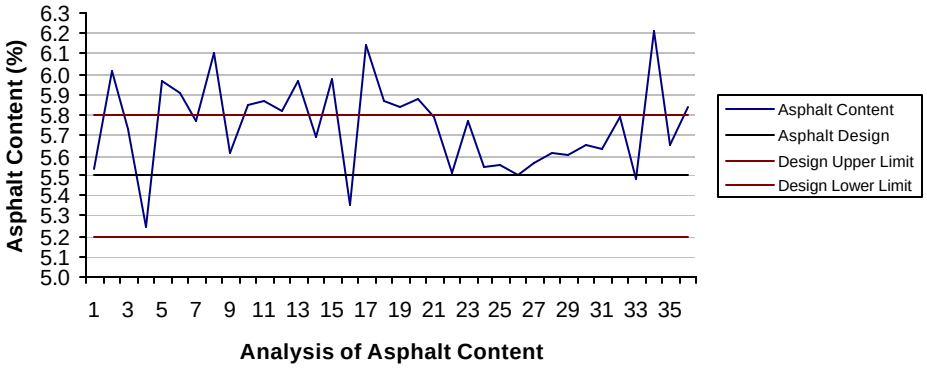
N = number of samples
X = mean or average value
s = standard deviation

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

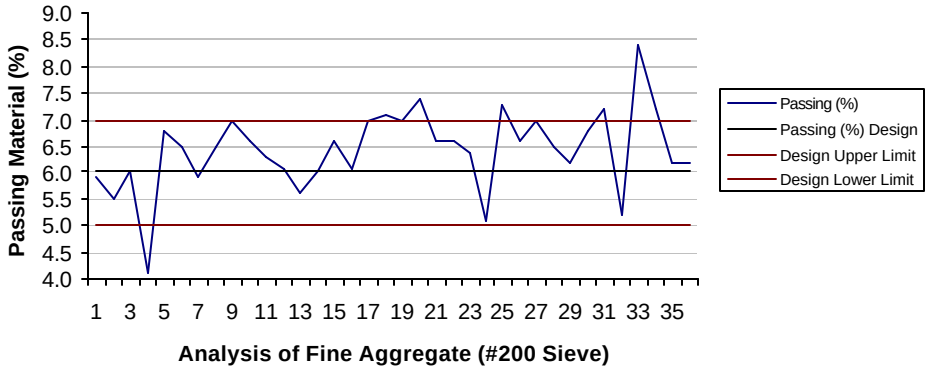
Notes: The non-matched statistical method (utilized for both aggregate gradation and asphalt content) is a comparison of the producer lot acceptance sample population to the VDOT monitor sample population, in which matched split sample results are excluded from the analysis, as specified in Virginia Test Method 59. As such, the analysis compared 30 producer samples to 6 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 19 producer samples and all 7 VDOT monitor samples.

In reviewing the data, it is clear that the mix design met all performance specifications over the life of the production period, which constituted 9 lots (~ 2000 tons per lot) and a partial 10th lot of 245 tons. As expected, there were some negative or non-conforming deviations recorded for all tests performed; however, these values represented an insignificant proportion of the total test data recorded (< 15%) and, for the most part, failed to manipulate overriding lot averages beyond the specified limits for any single test item. Still, it should be noted that there were multiple incidences of elevated asphalt content and/or excessive fines (material passing the #200 sieve) documented throughout the production period, which prompted further scrutiny and corrective action.



Analysis of Asphalt Content



Analysis of Fine Aggregate (#200 Sieve)

The examined asphalt contents in 22 of 44 separate test cycles (50.0%) consistently pushed or exceeded (> 5.75% AC) the upper limit specification of 5.8%. However, given the nature of the mix design (high RAP with ~ 42% passing the #8 sieve), these elevated values were determined to be acceptable by the District Materials Engineer (David Lee) and, therefore, required no lot adjustments or remedial action beyond plant notification and careful monitoring. The incidence of excessive fines (-200 material), on the other hand, was documented in just 6 of 44 separate test cycles (13.6%); thus yielding minimal negative impact on the overriding lot averages for that particular sieve (90% of all lots tested). Nonetheless, test samples taken from Lot No. 200705 produced a mean passing value of 7.1% for the #200 sieve and, in turn, resulted in a 0.3 point adjustment on October 10, 2007.

Note: There were other samples taken for additional testing (ex. rut testing) to be conducted at Elko and VTRC; however, the resulting data from these tests were not available for inclusion in this report.

Field Operations and Monitoring Issues

The primary inspection services for both placement operations (Route 221 and Route 58) were charged to Angie Oaks of M.B.P. Construction Engineering Incorporated; however, it should be noted that additional oversight services, to include material inspection and quality/independent assurance testing, were provided by Jeff Padgett and Mitch Price of the Salem District Materials Division. The following table outlines critical field specifications for this particular mix:

Minimum/Maximum Lay Down Temperatures	Minimum Density Requirements (% Maximum Theoretical Density)	Minimum Density Requirements (% Target Nuclear Density)
270 to 350° F	92.2%	98.0 to 102.0%

According to the project records, the high RAP asphalt materials for Route 221 were placed during the daylight hours (both morning and afternoon) between June 14 and June 29, 2007. The test data from these placements indicated that plant temperatures were consistently in the range of 335 and 345° F, with a composite mean plant temperature of 341° F for all values recorded. The mean transport interval was calculated at 64 minutes, although most loads arrived on-site in < 60 minutes, while lay down temperatures averaged 303° F, thus representing an approximate 35 to 45° F (10 to 13%) reduction in temperature from the plant to the project site. The target nuclear density (excluding any initial values taken between June 14 and June 18) was determined to be 140.8 lbs/ft^3 with all subsequent test values averaging 99.7% of this target value (min/max values were calculated at 99.3 and 100.3% respectively). Moreover, the mean % maximum theoretical density values for all cored specimens (also excluding any initial values taken between June 14 and June 18) were recorded at 96.6% (quality control samples) and 95.8% (monitor samples).

The placement operations on Route 58 predominately occurred during the daylight hours as well (both morning and afternoon with some incidences of night work) and were carried out between September 21 and October 15, 2007. The test data from these placements indicated that plant temperatures were maintained between 300 and 350° F, with a composite mean plant temperature of 317° F for all values recorded. The mean transport interval was calculated at 32 minutes; however, the statistical range for this period was 46 minutes, with min/max values recorded at 12 and 58 minutes respectively (much more sporadic than the transport intervals on Route 221). Still, the aspects of temporal variability rendered minimal negative impact on the resulting lay down temperatures, which averaged 292° F and represented comparable reductive values to those witnessed on Route 221. The target nuclear density was determined to be 137.9 lbs/ft^3 with all subsequent test values averaging 100.0% of this target value (min/max values were calculated at 98.8 and 101.2% respectively). Moreover, the mean % maximum theoretical density values for all cored specimens were recorded at 96.8% (quality control samples) and 96.6% (monitor samples)

In considering the data from both placement operations, it is clear that the recorded test values met or exceeded all relevant specifications; thus implying that the mix performed adequately throughout the entire production period. However, it should be noted that these values reflect post-adjustment test data only and fail to incorporate the non-conforming test values documented between June 14 and June 18, 2007. According to the project records, there were

numerous problems confronted during the initial production period (Route 221 placement). On June 14, Oaks indicated that there were two incidences of failing lay down temperatures, as well as issues with periodic “clumping” and insufficient aggregate coating. Moreover, the mix appeared to “creep” at the longitudinal edges and “shove” through the center of mat, which resulted in areas of tearing or cracking. In addition to these observations, Padgett documented failing density values for the initial core samples taken, which registered only 90.2% of the required minimum density, while gradation results prompted further concerns with regard to excessive fines. Nonetheless, after several adjustments and additional control strip testing, the density and gradation values improved and placement was continued with minimal disruption.

On the next placement date (June 15) however, the asphalt material, once again, appeared tender and sensitive to compaction, yet no failing density values were recorded. In fact, the nuclear density readings indicated that more than 50% of the test data exceeded the upper limit density specification of 102% and, as a result, led to further roller pattern/control strip testing. These test procedures consequently raised the target density value from 135.3 to 140.8 lbs/ft^3. Nonetheless, the June 18 placement experienced even more problems than those witnessed on the previous dates, and eventually led to a complete shutdown of the entire production operation later that day. During this period, Padgett indicated that shoving and cracking were “prevalent” throughout the mat while the longitudinal edges appeared to move “inches per roller pass”. In addition to these noted problems, the density values of the cored samples rendered failing test results at 89.6%, which ultimately provoked the shut down order. In turn, the Sylvatus Plant responded with slight modifications in the production process, to include elevating the drum mixing temperature (from ~ 440 to ~ 475º F) and extending the length of the sequential mixing cycle (composite mixing of aggregate, recycled material, and asphalt cement). Although requiring a 10% increase in No. 2 fuel oil, as well as a corresponding reduction in unit capacity (from 200 to 150 tons per hour), these simple adjustments clearly resulted in positive benefit, as no further problems were documented for the remainder of the production period.

Future Use of High RAP Asphalt Pavement

Currently, there are no routes selected for future application of high RAP Asphalt Cement Concrete within the Salem District. However, it may be assumed, with relative confidence, that engineering proposals will be submitted to the Department for review in the near future, especially for routes with similar traffic types and volumes as those discussed in the above text.

Form TL-127 (Rev. 11/05)

Attachment 1

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. 2065-2007-04 Design Lab No. S-1

Date 4/24/2007 Job Mix ID No. Calendar Yr. 2007 TSR Test No. 82%

Type Mix / Size Aggregate SM-9.5D (144)

Producer Name & Plant Location Adams Construction Co., Inc. Phone (276) 766-0410

Materials					Kind	Source
Approval Phase	A	B*	C			
Aggregate	40	40		%	#8 Quartzite	Salem Stone Co., Sylvatus, VA
Aggregate				%		
Rap	30	30		%	Processed Rap	Adams Construction Co., Roanoke, VA
Sand	17	17		%	Concrete Sand	Wythe Sand Co., Wytheville, VA
Screening	13	13		%	#10 Quartzite	Salem Stone, Sylvatus, VA
Lime				%		
Asphalt Cement	5.5	5.5			PG 64-22	Associated Asphalt, Roanoke, VA
Asphalt Prime/Tack						
Additives:	0.5	0.5			Adhere HP+	Arr Max Products, Winter Haven, 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	0	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	39	42	4	35-43	38-46		38-67
#200	6	6	1	5-7	5-7		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:	0.38
		Field Correction Factor ($G_{se} - G_{sb}$):	0.007
Lab Compaction Temperatures	293-302 °F (°C)	Pill Weight:	4850
		SMA Mixes	
		VCA_{DRC}:	
Producer Technician's Certification Number	M. Wallace	G_{CA}:	

MATERIALS DIVISION USE ONLY

Remarks	VMA=16.0, VFA=78.9, Ni=88.3, F/A=1.11, Perm <100, Gse=2.709, Pbe=5.42						
Nominal Max. Size Aggregate		Application Rates:	Min.	lb/yd² (kg/m²)	Max.	lb/yd² (kg/m²)	
Mix Properties at the Job-Mix Asphalt Content:	Compacted Unit Weight	149.9 lb/ft³ (kg/m³)	VTM:	3.4	G_{mm}:	2.486	
Checked By:	J.A. Henderson 4/26/2007						

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:	D.C. Landreth	Date:	4/25/2007
	☒ Part B:	J.A. Henderson	Date:	10/3/2007
	☐ Part C:		Date:	

Form TL-127 (Rev. 11/05)

Attachment 2

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. 2025-2005-31 Design Lab No. S-1

Date 1/2/2007 Job Mix ID No. _____ Calendar Yr. 2007 TSR Test No. 82%

Type Mix / Size Aggregate SM-9.5D (144)

Producer Name & Plant Location Adams Construction Co. Inc., Blacksburg Phone (540) 552-3799

Materials					Kind	Source
Approval Phase	A	B*	C			
Aggregate	45	45		%	#8 Quartzite	Salem Stone, Sylvatus VA
Aggregate				%		
Rap	15	15		%	Processed RAP	Adams Construction Co., Roanoke VA
Sand	15	15		%	Concrete Sand	Wythe Sand Co., Wytheville VA
Screening	25	25		%	#10 Quartzite	Salem Stone, Sylvatus VA
Lime				%		
Asphalt Cement	5.7	5.7			PG 70-22	Associated Asphalt, Roanoke VA
Asphalt Prime/Tack						
Additives:	0.5	0.5			Adhere HP+	Arr-Maz Products, Winter Haven 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	0	100	100		100
3/8"	90	90	4	86-94	86-94		90-100
#4	57	55	4	53-61	51-59		80 Max
#8	38	38	4	34-42	34-42		38-67
#200	6.0	6.0	1	5.0-7.0	5.0-7.0		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:	0.62
		Field Correction Factor ($G_{se} - G_{sb}$):	0.20
Lab Compaction Temperatures	284-293 °F (°C)	Pill Weight:	4850
		SMA Mixes	
		VCA_{DRC}:	
Producer Technician's Certification Number	M. Wallace	G_{CA}:	

MATERIALS DIVISION USE ONLY

Remarks	VMA=15.3, VFA=80, Ni=87.3, F/A=1.10, Pbe=5.43, Gse=2.702, Perm = 100						
Nominal Max. Size Aggregate		Application Rates:	Min.	lb/yd² (kg/m²)	Max.	lb/yd² (kg/m²)	
Mix Properties at the Job-Mix Asphalt Content:	Compacted Unit Weight	148.9 lb/ft³ (kg/m³)	VTM:	3.5	G_{mm}:	2.473	
Checked By:	J.A. Henderson 10/9/2007						

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:	R.P. Bryant	Date:	1/10/2007
	☒ Part B:	J.A. Henderson	Date:	10/9/2007
	☐ Part C:		Date:	

Attachment 3: Control Strip Location and Test Data (Montgomery County)

Schedule Quantities for Route 11 in Montgomery County (PM-2A-07)

Route	Pavement Description	From (MP)	To (MP)	Length (Mi)	Width (Ft)	Tonnage
11 Both	Mainline Pavement	3.78	8.22	4.44	36	7736
	Shoulder Pavement	3.78	8.22	8.88	2	860
	Connections & Crossovers					850

Gradation and Asphalt Content Test Data (Mix Design No. 2025-2005-31)

Test Item	Mix Design	Accept Range	Producer Results N	Producer Results X	Producer Results s	VDOT Monitor Results N	VDOT Monitor Results X	VDOT Monitor Results s	Non-Matched Statistical Data F	Non-Matched Statistical Data $F_{(99)}$	Non-Matched Statistical Data M-C	Non-Matched Statistical Data μ
1/2”	100	99-100	17	100.0	0.00	3	99.4	0.74	------	8.19	0.57	4.22
3/8”	90	86-94		92.0	1.44		92.0	1.13	1.64	199.42	0.01	3.05
#4	55	51-59		54.8	2.63		52.3	2.55	1.06	199.42	2.48	7.52
#8	38	34-42		38.0	1.86		36.7	2.83	2.32	8.19	1.33	9.97
#200	6	5-7		6.3	0.31		5.6	0.32	1.10	8.19	0.65	0.93
AC	5.7	5.4-6.0		5.9	0.12		5.9	0.19	0.38	8.19	0.01	0.67

Volumetric Test Data (Mix Design No. 2025-2005-31)

Test Item	Mix Design	Accept Range	Producer Results N	Producer Results X	Producer Results s	VDOT Monitor Results N	VDOT Monitor Results X	VDOT Monitor Results s	Statistical Data (All Samples) F	Statistical Data (All Samples) $F_{(99)}$	Statistical Data (All Samples) M-C	Statistical Data (All Samples) μ
VTM	3.5	2.0-5.0	9	2.10	0.61	3	2.67	1.15	3.51	11.04	0.57	4.06
VMA	15.3	15 Min.		15.22	0.49		15.83	0.85	3.05	11.04	0.61	3.02
VFA	80.0	68-84		85.56	2.60		83.33	6.51	6.25	11.04	2.22	38.26
F/A	1.10	0.6-1.2		1.07	0.05		0.95	0.03	2.69	199.37	0.12	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)
M-C = 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 14 producer samples to 3 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 9 producer samples and all 3 VDOT monitor samples.

Density samples were evaluated on October 1, 2007 and recorded at 93.3% (average of 6 cored specimens). The target nuclear density was determined to be 142.0 pounds per cubic foot.

Form TL-127 (Rev. 11/05)

Attachment 4

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. 2018-2005-26 Design Lab No. S-1

Date 1/2/2007 Job Mix ID No. _____ Calendar Yr. 2007 TSR Test No. 93%

Type Mix / Size Aggregate SM-9.5D (144)

Producer Name & Plant Location Adams Construction Co., Dublin Phone 540-674-0199

Materials					Kind	Source
Approval Phase	A	B*	C			
Aggregate	45	45		%	#8	Salem Stone, Sylvatus, VA
Aggregate				%		
Rap	15	15		%	Processed	Adams Construction CO., Roanoke, VA
Sand	15	15		%	Concrete Sand	Wyth Sand Co., Wythville, VA
Screening	25	25		%	#10	Salem Stone, Sylvatus, VA
Lime				%		
Asphalt Cement	5.7	5.7			PG 70-22	Associated Asphalt
Asphalt Prime/Tack						
Additives:	0.5	0.5			Adhere HP+	Arr Maz Products, Winter Haven, 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	0	100	100		100
3/8"	90	92	4	86-94	88-96		90-100
#4	57	55	4	53-61	51-59		80 Max
#8	38	38	4	34-42	64.42		38-67
#200	6	6	1	5-7	5-7		2-10
Asphalt (%)	5.7	5.7	.3	5.4-6.0	5.4-6.0		

Lay Down Temperatures	270-350 °F(°C)	Muffle Furnace Correction Factor:	0.62
		Field Correction Factor ($G_{se} - G_{sb}$):	.020
Lab Compaction Temperatures	293-302 °F (°C)	Pill Weight:	4850
		SMA Mixes	
		VCA_{DRC}:	
Producer Technician's Certification Number	M. Wallace	G_{CA}:	

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Remarks	VMA=15.3, VFA=80, Ni=87.3, F/A=1.10, Pbe=5.43, Gse=2.702, Perm=100						
Nominal Max. Size Aggregate		Application Rates:	Min.	lb/yd² (kg/m²)	Max.	lb/yd² (kg/m²)	
Mix Properties at the Job-Mix Asphalt Content:	Compacted Unit Weight	148.9 lb/ft³ (kg/m³)	VTM:	3.5	G_{mm}:	2.473	
Checked By: J.A. Henderson 10/24/2007							

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

Approvals				
☒	Part A:	R.P. Bryant	Date:	1/10/06
☒	Part B:	D.C. Landreth	Date:	1/10/2007
☐	Part C:		Date:	

Attachment 5: Control Strip Locations and Test Data (Giles County)

Schedule Quantities for Route 100 in Giles County (PM-2A-07)

Route	Pavement Description	From (MP)	To (MP)	Length (Mi)	Width (Ft)	Tonnage
100 Both	Mainline Pavement	16.19	16.84	0.65	36	1133
100 SBL	Mainline Pavement	9.04	10.54	1.50	24	1742
	Connections & Crossovers					300

Gradation and Asphalt Content Test Data (Mix Design No. 2018-2005-26)

Test Item	Mix Design	Accept Range	Producer Results N	Producer Results X	Producer Results s	VDOT Monitor Results N	VDOT Monitor Results X	VDOT Monitor Results s	Non-Matched Statistical Data F	$F_{(99)}$	M-C	μ
1/2"	100	99-100	6	100.0	0.00	2	99.8	0.28	------	------	------	------
3/8"	90	86-94		92.7	3.78		90.8	3.25	------	------	------	------
#4	55	51-59		52.4	4.66		50.2	6.29	------	------	------	------
#8	38	34-42		35.4	2.58		33.4	3.18	------	------	------	------
#200	6	5-7		6.2	0.41		5.5	0.42	------	------	------	------
AC	5.7	5.4-6.0		5.8	0.11		5.5	0.38	------	------	------	------

Volumetric Test Data (Mix Design No. 2018-2005-26)

Test Item	Mix Design	Accept Range	Producer Results N	Producer Results X	Producer Results s	VDOT Monitor Results N	VDOT Monitor Results X	VDOT Monitor Results s	Statistical Data (All Samples) F	$F_{(99)}$	M-C	μ
VTM	3.5	2.0-5.0	5	4.06	0.84	2	5.55	0.35	------	------	------	------
VMA	15.3	15 Min.		16.74	0.82		17.50	0.57	------	------	------	------
VFA	80.0	68-84		78.36	7.30		68.00	2.83	------	------	------	------
F/A	1.10	0.6-1.2		1.11	0.05		1.10	0.14	------	------	------	------

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

F = calculated value of F (test statistic of variability)
$F_{(99)}$ = critical value of F (rejection region)
M-C = difference of monitor/contractor mean test values (test statistic)
μ = critical value of *t* (rejection region)

Notes: Due to the limited number of samples taken, comparative statistics were not calculated.

Density samples were evaluated on October 17, 2007 and recorded at 92.7% (average of 6 cored specimens). The target nuclear density was determined to be 143.7 pounds per cubic foot.