APPENDIX C

ANALYSES OF ASPHALT MIXTURES BY THE VIRGINIA TRANSPORTATION RESEARCH COUNCIL

Samples of six mixes were provided to Virginia Transportation Research Council (VTRC) for characterization. Two were samples of Pennsylvania Department of Transportation's (PennDOT's) ID-2 surface mix and two were samples of PennDOT's BCBC base course, both from the Creekside Drive wooden bridge project. The remaining were samples of Virginia Department of Transportation's (VDOT's) SM-2A surface course and BM-2 base course. All of the mixes were designed using the Marshall mix design method. VTRC was to characterize the mixes, compare the mix properties to the SUPERPAVE mix criteria, and to measure performance properties of the mix which may be used to estimate their cracking potential. In no case was a sufficient quantity of material provided for testing using the SUPERPAVE protocols.

The asphalt content of each of the mixes was determined according to ASTM D 2172. Gradation analysis was performed according to ASTM C 117 and C 136. The asphalt contents and gradations for each of the mixes is reported in Table 1. Based on these results, all of the surface mixes (ID-2 and SM-2AL) would be classified as 9.5mm nominal maximum size (NMS) mixes under SUPERPAVE and all of the base mixes would be classified as 19 mm NMS mixes. Figures 1 and 2 show how the gradations would compare under SHRP criteria.

Sample	PennDOT ID-2 #1	PennDOT ID-2 #2	PennDOT BCBC #1	PennDOT BCBC #2	VDOT SM-2AL	VDOT BM-2
Sieve Size	Percent Passing					
25 mm	100	100	100	100	100	100
19 mm	100	100	91	87	100	93
12.5 mm	100	100	72	57	100	72
9.5 mm	97	96	66	49	92	62
4.75 mm	68	63	47	34	65	48
2.36 mm	44	41	30	24	41	29
1.18 mm	26	25	19	16	27	18
0.600 mm	16	16	13	11	19	13
0.300 mm	10	11	9	8	15	10
0.150 mm	7	8	7	6	13	8
0.075 mm	6	6	6	5	11	7
AC %	6.1	6.1	3.8	3.2	5.8	4.7

Table-C.1: Asphalt Content and Gradation of Test Mixtures

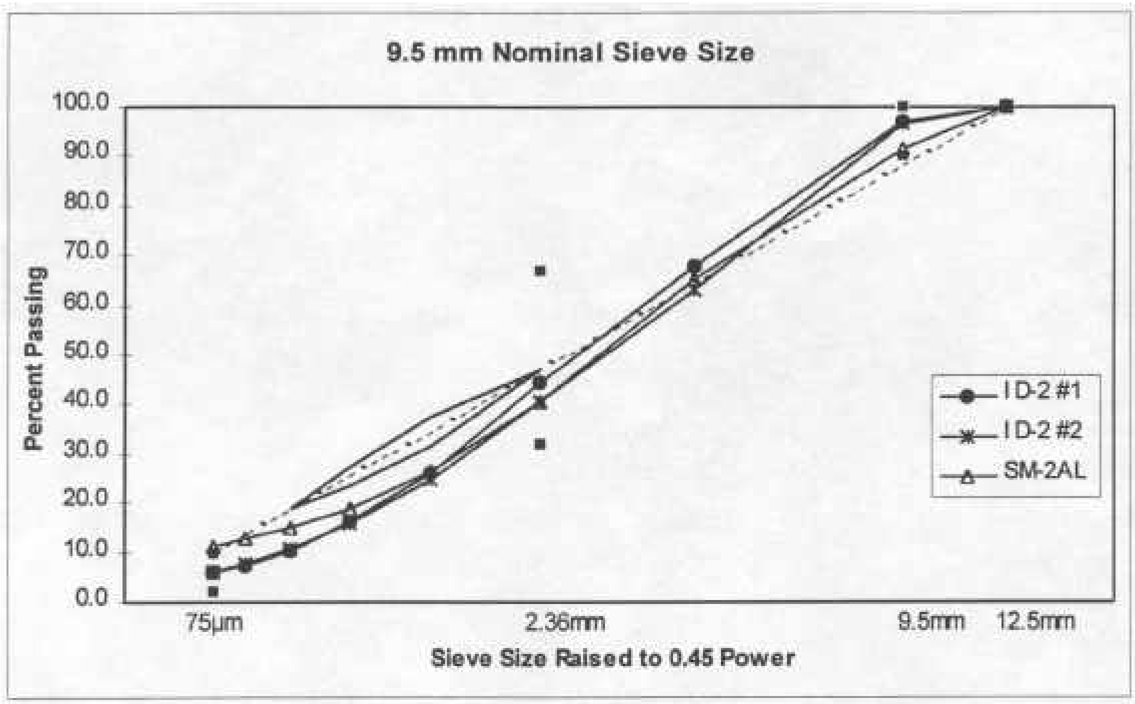

Figure-C.1: Surface Mix Gradations

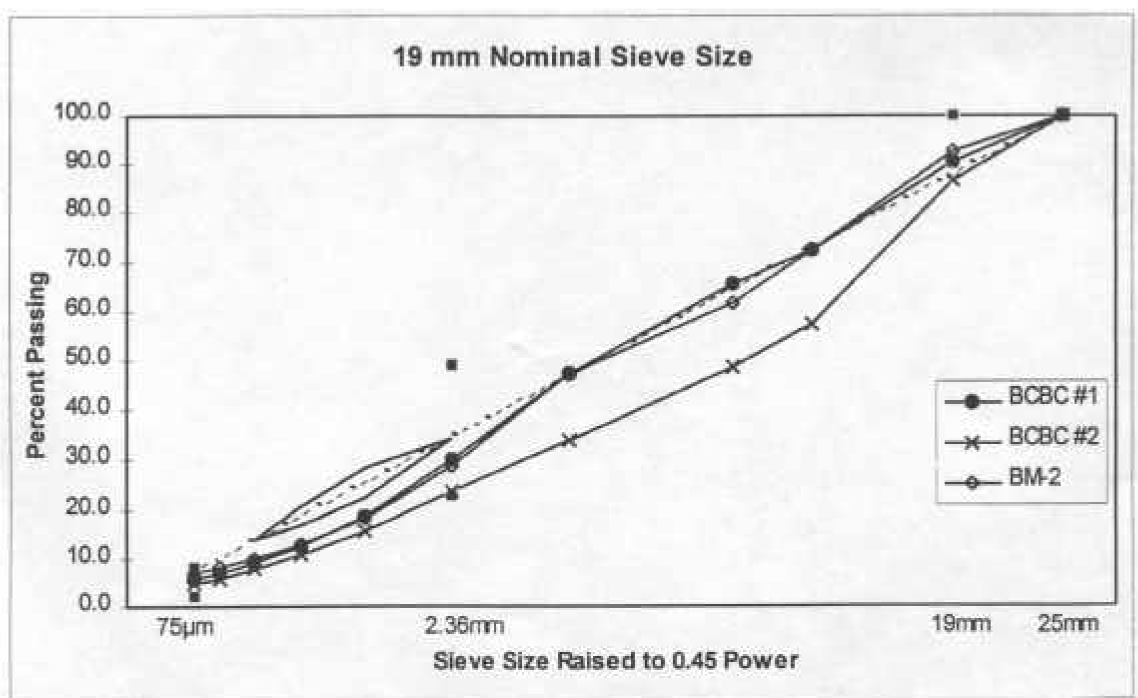

Figure-C.2: Base Mix Gradations

SUPERPAVE specifies gradation criteria based on the NMS of the mix. The NMS is defined as one sieve larger than the first sieve to retain at least 10%. The SUPERPAVE gradation criteria uses a system of control points and a recommended restricted zone within the frame work of the 0.45 power curve. The control points are displayed in Figures 1 & 2 for the nominal maximum sieve size, 2.36 mm sieve, and 0.075 mm sieve. The restricted zone is the area shown along the maximum density line which is to limit the use of intermediate fines, especially natural sands which may lead to a tender mix.

The SM-2AL shown in Figure 1 does not meet the SUPERPAVE criteria. VDOT's specifications for SM-2 mixes specify 4-7% passing (P) the 0.075 mm sieve with a 2% production tolerance around design for one sample. The gradation for this sample measured 11% P0.075 mm indicating this material is out of specifications. If the material was in specifications it would have met the SUPERPAVE gradation criteria. The remaining two mixtures meet the SUPERPAVE criteria.

It appears that BCBC #2 may have been segregated during sampling. This sample is non-typical of dense graded Marshall designed mixes. The sample does meet PennDOT's requirements for BCBC. However the sample does not meet the gradation requirements for a 25 mm NMS SUPERPAVE mix. The remaining two base mixes meet the SUPERPAVE gradation criteria.

Volumetric Properties

Samples were prepared for volumetric analysis according to AASHTO T 245. Where possible, 8 100 mm samples were prepared from the base mix. The 100 mm specimens were compacted with a 50 blow and the 150 mm specimens with a 75 blow effort of a mechanical Marshall hammer. The volumetric properties: voids in total mix (VTM), voids in mineral aggregate (VMA), and voids filled with asphalt (VFA) are summarized in Table 2.

Both the SM-2AL and the BM-2 have low VTM and high VFA based on VDOT's specifications for those mixes. It is difficult to estimate how the design of the mixes would be changed under the SUPERPAVE criteria. Under SUPERPAVE, laboratory compaction is performed with a SUPERPAVE gyratory compactor (SGC). The number of gyrations used for compaction is a function of the traffic loadings at the site. Since wooden bridges are generally placed on low-volume roads, the lowest compaction level, N_{design} = 68 gyrations which is good for up to 300,000 80 kN equivalent single axle loads (ESAL's) over the life of the pavement, would probably be valid. Though there is no direct correlation between Marshall blows and SGC gyrations, based on experience the compactive effort provided by 68 gyration would be slightly less than that provided by a 50 blow Marshall.

SUPERPAVE design volumetric properties are presented in Table 3. If the volumetric results from the 50 blow Marshall specimens were compacted to the SUPERPAVE design

Mix Sample	Asphalt Content, %	Bulk S.G.	VTM	VMA	VFA	Fines/AC Total
ID-2 #1	6.1	2.338	4.2	18.1	76.6	0.98
ID-2 #2	6.1	2.335	4.3	18.2	76.5	0.98
SM-2AL	5.8	2.483	2.3	14.4	84.4	1.90
BCBC #1	3.8	2.558	5.5	14.5	61.9	1.58
BCBC #2	3.2	2.372	7.3	14.7	50.3	1.56
BM-2	4.7	2.531	2.8	13.7	79.3	1.49

Table-C.2: Volumetric Properties

criteria the following observation could be made:

ID-2 #1 and #2

All of the volumetric properties are acceptable. SUPERPAVE specifies the fines to asphalt ratio be calculated based on the effective asphalt content. However, since the aggregate bulk specific gravity values were unavailable, fines/AC is reported based on the total asphalt content in the mix. Thus it is possible that the sample could fail this criteria.

Volumetric Property	Traffic Level, 80 kN ESALs	
	<0.3	0.3<1
VTM at N_{design}	4.0%	4.0%
VMA for 9.5 mm NMS	15.0%	15.0%
VMA for 19 mm NMS	13.0%	13.0%
VFA	70-80%	65-78%
Fines/Effective Asphalt	0.6-1.2	0.6-1.2

Table-C.3: SUPERPAVE Volumetric Criteria

SM-2AL

It is difficult to evaluate this mix due to the high P0.075 mm content. A lower P0.075 mm content would lead to higher VTM and VMA and lower VFA and dust to asphalt ratio. This would tend to increase the likelihood of the material meeting SUPERPAVE criteria.

BCBC #1 & #2

The asphalt content of both of these samples would need to be increased to lower the void content at N_{design}. This would also decrease the fines/asphalt ratio and increase the VFA. The increase in asphalt would tend to produce a more durable mix with more resistance to cracking.

BM-2

VTM at N_{design} would need to be increased to meet the SUPERPAVE criteria. The P0.075 mm content needs to be decreased to reduce the fines/AC, this will increase VTM.

Resilient Modulus Testing

Resilient modulus testing was conducted on 100 mm cores using AASHTO TP-31. Testing was completed at 5 and 25 °C for ID-2 #1 and SM-2AL before an equipment malfunction suspended testing. The results are reported in Table 4. Based on the similarities of the aggregate structures and asphalt grades, the differences between the ID-2 and the SM-2AL may be attributed to the high P0.075 mm content of the SM-2AL. High concentrations of 0.075 mm material can act to stiffen the binder. Additional testing will be completed when the equipment is repaired.

Mix Sample	5 °C			25 °C		
	Mean (psi)	Standard Deviation (psi)	Poisson's Ratio	Mean (psi)	Standard Deviation (psi)	Poisson's Ratio
SM-2AL	2472121	75611	0.41	704865	20375	0.40
ID-2 #1	1220232	34123	0.23	496302	10644	0.37

Table-C.4: Total Resilient Modulus Data