

# Designing Stone Matrix Asphalt Mixtures Volume V – Appendix For Phase II Work

Final Report

Prepared for:  
National Cooperative Highway Research Program  
Transportation Research Board  
National Research Council

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**This report has not been edited by TRB.**

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**N**ATIONAL **C**ENTER FOR  
**A**SPHALT **T**ECHNOLOGY

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# **APPENDIX A: Site Reports**

## **NCHRP 9-8 II - Task 8 SMA Construction Project No. 1**

### **Location and Background**

This project was constructed in May of 1997. NCAT staff were on-site from May 5 to May 8, 1997. While at the job-site, the contractor was constructing the middle of three lanes. Because construction was on the middle lane, paving operations were conducted at night. Placement of the SMA consisted of milling 38 mm (1.5 in) of existing pavement and filling with 38 mm of SMA. After completion of SMA placement, an open-graded friction course was to be placed on top of the SMA.

### **SMA Mixture Information**

While on this project, two different job-mix-formulas (JMF) were used (JMF-01-1 and JMF-01-2). There were two primary differences between the two JMF. First, two different sources of asphalt binder were used; however, both were a PG 76-22. Secondly, the contractor changed a source of No. 7 stone. This was not a result of problems with the mixture, but the contractor decided to use a source of coarse aggregate that could be obtained nearer the plant site. Tables 1.1 and 1.2 presents information for each JMF, while Table 1.3 presents the two gradations for the JMF's used on this project. Both of these gradations are 12.5 mm nominal maximum aggregate size. A column within Table 1.3 is entitled "Recommended Limits." This column shows the recommended gradation limits from the Phase I SMA mixture design procedure. Both mixtures utilized a crushed granite aggregate. Properties for the coarse and fine portions

of the aggregates are presented in Tables 1.4 and 1.5, respectively. Only the asphalt cement used for JMF-01-2 was sampled at the project. Properties of this binder are presented in Table 1.6. Cellulose fibers were used in a loose form for this project.

### **Plant Information**

The plant utilized for this project was an Astec Double-Barrel drum plant. The aggregate entered the drum opposite the flame, therefore the aggregate moved opposite the direction of the exhaust gas stream (counter-flow). The dust collection system consisted of only a baghouse. Baghouse fines were sent to a storage silo before being reintroduced into the mixture. The baghouse fines constituted a portion of the filler (fraction smaller than the 0.075 mm sieve).

This plant utilized three silos for different constituents of the mixture. One silo was used for lime (anti-strip), one for marble dust (mineral filler), and one for the baghouse fines. Both the lime and marble dust were brought to the plant-site in trucks and pneumatically blown into their respective silos. Each was then augered into the outside drum of the facility. The fiber was stored in bales next to the plant. Introduction of the fiber consisted of placing bails manually (forklift) into an automated hopper. This hopper had blades that rotated in opposite directions to make sure the fiber was of a consistency to auger to the outside barrel of the drum.

### **Laydown Procedures**

Paving on this project was accomplished at night. Observation of the laydown procedures occurred on the night of May 8, 1997. The ambient temperature was

approximately 58°F with a moderate wind. Table 1.7 presents information obtained from this observation.

### **Problems Encountered On-Site**

The only problem with the mixture encountered while on the job-site was fat-spots on the roadway. This occurred on the night of May 6, 1997. A sample of mixture was obtained from some of the mixture that showed these fat-spots (Sample 4). Results of testing on this sample showed high draindown values (0.8 percent). The section of pavement with fat spots was milled and replaced.

### **Sampling**

Materials obtained from this site include: each aggregate used in both mixtures, mineral filler, fiber, the asphalt binder used with JMF-01-2, and loose mixture. Table 1.8 presents the times and dates that each of the samples were obtained along with the average draindown values for each sample. Tables 1.9 through 1.16 present the results of testing performed on the samples obtained.

<b>Table 1.1: Site 1 SMA Mixture Data for JMF-01-1</b>	
JMF I.D. Number:	013X120+12.5SMA-1
Dates Used:	May 5 & 6
Number of Aggregate Stockpiles Used:	4
Design Voids in Coarse Aggregate:	38.3 percent*
Type Asphalt Binder Used:	PG 76-22
Modifier Type:	Stylink (Koch)
Design Asphalt Binder Content:	6.0 percent
Supplier of Asphalt Binder:	Shell Oil Company, Lithonia, Ga
Type Fiber Used:	Slag Wool (Sloss)
Form of Fiber:	Loose
Design Percentage of Fiber:	0.4 percent of total mix
Type Mineral Filler Used:	Marble Dust (RO4)
Design Percentage of Mineral Filler:	8.0 percent
Type Anti-Strip Additive Used:	Lime
Design Percentage of Anti-Strip:	1.0 percent
Compaction Method:	Marshall Hammer
Compactive Effort:	50 Blows per side
Laboratory Mixing Temperature:	335 °F
Laboratory Compaction Temperature:	325 °F
Design Voids in Total Mix:	3.7 percent
Design Mixture Density:	151.6 pcf
Design Voids in Mineral Aggregate:	17.9 percent
Design Voids Filled With Asphalt:	79.3 percent
Design Marshall Stability:	2110 lbs
Design Flow (0.01 in):	14.0
Loaded Wheel Test @ Design Asphalt Content:	3.41 mm

\* Value reported by agency.

<b>Table 1.2: Site 1 SMA Mixture Data for JMF-01-2</b>	
JMF I.D. Number:	120_12.5SMA-1
Dates Used:	May 7 & 8
Number of Aggregate Stockpiles Used:	4
Design Voids in Coarse Aggregate:	39.1 percent*
Type Asphalt Binder Used:	PG 76-22
Modifier Type:	Stylink (Koch)
Design Asphalt Binder Content:	5.9 percent
Supplier of Asphalt Binder:	Shell Oil Company
Type Fiber Used:	Slag Wool (Sloss)
Form of Fiber:	Loose
Design Percentage of Fiber:	0.4 percent of total mix
Type Mineral Filler Used:	Marble Dust (RO4)
Design Percentage of Mineral Filler:	8.0 percent
Type Anti-Strip Additive Used:	Lime
Design Percentage of Anti-Strip:	1.0 percent
Compaction Method:	Marshall Hammer
Compactive Effort:	50 Blows per side
Laboratory Mixing Temperature:	335 °F
Laboratory Compaction Temperature:	325 °F
Design Voids in Total Mix:	3.1 percent
Design Mixture Density:	154.7 pcf
Design Voids in Mineral Aggregate:	17.6 percent
Design Voids Filled With Asphalt:	82.0 percent
Design Marshall Stability:	2120 lbs
Design Flow (0.01 in):	13.6
Loaded Wheel Test @ Design Asphalt Content:	3.63 mm

\* Value reported by agency.

Table 1.3: Site 1 Design Gradations for Both JMF				
Sieve	Sieve Size, mm	Recommended Limits	Percent Passing	
			JMF-01-1	JMF-01-2
¾ in.	19.0	100	100	100
½ in.	12.5	85-95	98	93
⅜ in.	9.5	75 max.	70	70
No. 4	4.75	20-28	28	29
No. 8	2.36	16-24	19	19
No. 16	1.18	----	15	16
No. 30	0.600	12-16	14	14
No. 50	0.300	12-15	13	13
No. 100	0.150	----	12	12
No. 200	0.075	8-10	10	10

Table 1.4: Coarse Aggregate Properties for Site 1			
Test	No. 7's JMF-01-1	No. 7's JMF-01-02	No. 89's (Both JMF)
Los Angeles Abrasion, % Loss	19	18	
Flat & Elongated, %			
3 to 1	11	12	25
5 to 1			
Bulk/Apparent Specific Gravity	2.710 / 2.741	2.824 / 2.858	2.824/2.858
Absorption, %	0.42	0.40	0.40
Soundness (5 Cycles), % Loss			
Sodium Sulfate	0.8	0.2	0.2
Crushed Content, %			
One Face	100	100	100
Two Face	100	100	100

Data not provided by the agency are represented by blank data fields.

<b>Table 1.5: Fine Aggregate Properties for Site 1</b>	
Test	No. 810's Both JMF
Bulk/Apparent Specific Gravity	2.822/2.854
Absorption, %	0.41
Soundness (5 Cycles), % Loss	
Sodium Sulfate	
Angularity, %	48.5
Liquid Limit, %	
Plasticity Index, %	
Data not provided by the agency are represented by blank data fields.	

Table 1.6: Site 1 Asphalt Binder Properties

**SHRP ASPHALT BINDER GRADING SUMMARY**

ASPHALT: Site 1  
 OPERATOR: Wilson  
 PROJECT: NCHRP 9-8  
 DATE: 10/20/97

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: 0.13 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135: 2087 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
GRADE	TEMP °C	ORIGINAL	RTFOT	GRADE	TEMP °C	RTFOT + PAV	TEMP °C	RTFOT + PAV		
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		DT (1mm/mm)
		G'/sinδ (kPa) ≥ 1.00 kPa	G'/sinδ (kPa) ≥ 2.20 kPa					G'/sinδ (MPa) ≤ 5000 kPa	S. Stiffness (MPa) ≤ 300 MPa	m. Slope ≥ 0.300
94	94			-10	37		0			
88	88			-16	34		-6			
82	82	0.83211	1.7463	-22	31	1298	-12	174	300	6574
76	76	1.3669	3.0133	-28	28	1908	-18			
70	70			-34	25	2743	-24			
64	64			-40	22	4030	-30			
58	58			-46	19	5684	-36			
52	52			-52	16		-42			
46	46			-58	13		-48			

**GRADE: PG 76-22**

<b>Table 1.7: Laydown Information for Site 1</b>	
Manufacturer of Paver:	Roadtec
Other Equipment Used:	Roadtec Shuttle-Buggy
Number of Rollers Used:	3 (Breakdown/Intermediate/Finish)
Temperature of Mixture When Delivered (Truck):	308°F (1 <sup>st</sup> measurement) 287°F (2 <sup>nd</sup> measurement)
Temperature of Mixture Right Behind Paver:	325°F (1 <sup>st</sup> measurement) 322°F (2 <sup>nd</sup> measurement)
Type Breakdown Roller:	Vibratory
Number of Passes By Breakdown Roller:	4
Temperature of Mixture Before Breakdown Roller Began Compaction:	293°F
Temperature of Mixture After Breakdown Roller Ended Compaction:	232°F
Type Intermediate Roller:	Static Steel Wheel
Number of Passes By Intermediate Roller:	5
Temperature of Mixture After Intermediate Roller Ended Compaction:	204°F
Type Finish Roller:	Static Steel Wheel
Temperature of Mixture After Finish Roller Ended Compaction:	165°F
Comments:	The mixture seemed to have sufficient workability. Loose mixture was occasionally shoveled to level places next to the longitudinal joint. No mixture was sticking to any of the rollers or truck beds. A few fat spots were noted on the pavement surface while observing the paving operations.

<b>Table 1.8: Sampling Times and Dates for Loose Mix From Site 1</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	May 5	May 6	May 7	May 7	May 7	May 8
Time Obtained	10:30 pm	8:30 pm	1:10 am	8:30 pm	10:30 pm	1:30 am
Temperature of Mixture in Truck, °F	350	360	350	350	350	350
Truck Load of the Day's Production**	N/A	4	32	5	33	16
Average Draindown, %	0.3	0.8	0.7	0.8	0.9	1.2

\*\* When paving at night (early p.m. to early a.m.) a day's production extends over two days (see samples 2 and 3).

Table 1.14: Results of Loaded Wheel Testing

Site No. 1

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	5.2	2.93	3.96	4.72
R2	5.6	2.90	3.67	4.02
R3	5.3	3.52	4.31	4.79
R4	5.9	3.26	4.23	4.87
<b>Average</b>	<b>5.5</b>	<b>3.15</b>	<b>4.04</b>	<b>4.60</b>
<b>Std. Dev.</b>	<b>0.32</b>	<b>0.294</b>	<b>0.290</b>	<b>0.391</b>

\* The mixture used for this testing was obtained from JMF-01-2.

Table 1.15: Results of Superpave Analysis Testing

Site No. 1

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @ Constant Height		G*				
		Delta				
Simple Shear Test @ Constant Height		Strain Rate, mm/mm				
		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

\* The mixture used for this testing was obtained from JMF-01-2.

Table 1.13: Results of SGC Compactions For JMF-01-2

SITE NUMBER: 1			MATERIALS Limestone/Marble Dust/Slag Wool/ PG 78-22									COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate	DATE					
AC Sp Gr (Gb) = 1.028			Apparent Specific Gravity of the Agg (Gsa) = 2.841			Bulk Specific Gravity of the Agg (Gsb) = 2.778													Bulk Sp. Gravity of CA (Gca)	2.808	4/18/98							
			WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES		CORR. % Gmm			VOLUMES AT Ndes		VOIDS									
Sample Number	Replicate	Asphalt Content %	In Air gms	In Water gms	SSD gms	N <sub>in</sub> (8 Gyr) mm	N <sub>des</sub> (100 Gyr) mm	N <sub>max</sub> (158 Gyr) mm	N <sub>in</sub> (8 Gyr)	N <sub>des</sub> (100 Gyr)	N <sub>max</sub> (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	N <sub>in</sub> %	N <sub>des</sub> %	N <sub>max</sub> %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA drc %			
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z			
									G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
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									G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
									G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
									G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
									G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
									G	H	I	J	K	L	M	N	O	P										

Table 1.12: Results of SGC Compactions For JMF-01-1

SITE NUMBER: 1		MATERIALS: Limestone/Marble Dust/Slag Wool/ PG 76-22										COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 72.0	DATE: 4/16/98		
AC Sp. Gr (Gb) = 1.028		Apparent Specific Gravity of the Agg. (Gsa) = 2.813					Bulk Specific Gravity of the Agg. (Gsb) = 2.750										Bulk Sp. Gravity of CA (Gca): 2.775								
																	Unit Wt. Of CA in DRC (pcf): 104.3								
																	Unit Wt. Of CA in DRC (kg/m3): 1670.7								
Sample Number	Replicate	Asphalt Content %	WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES			CORR. % Gmm			VOLUMES AT Ndes			VOIDS				
			In Air gms	In Water gms	SSD gms	Nini (6 Gyr) mm	Ndes (100 Gyr) mm	Nmax (158 Gyr) mm	Nini (6 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	Nini %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA drc %
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
									D	D	D	D	D	Gmb Est. Gmb Meas.	J*O	K*O	L*O	(100-C)*K*O (Gsb)	C*K*O (Gb)	100-Q	100-S	100(V-U) V			
1	1	5.7	4904.3	2933.7	4868.3	127.2	112.8		2.164	2.440		2.514	2.554	1.030	87.3	98.4		86.2	13.9	1.6	13.8	88.7	36.5	39.7	0.968
1	2	5.7	4772.3	2879.2	4776.5	124.8	110.5		2.164	2.444		2.515	2.554	1.029	87.2	98.5		86.3	13.9	1.5	13.7	89.0	36.5	39.7	0.968
1	3	5.7	4825.7	2908.1	4630.5	126.8	112.3		2.154	2.432		2.510	2.554	1.032	87.0	98.3		86.1	13.9	1.7	13.9	87.7	36.6	39.7	0.971
2	1	5.7	4850.8	2885.7	4858.1	133.0	117.9		2.064	2.328		2.435	2.559	1.046	84.3	95.1		83.5	13.5	4.9	16.5	70.6	40.4	39.7	1.018
2	2	5.7	4790.2	2794.4	4806.8	133.5	118.7		2.030	2.284		2.382	2.559	1.043	82.7	93.1		81.7	13.2	6.9	18.3	82.2	41.7	39.7	1.050
2	3	5.7	4734.8	2799.0	4748.6	133.2	117.9	115.9	2.012	2.273	2.312	2.427	2.559	1.050	82.5	93.2	94.8	81.8	13.2	6.8	18.2	82.8	41.6	39.7	1.047
3	1	5.8	4793.7	2821.3	4802.6	130.7	116.7		2.076	2.324		2.419	2.554	1.041	84.8	94.7		82.9	13.7	5.3	17.1	89.2	40.9	39.7	1.028
3	2	5.8	4798.2	2828.6	4806.0	130.8	116.4		2.076	2.333		2.427	2.554	1.040	84.5	95.0		83.1	13.7	5.0	16.9	70.4	40.7	39.7	1.024
3	3	5.8	4781.3	2838.4	4781.3	131.6	116.7	114.8	2.056	2.318	2.357	2.446	2.554	1.038	83.5	94.2	95.8	82.4	13.6	5.8	17.6	87.0	41.2	39.7	1.037
4	1																								
4	2		JMF-01-2 SAMPLES																						
4	3																								
5	1																								
5	2		JMF-01-2 SAMPLES																						
5	3																								
6	1																								
6	2		JMF-01-2 SAMPLES																						
6	3																								

Input By: \_\_\_\_\_ Checked By: A. Cooley  
 SSD = Saturated Surface Dry cc = cubic centimeter Gmb = Bulk Specific Gravity of Compacted Mixture Gsb = Bulk Specific Gravity of Aggregate VTM = Voids in Total Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gmm = Theoretical Maximum Density of Mixture Gb = Specific Gravity of Asphalt Cement VMA = Voids in Mineral Aggregate  
 gm = gram pcf = pounds per cubic foot Gsa = Apparent Specific Gravity of Aggregate VCA = Voids in Coarse Aggregate VFA = Voids Filled With Asphalt Cement

\* VCA drc determined at NCAT laboratory on materials obtained from project. Value differs slightly from that reported by agency.

Table 1.11: Results of Marshall Hammer Compactions for JMF-01-2

SITE NUMBER: 1			MATERIALS: Limestone/Marble Dust/Slag Wool/ PG 76-22					COARSE AGGREGATE INFORMATION					Percent Coarse Aggregate: 71.0		DATE: 4/16/98		
AC Sp. Gr. (G <sub>b</sub> ) = 1.028			Apparent Specific Gravity of the Agg. (G <sub>sa</sub> ) = 2.841			Bulk Specific Gravity of the Agg. (G <sub>sb</sub> ) = 2.778							Bulk Sp. Gravity of CA (G <sub>ca</sub> ) = 2.808		Unit Wt. Of CA in DRC (pcf): 106.6		
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	Unit Weight pcf	VTM %	VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
						F-E	$\frac{D}{G}$		$\frac{(100-C) \cdot H}{G_{sb}}$	$\frac{C \cdot H}{G_b}$	H * 62.4	100(1-H/I)	100 - J	$\frac{100 (N-M)}{N}$			
1	1																
1	2	JMF-01-1	SAMPLES														
1	3																
2	1																
2	2	JMF-01-1	SAMPLES														
2	3																
3	1																
3	2	JMF-01-1	SAMPLES														
3	3																
4	1	5.7	1132.8	670.2	1137.0	466.8	2.427	2.587	83.3	11.0	151.4	6.2	16.7	63.0	41.5	39.1	1.061
4	2	5.7	1118.1	659.6	1128.8	467.2	2.393	2.587	82.3	10.3	149.3	7.5	17.7	57.6	42.2	39.1	1.078
4	3	5.7	1158.6	685.4	1171.8	486.4	2.382	2.587	82.4	13.2	148.6	7.9	17.6	55.0	42.1	39.1	1.076
5	1																
5	2	SAMPLES NOT OBTAINED															
5	3																
6	1	5.8	1154.3	683.3	1157.3	474.0	2.435	2.566	83.5	11.3	152.0	5.1	15.5	69.2	41.4	39.1	1.057
6	2	5.8	1154.3	681.0	1158.0	477.0	2.420	2.566	83.4	13.7	151.0	5.7	16.6	65.8	41.4	39.1	1.059
6	3	5.8	1153.7	676.5	1156.9	478.4	2.412	2.566	82.9	13.6	150.5	6.0	17.1	64.9	41.8	39.1	1.068

Input By:							Checked By: A. Cooley
SSD = Saturated Surface Dry	cc = cubic centimeter	Gmb = Bulk Specific Gravity of Compacted Mixture	Gsb = Bulk Specific Gravity of Aggregate	VTM = Voids in Total Mix			
TMD = Theoretical Maximum Density	AC = Asphalt Cement	Gmm = Theoretical Maximum Density of Mixture	Gb = Specific Gravity of Asphalt Cement	VMA = Voids in Mineral Aggregate			
gm = gram	pcf = pounds per cubic foot	Gsa = Apparent Specific Gravity of Aggregate	VCA = Voids in Coarse Aggregate	VFA = Voids Filled With Asphalt Cement			

Table 1.10: Results of Marshall Hammer Compactions For JMF-01-1

Marshall Hammer: 50 Blows per Side																		
SITE NUMBER: 1		MATERIALS: Limestone/Marble Dust/Slag Wool/ PG 76-22							COARSE AGGREGATE INFORMATION				Percent Coarse Aggregate: 72.0		DATE: 4/16/98			
AC Sp. Gr. (Gb) = 1.028		Apparent Specific Gravity of the Agg. (Gsa) = 2.813				Bulk Specific Gravity of the Agg. (Gsb) = 2.750							Bulk Sp. Gravity of CA (Gca): 2.775		Unit Wt. Of CA in DRC (pcf): 104.3		Unit Wt. Of CA in DRC (kg/m3) 1670.7	
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	Unit Weight pcf	VTM %	VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
						F-E	$\frac{D}{G}$		$\frac{(100-C) * H}{Gsb}$	$\frac{C * H}{Gb}$	H * 62.4	$100(1-H/I)$	100 - J	$\frac{100(N-M)}{N}$				
1	1	5.7	1152.7	688.5	1153.3	464.8	2.480	2.554	85.0	11.4	154.8	2.9	15.0	80.6	39.3	39.7	0.974	
1	2	5.7	1153.5	685.6	1156.9	471.3	2.447	2.554	85.1	10.3	152.7	4.2	14.9	71.9	39.3	39.7	0.988	
1	3	5.7	1153.9	681.0	1157.8	476.8	2.420	2.554	83.0	13.4	151.0	5.2	17.0	69.2	40.8	39.7	1.027	
2	1	5.7	1150.6	673.5	1153.7	480.2	2.396	2.513	82.2	10.4	149.5	6.4	17.8	62.0	41.4	39.7	1.022	
2	2	5.7	1158.4	678.7	1161.9	483.2	2.397	2.513	83.2	10.6	149.6	6.3	16.8	62.3	41.3	39.7	1.041	
2	3	5.7	1148.6	674.4	1153.5	479.1	2.397	2.513	82.2	13.3	149.6	6.3	17.8	64.6	40.6	39.7	1.021	
3	1	5.8	1166.5	688.6	1169.5	480.9	2.426	2.513	83.1	13.7	151.4	5.0	16.9	69.0	40.7	39.7	1.025	
3	2	5.8	1165.2	687.2	1166.9	479.7	2.429	2.513	83.2	11.4	151.6	4.9	16.8	69.3	40.6	39.7	1.023	
3	3	5.8	1159.5	679.6	1183.1	483.5	2.398	2.513	83.2	10.6	149.6	6.1	16.8	63.6	41.4	39.7	1.022	
4	1																	
4	2	JMF-01-2 SAMPLES																
4	3																	
5	1																	
5	2	JMF-01-2 SAMPLES																
5	3																	
6	1																	
6	2	JMF-01-2 SAMPLES																
6	3																	

Input By: \_\_\_\_\_ Checked By: A. Cooley

SSD = Saturated Surface Dry      cc = cubic centimeter      Gmb = Bulk Specific Gravity of Compacted Mixture      Gsb = Bulk Specific Gravity of Aggregate      VTM = Voids in Total Mix  
 TMD = Theoretical Maximum Density      AC = Asphalt Cement      Gmm = Theoretical Maximum Density of Mixture      Gb = Specific Gravity of Asphalt Cement      VMA = Voids in Mineral Aggregate  
 gm = gram      pcf = pounds per cubic foot      Gsa = Apparent Specific Gravity of Aggregate      VCA = Voids in Coarse Aggregate      VFA = Voids Filled With Asphalt Cement

\* VCA drc determined at NCAT laboratory on materials obtained from project. Value differs slightly from that reported by agency.

Table 1.9: Gradations For Samples Obtained In-Field

Site: 1  
 Sample: 1

Sieve mm	JMF % Passing	Loose Mix Samples						Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Rep 1	Rep 2	Rep 3	Average	Std. Deviation
A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T
25.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00
19.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00
12.5	98.0	94.9	94.7	92.3	94.0	1.45	4.0	95.9	95.1	92.9	94.6	1.55	95.1	96.0	94.7	95.3	0.67
9.5	70.0	68.6	68.0	62.9	66.5	3.13	3.5	70.8	72.1	69.6	70.8	1.25	70.7	69.5	68.5	69.6	1.10
4.75	28.0	30.7	31.8	29.5	30.7	1.15	-2.7	33.5	35.0	32.6	33.7	1.21	34.4	34.6	33.6	34.2	0.53
2.36	19.0	20.5	21.1	19.8	20.5	0.65	-1.5	20.9	22.1	20.6	21.2	0.79	23.0	23.4	22.7	23.0	0.35
1.18	15.0	17.5	18.0	16.9	17.5	0.55	-2.5	16.6	17.6	16.3	16.8	0.68	19.3	19.6	19.0	19.3	0.30
0.60	14.0	16.1	16.7	15.6	16.1	0.55	-2.1	14.9	15.7	14.4	15.0	0.66	17.5	17.8	17.2	17.5	0.30
0.30	13.0	15.4	15.8	14.9	15.4	0.45	-2.4	13.9	14.8	13.5	14.0	0.56	16.5	16.8	16.1	16.5	0.35
0.150	12.0	14.5	14.7	13.9	14.4	0.42	-2.4	13.0	13.6	12.6	13.1	0.50	15.3	15.7	14.8	15.3	0.45
0.075	10.0	12.1	12.1	11.4	11.9	0.40	-1.9	10.6	11.2	10.6	10.9	0.31	12.7	13.3	12.1	12.7	0.60

Site: 1  
 Sample: 2

Sieve mm	JMF % Passing	Loose Mix Samples						Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Rep 1	Rep 2	Rep 3	Average	Std. Deviation
A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T
25.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00
19.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00
12.5	98.0	91.9	93.2	91.5	92.2	0.89	5.8	92.8	95.5	95.0	94.4	1.44	95.1	93.7	95.4	94.7	0.91
9.5	70.0	81.5	62.9	62.9	62.4	0.81	7.6	67.2	72.2	69.3	69.6	2.51	64.6	64.6	64.9	64.7	0.17
4.75	28.0	24.0	25.4	25.0	24.8	0.72	3.2	29.3	30.8	30.3	30.1	0.76	28.3	27.4	27.5	27.7	0.49
2.36	19.0	15.9	16.7	16.7	16.4	0.46	2.6	18.0	18.9	18.7	18.5	0.47	18.0	17.6	18.2	17.9	0.31
1.18	15.0	13.5	14.0	14.0	13.8	0.29	1.2	14.1	14.7	14.5	14.4	0.31	15.1	14.4	14.8	14.8	0.35
0.60	14.0	12.3	12.7	12.8	12.6	0.26	1.4	12.3	12.9	12.7	12.6	0.31	13.4	12.8	13.2	13.1	0.31
0.30	13.0	11.7	12.0	12.1	11.9	0.21	1.1	11.4	11.9	11.8	11.7	0.26	12.5	11.9	12.2	12.2	0.30
0.150	12.0	11.0	11.2	11.2	11.1	0.12	0.9	10.6	11.1	10.9	10.9	0.25	11.6	11.0	11.4	11.3	0.31
0.075	10.0	9.0	9.0	8.9	9.0	0.06	1.0	8.6	9.1	9.1	8.9	0.29	9.4	8.7	9.2	9.1	0.36

Site: 1  
 Sample: 3

Sieve mm	JMF % Passing	Loose Mix Samples						Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Rep 1	Rep 2	Rep 3	Average	Std. Deviation
A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T
25.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00
19.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00
12.5	98.0	97.2	96.2	96.4	96.6	0.53	1.4	97.9	96.9	96.5	97.1	0.72	96.5	96.2	96.4	96.4	0.15
9.5	70.0	71.2	70.7	68.2	70.0	1.61	0.0	77.4	75.4	74.2	75.7	1.62	72.4	72.1	72.3	72.3	0.15
4.75	28.0	30.5	29.7	30.5	30.2	0.46	-2.2	34.9	35.6	32.5	34.3	1.63	31.5	32.2	32.5	32.1	0.51
2.36	19.0	18.3	17.7	17.7	17.9	0.35	1.1	20.9	20.4	19.0	20.1	0.98	19.4	19.6	19.8	19.8	0.20
1.18	15.0	15.0	14.7	14.6	14.8	0.21	0.2	16.2	15.7	14.8	15.6	0.71	15.6	15.9	15.9	15.8	0.17
0.60	14.0	13.5	13.3	13.2	13.3	0.15	0.7	14.1	13.6	12.8	13.5	0.66	13.8	14.0	14.1	14.0	0.15
0.30	13.0	12.8	12.6	12.4	12.6	0.20	0.4	13.1	12.6	11.8	12.5	0.66	12.8	13.1	13.1	13.0	0.17
0.150	12.0	11.9	11.9	11.7	11.8	0.12	0.2	12.2	11.8	11.0	11.7	0.61	11.9	12.2	12.3	12.1	0.21
0.075	10.0	7.4	9.8	9.5	8.9	1.31	1.1	9.8	9.5	9.0	9.4	0.40	9.7	10.0	10.0	9.9	0.17

Table 1.9 (Continued): Gradations For Samples Obtained In-Field

Site: 1  
Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples						Std. Deviation	Diff. From JMF	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Diff. From JMF			Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Rep 1	Rep 2	Rep 3	Average	Std. Deviation
A	B	C	D	E	F	G	H	B-F	J	K	L	M	N	P	Q	R	S	T	
25.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0		100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00	
19.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0		100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00	
12.5	93.0	92.2	93.3	92.8	92.8	0.55	0.2		93.4	89.5	91.0	91.3	1.97	91.5	95.5	90.4	92.5	2.68	
9.5	70.0	62.4	68.5	66.1	66.3	3.41	3.7		72.0	67.4	65.7	68.4	3.26	66.1	63.9	63.5	64.5	1.40	
4.75	29.0	25.1	26.6	27.3	26.3	1.12	2.7		32.6	28.8	25.7	29.4	2.99	27.3	27.8	26.8	27.3	0.50	
2.36	19.0	15.4	16.5	16.4	16.1	0.61	2.9		19.1	16.6	15.6	17.1	1.80	16.9	17.1	16.6	16.9	0.25	
1.18	16.0	12.9	14.0	13.8	13.6	0.59	2.4		14.8	13.0	12.1	13.3	1.37	13.8	14.0	13.5	13.8	0.25	
0.60	14.0	11.8	12.8	12.6	12.4	0.53	1.6		12.9	11.4	10.7	11.7	1.12	12.3	12.6	12.0	12.3	0.30	
0.30	13.0	11.3	12.3	12.0	11.9	0.51	1.1		12.0	10.7	10.0	10.9	1.01	11.6	11.9	11.3	11.6	0.30	
0.150	12.0	10.7	11.6	11.4	11.2	0.47	0.8		11.2	10.0	9.4	10.2	0.92	10.8	11.1	10.5	10.8	0.30	
0.075	10.0	8.8	9.6	9.3	9.2	0.40	0.8		9.1	8.1	7.9	8.4	0.64	8.8	9.2	8.5	8.8	0.35	

Site: 1  
Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples						Std. Deviation	Diff. From JMF	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Diff. From JMF			Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Rep 1	Rep 2	Rep 3	Average	Std. Deviation
A	B	C	D	E	F	G	H	B-F	J	K	L	M	N	P	Q	R	S	T	
25.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0							100.0	100.0	100.0	100.0	0.00	
19.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0							100.0	100.0	100.0	100.0	0.00	
12.5	93.0	96.7	92.9	95.8	95.1	1.99	-2.1							93.4	94.1	93.9	93.8	0.36	
9.5	70.0	72.1	65.5	70.9	69.5	3.52	0.5							67.7	67.7	71.2	68.9	2.02	
4.75	29.0	30.7	27.7	32.5	30.3	2.42	-1.3							28.4	28.0	30.7	29.0	1.46	
2.36	19.0	18.4	16.7	19.1	18.1	1.23	0.9							17.0	16.5	19.0	17.5	1.32	
1.18	16.0	15.4	13.8	15.9	15.0	1.10	1.0							13.8	12.2	15.6	13.9	1.70	
0.60	14.0	14.1	12.6	14.4	13.7	0.96	0.3							12.3	11.8	14.0	12.7	1.15	
0.30	13.0	13.4	12.0	13.7	13.0	0.91	0.0							11.5	11.0	13.2	11.9	1.15	
0.150	12.0	12.7	11.3	12.7	12.2	0.81	-0.2							10.8	10.2	12.2	11.1	1.03	
0.075	10.0	10.4	9.0	10.2	9.9	0.76	0.1							8.7	8.2	9.6	8.8	0.71	

Site: 1  
Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples						Std. Deviation	Diff. From JMF	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Diff. From JMF			Rep 1	Rep 2	Rep 3	Average	Std. Deviation	Rep 1	Rep 2	Rep 3	Average	Std. Deviation
A	B	C	D	E	F	G	H	B-F	J	K	L	M	N	P	Q	R	S	T	
25.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0		100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00	
19.0	100.0	100.0	100.0	100.0	100.0	0.00	0.0		100.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	0.00	
12.5	93.0	95.1	93.3	93.3	93.9	1.04	-0.9		92.8	90.4	92.2	91.8	1.25	93.6	93.4	93.5	93.5	0.10	
9.5	70.0	71.4	68.0	66.7	68.7	2.43	1.3		74.0	68.6	70.0	70.9	2.80	64.9	67.1	68.9	67.0	2.00	
4.75	29.0	29.7	27.3	26.7	27.9	1.59	1.1		31.9	30.9	31.9	31.6	0.58	27.1	28.1	29.4	28.2	1.15	
2.36	19.0	18.4	16.3	16.3	17.0	1.21	2.0		18.5	17.6	17.9	18.0	0.46	16.8	17.1	17.7	17.2	0.46	
1.18	15.0	15.4	13.6	13.6	14.2	1.04	0.8		14.5	13.6	13.9	14.0	0.46	13.7	13.9	14.4	14.0	0.36	
0.60	14.0	14.1	12.4	12.4	13.0	0.98	1.0		12.7	11.9	12.1	12.2	0.42	12.2	12.4	12.9	12.5	0.36	
0.30	13.0	13.4	11.8	11.8	12.3	0.92	0.7		11.8	11.0	11.2	11.3	0.42	11.4	11.6	12.1	11.7	0.36	
0.150	12.0	12.5	11.1	11.1	11.6	0.81	0.4		10.9	10.3	10.5	10.6	0.31	10.7	10.8	11.3	11.1	0.35	
0.075	10.0	9.7	8.9	9.0	9.2	0.44	0.8		8.8	8.3	8.5	8.5	0.25	8.6	8.5	9.2	8.8	0.38	

Table 2.5: Site 2A Asphalt Binder Properties

**SHRP ASPHALT BINDER GRADING SUMMARY**

ASPHALT: Site 2  
 OPERATOR: Wilson  
 PROJECT: NCHRP 9-8  
 DATE: 10/21/97

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss 0.15 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135: 1833 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
GRADE	TEMP °C	ORIGINAL	RTFOT	GRADE	TEMP °C	RTFOT + PAV	TEMP °C	RTFOT + PAV		
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		DT (1mm/min)
		G/sinδ (kPa) ≥ 1.00 kPa	G/sinδ (kPa) ≥ 2.20 kPa			G/sinδ (MPa) ≤ 5000 kPa		S, Stiffness (MPa) ≤ 300 MPa	m, Slope ≥ 0.300	Failure Strain ≥ 1.0%
94	94			-10	37		0			
88	88			-16	34		-6			
82	82	0.7869	1.4514	-22	31		-12			
76	76	1.4008	2.5245	-28	28	783	-18	211	0.372	.7046
70	70			-34	25	1150	-24			
64	64			-40	22		-30			
58	58			-46	19		-36			
52	52			-52	16		-42			
46	46			-58	13		-48			

**GRADE: PG 76-28**

NCAT

## **NCHRP 9-8 II - Task 8 SMA Construction Project No. 2**

### **Location and Background**

Site No. 2 was constructed in May of 1997. NCAT staff were on-site from May 19 to May 23, 1997. This project called for a 38 mm (1.5 in) overlay of an existing pavement. Within the extent of this project, the interstate was a four-lane divided highway. While at the project, paving was accomplished on both the inside and outside lanes on the eastbound side.

### **SMA Mixture Information**

The SMA mixture used for this project was a 12.5 mm nominal maximum aggregate size mix. Information about the mixture is presented in Table 2.1. The aggregate used to produce the mixture was a crushed basalt gravel. Figures 2.1 and 2.2 show this aggregate before and after crushing, respectively. The design gradation is presented in Table 2.2. Properties of the coarse and fine aggregates are presented in Tables 2.3 and 2.4, respectively. A PG 76-28 asphalt binder was used for this mixture. Properties of this binder are presented in Table 2.5. No stabilizing fibers were used on this project.

### **Plant Information**

The facility used to produce the SMA mixture was a Barber-Greene batch plant. However, several modifications were made to this plant. The screen decks had been removed. The aggregate exiting the hot elevator fell straight into a weigh hopper. From

the weigh hopper, the aggregate fell into a pugmill where the asphalt was immediately injected and the mixture was mixed. There was no “dry” mixing time in the pugmill. The “wet” mixing time was from 15 to 20 seconds.

This facility utilized only one storage silo, which was for the mineral filler. The mineral filler was blown from the storage silo straight to the pugmill. Hydrated lime was used as an anti-stripping agent, but it was pneumatically blown from a truck. The lime was added at a pugmill located along the cold feed conveyor belt. This pugmill mixed the cold feed aggregate and lime with water before sending them to the dryer.

### **Laydown Procedures**

Paving operations were observed on May 20 and May 21, 1997. On both days, it was overcast with an ambient temperature of approximately 70°F. Additional information about the observed laydown procedures are presented in Table 2.6.

For this project, “belly” dump trucks were used. The trucks would drop the mixture in windrows onto the existing pavement. A windrow elevator was attached to the front of the paver to pick the mixture up and deposit it into the paver.

When paving the outside lane, the paver was utilizing a front-mounted extendable screed. With the extensions, the paver was pulling a width of 6.7 m (22 ft). This is illustrated in Figure 2.3. In one pull, the contractor was paving both the lane width and the shoulder width.

For longitudinal joint construction, the contractor was utilizing a tapered joint. This is illustrated in Figure 2.4.

For the two days of observation, the contractor was using two rollers (16-ton and 12-ton) to compact the mixture; however, two different rolling patterns were used. On May 20<sup>th</sup>, the contractor was using four passes by the 16-ton roller for breakdown. The roller would alternate between vibratory and static mode. The first pass would be in vibratory mode, the second in static, the third in vibratory, and the last in static. The 12-ton roller was used as the finish roller and made two passes in a static mode.

On May 21<sup>st</sup>, the contractor was again using the 16 ton roller for breakdown, but was making two passes in a static mode. The 12-ton roller would then make four passes alternating between vibratory and static modes. The first pass was made in a vibratory mode, the second in static, the third in vibratory, and the last in static.

### **Problems Encountered On-Site**

No problems were encountered with the mixture while on the job site. However, mixture was noticed to be sticking to trucks when emptying onto the roadway. Releasing agents were being used.

### **Sampling**

Samples obtained from this project included: each aggregate used to within the mixture, mineral filler, asphalt binder, loose mixture, and ten cores. Table 2.7 presents the times and dates that the loose mix samples were obtained along with average draindown values for each sample. Quality control practices in this state require an independent laboratory to perform testing. As part of quality control, specimens were compacted with the Marshall hammer (50 blows per side). Therefore, NCAT personnel

did not compact specimens using the Marshall hammer for this project. However, the data and specimens accumulated by the independent laboratory were obtained. Tables 2.8 through 2.13 present the results of testing performed in the field and in the laboratory. Table 2.9 reflects the times and dates that the independent contractor compacted Marshall specimens.

<b>Table 2.1: Site 2 SMA Mixture Information</b>	
JMF I.D. Number:	197-255
Dates on Project:	May 19 through 23, 1997
Number of Aggregate Stockpiles Used:	3
Design Voids in Coarse Aggregate:	41.3 percent*
Type Asphalt Binder Used:	PG 76-28
Modifier Type:	Styrelf
Design Asphalt Binder Content:	7.1 percent
Supplier of Asphalt Binder:	Koch
Type Fiber Used:	None
Form of Fiber:	N/A
Design Percentage of Fiber:	N/A
Type Mineral Filler Used:	Limestone Dust
Design Percentage of Mineral Filler:	4.6 percent
Type Anti-Strip Additive Used:	Hydrated Lime
Design Percentage of Anti-Strip:	1.0 percent
Compaction Method:	Marshall Hammer
Compactive Effort:	50 Blows per side
Laboratory Mixing Temperature:	325 °F
Laboratory Compaction Temperature:	300 °F
Design Voids in Total Mix:	3.7 percent
Design Mixture Density:	144.2 pcf
Design Voids in Mineral Aggregate:	17.5 percent
Design Voids Filled With Asphalt:	78.9 percent
Design Marshall Stability:	2590 lbs
Design Flow (0.01 in):	15
Loaded Wheel Test @ Design Asphalt Content:	

\* Performed at NCAT laboratory on materials obtained from the project.

<b>Table 2.2: Design Gradation for Site 2</b>			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
¾ in.	19.0	100	100
½ in.	12.5	85-95	100
⅜ in.	9.5	75 max.	87
No. 4	4.75	20-28	30
No. 8	2.36	16-24	19
No. 16	1.18	----	15
No. 30	0.600	12-16	13
No. 50	0.300	12-15	11
No. 100	0.150	----	9
No. 200	0.075	8-10	8

<b>Table 2.3: Coarse Aggregate Properties for Site 2</b>	
Test	Combined Aggregates
Los Angeles Abrasion, % Loss	20.6
Flat & Elongated, %	
3 to 1	
5 to 1	
Bulk/Apparent Specific Gravity	2.595/
Absorption, %	
Soundness (5 Cycles), % Loss	
Sodium Sulfate	3
Crushed Content, %	
One Face	100*
Two Face	98.5
Data not provided by the agency represented by blank data fields.	

\* Performed at NCAT laboratory on materials obtained from the project.

<b>Table 2.4: Fine Aggregate Properties for Site 2</b>	
Test	Combined Aggregates
Bulk/Apparent Specific Gravity	2.595/
Absorption, %	
Soundness (5 Cycles), % Loss	
Sodium Sulfate	3
Angularity, %	47.9*
Liquid Limit, %	NL
Plasticity Index, %	NP
Data not provided by agency represented by blank data fields.	

\* Performed at NCAT laboratory on materials obtained from the project.

<b>Table 2.6: Laydown Information from Site 2</b>	
Manufacturer of Paver:	Blaw Knox
Other Equipment Used:	Windrow Elevator
Number of Rollers Used:	2
Temperature of Mixture When Delivered (Truck):	335 °F (May 20 <sup>th</sup> ) 340 °F (May 21 <sup>st</sup> )
Temperature of Mixture After Finish Roller Ended Compaction:	270 °F (May 20 <sup>th</sup> ) 278 °F (May 21 <sup>st</sup> )
Comments:	The mixture was noticed to be sticking to trucks.

<b>Table 2.7: Sampling Times and Dates for Loose Mix Samples From Site 2</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	May 19	May 20	May 20	May 21	May 21	May 21
Time Obtained	12:35 pm	10:15 am	1:15 pm	9:20 am	11:20 am	4:45 pm
Temperature of Mixture in Truck, °F	335	335	340	325	335	340
Average Draindown, %	0.9	1.4	1.2	1.3	1.0	0.8

Table 2.8: Gradations For Samples Obtained In-Field

Site: 2  
Sample: 1

Sieve mm	JMF % Passing	Loose Mix Samples						Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	5/19/97 12:45		5/19/97 12:45	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	
		C	D	F	G	H	J		K	M	N	O	P	Q	S	T	U	
							B-F						I-M					I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	0.0
12.5	100.0	99.8	100.0	99.9	0.14	0.1	99.8	99.7	100.0	99.9	0.21	-0.3	99.9	99.8	99.8	0.07	-0.3	-0.3
9.5	87.0	86.3	86.6	86.5	0.21	0.6	87.8	88.9	86.3	87.6	1.84	0.0	86.8	84.1	85.5	1.91	2.2	2.2
4.75	30.0	29.1	33.2	31.2	2.90	-1.2	36.0	36.3	36.1	36.2	0.14	-0.2	33.8	33.1	33.5	0.49	2.6	2.6
2.36	19.0	19.8	22.6	21.2	1.98	-2.2	24.3	23.1	22.4	22.8	0.49	1.5	22.5	22.4	22.5	0.07	1.8	1.8
1.18	15.0	15.9	18.5	17.2	1.84	-2.2	19.5	17.8	17.3	17.6	0.35	1.9	18.0	18.0	18.0	0.00	1.5	1.5
0.60	13.0	13.7	16.0	14.9	1.63	-1.9	16.6	14.9	14.3	14.6	0.42	2.0	15.3	15.5	15.4	0.14	1.2	1.2
0.30	11.0	12.0	14.0	13.0	1.41	-2.0	14.3	12.7	12.1	12.4	0.42	1.9	13.2	13.6	13.4	0.28	0.9	0.9
0.150	9.0	10.1	11.8	11.0	1.20	-2.0	12.1	10.4	9.9	10.2	0.35	2.0	11.0	11.3	11.2	0.21	1.0	1.0
0.075	8.0	8.0	9.3	8.7	0.92	-0.7	9.8	8.1	7.7	7.9	0.28	1.9	8.6	8.9	8.8	0.21	1.1	1.1

Site: 2  
Sample: 2

Sieve mm	JMF % Passing	Loose Mix Samples						Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	5/21/97 13:45		5/21/97 13:45	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	
		C	D	F	G	H	J		K	M	N	O	P	Q	S	T	U	
							B-F						I-M					I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	0.0
12.5	100.0	99.8	99.8	99.7	0.14	0.3	99.8	99.6	100.0	99.8	0.28	-0.2	99.8	100.0	99.8	0.28	-0.2	-0.2
9.5	87.0	85.8	87.2	86.5	0.99	0.5	87.8	84.7	86.3	85.5	1.13	2.1	85.1	86.9	86.0	1.27	1.8	1.8
4.75	30.0	30.2	32.1	31.2	1.34	-1.2	36.0	34.7	34.3	34.5	0.28	1.5	31.4	32.4	31.9	0.71	4.1	4.1
2.36	19.0	19.4	20.1	19.6	0.49	-0.8	24.3	22.4	22.3	22.4	0.07	1.9	20.1	21.0	20.6	0.64	3.7	3.7
1.18	15.0	15.3	16.0	15.7	0.49	-0.7	19.5	17.3	17.3	17.3	0.00	2.2	15.7	16.4	16.1	0.49	3.4	3.4
0.60	13.0	13.0	13.5	13.3	0.42	-0.3	16.6	14.3	14.4	14.4	0.07	2.2	13.2	13.8	13.5	0.42	3.1	3.1
0.30	11.0	11.2	11.8	11.5	0.42	-0.5	14.3	12.1	12.1	12.1	0.00	2.2	11.3	11.8	11.6	0.35	2.8	2.8
0.150	9.0	9.3	9.7	9.5	0.28	-0.5	12.1	9.8	9.8	9.8	0.00	2.3	9.2	9.6	9.4	0.28	2.7	2.7
0.075	8.0	7.2	7.6	7.4	0.28	0.6	9.8	7.5	7.5	7.5	0.00	2.3	7.2	7.4	7.3	0.14	2.5	2.5

Site: 2  
Sample: 3

Sieve mm	JMF % Passing	Loose Mix Samples						Average Core Gradation	Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1		Rep 2	Average	Std. Deviation	Diff. From Cores	
		C	D	F	G	H	P		Q	S	T	U	
							B-F						I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	0.0
12.5	100.0	100.0	99.8	99.9	0.14	0.1	99.6	100.0	95.2	97.6	3.39	2.0	2.0
9.5	87.0	83.3	85.7	84.5	1.70	2.5	87.6	83.8	84.9	84.4	0.78	3.3	3.3
4.75	30.0	27.7	27.7	27.7	0.00	2.3	36.0	30.7	29.2	30.0	1.06	6.1	6.1
2.36	19.0	17.7	17.0	17.4	0.49	1.7	24.3	19.1	18.4	18.8	0.49	5.5	5.5
1.18	15.0	13.5	13.0	13.3	0.42	1.7	19.5	14.5	13.9	14.2	0.42	5.3	5.3
0.60	13.0	11.2	10.7	11.0	0.35	2.1	16.6	11.8	11.3	11.6	0.35	5.0	5.0
0.30	11.0	9.4	9.0	9.2	0.28	1.8	14.3	9.8	9.4	9.6	0.28	4.7	4.7
0.150	9.0	7.6	7.9	7.9	0.07	1.2	12.1	8.0	7.7	7.9	0.21	4.3	4.3
0.075	8.0	6.2	5.9	6.1	0.21	2.0	9.8	6.3	6.0	6.2	0.21	3.7	3.7

Table 2.8 (Continued): Gradations For Samples Obtained In-Field

Site: 2  
 Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
		C	D	F	G	H		P	Q	S	T	U
A	B	C	D	F	G	H	I	P	Q	S	T	U
						B-F						I-S
25.0	100.0	100.0	10.0	55.0	63.64	45.0	100.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0
12.5	100.0	99.8	99.7	99.8	0.07	0.3	99.6	99.5	100.0	99.8	0.35	-0.2
9.5	87.0	85.0	85.4	85.2	0.28	1.8	87.6	86.7	83.8	85.3	2.05	2.4
4.75	30.0	27.0	28.2	27.6	0.85	2.4	36.0	31.1	28.9	30.0	1.56	6.0
2.36	19.0	17.9	17.9	17.9	0.00	1.1	24.3	19.9	19.2	19.6	0.49	4.7
1.18	15.0	14.1	14.2	14.2	0.07	0.9	19.5	15.3	15.0	15.2	0.21	4.3
0.60	13.0	11.9	11.9	11.9	0.00	1.1	16.6	12.6	12.5	12.6	0.07	4.0
0.30	11.0	10.2	10.2	10.2	0.00	0.8	14.3	10.5	10.6	10.6	0.07	3.8
0.150	9.0	8.4	8.4	8.4	0.00	0.6	12.1	8.6	8.7	8.7	0.07	3.5
0.075	8.0	6.6	6.6	6.6	0.00	1.4	9.8	6.5	6.8	6.7	0.21	3.2

Site: 2  
 Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
		C	D	F	G	H		P	Q	S	T	U
A	B	C	D	F	G	H	I	P	Q	S	T	U
						B-F						I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0
12.5	100.0	99.7	99.8	99.8	0.07	0.3	99.6	99.6	100.0	99.8	0.28	-0.2
9.5	87.0	84.3	81.7	83.0	1.84	4.0	87.6	86.7	85.8	86.3	0.64	1.4
4.75	30.0	28.4	28.4	28.4	0.00	1.6	36.0	33.8	32.1	33.0	1.20	3.1
2.36	19.0	18.6	18.7	19.7	0.07	-0.6	24.3	23.6	22.5	23.1	0.78	1.2
1.18	15.0	16.0	16.1	16.1	0.07	-1.1	19.5	18.9	18.0	18.5	0.64	1.0
0.60	13.0	14.0	14.1	14.1	0.07	-1.1	16.6	16.2	15.5	15.9	0.49	0.7
0.30	11.0	12.4	12.6	12.5	0.14	-1.5	14.3	14.2	13.7	14.0	0.35	0.4
0.150	9.0	10.8	10.8	10.8	0.00	-1.8	12.1	12.1	11.6	11.9	0.35	0.3
0.075	8.0	8.8	8.8	8.8	0.00	-0.8	9.8	9.7	9.3	9.5	0.28	0.3

Site: 2  
 Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
		C	D	F	G	H		P	Q	S	T	U
A	B	C	D	F	G	H	I	P	Q	S	T	U
						B-F						I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0
12.5	100.0	99.6	99.8	99.7	0.14	0.3	99.6	100.0	100.0	100.0	0.00	-0.4
9.5	87.0	86.5	89.5	88.0	2.12	-1.0	87.6	87.2	88.0	87.6	0.57	0.0
4.75	30.0	31.6	32.5	32.1	0.64	-2.1	36.0	34.1	34.0	34.1	0.07	2.0
2.36	19.0	21.0	21.8	21.4	0.57	-2.4	24.3	22.8	23.1	23.0	0.21	1.3
1.18	15.0	16.9	17.8	17.4	0.64	-2.4	19.5	17.9	18.4	18.2	0.35	1.3
0.60	13.0	14.5	15.4	15.0	0.64	-2.0	16.6	15.0	15.6	15.3	0.42	1.3
0.30	11.0	12.7	13.6	13.2	0.64	-2.2	14.3	12.7	13.5	13.1	0.57	1.2
0.150	9.0	10.6	11.3	11.0	0.49	-2.0	12.1	10.4	11.4	10.9	0.71	1.2
0.075	8.0	8.4	9.0	8.7	0.42	-0.7	9.8	8.1	9.3	8.7	0.85	1.1



Table 2.10: Results of SGC Compactions

SITE NUMBER: 2		MATERIALS: Basalt/Limestone Dust/ PG 76-22										COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 71.0		DATE: 1/30/98																
AC Sp. Gr. (G <sub>b</sub> ) = 1.028		Apparent Specific Gravity of the Agg. (G <sub>sa</sub> ) = 2.725										Bulk Specific Gravity of the Agg. (G <sub>sb</sub> ) = 2.820										Bulk Sp. Gravity of CA (G <sub>ca</sub> ): 2.845		Unit Wt. Of CA in DRC (pcf): 98.8																
		WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES		CORR. % Gmm			VOLUMES AT Ndes			VOIDS																					
Sample Number	Replicate	Asphalt Content %	In Air gms	In Water gms	SSD gms	Nini (8 Gyr) mm	N10s (100 Gyr) mm	Nmax (158 Gyr) mm	Nini (8 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	Nini %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA VCA drc %															
A	B	C	D	E	F	G	H	I	J	K	L	M	N	D	P	Q	R	S	T	U	V	W	X	Y	Z															
			G*17.67			H*17.67			I*17.67			D		Gmb, Est. Gmb Meas.			J*O			K*O			L*O			(100-C)*K*O (Gsb)			C*K*O (Gsb)			100-Q			100-S			100(V-U) V		
1	1	5.8	4947.2	2783.2	4987.5	143.2	127.9		1.955	2.180		2.244	2.433	1.025	82.4	92.2		80.4	12.7	7.8	19.6	80.4	43.2	41.3	1.047															
1	2	5.8	4749.2	2989.3	4774.9	135.1	122.6		1.946	2.192		2.256	2.433	1.029	82.3	92.7		80.8	12.7	7.3	19.2	82.0	43.0	41.3	1.040															
1	3	5.8	4425.0	2513.1	4442.2	125.5	112.3		1.979	2.230		2.294	2.433	1.029	83.7	94.3		82.2	12.9	5.7	17.8	67.9	42.0	41.3	1.016															
2	1	6.2	4395.5	2432.6	4389.5	126.6	114.3		1.919	2.163		2.232	2.440	1.032	81.2	91.5		79.6	13.5	8.5	20.4	58.2	43.8	41.3	1.060															
2	2	6.2	4516.8	2501.0	4547.2	133.9	118.4		1.909	2.159		2.207	2.440	1.023	80.0	90.5		78.6	13.3	9.5	21.2	55.1	44.4	41.3	1.076															
2	3	6.2	4471.1	2506.5	4529.5	135.2	120.1		1.671	2.107		2.210	2.440	1.049	80.5	90.6		78.9	13.3	9.4	21.1	55.4	44.4	41.3	1.073															
3	1	5.9	4480.7	2474.3	4519.1	134.8	120.0		1.981	2.113		2.191	2.456	1.037	79.4	89.2		76.4	12.9	10.8	21.6	50.0	44.5	41.3	1.061															
3	2	5.9	4420.3	2457.9	4480.0	134.3	119.2	117.3	1.853	2.098	2.132	2.206	2.456	1.036	78.5	88.5	89.9	77.8	12.4	11.5	22.2	48.1	45.1	41.3	1.062															
3	3	5.9	4361.3	2442.2	4397.3	130.6	119.2	114.4	1.890	2.124	2.157	2.231	2.456	1.034	79.6	89.4	90.8	78.6	12.9	10.6	21.4	50.5	44.5	41.3	1.078															
4	1	5.7	4345.2	2317.7	4391.8	129.0	114.3		1.908	2.151		2.095	2.420	0.974	76.7	86.8		75.2	11.9	13.4	24.8	49.0	47.0	41.3	1.137															
4	2	5.7	4387.8	2318.9	4422.0	131.0	116.3		1.900	2.140		2.091	2.420	0.977	76.7	86.4		75.0	11.6	13.6	25.0	45.8	47.1	41.3	1.139															
4	3	5.7	4399.8	2342.6	4424.3	130.4	116.1		1.909	2.144		2.113	2.420	0.986	77.8	87.3		75.6	11.7	12.7	24.2	47.6	46.5	41.3	1.125															
5	1	5.9	4436.9	2512.8	4446.9	127.2	112.8		1.974	2.224		2.284	2.418	1.032	84.3	95.0		82.1	13.1	5.0	17.9	71.7	42.0	41.3	1.017															
5	2	5.9	4448.7	2495.1	4483.4	129.6	114.8		1.942	2.193		2.280	2.418	1.031	82.9	93.6		80.9	12.9	6.4	19.1	69.2	42.9	41.3	1.038															
5	3	5.9	4443.2	2544.2	4453.6	126.3	112.4		1.981	2.237		2.327	2.418	1.040	85.7	96.3		83.3	13.3	3.7	16.7	77.8	41.2	41.3	0.997															
6	1	6.2	4378.3	2483.0	4389.1	125.4	110.3		1.976	2.246		2.277	2.445	1.014	81.9	93.1		81.3	13.6	6.9	18.7	63.9	42.7	41.3	1.032															
6	2	6.2	4399.8	2496.0	4412.6	126.6	114.1		1.932	2.181		2.256	2.445	1.030	81.8	92.4		80.6	13.5	7.8	19.4	50.7	43.1	41.3	1.043															
6	3	6.2	4413.4	2461.3	4437.5	130.5	116.3		1.914	2.147		2.235	2.445	1.040	81.4	91.3		79.7	13.4	8.7	20.3	57.3	43.7	41.3	1.059															

Input By: \_\_\_\_\_ Checked By: A. Cooley  
SSD = Saturated Surface Dry      cc = cubic centimeter      Gmb = Bulk Specific Gravity of Compacted Mixture      Gsb = Bulk Specific Gravity of Aggregate      VTM = Voids in Total Mix  
TMD = Theoretical Maximum Density      Gmm = Theoretical Maximum Density of Mixture      Gc = Specific Gravity of Asphalt Cement      VMA = Voids in Mineral Aggregate  
gm = gram      pcf = pounds per cubic foot      Gsa = Apparent Specific Gravity of Aggregate      VCA = Voids in Coarse Aggregate      VFA = Voids Filled With Asphalt Cement

Table 2.11: Results of Loaded Wheel Testing

Site No.: 2

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	9.5	2.01	4.3	5.48
R2	7.3	2.47	2.96	4.04
R3	7.5	3.61	4.66	5.18
R4	10.1	2.48	5.22	5.91
<b>Average</b>	<b>8.6</b>	<b>2.64</b>	<b>4.29</b>	<b>5.15</b>
<b>Std. Dev.</b>	<b>1.41</b>	<b>0.681</b>	<b>0.961</b>	<b>0.800</b>

Table 2.12: Results of Superpave Analysis Testing

Site No.: 2

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @		G*				
Constant Height		Delta				
Simple Shear Test @		Strain Rate, mm/mm				
Constant Height		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

Table 2.13: Results of Rut Testing on Cores Obtained In-Field

Site No.: 2

Sieve mm	Percent Passing										Average	Std. Dev.	
	Core 1	Core 2	Core 3	Core 4	Core 5	Core 6	Core 7	Core 8	Core 9	Core 10			
25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.00
19.0	100.0	100.0	100.0	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.06
12.5	99.6	100.0	99.5	99.0	99.9	99.7	100.0	99.4	99.3	99.6	99.6	99.6	0.32
9.5	92.1	88.4	86.1	87.3	88.3	86.4	85.7	88.3	86.3	87.3	87.6	87.6	1.86
4.75	40.4	36.2	36.7	37.3	36.8	32.9	33.1	38.3	34.7	33.8	36.0	36.0	2.40
2.36	26.1	23.9	24.4	25.2	24.9	21.7	22.4	26.7	24.4	22.9	24.3	24.3	1.59
1.18	20.8	19.2	19.6	20.3	19.8	17.1	17.9	21.9	19.6	18.4	19.5	19.5	1.41
0.60	17.6	16.2	16.7	17.3	16.8	14.4	15.2	19.0	16.8	15.7	16.6	16.6	1.30
0.30	15.5	13.8	14.5	14.9	14.4	12.3	12.9	16.6	14.5	13.6	14.3	14.3	1.24
0.150	12.9	11.5	12.1	12.6	12.2	10.7	10.8	14.7	12.2	11.5	12.1	12.1	1.16
0.075	10.6	9.3	9.8	10.3	9.8	8.6	8.6	12.1	9.9	9.3	9.8	9.8	1.03
Gmb	2.285	2.207	2.186	2.212	2.199	2.215	2.239	2.237	2.338	2.288	2.241	2.241	0.05
Unit Weight, pcf	142.6	137.7	136.4	138.0	137.2	138.2	139.7	139.6	145.9	142.8	139.8	139.8	3.03
VTM, %	6.7	9.9	10.7	9.7	10.2	8.7	7.7	7.8	3.6	5.7	8.1	8.1	2.25



**Figure 2.1: Uncrushed Basalt Gravel Used For Site 2**



**Figure 2.2: Crushed Basalt Gravel Used For Site 2**



**Figure 2.3: Paver With Front-Mounted Extendable Screed Used For Site 2**



**Figure 2.4: Tapered Longitudinal Joint Used For Site 2**

## **NCHRP 9-8 II - Task 8 SMA Construction Project No. 3**

### **Location and Background**

Site No. 3 was constructed in May of 1997. NCAT staff were on-site from May 27 to May 29, 1997. This project called for milling 25 mm (1 in) of existing pavement and filling with 38 mm (1.5 in) of SMA. Within the extent of this project, the interstate was a four-lane divided highway. While at the project, paving was accomplished in the outside lane on the southbound side.

### **SMA Mixture Information**

The SMA mixture used for this project was a 12.5 mm nominal maximum aggregate size mix. Information about the mixture is presented in Table 3.1. Aggregates used for this project consisted of a crushed “river rock”. The design gradation for the mixture is presented in Table 3.2. Properties of the coarse and fine aggregates are presented in Tables 3.3 and 3.4, respectively. An AC-20 asphalt binder was used for this mixture. Properties of this binder are presented in Table 3.5.

### **Plant Information**

The facility used to produce the SMA mixture was a CMI drum plant. The dust collection system for this plant consisted of both a primary collector (knockout box) and a secondary collector (baghouse). The combined collector fines were added back to the mixing process by an auger chute to the drum.

The contractor did not use storage silos for either the mineral filler or fiber. The

mineral filler was placed into a separate aggregate bin and metered onto the cold feed conveyor belt. The fibers used for this project were in the form of a pellet. Bags of pellets were emptied into an aggregate bin, transported to the mixing process by a conveyor belt, and introduced at the point recycled asphalt pavement (RAP) would be introduced.

### **Laydown Procedures**

Paving operations were observed on May 28, 1997. For this project, “belly” dump trucks were used. The trucks would drop the mixture in windrows onto the existing pavement. A windrow elevator was attached to the front of the paver to pick the mixture up and deposit it into the paver.

For longitudinal joint construction, the contractor was utilizing a tapered joint. Additional information about the observed laydown procedures are presented in Table 3.5.

### **Problems Encountered On-Site**

No problems were encountered with the mixture while on the job site.

### **Sampling**

Samples obtained from this project include: each aggregate used to fabricate the mixture, mineral filler, fiber, asphalt binder, loose mixture, and ten cores. Table 3.8 presents the times and dates that the loose mix samples were obtained. As part of the quality control program, Marshall specimens were compacted using 50 blows per side. For this state, the quality control practices are to obtain samples at the paving location.

Samples were then taken to a laboratory for testing. Tables 3.8 through 3.13 present the results of testing performed on the loose mix and cores. Because the state was compacting Marshall specimens, NCAT personnel did not perform this test. This is reflected in Table 3.9.

<b>Table 3.1: Site 3 SMA Mixture Information</b>	
JMF I.D. Number:	MV-AMD2-97
Dates Used:	May 27 through 29
Number of Aggregate Stockpiles Used:	4
Design Voids in Coarse Aggregate:	42.6 percent*
Type Asphalt Binder Used:	AC-20
Modifier Type:	None
Design Asphalt Binder Content:	7.4 percent
Supplier of Asphalt Binder:	Chevron
Type Fiber Used:	Cellulose
Form of Fiber:	Pellet (66/34 Bitumen Granulation)
Design Percentage of Fiber:	0.46 percent
Type Mineral Filler Used:	Perlite
Design Percentage of Mineral Filler:	11.0 percent
Type Anti-Strip Additive Used:	Liquid (Ad-Here LOF 65-100)
Design Percentage of Anti-Strip:	1.0 percent
Compaction Method:	Marshall Hammer
Compactive Effort:	50 Blows per side
Laboratory Mixing Temperature:	312 ± 20°F
Laboratory Compaction Temperature:	292 ± 20°F
Design Voids in Total Mix:	3.4 percent
Design Mixture Density:	131.7 pcf
Design Voids in Mineral Aggregate:	17.1 percent
Design Voids Filled With Asphalt:	80.1 percent
Design Marshall Stability:	1510 lbs
Design Flow (0.01 in):	13.3
Retained Tensile Strength:	88.8 percent
Loaded Wheel Test @ Design Asphalt Content:	

\* Performed at NCAT laboratory on materials obtained from the project.

<b>Table 3.2: Design Gradation for Site 3</b>			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
¾ in.	19.0	100	100
½ in.	12.5	85-95	86
⅜ in.	9.5	75 max.	67
No. 4	4.75	20-28	27
No. 8	2.36	16-24	17
No. 30	0.600	12-16	14
No. 50	0.300	12-15	13
No. 200	0.075	8-10	9.7

<b>Table 3.3: Coarse Aggregate Properties for Site 3</b>	
Test	Combined Gradation
Los Angeles Abrasion, % Loss	23.2*
Flat & Elongated, %	
3 to 1	47*
5 to 1	3*
Bulk/Apparent Specific Gravity	2.346/2.549
Absorption, %	3.39
Soundness (5 Cycles), % Loss	
Sodium Sulfate	
Crushed Content, %	
One Face	
Two Face	
Data not provided by agency represented by blank data fields.	

\* Performed at NCAT laboratory on materials obtained from the project.

Table 3.4: Fine Aggregate Properties for Site 3	
Test	Results
Bulk/Apparent Specific Gravity	2.353/2.608*
Absorption, %	4.2*
Soundness (5 Cycles), % Loss	
Sodium Sulfate	
Angularity, %	48.9*
Liquid Limit, %	
Plasticity Index, %	
Data not provided by agency represented by blank data fields.	

\* Performed at NCAT laboratory on materials obtained from the project.

Table 3.5: Site 3 Asphalt Binder Properties

**SHRP ASPHALT BINDER GRADING SUMMARY**

**ASPHALT: Site 3**  
**OPERATOR: Wilson**  
**PROJECT: NCHRP 9-8**  
**DATE: 10/17/97**

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: +0.023 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135: 517 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
GRADE	TEMP °C	ORIGINAL	RTFOT	GRADE	TEMP °C	RTFOT + PAV	TEMP °C	RTFOT + PAV		DT (1mm/min)
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		
		G/sinδ (kPa) ≥ 1.00 kPa	G/sinδ (kPa) ≥ 2.20 kPa			G/sinδ (MPa) ≤ 5000 kPa		S, Stiffness(MPa) ≤ 300 MPa	m, Slope ≥ 0.300	
94	94			-10	31		0			
88	88			-16	28		-6			
82	82			-22	25	1620	-12	98	305	1.4602
76	76			-28	22	2423	-18			
70	70	0.64066	1.3411	-34	19	3447	-24			
64	64	1.3433	2.9916	-40	16	4798	-30			
58	58	3.0133	6.7439	-46	13	6473	-36			
52	52			-52	10		-42			
46	46			-58	7		-48			

**GRADE: PG 64-22**

<b>Table 3.6: Laydown Information from Site 3</b>	
Manufacturer of Paver:	Blaw Knox
Other Equipment Used:	Windrow Elevator
Number of Rollers Used:	3 (Breakdown/Intermediate/Finish)
Type of Breakdown Roller:	30-ton Static Steel Wheel
Number of Passes By Breakdown Roller:	3
Type of Intermediate Roller:	30-ton Static Steel Wheel
Number of Passes By Intermediate Roller:	2
Type Finish Roller:	30-ton Static Steel Wheel
Number of Passes By Finish Roller:	Smooth Irregularities
Temperature of Mixture After Finish Roller Ended Compaction:	
Comments:	The contractor was using a releasing agent. During the observation of the paving operations, it was noted that this pavement looked porous. The surface voids seemed large by visible inspection.

<b>Table 3.7: Sampling Times and Dates for Loose Mix Samples From Site 3</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	May 27	May 27	May 27	May 28	May 28	May 28
Time Obtained	9:20 am	2:20 pm	4:50 pm	7:45 am	10:50 am	2:30 pm
Day's Tonnage	N/A	1031	N/A	399	1180	2089
Temperature of Mixture in Truck, °F	330	N/A	N/A	315	300	300
Average Draindown, %	0.1	0.1	0.2	0.1	0.1	0.1

N/A - Not Available

Table 3.8: Gradations For Samples Obtained In-field

Site: 3  
 Sample: 1

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		5/28/97 P1	5/28/97 P2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M										
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	86.0	88.0	89.3	88.7	0.92	-2.7	89.5	92.0	87.9	90.0	2.90	-0.5	87.0	88.7	87.9	1.20	1.6
9.5	67.0	66.9	69.1	68.0	1.56	-1.0	74.7	73.8	79.2	76.5	3.82	-1.8	69.0	69.4	69.2	0.28	5.5
4.75	27.0	29.9	33.0	31.5	2.19	-4.5	40.6	37.2	34.3	35.8	2.05	4.9	35.2	35.4	35.3	0.14	5.3
2.36	17.0	18.9	20.0	19.5	0.78	-2.5	26.2	22.5	20.5	21.5	1.41	4.7	22.0	22.5	22.3	0.35	4.0
1.18	14.0	15.9	17.0	16.5	0.78	-0.9	20.9	17.5	15.8	16.7	1.20	4.2	17.6	18.1	17.9	0.35	3.0
0.60	14.0	14.3	15.4	14.9	0.78	-0.9	17.5	15.0	13.3	14.2	1.20	3.4	15.3	15.7	15.5	0.28	2.0
0.30	13.0	13.2	14.2	13.7	0.71	-0.7	15.0	13.3	11.7	12.5	1.13	2.5	13.7	14.1	13.9	0.28	1.1
0.150	9.7	12.3	13.2	12.8	0.64	-0.7	12.9	11.8	10.3	11.1	1.06	1.9	12.2	12.6	12.4	0.28	0.5
0.075	9.7	10.7	11.6	11.2	0.64	-1.5	10.8	10.1	8.7	9.4	0.99	1.4	10.6	11.0	10.8	0.28	0.0

Site: 3  
 Sample: 2

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		5/28/97 P4	5/28/97 P5	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M										
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	86.0	82.7	85.5	84.1	1.98	1.9	89.5	90.7	90.2	90.5	0.35	-1.0	88.3	87.4	87.9	0.64	1.6
9.5	67.0	62.4	66.9	64.7	3.18	2.3	74.7	70.9	69.3	70.1	1.13	4.6	70.5	68.7	69.6	1.27	5.1
4.75	27.0	28.1	29.3	28.7	0.85	-1.7	40.6	36.7	36.2	36.5	0.35	4.2	34.9	33.7	34.3	0.85	6.3
2.36	17.0	17.6	18.1	17.9	0.35	-0.9	26.2	22.1	22.7	22.4	0.42	3.8	21.8	21.2	21.5	0.42	4.7
1.18	14.0	14.9	15.3	15.1	0.28	-0.9	20.9	17.1	18.2	17.7	0.78	3.2	17.3	17.0	17.2	0.21	3.7
0.60	14.0	13.3	13.8	13.6	0.35	0.4	17.5	14.7	15.8	15.3	0.78	2.3	14.9	14.7	14.8	0.14	2.7
0.30	13.0	12.2	12.6	12.4	0.28	0.6	15.0	13.1	14.4	13.8	0.92	1.3	13.3	13.1	13.2	0.14	1.8
0.150	9.7	11.2	11.4	11.3	0.14	-0.1	12.9	11.6	12.7	12.2	0.78	0.8	11.8	11.8	11.8	0.00	1.1
0.075	9.7	9.7	9.9	9.8	0.14	-0.1	10.8	9.9	10.8	10.4	0.64	0.4	10.0	10.2	10.1	0.14	0.7

Site: 3  
 Sample: 3

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		5/29/97 P1	5/29/97 P2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M										
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	86.0	85.1	86.1	85.6	0.71	0.4	89.5	86.6	89.3	88.0	1.91	1.5	88.3	88.0	88.2	0.21	1.3
9.5	67.0	64.2	65.6	64.9	0.99	2.1	74.7	69.5	69.6	69.6	0.07	5.2	70.8	66.9	68.9	2.76	5.9
4.75	27.0	29.9	28.9	29.4	0.71	-2.4	40.6	35.9	36.2	36.1	0.21	4.6	35.3	33.1	34.2	1.56	6.4
2.36	17.0	17.8	17.1	17.5	0.49	-0.5	26.2	22.7	22.9	22.8	0.14	3.4	21.6	20.5	21.1	0.78	5.2
1.18	14.0	14.9	14.3	14.6	0.42	-0.5	20.9	17.8	18.1	18.0	0.21	2.9	17.2	16.2	16.7	0.71	4.2
0.60	14.0	13.4	12.7	13.1	0.49	0.9	17.5	15.4	15.8	15.6	0.28	1.9	14.8	14.0	14.4	0.57	3.1
0.30	13.0	12.3	11.6	12.0	0.49	1.1	15.0	13.9	14.3	14.1	0.28	0.9	13.2	12.6	12.9	0.42	2.1
0.150	9.7	11.1	10.5	10.8	0.42	0.3	12.9	12.4	12.8	12.6	0.28	0.3	11.8	11.2	11.5	0.42	1.4
0.075	9.7	9.5	9.3	9.4	0.14	0.3	10.8	10.5	11.0	10.8	0.35	0.0	10.0	9.4	9.7	0.42	1.1

Table 3.8(Continued): Gradations for Samples Obtained In-Field

Site: 3  
Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		5/29/97 P4	5/29/97 P5	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	86.0	87.4	84.8	86.1	1.84	-0.1	89.5	89.3	86.8	88.1	1.77	1.4	87.2	88.6	87.9	0.99	1.6
9.5	67.0	68.6	66.4	67.5	1.56	-0.5	74.7	71.0	69.7	70.4	0.92	4.4	70.5	69.7	70.1	0.57	4.6
4.75	27.0	29.1	28.3	28.7	0.57	-1.7	40.6	37.8	35.4	36.6	1.70	4.0	43.6	33.0	38.3	7.50	2.3
2.36	17.0	17.3	16.7	17.0	0.42	0.0	26.2	23.5	21.5	22.5	1.41	3.7	20.8	19.5	20.1	0.78	6.2
1.18		14.3	13.7	14.0	0.42		20.9	18.6	16.7	17.7	1.34	3.2	16.1	15.4	15.8	0.49	5.1
0.60	14.0	12.7	12.1	12.4	0.42	1.6	17.5	16.2	14.2	15.2	1.41	2.3	13.7	13.2	13.5	0.35	4.1
0.30	13.0	11.4	10.9	11.2	0.35	1.9	15.0	14.6	12.6	13.6	1.41	1.4	12.2	11.6	11.9	0.42	3.1
0.150		10.1	9.6	9.9	0.35		12.9	13.1	11.1	12.1	1.41	0.8	10.6	10.2	10.4	0.28	2.5
0.075	9.7	8.6	8.1	8.4	0.35	1.4	10.8	11.2	9.5	10.4	1.20	0.4	9.0	8.6	8.8	0.28	2.0

Site: 3  
Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	P	Q	S	T	U
		B-F					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1
12.5	86.0	85.5	85.9	85.7	0.28	0.3	89.5	86.9	85.7	86.3	0.85	3.2
9.5	67.0	64.4	65.7	65.1	0.92	1.9	74.7	69.7	68.9	69.3	0.57	5.4
4.75	27.0	28.1	29.1	28.6	0.71	-1.6	40.6	35.6	34.6	35.1	0.71	5.5
2.36	17.0	16.8	17.5	17.2	0.49	-0.1	26.2	21.5	21.1	21.3	0.28	4.9
1.18		14.0	14.5	14.3	0.35		20.9	17.0	16.5	16.8	0.35	4.1
0.60	14.0	12.5	12.9	12.7	0.28	1.3	17.5	14.6	14.1	14.4	0.35	3.2
0.30	13.0	11.4	11.8	11.6	0.28	1.4	15.0	13.0	12.8	12.8	0.28	2.2
0.150		10.3	10.6	10.5	0.21		12.9	11.6	11.4	11.5	0.14	1.4
0.075	9.7	8.9	9.2	9.0	0.23	0.7	10.8	9.9	9.7	9.8	0.14	1.0

Site: 3  
Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	P	Q	S	T	U
		B-F					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1
12.5	86.0	85.6	82.1	84.0	2.62	2.1	89.5	88.4	85.2	86.8	2.24	2.6
9.5	67.0	68.3	64.1	66.2	2.97	0.8	74.7	68.9	70.7	69.8	1.24	4.9
4.75	27.0	30.3	29.6	30.0	0.49	-3.0	40.6	34.3	35.0	34.6	0.49	6.0
2.36	17.0	19.6	19.1	19.4	0.35	-2.4	26.2	21.8	22.9	22.4	0.79	3.9
1.18		16.9	16.5	16.7	0.28		20.9	17.5	18.5	18.0	0.69	2.9
0.60	14.0	15.4	15.0	15.2	0.28	-1.2	17.5	15.2	16.1	15.6	0.63	1.9
0.30	13.0	14.3	14.0	14.2	0.21	-1.2	15.0	13.7	14.5	14.1	0.57	0.9
0.150		13.1	12.8	13.0	0.21		12.9	12.4	13.0	12.7	0.45	0.2
0.075	9.7	11.3	11.1	11.2	0.14	-1.5	10.8	10.3	11.1	10.7	0.58	0.1

Table 3.9: Results of Marshall Hammer Compactions

Marshall Hammer: 50 Blows per Side																		
SITE NUMBER: 3			MATERIALS: River Rock/Perlite/Cellulose/AC-20						COARSE AGGREGATE INFORMATION				Percent Coarse Aggregate: 73.0		DATE: 1/30/98			
AC Sp. Gr. (G <sub>b</sub> ) = 1.001			Effective Specific Gravity of Agg. (G <sub>se</sub> ): 2.417			Bulk Specific Gravity of the Agg. (G <sub>sb</sub> ) = 2.359							Bulk Sp. Gravity of CA (G <sub>ca</sub> ): 2.346		Unit Wt. Of CA in DRC (pcf): 84.0			
													Unit Wt. Of CA in DRC (kg/m <sup>3</sup> ): 1344.8					
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES		Unit Weight pcf	VOIDS					
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	VTM %		VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
						F-E	$\frac{D}{G}$		$\frac{(100-C) \cdot H}{G_{sb}}$	$\frac{C \cdot H}{G_b}$	H * 62.4	100(1-H/I)	100 - J	$\frac{100(N-M)}{N}$				
5/28/97-P1	1	7.5					2.099	2.198	82.3	15.7	131.0	4.5	17.7	74.5	39.6	42.6	0.929	
5/28/97-P2	2	7.5					2.084	2.198	81.7	15.6	130.0	5.2	18.3	71.6	40.0	42.6	0.939	
5/28/97-P3	3	7.5					2.095	2.198	82.1	15.7	130.7	4.7	17.9	73.8	39.7	42.6	0.931	
5/28/97-P4	1	7.8					2.088	2.190	81.7	15.8	130.2	4.7	18.3	74.0	40.0	42.6	0.939	
5/28/97-P5	2	7.9					2.104	2.190	82.4	16.0	131.3	3.9	17.6	77.7	39.5	42.6	0.927	
5/28/97-P6	3	7.6					2.084	2.190	81.6	15.8	130.0	4.8	18.4	73.7	40.1	42.6	0.940	
5/29/97-P1	1	7.9					2.017	2.194	78.7	15.9	125.9	8.1	21.3	62.0	42.2	42.6	0.990	
5/29/97-P2	2	7.9					1.989	2.194	78.0	15.8	124.7	8.9	22.0	59.5	42.7	42.6	1.002	
5/29/97-P3	3	7.9					1.995	2.194	77.9	15.8	124.5	9.1	22.1	59.0	42.8	42.6	1.005	
5/29/97-P4	1	7.9					1.996	2.194	77.9	15.8	124.6	9.0	22.1	59.1	42.8	42.6	1.004	
5/29/97-P5	2	7.9					2.019	2.194	78.8	15.9	128.0	8.0	21.2	62.3	42.1	42.6	0.988	
5/29/97-P6	3	7.9					1.965	2.194	76.7	15.5	122.6	10.4	23.3	55.2	43.7	42.6	1.025	
Input By:												Checked By: A. Cooley						
SSD = Saturated Surface Dry			cc = cubic centimeter			Gmb = Bulk Specific Gravity of Compacted Mixture			Gsb = Bulk Specific Gravity of Aggregate			VTM = Voids in Total Mix						
TMD = Theoretical Maximum Density			AC = Asphalt Cement			Gmm = Theoretical Maximum Density of Mixture			Gb = Specific Gravity of Asphalt Cement			VMA = Voids in Mineral Aggregate						
gm = gram			pcf = pounds per cubic foot			Gsa = Apparent Specific Gravity of Aggregate			VCA = Voids in Coarse Aggregate			VFA = Voids Filled With Asphalt Cement						

\*\* Data Obtained From Contractor

Table 3.10: Results of SGC Compactions

SITE NUMBER: 3			MATERIALS: River Rock/Perlite/Celulose/AC-20									COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 73.0		DATE: 2/1/98							
AC Sp. Gr. (Gsb) = 1.001			Effective Specific Gravity of Agg. (Gse) = 2.417						Bulk Specific Gravity of the Agg. (Gsb) = 2.358													Bulk Sp. Gravity of CA (Gca): 2.346									
			WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES			CORR. % Gmm			VOLUMES AT Ndes		VOIDS											
Sample Number	Replicate	Asphalt Content %	In Air gms	In Water gms	SSD gms	Nmin (8 Gyr) mm	Ndes (100 Gyr) mm	Nmax (158 Gyr) mm	Nmin (8 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	Nmin %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA drc %						
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z						
									G <sup>17.67</sup>			D			Gmb, Est. Gmb Meas.			K <sup>10</sup> O		L <sup>10</sup> O		100-C		K <sup>10</sup> O		100-Q		100-S		100(V-U)	
1	1	7.9	4186.5	2203.0	4196.0	129.3	115.4		1.832	2.063		2.101	2.179	1.023	86.0	96.4		82.0	16.6	3.8	18.0	80.0	39.8	42.6	0.935						
1	2	7.9	4310.8	2277.3	4323.8	136.7	120.3		1.784	2.028		2.108	2.179	1.039	85.1	96.7		82.2	16.6	3.3	17.8	81.2	39.6	42.6	0.931						
1	3	7.9	4218.6	2227.5	4234.4	134.4	118.2		1.776	2.020		2.102	2.179	1.041	84.8	96.5		82.1	16.6	3.5	17.9	80.3	39.8	42.6	0.934						
2	1	7.9	4159.0	2156.3	4173.3	134.3	117.3		1.752	2.006		2.062	2.184	1.028	82.5	94.4		80.5	16.3	5.8	19.5	71.3	40.9	42.6	0.961						
2	2	7.9	4151.2	2182.8	4180.3	132.9	117.0	115.0	1.768	2.008	2.043	2.110	2.184	1.033	83.8	95.0	96.8	81.0	16.4	5.0	19.0	73.5	40.6	42.6	0.953						
2	3	7.9	4139.0	2183.6	4152.0	134.5	117.0	115.8	1.741	2.002	2.023	2.103	2.184	1.040	82.9	95.3	96.3	81.3	16.4	4.7	18.7	74.9	40.4	42.6	0.948						
3	1	8.0	4073.5	2085.3	4095.5	130.8	114.7		1.782	2.010		2.037	2.184	1.013	81.8	93.2		79.4	16.3	8.8	20.6	67.2	41.7	42.6	0.979						
3	2	8.0	4075.8	2113.5	4092.1	131.4	115.8		1.755	1.982		2.060	2.184	1.034	83.1	94.3		80.4	16.5	5.7	19.6	71.2	41.0	42.6	0.993						
3	3	8.0	4029.7	2048.9	4053.1	131.4	115.7		1.735	1.970		2.059	2.184	1.045	83.0	94.3		80.3	16.5	5.7	19.7	71.0	41.0	42.6	0.964						
4	1	7.8	4105.8	2094.5	4125.9	127.2	112.8		1.827	2.090		2.021	2.186	0.981	82.0	92.5		79.0	15.8	7.5	21.0	64.1	42.0	42.6	0.967						
4	2	7.8	4148.9	2140.1	4175.1	127.2	112.8		1.845	2.060		2.038	2.186	0.980	82.7	93.2		79.5	15.9	6.8	20.4	66.7	41.5	42.6	0.975						
4	3	7.8	4133.8	2121.5	4196.5	127.2	112.8		1.830	2.074		2.021	2.186	0.975	82.0	92.5		79.0	15.8	7.5	21.0	64.1	42.0	42.6	0.966						
5	1	7.5	4134.4	2124.9	4150.0	133.5	117.5		1.753	1.991		2.042	2.186	1.025	82.2	93.4		80.1	15.3	6.6	19.9	66.9	41.2	42.6	0.968						
5	2	7.5	4129.8	2136.0	4149.1	134.6	117.9		1.736	1.962		2.051	2.186	1.035	82.2	93.8		80.4	15.4	6.2	19.6	66.5	41.0	42.6	0.962						
5	3	7.5	4148.8	2147.3	4170.1	135.1	119.1		1.736	1.972		2.051	2.186	1.040	82.7	93.8		80.4	15.4	6.2	19.6	66.5	41.0	42.6	0.962						
6	1	8.0	4098.7	2132.0	4109.0	129.7	113.6		1.788	2.042		2.073	2.190	1.015	82.6	94.7		80.9	16.6	5.3	19.1	72.1	40.8	42.6	0.955						
6	2	8.0	4129.3	2177.4	4143.9	131.2	115.1		1.781	2.030		2.100	2.190	1.034	84.1	95.9		81.9	16.8	4.1	18.1	77.3	39.9	42.6	0.937						
6	3	8.0	4078.3	2158.6	4089.8	129.8	113.5		1.780	2.032		2.111	2.190	1.039	84.4	95.4		82.3	16.9	3.8	17.7	79.5	39.8	42.6	0.929						

Input By: \_\_\_\_\_ Checked By: A. Cooley

SSD = Saturated Surface Dry cc = cubic centimeter Gmb = Bulk Specific Gravity of Compacted Mixture Gb = Bulk Specific Gravity of Aggregate VTM = Voids in Total Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gmm = Theoretical Maximum Density of Mixture Gc = Specific Gravity of Asphalt Cement VMA = Voids in Mineral Aggregate  
gm = gram pcf = pounds per cubic foot Gsa = Apparent Specific Gravity of Aggregate VCA = Voids in Coarse Aggregate VFA = Voids Filled With Asphalt Cement

Table 3.11: Results of Loaded Wheel Testing

Site No.:     3    

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	<b>NOT TESTED - SAMPLE DAMAGED</b>			
R2	3.4	2.65	2.93	4.88
R3	3.4	2.97	3.10	5.21
R4	3.7	2.40	3.00	4.48
<b>Average</b>	<b>3.5</b>	<b>2.67</b>	<b>3.01</b>	<b>4.86</b>
<b>Std. Dev.</b>	<b>0.17</b>	<b>0.286</b>	<b>0.085</b>	<b>0.366</b>

Table 3.12: Results of Superpave Analysis Testing

Site No.:     3    

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @ Constant Height		G*				
		Delta				
Simple Shear Test @ Constant Height		Strain Rate, mm/mm				
		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

Table 3.13: Results of Testing on Cores Obtained In-Field

Site No. 3

Sieve mm	Percent Passing											
	Core 6-2	Core 5-1	Core 4-2	Core 3-2	Core 2-2	Core 1-1	Core 2-1	Core 3-1	Core 4-1	Core 5-2	Average	Std. Dev.
25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.00
19.0	99.7	100.0	99.5	100.0	100.0	100.0	100.0	100.0	100.0	99.5	99.9	0.22
12.5	87.6	90.9	87.3	92.0	88.5	90.8	92.2	87.6	88.4	89.3	89.5	1.87
9.5	72.7	77.0	72.4	77.4	74.7	75.0	79.3	73.1	72.7	72.8	74.7	2.43
4.75	39.0	42.8	41.4	42.0	42.6	39.4	41.9	38.1	37.9	41.1	40.6	1.85
2.36	23.8	28.2	27.3	26.9	27.8	25.3	26.6	25.0	24.1	27.4	26.2	1.57
1.18	18.8	22.2	21.7	21.2	22.0	19.8	21.1	19.9	19.9	22.2	20.9	1.20
0.60	15.8	18.3	18.1	17.7	18.3	16.3	17.7	16.8	17.4	18.8	17.5	0.96
0.30	13.6	15.4	15.4	15.0	15.5	13.8	15.3	14.4	15.5	16.2	15.0	0.82
0.150	11.6	13.0	13.0	12.9	13.4	11.7	13.5	12.2	13.8	14.1	12.9	0.85
0.075	9.5	10.7	10.8	10.7	11.3	9.7	11.5	10.2	11.8	11.7	10.8	0.80
Gmb	2.048	2.029	2.013	2.037	2.067	2.011	1.998	1.995	1.997	2.024	2.022	0.02
Unit Weight, pcf	127.8	126.6	125.6	127.1	129.0	125.5	124.7	124.5	124.6	126.3	126.2	1.49
VTM, %	6.3	7.2	7.9	6.8	5.4	8.0	8.6	8.7	8.7	7.4	7.5	1.10

## **NCHRP 9-8 II - Task 8 SMA Construction Project No. 4**

### **Location and Background**

Construction project No. 4 was constructed in June of 1997. NCAT staff were on site between June 10 and June 13, 1997. Two contractors were working together on this project. One contractor was supplying the SMA mixture, while another contractor was placing the mixture on the roadway.

This project consisted of milling 38 mm (1.5 in) of existing pavement and filling with 38 mm of SMA. This interstate consisted of three northbound lanes and three southbound lanes. The first day that NCAT staff were on this project, the contractor was paving the outside lane on the southbound side. Paving for this stretch of pavement was during the day. The contractor then switched to paving on the inside lane on the northbound side which was constructed at night. After completion of SMA placement, an open-graded friction course was to be placed over the SMA layer.

### **SMA Mixture Information**

The SMA mixture used for this project was a 12.5 mm nominal maximum aggregate size mixture. Information about this SMA mixture is presented in Table 4.1. This mixture was designed to have an asphalt content of 5.9 percent; however, the DOT had changed this value to 5.7 percent. Design values given in Table 4.1 represent values at 5.7 percent asphalt. A crushed granite was used to produce this mixture. The design gradation is presented in Table 4.2. Properties of the coarse and fine aggregates are

presented in Tables 4.3 and 4.4, respectively. A PG 76-22 asphalt binder was used for this mixture. Properties of this binder are presented in Table 4.5. Mineral fibers in a loose form were used in the mixture.

### **Plant Information**

The facility used for this project was a 3-ton batch plant. The dust collection system consisted of a primary collector (vertical cyclone) and a secondary collector (baghouse). Fines collected from both dust collectors were reintroduced back into the mixing process at the hot elevator.

This plant utilized two storage silos. One silo was used for the mineral filler and one for the hydrated lime. The hydrated lime was used as an anti-stripping additive. The mineral filler was added back to the mixture at the weigh hopper through a pneumatic line. The lime was also added to the weigh hopper by a pneumatic line.

Bales of fiber were manually (forklift) introduced into a hopper (Figure 4.1) to be broken down and subsequently blown to the weigh hopper.

### **Laydown Procedures**

Paving operations were observed on the night of June 12, 1997. The ambient temperature was approximately 70°F. The DOT project manager on this site said that the SMA mixture was very sensitive to temperature. At a temperature of approximately 335°F, the mixture was workable and the paving operations went smooth. At temperatures higher than 340°F and lower than 325°F, the mixture was difficult to work with. Outside this range, the contractor had difficulty obtaining density. Table 4.6

presents additional information obtained while observing the paving operations.

Two rollers were used in tandem for compaction. The two rollers were side-by-side behind the paver. Each roller made three passes in the vibratory mode and two passes in static mode.

During the observation of the rolling patterns, a fat spot appeared on the pavement's surface. While watching the rollers pass back and forth over this spot, the fat spot continued to grow. This fat spot was approximately 100 mm (4 in) in diameter when it was first noticed and had a final diameter was approximately 200 mm (8 in) after completion of rolling.

#### **Problems Encountered On-Site**

During the two nights that NCAT staff were on site, the plant had problems with the introduction of the mineral filler. Two samples were obtained from some mixture that had the mineral filler problems (Samples 4 and 5). Sample 4 was obtained on the night of June 11 and Sample 5 was obtained on the night of June 12, 1997. Therefore, this constitutes two different lots of SMA mixture. Both of these samples showed high draindown values (2 to 3 percent).

While observing the paving operations on the night of June 12, 1997, the DOT project manager pointed out a fat spot from the previous night's paving. This fat-spot was approximately 20 cm wide by 91 cm long (8 x 36 in). In talking to him, it was estimated that this fat spot probably came from the truck that Sample 4 was obtained or from a load of mixture in close proximity. This assumption could be made because

Sample 4 was one of the last loads produced on the night of June 11,1997. The fat spot was located within the last 100 ft. of that night's paving.

### **Sampling**

Samples obtained while at this project include: each aggregate used to produce the mixture, mineral filler, fiber, asphalt binder, loose mixture, and ten cores. Each of these materials were brought back to the NCAT laboratory for additional testing. A total of six loose mix samples were obtained. Table 4.7 presents the dates and times that these loose mix samples were obtained along with the average draindown values. Tables 4.8 through 4.13 present the results of testing performed on all samples.

<b>Table 4.1: Site 4 SMA Mixture Information</b>	
JMF I.D. Number:	024_12.5SMA-2
Dates on Project:	June 10 to 13, 1997
Number of Aggregate Stockpiles Used:	3
Design Voids in Coarse Aggregate:	38.5 percent
Type Asphalt Binder Used:	PG 76-22
Modifier Type:	SBS
Design Asphalt Binder Content:	5.7 percent
Supplier of Asphalt Binder:	Amoco Oil Co.
Type Fiber Used:	Slag Wool (Sloss)
Form of Fiber:	Loose
Design Percentage of Fiber:	0.4 percent of total mix
Type Mineral Filler Used:	Marble Dust
Design Percentage of Mineral Filler:	10.0
Type Anti-Strip Additive Used:	Hydrated Lime
Design Percentage of Anti-Strip:	1.0 percent
Compaction Method:	Marshall Hammer
Compactive Effort:	50 Blows per side
Laboratory Mixing Temperature:	340 °F
Laboratory Compaction Temperature:	325 °F
Design Voids in Total Mix:	4.1 percent
Design Mixture Density:	145.5 pcf
Design Voids in Mineral Aggregate:	17.1 percent
Design Voids Filled With Asphalt:	75.1 percent
Design Marshall Stability:	1537 lbs
Design Flow (0.01 in):	11.2
Design Laboratory Draindown:	0.03 percent
Loaded Wheel Test @ Design Asphalt Content:	2.22

<b>Table 4.2: Design Gradation for Site 4</b>			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
¾ in.	19.0	100	100
½ in.	12.5	85-95	94
⅜ in.	9.5	75 max.	69
No. 4	4.75	20-28	29
No. 8	2.36	16-24	19
No. 16	1.18	----	17
No. 30	0.600	12-16	16
No. 50	0.300	12-15	14
No. 100	0.150	----	12
No. 200	0.075	8-10	10

<b>Table 4.3: Coarse Aggregate Properties for Site 4</b>		
Test	78's	7's
Los Angeles Abrasion, % Loss	42	42
Flat & Elongated, %		
3 to 1	10	9
5 to 1		
Bulk/Apparent Specific Gravity	2.595/2.644	2.595/2.644
Absorption, %	0.75	0.75
Soundness (5 Cycles), % Loss		
Sodium Sulfate	1.1	1.1
Crushed Content, %		
One Face	100	100
Two Face	100	100
Data not provided by agency is presented by blank data field.		

<b>Table 4.4: Fine Aggregate Properties for Site 4</b>	
Test	W10's
Bulk/Apparent Specific Gravity	2.599/2.623
Absorption, %	0.49
Soundness (5 Cycles), % Loss	
Sodium Sulfate	
Angularity, %	46.7*
Liquid Limit, %	
Plasticity Index, %	
Data not provided by agency is represented by blank data fields.	

\* Performed at NCAT laboratory on materials obtained from project.

Table 4.5: Site 4 Asphalt Binder Properties

### SHRP ASPHALT BINDER GRADING SUMMARY

**ASPHALT: Site 4**  
**OPERATOR: Wilson**  
**PROJECT: NCHRP 9-8**  
**DATE: 10/21/97**

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: 0.25 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135: 1691 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING							
G R A D E	T E M P °C	ORIGINAL	RTFOT	G R A D E	T E M P °C	RTFOT + PAV	T E M P °C	RTFOT + PAV		D T (1mm/min)	
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)			Failure Strain ≥ 1.0%
		G' / sinδ (kPa) ≥ 1.00 kPa	G' / sinδ (kPa) ≥ 2.20 kPa			G' / sinδ (MPa) ≤ 5000 kPa		S, Stiffness (MPa) ≤ 300 MPa	m, Slope ≥ 0.300		
94	94			-10	37		0				
88	88			-16	34		-6				
82	82	0.8334	1.5337	-22	31	1100	-12	157	0.324	2.4936	
76	76	1.5073	2.7436	-28	28	2037	-18				
70	70			-34	25	3012	-24				
64	64			-40	22	4416	-30				
58	58			-46	19	6369	-36				
52	52			-52	16		-42				
46	46			-58	13		-48				

**GRADE: PG 76-22**

<b>Table 4.6: Laydown Information from Site 4</b>	
Manufacturer of Paver:	Blaw Knox
Other Equipment Used:	Roadtec Shuttle-Buggy
Number of Rollers Used:	2
Temperature of Mixture When Delivered (Truck):	328 °F (1 <sup>st</sup> measurement) 320 °F (2 <sup>nd</sup> measurement)
Temperature of Mixture Right Behind Paver:	289 °F (1 <sup>st</sup> measurement) 305 °F (2 <sup>nd</sup> measurement)
Sizes of Rollers:	10 & 12 tons
Rolling Pattern (each roller):	3 passes in vibratory mode and 2 passes in static mode
Temperature of Mixture After Finish Roller Ended Compaction:	155 °F
Comments:	The mixture seemed to have sufficient workability at the time of observation. Persons on-site said that the mixture had been sticking to some trucks. This occurred even though the trucks were using a releasing agent (Hydra-Slide). No mixture was sticking to the rollers. A few fat spots were noted on the pavement surface.

<b>Table 4.7: Sampling Times and Dates for Loose Mix Samples From Site 4</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	June 10	June 10	June 11	June 12	June 12	June 12
Time Obtained	10:30 am	2:15 pm	9:15 pm	12:15 am	3:45 am	9:50 pm
Temperature of Mixture in Truck, °F	340	350	340	325	340	360
Truck Load of the Day's Production	5	30	4	25	41	9
Average Draindown, %	1.0	0.7	0.8	2.7	2.8	0.8



Table 4.8(Continued): Gradations For Samples Obtained In-Field

Site: 4  
 Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	94.0	94.2	96.3	95.3	1.48	-1.3	96.6	97.4	96.7	97.1	0.49	-0.4	96.0	95.4	95.7	0.42	0.9
9.5	89.0	68.7	69.9	69.3	0.85	-0.3	77.2	71.6	70.9	71.3	0.49	6.0	71.3	69.3	70.3	1.41	6.9
4.75	29.0	26.4	26.3	26.4	0.07	2.7	33.0	33.7	32.9	33.3	0.57	-0.3	30.3	29.2	29.8	0.78	3.2
2.36	19.0	17.6	17.6	17.6	0.00	1.4	21.9	21.8	21.4	21.6	0.26	0.3	20.3	19.5	19.9	0.57	2.0
1.18	17.0	16.9	16.8	16.9	0.07	0.1	20.0	18.9	18.7	18.8	0.14	1.2	18.3	17.5	17.9	0.57	2.1
0.60	16.0	16.7	16.6	16.7	0.07	-0.6	19.4	17.7	17.5	17.6	0.14	1.8	17.4	16.5	17.0	0.64	2.4
0.30	14.0	18.2	14.3	15.3	1.34	-1.3	18.3	16.2	16.1	16.2	0.07	2.2	16.2	15.4	15.8	0.57	2.5
0.150	12.0	14.2	9.8	12.1	3.04	-0.1	15.2	13.3	13.2	13.3	0.07	2.0	13.6	12.9	13.3	0.49	2.0
0.075	10.0	9.8	8.9	9.4	0.64	0.6	10.8	8.9	8.8	8.9	0.07	1.9	9.3	8.8	9.1	0.35	1.7

Site: 4  
 Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	99.5	99.8	0.35	0.2
12.5	94.0	94.6	93.6	94.1	0.71	-0.1	96.6	95.3	92.8	94.1	1.77	2.6	94.2	94.3	94.3	0.07	2.4
9.5	89.0	63.1	64.8	64.8	2.33	4.3	77.2	87.3	68.9	68.1	1.13	9.1	64.9	66.6	65.8	1.20	11.5
4.75	29.0	24.0	22.3	23.2	1.20	5.9	33.0	30.1	30.8	30.5	0.49	2.5	29.2	29.8	29.5	0.42	3.5
2.36	19.0	15.0	14.2	14.8	0.57	4.4	21.9	18.3	19.1	18.7	0.57	3.2	19.4	19.5	19.5	0.07	2.4
1.18	17.0	14.5	13.6	14.1	0.64	3.0	20.0	16.0	16.8	16.4	0.57	3.6	17.4	17.5	17.5	0.07	2.6
0.60	16.0	14.3	13.5	13.9	0.57	2.1	19.4	15.0	15.8	15.4	0.57	4.0	16.7	16.8	16.8	0.07	2.6
0.30	14.0	14.0	13.2	13.6	0.57	0.4	18.3	13.9	14.6	14.3	0.49	4.1	15.9	16.0	16.0	0.07	2.4
0.150	12.0	12.9	12.0	12.5	0.64	-0.4	15.2	11.8	12.4	12.1	0.42	3.1	13.6	13.6	13.6	0.00	1.8
0.075	10.0	9.5	8.7	9.1	0.57	0.9	10.8	8.2	8.6	8.4	0.28	2.4	9.4	9.3	9.4	0.07	1.4

Site: 4  
 Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	94.0	96.9	97.3	97.1	0.28	-3.1	96.6	96.5	97.0	96.8	0.35	-0.1	98.1	96.2	97.2	1.34	-0.6
9.5	89.0	75.1	77.5	76.3	1.70	-7.3	77.2	76.4	77.7	77.1	0.92	0.2	78.9	76.9	77.9	1.41	-0.7
4.75	29.0	31.4	32.8	32.1	0.99	-3.1	33.0	37.0	38.2	37.6	0.85	-4.6	37.3	38.9	37.1	0.28	-4.1
2.36	19.0	23.3	24.1	23.7	0.57	-4.7	21.9	26.5	26.9	26.7	0.28	-4.8	27.2	28.5	26.9	0.49	-5.0
1.18	17.0	21.9	22.6	22.3	0.49	-5.3	20.0	23.7	23.9	23.8	0.14	-3.8	24.5	24.0	24.3	0.35	-4.2
0.60	16.0	21.3	22.1	21.7	0.57	-5.7	19.4	22.5	22.7	22.6	0.14	-3.2	23.5	23.1	23.3	0.28	-3.9
0.30	14.0	20.5	21.2	20.9	0.49	-6.9	18.3	20.8	20.9	20.9	0.07	-2.6	22.1	21.7	21.9	0.28	-3.6
0.150	12.0	17.2	17.8	17.5	0.42	-5.5	15.2	16.7	16.7	16.7	0.00	-1.5	17.9	17.7	17.8	0.14	-2.6
0.075	10.0	11.3	11.7	11.5	0.28	-1.5	10.8	10.8	10.8	10.8	0.00	0.0	11.7	11.7	11.7	0.00	-0.9

Table 4.9: Results of Marshall Hammer Compactions

Marshall Hammer: 50 Blows per Side																	
SITE NUMBER: 4			MATERIALS: GranitePG 76-22Marble DustSlag wool						COARSE AGGREGATE INFORMATION				Percent Coarse Aggregate: 71.0			DATE: 2/1/98	
AC Sp. Gr. (Gb) = 1.029			Apparent Specific Gravity of the Agg. (Gsa) = 2.639			Bulk Specific Gravity of the Agg. (Gsb) = 2.588							Bulk Sp. Gravity of CA (Gca): 2.595			Unit Wt. Of CA in DRC (pcf): 99.6	
													Unit Wt. Of CA in DRC (kg/m3) 1595.4				
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	Unit Weight pcf	VTM %	VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
						F-E	D		(100-C) * H	C * H	H * 62.4	100(1-H/I)	100 - J	100 ( N-M)			
						G	Gsb		Gsb	Gsb	Gsb			N			
1	1	5.7	1194.8	686.3	1197.2	510.9	2.339	2.424	85.2	13.0	145.9	3.5	14.8	76.2	39.7	38.5	1.031
1	2	5.7	1219.0	696.4	1221.8	525.4	2.320	2.424	84.5	12.9	144.8	4.3	15.5	72.3	40.1	38.5	1.044
1	3	5.7	1200.3	686.9	1202.8	515.9	2.327	2.424	84.8	12.9	145.2	4.0	15.2	73.6	40.0	38.5	1.039
2	1	5.9	1199.4	687.9	1202.1	514.2	2.333	2.416	84.6	13.4	145.6	3.5	15.2	76.7	39.9	38.5	1.039
2	2	5.9	1206.5	689.0	1208.9	519.9	2.321	2.416	84.4	13.3	144.8	4.0	15.6	74.2	40.2	38.5	1.047
2	3	5.9	1210.3	691.4	1213.3	521.9	2.319	2.416	84.3	13.3	144.7	4.1	15.7	73.9	40.3	38.5	1.046
3	1	5.8	1200.8	685.0	1203.4	515.4	2.330	2.419	84.8	13.1	145.4	3.7	15.2	75.7	39.9	38.5	1.038
3	2	5.8	1197.4	686.3	1199.6	513.3	2.333	2.419	84.9	13.1	145.6	3.6	15.1	76.3	39.9	38.5	1.036
3	3	5.8	1203.4	689.5	1205.1	515.6	2.334	2.419	85.0	13.1	145.6	3.5	15.0	76.6	39.8	38.5	1.036
4	1	5.7	1208.6	678.3	1218.8	540.5	2.236	2.430	81.5	12.3	139.5	8.0	18.5	56.9	42.3	38.5	1.100
4	2	5.7	1117.5	631.9	1132.9	501.0	2.231	2.430	81.3	12.3	139.2	8.2	18.7	56.1	42.4	38.5	1.104
4	3	5.7	1141.6	641.7	1153.5	511.8	2.231	2.430	81.3	12.3	139.2	8.2	18.7	56.1	42.4	38.5	1.104
5	1	5.7	1192.9	684.3	1203.3	539.0	2.213	2.433	80.6	12.3	138.1	9.0	19.4	53.3	42.9	38.5	1.116
5	2	5.7	1199.5	670.7	1216.0	545.3	2.200	2.433	80.1	12.2	137.3	9.6	19.9	51.7	43.3	38.5	1.125
5	3	5.7	1206.6	677.2	1222.7	545.5	2.212	2.433	80.6	12.3	138.0	9.1	19.4	53.2	42.9	38.5	1.116
6	1	5.8	1191.2	679.6	1194.1	514.5	2.315	2.417	84.2	13.1	144.5	4.2	15.8	73.3	40.3	38.5	1.049
6	2	5.8	1213.1	692.6	1214.7	522.1	2.324	2.417	84.5	13.2	145.0	3.9	15.5	75.0	40.1	38.5	1.044
6	3	5.8	1186.6	676.2	1189.6	513.4	2.311	2.417	84.1	13.1	144.2	4.4	15.9	72.5	40.4	38.5	1.052

Input By:										Checked By: A. Cooley							
SSD = Saturated Surface Dry	cc = cubic centimeter	Gmb = Bulk Specific Gravity of Compacted Mixture	Gsb = Bulk Specific Gravity of Aggregate	VTM = Voids in Total Mix													
TMD = Theoretical Maximum Density	AC = Asphalt Cement	Gmm = Theoretical Maximum Density of Mixture	Gb = Specific Gravity of Asphalt Cement	VMA = Voids in Mineral Aggregate													
gm = gram	pcf = pounds per cubic foot	Gsa = Apparent Specific Gravity of Aggregate	VCA = Voids in Coarse Aggregate	VFA = Voids Filled With Asphalt Cement													

Table 4.10: Results of SGC Compactions

SITE NUMBER: 4		MATERIALS: Granite/PG 76-22/ Marble Dust/Slag wool									COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 71.0	DATE: 2/1/98						
AC Sp. Gr. (Gb) = 1.029		Apparent Specific Gravity of the Agg. (Gsa) = 2.639						Bulk Specific Gravity of the Agg. (Gsb) = 2.588													Bulk Sp. Gravity of CA (Gca): 2.595	Unit Wt. Of CA in DRC (pcf): 99.6	Unit Wt. Of CA in DRC (kg/m3): 1595.4					
Sample Number	Replicate	Asphalt Content %	WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES			CORR. % Gmm			VOLUMES AT Ndes				VOIDS						
			In Air gms	In Water gms	SSD gms	Nmin (8 Gyr) mm	Ndes (100 Gyr) mm	Nmax (158 Gyr) mm	Nmin (8 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	Nini %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA VCA drc			
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z			
			G*17.67			H*17.67			I*17.67			F-E			Gmb Est. Gmb Meas.			J*O K*O L*O			(100-C)*K*O (Gb)				C*K*O (Gb)			
1	1	5.7	4775.6	2754.8	4781.6	135.5	118.4		1.994	2.282		2.358	2.424	1.032	84.9	97.2		85.9	13.1	2.8	14.1	80.2	39.2	38.5	1.020			
1	2	5.7	4711.4	2715.8	4719.6	134.9	117.5		1.978	2.289		2.351	2.424	1.036	84.5	97.0		85.7	13.0	3.0	14.3	79.0	39.3	38.5	1.023			
1	3	5.7	4877.2	2890.2	4890.1	134.4	118.0		1.999	2.243		2.340	2.424	1.043	84.8	96.5		85.3	13.0	3.5	14.7	78.5	39.8	38.5	1.030			
2	1	5.9	4640.8	2696.8	4643.4	129.2	119.0		2.033	2.324		2.383	2.418	1.025	88.2	98.5		88.8	13.7	1.5	13.4	80.1	38.7	38.5	1.005			
2	2	5.9	4838.6	2891.6	4839.8	131.3	113.4		1.998	2.314		2.380	2.418	1.029	86.0	98.4		88.5	13.6	1.6	13.5	88.3	38.7	38.5	1.007			
2	3	5.9	4614.6	2687.7	4617.2	133.0	116.0	112.5	1.983	2.271	2.321	2.382	2.418	1.030	83.7	96.8	98.9	85.1	13.4	3.2	14.9	78.3	39.8	38.5	1.034			
3	1	5.8	4871.7	2707.1	4875.8	131.8	114.6		2.008	2.307		2.373	2.419	1.029	85.3	98.1		88.4	13.4	1.9	13.6	86.0	38.8	38.5	1.010			
3	2	5.8	4855.3	2698.7	4862.7	132.4	115.4		1.990	2.283		2.356	2.419	1.032	84.9	97.4		88.8	13.3	2.6	14.2	81.7	39.3	38.5	1.021			
3	3	5.8	4874.7	2697.8	4880.9	133.4	116.1		1.983	2.279		2.357	2.419	1.035	84.8	97.4		88.8	13.3	2.6	14.2	82.0	39.2	38.5	1.020			
4	1	5.7	4827.8	2582.9	4843.2	138.5	121.4		1.891	2.157		2.257	2.430	1.048	81.4	92.9		82.2	12.5	7.1	17.8	59.0	41.8	38.5	1.086			
4	2	5.7	4842.2	2615.0	4881.5	140.5	123.0		1.870	2.138		2.248	2.430	1.052	80.9	92.4		81.9	12.4	7.6	18.1	58.4	42.0	38.5	1.063			
4	3	5.7	4814.9	2616.8	4886.3	141.5	123.8		1.848	2.113		2.252	2.430	1.068	80.9	92.7		82.0	12.5	7.3	18.0	58.1	41.9	38.5	1.060			
5	1	5.7	4577.1	2593.8	4909.4	141.4	123.4		1.832	2.099		2.227	2.433	1.061	79.9	91.5		81.1	12.3	8.5	18.9	56.0	42.6	38.5	1.108			
5	2	5.7	4688.5	2621.4	4711.8	145.4	126.5		1.819	2.086		2.232	2.433	1.069	78.8	91.8		81.3	12.4	8.2	18.7	55.8	42.4	38.5	1.103			
5	3	5.7	4579.8	2596.5	4807.4	139.8	121.5	119.3	1.854	2.133	2.172	2.280	2.433	1.049	80.0	92.0	93.7	81.8	12.4	8.0	18.4	56.6	42.2	38.5	1.089			
6	1	5.8	4646.8	2707.4	4648.1	128.1	112.0		2.053	2.348		2.394	2.417	1.020	86.6	98.1		87.1	13.5	0.9	12.9	82.7	38.3	38.5	0.998			
6	2	5.8	4838.0	2696.6	4841.8	129.7	112.8		2.024	2.327		2.385	2.417	1.025	85.8	98.7		86.8	13.4	1.3	13.2	86.9	38.5	38.5	1.002			
6	3	5.8	4668.2	2690.7	4883.3	132.1	115.4		1.995	2.283		2.360	2.417	1.034	85.3	97.7		85.9	13.3	2.3	14.1	83.4	38.2	38.5	1.018			

Input By: \_\_\_\_\_ Checked By: A. Cooley  
SSD = Saturated Surface Dry cc = cubic centimeter Gmb = Bulk Specific Gravity of Compacted Mixture Gsb = Bulk Specific Gravity of Aggregate VTM = Voids in Total Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gmm = Theoretical Maximum Density of Mixture Gb = Specific Gravity of Asphalt Cement Gc = Specific Gravity of Coarse Aggregate VMA = Voids in Mineral Aggregate  
gm = gram pcf = pounds per cubic foot Gsa = Apparent Specific Gravity of Aggregate VCA = Voids in Coarse Aggregate VFA = Voids Filled With Asphalt Cement

Table 4.11: Results of Loaded Wheel Testing

Site No.: 4

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	3.6	2.1	2.5	3.6
R2	5.7	1.9	2.1	2.5
R3	5.8	1.5	1.8	2.4
R4	6.2	2.9	3.2	4.0
<b>Average</b>	<b>5.3</b>	<b>2.10</b>	<b>2.37</b>	<b>3.13</b>
<b>Std. Dev.</b>	<b>1.17</b>	<b>0.581</b>	<b>0.616</b>	<b>0.789</b>

Table 1.15: Results of Superpave Analysis Testing

Site No.: 4

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @ Constant Height		G*				
		Delta				
Simple Shear Test @ Constant Height		Strain Rate, mm/mm				
		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

Table 4.13: Results of Testing on Cores Obtained In-Field

Site No.: 4

Sieve mm	Percent Passing										Average	Std. Dev.	
	Core 1	Core 2	Core 3	Core 4	Core 5	Core 6	Core 7	Core 8	Core 9	Core 10			
25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.00
19.0	99.9	100.0	100.0	100.0	100.0	100.0	99.8	100.0	100.0	99.7	99.9	99.9	0.11
12.5	96.1	96.6	96.0	96.8	96.9	98.3	96.4	96.9	97.3	94.8	96.6	96.6	0.91
9.5	77.3	75.4	77.0	74.5	79.3	79.9	79.3	78.1	78.8	72.5	77.2	77.2	2.41
4.75	32.9	32.1	33.0	30.3	31.0	32.9	35.8	36.4	34.0	31.2	33.0	33.0	1.99
2.36	22.9	19.3	21.2	19.0	18.4	22.3	25.0	26.4	23.3	21.0	21.9	21.9	2.62
1.18	21.2	17.2	19.2	17.0	16.7	20.4	22.9	24.6	21.6	19.5	20.0	20.0	2.63
0.60	20.6	16.5	18.6	16.3	16.0	19.6	22.2	24.0	21.0	18.8	19.4	19.4	2.66
0.30	19.7	15.4	17.5	15.3	15.1	18.5	21.0	22.9	20.1	17.9	18.3	18.3	2.63
0.150	16.1	12.4	14.7	12.5	12.6	15.4	17.1	19.0	17.2	15.4	15.2	15.2	2.24
0.075	11.4	8.8	10.3	8.5	9.2	10.5	11.8	13.6	12.6	11.2	10.8	10.8	1.66
Gmb	2.191	2.143	2.162	2.176	2.123	2.244	2.221	2.210	2.200	2.189	2.186	2.186	0.04
Unit Weight, pcf	136.7	133.7	134.9	135.8	132.5	140.0	138.6	137.9	137.3	136.6	136.4	136.4	2.26
VTM, %	9.6	11.6	10.8	10.2	12.4	7.5	8.4	8.9	9.3	9.7	9.8	9.8	1.47



**Figure 4.1: Hopper Utilized for Fiber Introduction at Site 4**

## **NCHRP 9-8 II - Task 8 SMA Construction Project No. 5**

### **Location and Background**

Construction project No. 5 was constructed in July of 1997. NCAT representatives were on-site between July 21 and 24, 1997. This project consisted of a 38 mm (1.5 in) overlay of SMA. The pavement structure under the overlay consisted of a concrete pavement with several asphalt concrete overlays.

### **SMA Mixture Information**

The SMA mixture used for this project was a 19.0 mm nominal maximum aggregate size mixture; however, 100 percent of the aggregate blend passed the 19.0 mm sieve. This SMA mixture was the only one encountered during the field evaluation that was designed using the Superpave gyratory compactor. The design was conducted using 158 revolutions. Additional information about this SMA mixture is presented in Table 5.1. The design gradation is provided in Table 5.2. Aggregates used for this project were a limestone. Properties of the coarse and fine aggregates used in this mixture are presented in Tables 5.3 and 5.4, respectively, while properties of the asphalt binder used is presented in Table 5.5. Aggregates used for this project were a limestone. A pelletized cellulose fiber was used for this project. However, the pellets did not contain any asphalt. They were held together by a small amount of glue.

### **Plant Information**

The plant used for this project was a Standard Havens drum plant. The aggregate entered the plant under the flame and therefore moved with the flame (parallel flow). The dust collection system consisted of a knockout box at the end of the drum and a baghouse as the secondary collector. Baghouse fines did constitute part of the mineral filler.

The mineral filler was stockpiled (Figure 5.1) and added via an aggregate bin onto the cold feed conveyor belt. The fibers were introduced into a fiber hopper designed to blow the fibers into the drum (Figure 5.2). This hopper had metal arms (Figure 5.3) that rotated in different directions to break up the pellets (Figure 5.4) to be pneumatically blown to the drum. The contractor calibrated the amount of fibers being transported through the hopper and regulated the amount of SMA mixture being produced to ensure that 0.3 percent of fiber (total mixture) was added.

### **Laydown Procedures**

Observation of the laydown procedures occurred on July 22, 1997. The ambient temperature was approximately 85° F. The contractor informed the NCAT representatives that the paver speed on the inside lane was 21 feet per minute (fpm) and the paver speed on the outside lane was 27 fpm. The longitudinal joints were vertical. Table 5.6 presents additional information obtained from this observation.

### **Problems Encountered On-Site**

No problems were encountered with the mixture or laydown operations while on-site.

**Sampling**

Samples obtained from this project include: each aggregate used in the mixture, mineral filler, fiber, asphalt binder, loose mix, and ten cores. Table 5.7 presents the times and dates that the loose mix samples were obtained along with the average draindown values for each sample. Tables 5.8 through 5.13 present the results of testing performed on the samples brought back to the NCAT laboratory.

<b>Table 5.1: Site 5 SMA Mixture Data</b>	
JMF I.D. Number:	E96131SMA01F
Dates Used:	July 21 to 24, 1997
Number of Aggregate Stockpiles Used:	3
Design Voids in Coarse Aggregate:	41.9 percent*
Type Asphalt Binder Used:	PG 70-22
Modifier Type:	Unmodified
Design Asphalt Binder Content:	6.5 percent
Supplier of Asphalt Binder:	Citgo Asphalt
Type Fiber Used:	Cellulose
Form of Fiber:	Pellets
Design Percentage of Fiber:	0.3 percent
Type Mineral Filler Used:	Limestone Dust
Design Percentage of Mineral Filler:	11 percent
Type Anti-Strip Additive Used:	Liquid (Arca 600L)
Design Percentage of Anti-Strip:	0.2 percent
Compaction Method:	Superpave Gyrotory Compactor
Compactive Effort:	100 revolutions
Laboratory Mixing Temperature:	324 - 337 °F
Laboratory Compaction Temperature:	299 - 310 °F
Design Voids in Total Mix:	3.4 percent
Design Mixture Density:	148.4 pcf
Design Voids in Mineral Aggregate:	19.4 percent
Design Voids Filled With Asphalt:	79.4 percent
Design Marshall Stability:	
Design Flow (0.01 in):	
Loaded Wheel Test @ Design Asphalt Content:	

\* Performed at NCAT laboratory on materials obtained from project.

<b>Table 5.2: Site 5 Design Gradation</b>			
Sieve	Sieve Size, mm	Recommended Limits	% Passing
¾ in.	19.0	100	100
½ in.	12.5	85-95	96.0
⅜ in.	9.5	75 max.	83.0
No. 4	4.75	20-28	33.0
No. 8	2.36	16-24	19.0
No. 16	1.18	----	16.0
No. 30	0.600	12-16	15.0
No. 50	0.300	12-15	14.0
No. 100	0.150	----	12.0
No. 200	0.075	8-10	9.0

<b>Table 5.3: Coarse Aggregate Properties for Site 5</b>	
Test	Combined Aggregates
Los Angeles Abrasion, % Loss	25.2*
Flat & Elongated, %	
3 to 1	
5 to 1	5.0
Bulk/Apparent Specific Gravity	2.675/2.714
Absorption, %	0.5
Soundness (5 Cycles), % Loss	
Sodium Sulfate	
Crushed Content, %	
One Face	100
Two Face	100

Data not provided by the agency are represented by blank data fields.

\* Determined at NCAT laboratory on materials obtained from project.

Table 5.4: Fine Aggregate Properties for Site 5	
Test	No. 8's
Bulk/Apparent Specific Gravity	2.663/
Absorption, %	
Soundness (5 Cycles), % Loss	
Sodium Sulfate	
Angularity, %	46.2*
Liquid Limit, %	
Plasticity Index, %	
Data not provided by the agency are represented by blank data fields.	

\* Determined at NCAT laboratory on materials obtained from project.

Table 5.5: Site 5 Asphalt Binder Properties

### SHRP ASPHALT BINDER GRADING SUMMARY

**ASPHALT: Site 5**  
**OPERATOR: Wilson**  
**PROJECT: NCHRP 9-8**  
**DATE: 10/21/97**

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: 0.15 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135:562 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
GRADE	TEMP °C	ORIGINAL	RTFOT	GRADE	TEMP °C	RTFOT + PAV	TEMP °C	RTFOT + PAV		
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		DT (1mm/min)
		G'/sinδ (kPa) ≥ 1.00 kPa	G'/sinδ (kPa) ≥ 2.20 kPa					G' sinδ (MPa) ≤ 5000 kPa	S, Stiffness(MPa) ≤ 300 MPa	m, Slope ≥ 0.300
94	94			-10	34		0			
88	88			-16	31		-6			
82	82			-22	28	3636	-12	293	0.350	0.2245
76	76	0.5979	1.3065	-28	25	5359	-18			
70	70	1.2956	2.8899	-34	22		-24			
64	64	1.9303		-40	19		-30			
58	58			-46	16		-36			
52	52			-52	13		-42			
46	46			-58	10		-48			

**GRADE: PG 70-22**

<b>Table 5.6: Laydown Information for Site 5</b>	
Manufacturer of Paver:	Blaw Knox
Other Equipment Used:	Material Transfer Device
Number of Rollers Used:	3
Temperature of Mixture When Delivered (Truck):	
Temperature of Mixture Right Behind Paver:	289 °F (1 <sup>st</sup> measurement) 285 °F (2 <sup>nd</sup> measurement)
Type Breakdown Roller:	Static Steel Wheel (10 ton)
Number of Passes By Breakdown Roller:	5
Temperature of Mixture Before Breakdown Roller Began Compaction:	285 °F
Temperature of Mixture After Breakdown Roller Ended Compaction:	245 °F
Type Intermediate Roller:	Static Steel Wheel (10 ton)
Number of Passes By Intermediate Roller:	4
Type Finish Roller:	Static Steel Wheel (10 ton)
Number of Passes By Finish Roller:	5
Temperature of Mixture After Finish Roller Ended Compaction:	206 °F
Comments:	Observations showed that the breakdown roller did pick up some mix on the first pass; however, there was not a large amount (more like small popouts). The material transfer device was essentially a slat conveyor to move the mixture. It did not re-mix the mixture.

<b>Table 5.7: Sampling Times and Dates for Loose Mix From Site 5</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5*	Sample 6*
Date Obtained	7/21/97	7/21/97	7/22/97	7/22/97	7/29/97	7/28/97
Time Obtained	9:20am	11:15am	7:36am	10:30am	12:00pm	4:30pm
Temperature of Mixture in Truck, °F	325	325	315	325	N/A	N/A
Day's Tonnage	585	700	210	739	N/A	N/A
Truck Load of the Day's Production	24	33	10	36	N/A	N/A
Average Draindown, %	0.1	0.1	0.2	0.2	N/A	N/A

N/A - Not available

\* Samples obtained and tested by contractor. Loose mixture and compacted samples sent to NCAT.

Table 5.8: Gradations For Samples Obtained In-Field

Site: 5  
 Sample: 1

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	96.0	94.5	97.4	96.0	2.05	0.0	97.2	95.8	96.4	96.1	0.42	1.1	96.5	96.6	96.6	0.07	0.6
9.5	83.0	77.8	80.1	79.0	1.63	4.1	83.3	81.3	80.4	80.9	0.64	2.5	80.5	79.5	80.0	0.71	3.3
4.75	33.0	29.4	30.4	29.9	0.71	3.1	36.5	37.9	38.2	37.1	1.20	-0.6	36.8	35.1	35.9	1.06	0.8
2.36	19.0	16.6	16.9	16.8	0.21	2.3	20.9	21.9	21.7	21.8	0.14	-0.9	21.8	20.8	21.3	0.71	-0.4
1.18	16.0	14.2	14.5	14.4	0.21	1.7	17.6	17.6	17.4	17.5	0.14	0.1	17.9	17.1	17.5	0.57	0.1
0.60	15.0	13.0	13.3	13.2	0.21	1.9	15.9	15.4	15.3	15.4	0.07	0.6	15.9	15.1	15.5	0.57	0.4
0.30	14.0	11.8	12.2	12.0	0.28	2.0	14.4	13.5	13.5	13.5	0.00	0.9	14.2	13.2	13.7	0.71	0.7
0.150	12.0	10.4	10.7	10.6	0.21	1.5	12.5	11.5	11.4	11.5	0.07	1.1	12.1	11.5	11.8	0.42	0.7
0.075	9.0	8.0	8.3	8.2	0.21	0.9	10.0	8.9	8.9	8.9	0.00	1.1	9.4	9.1	9.3	0.21	0.8

Site: 5  
 Sample: 2

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	96.0	96.9	97.1	97.0	0.14	-1.0	97.2	97.1	97.1	97.1	0.00	0.1	97.8	95.1	96.4	1.66	0.7
9.5	83.0	78.1	76.6	77.4	1.06	5.7	83.3	80.1	82.0	81.1	1.34	2.3	82.2	78.3	80.2	2.75	3.1
4.75	33.0	28.2	28.0	28.1	0.14	4.9	36.5	35.7	37.7	36.7	1.41	-0.2	35.0	34.5	34.7	0.37	1.8
2.36	19.0	16.4	16.4	16.4	0.00	2.6	20.9	20.3	21.4	20.9	0.78	0.0	21.1	20.6	20.9	0.32	0.0
1.18	16.0	14.1	14.2	14.2	0.07	1.9	17.6	16.2	17.1	16.7	0.64	1.0	17.3	16.9	17.1	0.34	0.5
0.60	15.0	12.9	13.1	13.0	0.14	2.0	15.9	14.1	15.0	14.6	0.64	1.4	15.3	14.9	15.1	0.33	0.8
0.30	14.0	11.7	12.0	11.9	0.21	2.2	14.4	12.2	13.1	12.7	0.64	1.8	13.6	13.1	13.4	0.33	1.1
0.150	12.0	10.3	10.5	10.4	0.14	1.6	12.5	10.3	11.0	10.7	0.49	1.9	11.8	11.3	11.6	0.31	1.0
0.075	9.0	8.0	8.3	8.2	0.21	0.9	10.0	8.0	8.6	8.3	0.42	1.7	9.2	8.9	9.1	0.22	0.9

Site: 5  
 Sample: 3

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	96.0	96.0	98.1	97.1	1.48	-1.1	97.2	97.6	98.1	97.9	0.35	-0.7	96.9	95.8	96.4	0.78	0.8
9.5	83.0	82.8	83.1	83.0	0.21	0.1	83.3	84.8	87.6	86.2	1.98	-2.9	82.5	82.5	82.5	0.00	0.8
4.75	33.0	32.6	32.1	32.4	0.35	0.6	36.5	40.4	39.3	39.9	0.78	-3.4	36.4	35.3	35.9	0.78	0.6
2.36	19.0	18.0	17.6	17.8	0.28	1.2	20.9	22.7	22.2	22.5	0.35	-1.6	21.4	20.5	21.0	0.64	-0.1
1.18	16.0	15.5	15.1	15.3	0.28	0.7	17.6	18.1	17.6	17.9	0.35	-0.2	17.6	16.8	17.2	0.57	0.4
0.60	15.0	14.2	13.9	14.1	0.21	0.9	15.9	15.8	15.3	15.6	0.35	0.4	15.6	15.0	15.3	0.42	0.6
0.30	14.0	13.0	12.7	12.9	0.21	1.2	14.4	13.9	13.4	13.7	0.35	0.8	13.9	13.3	13.6	0.42	0.8
0.150	12.0	11.5	11.1	11.3	0.28	0.7	12.5	11.8	11.4	11.6	0.28	0.9	11.8	11.4	11.6	0.28	0.9
0.075	9.0	9.1	8.8	9.0	0.21	0.1	10.0	9.2	8.8	9.0	0.28	1.0	9.3	8.9	9.1	0.28	0.9

Table 5.8(Continued): Gradations For Samples Obtained In-Field

Site: 5  
Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	96.0	95.7	96.0	95.9	0.21	0.2	97.2	96.3	95.9	96.1	0.28	1.1	96.3	96.0	96.2	0.21	1.0
9.5	83.0	80.8	80.8	80.8	0.00	2.2	83.3	83.3	83.9	83.6	0.42	-0.3	82.6	81.6	82.1	0.71	1.2
4.75	33.0	31.0	31.1	31.1	0.07	2.0	36.5	38.6	36.8	37.7	1.27	-1.2	35.8	36.5	36.2	0.49	0.3
2.36	19.0	17.2	16.8	17.0	0.28	2.0	20.9	22.2	21.3	21.8	0.64	-0.9	20.9	21.1	21.0	0.14	-0.1
1.18	16.0	14.8	14.6	14.7	0.14	1.3	17.6	17.8	16.9	17.4	0.64	0.3	17.1	17.1	17.1	0.00	0.5
0.60	15.0	13.6	13.4	13.5	0.14	1.5	15.9	15.5	14.7	15.1	0.57	0.8	15.1	15.1	15.1	0.00	0.8
0.30	14.0	12.5	12.3	12.4	0.14	1.6	14.4	13.4	13.0	13.2	0.28	1.2	13.3	13.3	13.3	0.00	1.1
0.150	12.0	10.9	10.8	10.9	0.07	1.2	12.5	11.3	10.7	11.0	0.42	1.5	11.3	11.3	11.3	0.00	1.2
0.075	9.0	8.6	8.5	8.6	0.07	0.4	10.0	8.7	8.2	8.5	0.35	1.6	8.8	8.8	8.8	0.00	1.2

Site: 5  
Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	96.0	96.6	97.3	97.0	0.49	-0.9	97.2	97.3	96.7	97.0	0.42	0.2	97.7	97.0	97.4	0.49	-0.2
9.5	83.0	79.9	81.4	80.7	1.06	2.3	83.3	84.1	81.8	83.0	1.63	0.4	82.7	83.4	83.1	0.49	0.3
4.75	33.0	32.6	32.7	32.7	0.07	0.3	36.5	41.4	39.0	40.2	1.73	-3.7	39.2	39.5	39.4	0.21	-2.9
2.36	19.0	17.1	17.4	17.3	0.21	1.8	20.9	23.4	21.5	22.5	1.35	-1.6	22.3	22.5	22.4	0.14	-1.5
1.18	16.0	14.7	14.8	14.8	0.07	1.3	17.6	18.6	17.1	17.9	1.09	-0.2	17.9	18.0	18.0	0.07	-0.3
0.60	15.0	13.6	13.7	13.7	0.07	1.4	15.9	16.4	14.8	15.6	1.15	0.3	15.7	15.8	15.8	0.07	0.2
0.30	14.0	12.5	12.5	12.5	0.00	1.5	14.4	14.6	12.9	13.7	1.17	0.7	13.9	14.0	14.0	0.07	0.5
0.150	12.0	11.0	11.0	11.0	0.00	1.0	12.5	12.6	10.9	11.8	1.22	0.8	11.8	11.9	11.9	0.07	0.7
0.075	9.0	8.7	8.7	8.7	0.00	0.3	10.0	10.1	9.2	9.1	1.34	0.9	9.2	9.2	9.2	0.00	0.8

Site: 5  
Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	96.0	97.0	95.5	96.3	1.06	-0.3	97.2	94.9	96.5	95.7	1.10	1.4	97.2	97.6	97.4	0.28	-0.2
9.5	83.0	80.9	81.5	81.2	0.42	1.8	83.3	80.1	79.5	79.8	0.45	3.5	82.3	80.8	81.6	1.06	1.8
4.75	33.0	33.0	33.9	33.5	0.64	-0.5	36.5	31.5	40.3	35.9	6.24	0.6	37.9	37.6	37.8	0.21	-1.3
2.36	19.0	17.6	17.8	17.7	0.14	1.3	20.9	21.3	23.1	22.2	1.30	-1.3	21.0	21.8	21.4	0.57	-0.5
1.18	16.0	14.9	15.1	15.0	0.14	1.0	17.6	17.0	18.7	17.8	1.21	-0.2	17.5	17.6	17.6	0.07	0.1
0.60	15.0	13.7	13.8	13.8	0.07	1.3	15.9	15.1	16.5	15.8	0.98	0.1	15.4	15.5	15.5	0.07	0.5
0.30	14.0	12.5	12.6	12.6	0.07	1.5	14.4	13.5	14.8	14.0	0.80	0.4	13.7	13.8	13.8	0.07	0.7
0.150	12.0	11.0	11.1	11.1	0.07	0.9	12.5	11.8	12.5	12.1	0.53	0.4	11.7	11.8	11.8	0.07	0.8
0.075	9.0	8.7	8.7	8.7	0.00	0.3	10.0	9.3	9.7	9.5	0.28	0.5	9.1	9.3	9.2	0.14	0.8

Table 5.9: Results of Marshall Hammer Compactions

Marshall Hammer: 50 Blows per Side																		
SITE NUMBER: 5			MATERIALS: Granite/Limestone Dust/Cellulose/Pg 70-22					COARSE AGGREGATE INFORMATION				Percent Coarse Aggregate: 67.0		DATE: 2/23/98				
AC Sp. Gr. (G <sub>b</sub> ) = 1.035			Apparent Specific Gravity of the Agg. (G <sub>sa</sub> ) = 2.714			Bulk Specific Gravity of the Agg. (G <sub>sb</sub> ) = 2.675							Bulk Sp. Gravity of CA (G <sub>ca</sub> ): 2.663		Unit Wt. Of CA in DRC (pcf): 96.5			
													Unit Wt. Of CA in DRC (kg/m <sup>3</sup> ): 1545.8					
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	Unit Weight pcf	VTM %	VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
						F-E	$\frac{D}{G}$		$\frac{(100-C) \cdot H}{Gsb}$	$\frac{C \cdot H}{Gb}$	H * 62.4	$\frac{100(1-H/I)}{100 - J}$	$\frac{100(N-M)}{N}$					
1	1	6.2	1225.0	690.6	1229.7	539.1	2.272	2.433	79.7	13.7	141.8	6.6	20.3	67.5	46.4	41.9	1.107	
1	2	6.2	1214.4	682.6	1220.9	538.3	2.256	2.433	79.1	13.6	140.8	7.3	20.9	65.2	46.8	41.9	1.117	
1	3	6.2	1189.5	671.1	1194.8	523.7	2.271	2.433	79.6	13.7	141.7	6.6	20.4	67.4	46.4	41.9	1.108	
2	1	6.3	1150.5	650.2	1157.0	508.8	2.270	2.438	79.5	13.8	141.7	6.9	20.5	66.4	46.5	41.9	1.109	
2	2	6.3	1179.7	666.3	1186.5	520.2	2.268	2.438	79.4	13.8	141.5	7.0	20.6	66.0	46.5	41.9	1.111	
2	3	6.3	1167.4	660.4	1177.2	516.8	2.259	2.438	79.1	13.7	141.0	7.3	20.9	64.8	46.7	41.9	1.116	
3	1	6.4	1195.8	679.5	1198.0	518.5	2.306	2.445	80.7	14.3	143.9	5.7	19.3	70.6	45.7	41.9	1.091	
3	2	6.4	1206.8	688.2	1209.6	521.4	2.315	2.445	81.0	14.3	144.4	5.3	19.0	71.9	45.5	41.9	1.086	
3	3	6.4	1184.5	675.6	1187.6	512.0	2.313	2.445	80.9	14.3	144.4	5.4	19.1	71.8	45.5	41.9	1.087	
4	1	6.4	1198.1	680.4	1200.9	520.5	2.302	2.442	80.6	14.2	143.6	5.7	19.4	70.5	45.8	41.9	1.093	
4	2	6.4	1211.0	687.8	1213.6	525.8	2.303	2.442	80.6	14.2	143.7	5.7	19.4	70.7	45.8	41.9	1.092	
4	3	6.4	1217.1	690.1	1220.0	529.9	2.297	2.442	80.4	14.2	143.3	5.9	19.6	69.7	45.9	41.9	1.096	
5	1	6.2					2.330	2.449	81.7	14.0	145.4	4.9	18.3	73.5	45.0	41.9	1.075	
5	2	6.2					2.334	2.449	81.8	14.0	145.6	4.7	18.2	74.2	44.9	41.9	1.072	
5	3	6.2					2.334	2.449	81.8	14.0	145.6	4.7	18.2	74.2	44.9	41.9	1.072	
6	1	6.2					2.399	2.446	84.1	14.5	149.7	1.9	15.9	87.9	43.4	41.9	1.036	
6	2	6.2					2.393	2.446	83.9	14.4	149.3	2.2	16.1	86.6	43.6	41.9	1.039	
6	3																	
							2.300	2.446	84.0	14.4	149.5	2.0	16.0	87.2	43.5	41.9		

Input By: \_\_\_\_\_ Checked By: A. Cooley  
 SSD = Saturated Surface Dry cc = cubic centimeter Gmb = Bulk Specific Gravity of Compacted Mixture Gsb = Bulk Specific Gravity of Aggregate VTM = Voids in Total Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gmm = Theoretical Maximum Density of Mixture Gb = Specific Gravity of Asphalt Cement VMA = Voids in Mineral Aggregate  
 gm = gram pcf = pounds per cubic foot Gsa = Apparent Specific Gravity of Aggregate VCA = Voids in Coarse Aggregate VFA = Voids Filled With Asphalt Cement

\* Samples 5 and 6 were compacted by the contractor and sent to NCAT.

Table 5.10: Results of SGC Compactions

SITE NUMBER: 5		MATERIALS: Granite/Limestone Dust/Celulose/PG 70-22										COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 67.0		DATE: 4/16/98		
AC Sp Gr (Gb) = 1.035		Apparent Specific Gravity of the Agg. (Gsa) = 2.714					Bulk Specific Gravity of the Agg. (Gsb) = 2.975					Bulk Sp. Gravity of CA (Gca): 2.863					Unit Wt. Of CA in DRC (pcf): 98.5					Unit Wt. Of CA in DRC (kg/m3): 1545.8				
Sample Number	Replicate	Asphalt Content %	WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES		CORR. % Gmm			VOLUMES AT Ndes			VOIDS						
			In Air gms	In Water gms	SSD gms	Nini (8 Gyr) mm	Ndes (100 Gyr) mm	Nmax (158 Gyr) mm	Nini (8 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	Nini %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA VCA drc	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
									G*17.87			D		Gmb Est. Gmb Meas.			J*O K*O L*O			(100-C)*K*O (Gab)			100-Q 100-S 100(V-U) V			
1	1	8.2	4579.0	2594.5	4588.0	132.4	118.4		1.957	2.220		2.297	2.433	1.032	83.0	94.4		80.5	13.8	5.8	19.5	71.3	45.8	41.9	1.093	
1	2	8.2	4577.4	2580.4	4586.4	132.2	118.8		1.959	2.218		2.282	2.433	1.029	82.9	93.8		80.0	13.7	6.2	20.0	68.0	46.2	41.9	1.102	
1	3	8.2	4591.9	2604.3	4604.3	133.0	118.9		1.954	2.223		2.296	2.433	1.033	82.9	94.4		80.5	13.8	5.8	19.5	71.1	45.8	41.9	1.094	
2	1	8.3	4570.8	2622.8	4580.3	131.8	115.8		1.982	2.234		2.311	2.438	1.035	83.3	94.8		81.0	14.0	5.2	19.0	72.7	45.5	41.9	1.088	
2	2	8.3	4558.4	2581.3	4568.0	131.7	118.1		1.955	2.221		2.283	2.438	1.033	82.9	94.1		80.3	13.9	5.9	19.7	69.9	45.9	41.9	1.096	
2	3	8.3	4561.8	2605.1	4570.8	131.8	118.5	114.7	1.959	2.216	2.251	2.321	2.438	1.031	82.8	93.7	95.2	80.0	13.9	6.3	20.0	68.5	46.1	41.9	1.101	
3	1	8.4	4573.8	2632.5	4579.5	128.9	114.1		2.008	2.268		2.349	2.445	1.036	85.0	96.1		82.2	14.5	3.9	17.8	78.0	44.7	41.9	1.067	
3	2	8.4	4585.5	2629.8	4593.8	128.9	114.8		2.013	2.260		2.335	2.445	1.033	85.1	95.5		81.7	14.5	4.5	18.3	75.4	45.0	41.9	1.075	
3	3	8.4	4562.0	2659.0	4596.4	129.4	115.1	113.8	2.008	2.258	2.287	2.368	2.445	1.035	85.0	95.8	98.8	81.8	14.5	4.4	18.2	75.8	45.0	41.9	1.073	
4	1	8.4	4556.4	2622.0	4561.7	128.3	113.3		2.010	2.278		2.349	2.442	1.032	84.9	96.2		82.2	14.5	3.8	17.8	78.6	44.7	41.9	1.066	
4	2	8.4	4517.8	2590.3	4525.0	126.2	113.0		2.028	2.262		2.335	2.442	1.032	85.8	95.8		81.7	14.4	4.4	18.3	78.1	45.0	41.9	1.074	
4	3	8.4	4500.5	2552.5	4510.0	126.4	114.2		2.015	2.230		2.299	2.442	1.031	85.1	94.1		80.5	14.2	5.9	19.5	70.0	45.8	41.9	1.084	
5	1	8.2	4565.0			127.8	113.5	111.7	2.024	2.278	2.313	2.368	2.448	1.024	84.6	95.2	96.7	81.7	14.0	4.8	18.3	73.5	45.0	41.9	1.074	
5	2	8.2	4548.0			128.1	114.4	112.5	2.008	2.249	2.287	2.373	2.449	1.038	85.1	95.3	96.9	81.8	14.0	4.7	18.2	74.1	44.9	41.9	1.073	
5	3	8.2	4504.0			128.6	114.6	112.8	1.982	2.224	2.260	2.371	2.449	1.049	84.9	95.3	96.8	81.8	14.0	4.7	18.2	74.1	44.9	41.9	1.072	
6	1	8.2	4628.0			129.5	113.9	112.1	2.021	2.298	2.335	2.398	2.448	1.027	84.9	96.5	98.1	82.8	14.2	3.5	17.2	79.9	44.3	41.9	1.057	
6	2	8.2	4628.0			129.5	114.5	112.6	2.023	2.288	2.326	2.393	2.448	1.029	85.1	96.2	97.8	82.5	14.2	3.8	17.5	78.4	44.5	41.9	1.062	
6	3	8.2	4628.0			129.5	114.2	112.4	2.022	2.293	2.330	2.398	2.448	1.028	85.0	96.4	98.0	82.7	14.2	3.8	17.3	79.3	44.4	41.9	1.059	

Input By: \_\_\_\_\_ Checked By: A. Cooley  
 SSD = Saturated Surface Dry cc = cubic centimeter Gmb = Bulk Specific Gravity of Compacted Mixture Gab = Bulk Specific Gravity of Aggregate VTM = Voids in Total Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gmm = Theoretical Maximum Density of Mixture Gb = Specific Gravity of Asphalt Cement Gb = Voids in Mineral Aggregate  
 g/m = gram pcf = pounds per cubic foot Gsa = Apparent Specific Gravity of Aggregate VCA = Voids in Coarse Aggregate VFA = Voids Filled With Asphalt Cement

\* Samples 5 and 6 were compacted by the contractor and sent to NCAT.

Table 5.11: Results of Loaded Wheel Testing

Site No. 5

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	4.5	2.55	4.49	5.31
R2	5.0	2.41	3.32	4.35
R3	5.0	1.27	2.08	2.89
R4	5.7	0.47	1.44	1.58
Average	5.0	1.68	2.83	3.53
Std. Dev.	0.51	0.987	1.353	1.638

Table 5.12: Results of Superpave Analysis Testing

Site No.: 5

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @		G*				
Constant Height		Delta				
Simple Shear Test @		Strain Rate, mm/mm				
Constant Height		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

Table 5.13: Results of Testing on Cores Obtained In-Field

Site No.: 5

Sieve mm	Percent Passing										Average	Std. Dev.	
	Core 1	Core 2	Core 3	Core 4	Core 5	Core 6	Core 7	Core 8	Core 9	Core 10			
25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.00
19.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	100.0	100.0	100.0	99.9	0.19	
12.5	97.6	92.7	98.7	97.0	98.4	99.4	96.3	96.9	96.1	98.6	97.2	1.92	
9.5	86.2	76.2	83.1	84.4	84.4	85.7	81.9	86.6	81.5	83.1	83.3	3.04	
4.75	37.1	35.9	35.0	37.6	38.8	38.7	34.8	37.2	33.5	36.3	36.5	1.72	
2.36	20.5	20.2	20.6	21.5	22.0	21.4	20.1	20.9	20.4	21.1	20.9	0.62	
1.18	17.4	16.6	17.5	17.8	18.7	18.2	17.2	17.7	17.5	17.8	17.6	0.56	
0.60	15.7	14.7	15.9	15.9	16.9	16.5	15.6	16.0	16.0	16.1	15.9	0.58	
0.30	14.2	13.1	14.5	14.3	15.3	15.0	14.1	14.5	14.6	14.5	14.4	0.58	
0.150	12.3	11.2	12.7	12.3	13.4	13.1	12.2	12.7	12.8	12.6	12.5	0.60	
0.075	9.7	8.7	10.1	9.8	10.7	10.6	9.8	10.2	10.4	10.2	10.0	0.57	
Gmb	2.181	2.188	2.155	2.181	2.183	2.258	2.189	2.220	2.189	2.205	2.195	0.03	
Unit Weight, pcf	136.1	136.5	134.5	136.1	136.2	140.9	136.6	138.5	136.6	137.6	137.0	1.73	
VTM, %	10.4	10.2	11.5	10.4	10.4	7.6	10.4	9.2	10.4	9.8	10.0	1.03	



**Figure 5.1: Mineral Filler Stockpile Used At Site 5**



**Figure 5.2: Hopper Used For Fiber Introduction  
at Site 5**



**Figure 5.3: Metal Arms Within Fiber Hopper**



**Figure 5.4: Broken-Up Fiber Pellets**

**NCHRP 9-8 II - Task 8**  
**SMA Construction Project No. 6**

**Location and Background**

Project No. 6 was constructed in August of 1997. NCAT staff was on-site from August 4 to August 7, 1997. This project called for a 44 mm (1.75 in) overlay of an existing pavement. The existing pavement consisted of a continuously reinforced concrete pavement with many asphalt concrete patches. Before placing the SMA, the asphalt concrete patches were milled down to the concrete pavement. A leveling course was placed on the ramps and where needed along the roadway.

**SMA Mixture Information**

Table 6.1 presents information about the SMA mixture used for this project. As can be seen in Table 6.2 (Design Gradation), this particular state does not use the 12.5 mm (½ in) sieve; however, based on the design gradation, this mixture would probably be considered a 12.5 mm nominal maximum aggregate size mixture. The aggregates used for this mixture were a rhyolite. Only two stockpiles were used to blend the gradation. Both aggregates would be considered coarse aggregates. Properties for these two aggregates are presented in Table 6.3. The mineral filler used was a dolomite dust created from crushing operations. The fiber was a cellulose that was in the form of a pellets that consisted of 66 percent asphalt and 34 percent cellulose. The asphalt binder was a Multi-Grade 20-40. Its properties are presented in Table 6.4.

Before the arrival of NCAT personnel, the DOT changed the gradation of the mixture. Design VMA for this mixture was 20.0 percent. The DOT thought that this high value may require too much asphalt to be added to the mixture in order to reduce the voids in total mix. To accomplish the reduction in VMA, the DOT increased the percent passing the 4.75 mm (No. 4) sieve by one percent. This was done to try and reduce the VMA to 19.0 percent. Based on conversations with the DOT, this change appeared to work well.

### **Plant Information**

The plant used for this project was a Cedar Rapids drum mixer. The dust collection system consisted of a vertical cyclone (primary) collector and a baghouse (secondary). For this project, the contractor selected to waste the baghouse fines; therefore, the baghouse fines were not included as mineral filler.

Both the mineral filler and fibers were introduced into the mixture within the drum. They were introduced at the point of asphalt injection to minimize the amount of filler and fiber entering the exhaust gas stream within the drum. The mineral filler was stored in a silo from which it was augered to the drum. A hopper was used for the introduction of the fiber pellets. Large bags of pellets (Figure 6.1) were emptied into the hopper. The pellets were then blown pneumatically to the introduction point.

The state in which this project took place only allows contractors to produce mixtures at temperatures less than 325°F for air quality purposes. For this reason, the mixture was produced at a temperature of less than 325°F even though the mixing

temperature for the asphalt binder was 340°F.

### **Laydown Procedures**

Paving operations were observed on August 6, 1997. This day was sunny with an ambient temperature of approximately 95°F. For this project, the contractor used three 12-ton steel wheel rollers, all in a static mode. This was a result of problems encountered before NCAT's visit. Apparently, the contractor began the project using the breakdown roller in a vibratory mode. Under vibratory mode, the contractor indicated that the mixture was tender. The contractor also indicated that large fat-spots were encountered on the roadway while the breakdown roller was in vibratory mode. However, when the contractor changed the breakdown roller to static mode, the tenderness fat-spot problems ceased. Additional information obtained while observing the paving operations is presented in Table 6.5.

### **Problems Encountered On-Site**

Besides the problems with tenderness and fat-spots encountered prior to NCAT's visit, no problems were encountered.

### **Sampling**

Samples obtained from this project include: each aggregate used in the mixture, mineral filler, fiber, asphalt binder, loose mix, and five cores. Only five cores were obtained because the contractor removed traffic control on the project before the cores could be obtained. Table 6.6 presents the times and dates that the loose mix samples were obtained along with the average draindown values. Tables 6.7 through 6.12 provide

the results of testing performed on the different samples subsequent to bringing these samples back to NCAT's laboratory.

<b>Table 6.1: Site 6 SMA Mixture Data</b>	
JMF I.D. Number:	729
Dates Used:	August 4 through 6, 1997
Number of Aggregate Stockpiles Used:	2
Design Voids in Coarse Aggregate:	42.3*
Type Asphalt Binder Used:	Multi-Grade 20-40
Modifier Type:	N/A
Design Asphalt Binder Content:	7.1 percent
Supplier of Asphalt Binder:	Asphalt Materials, Inc.
Type Fiber Used:	Cellulose
Form of Fiber:	Pellet (66/34 bitumen granulation)
Design Percentage of Fiber:	0.3 percent
Type Mineral Filler Used:	Dolomite Dust
Design Percentage of Mineral Filler:	15.0 percent
Type Anti-Strip Additive Used:	Liquid
Design Percentage of Anti-Strip:	1.0 percent
Compaction Method:	Marshall Hammer
Compactive Effort:	51 Blows per Side
Laboratory Mixing Temperature:	340 °F
Laboratory Compaction Temperature:	290 °F
Design Voids in Total Mix:	4.0 percent
Design Mixture Density:	147.7 pcf
Design Voids in Mineral Aggregate:	20.0 percent
Design Voids Filled With Asphalt:	80.0 percent
Design Marshall Stability:	
Design Flow (0.01 in):	
Loaded Wheel Test @ Design Asphalt Content:	

\* Determined at NCAT laboratory on materials obtained from project.

<b>Table 6.2: Site 6 Design Gradation</b>			
Sieve	Sieve Size, mm	Recommended Limits	% Passing
7/8 in.	22.4	----	100
3/4 in.	19.0	100	----
5/8 in.	16.0	----	99.9
1/2 in.	12.5	85-95	----
3/8 in.	9.5	75 max.	66.7
No. 4	4.75	20-28	26.1
No. 8	2.36	16-24	----
No. 10	2.00	----	16.2
No. 30	0.600	12-16	----
No. 40	0.425	----	15.4
No. 50	0.300	12-15	----
No. 80	0.180	----	15.2
No. 200	0.075	8-10	11.1

Table 6.3: Coarse Aggregate Properties for Site 6		
Test	WD ¾"	WD Type D
Los Angeles Abrasion, % Loss	16	16
Flat & Elongated, %		
3 to 1	9.8*	30.7*
5 to 1	2.5*	6.1*
Bulk/Apparent Specific Gravity	2.726/----	2.726/----
Absorption, %		
Soundness (5 Cycles), % Loss		
Magnesium Sulfate	5	5
Crushed Content, %		
One Face	100	100
Two Face	100	100
Data not provided by the agency are represented by blank data fields.		

\*Determined at NCAT laboratory on materials obtained from project.

Table 6.4: Site 6 Asphalt Binder Properties

### SHRP ASPHALT BINDER GRADING SUMMARY

**ASPHALT:** Site 6  
**OPERATOR:** Wilson  
**PROJECT:** NCHRP 9-8  
**DATE:** 10/21/97

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: 0.29 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135: 1234 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
GRADE	TEMP °C	ORIGINAL	RTFOT	GRADE	TEMP °C	RTFOT + PAV	TEMP °C	RTFOT + PAV		
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		DT (1mm/min)
		G' / sinδ (kPa) ≥ 1.00 kPa	G' / sinδ (kPa) ≥ 2.20 kPa			G' sinδ (MPa) ≤ 5000 kPa		S, Stiffness (MPa) ≤ 300 MPa	m, Slope ≥ 0.300	Failure Strain ≥ 1.0%
94	94			-10	31		0			
88	88			-16	28		-6			
82	82			-22	25	1745	-12	123	0.330	.1386
76	76		1.0829	-28	22	2539	-18	Sample broke	at	loading
70	70	0.8458	2.2662	-34	19	3720	-24			
64	64	1.7140	4.4325	-40	16	5220	-30			
58	58			-46	13		-36			
52	52			-52	10		-42			
46	46			-58	7		-48			

**GRADE: PG 64-22**

<b>Table 6.5: Laydown Information for Site 6</b>	
Manufacturer of Paver:	Cedar Rapids
Other Equipment Used:	None
Number of Rollers Used:	3
Temperature of Mixture Right Behind Paver:	280 °F (1 <sup>st</sup> measurement) 260 °F (2 <sup>nd</sup> measurement)
Type Breakdown Roller:	Static Steel Wheel (12 ton)
Number of Passes By Breakdown Roller:	4
Temperature of Mixture Before Breakdown Roller Began Compaction:	275 °F
Type Intermediate Roller:	Static Steel Wheel (12 ton)
Number of Passes By Intermediate Roller:	4
Type Finish Roller:	Static Steel Wheel (12 ton)
Number of Passes By Finish Roller:	3
Comments:	When the breakdown roller got too close to the paver, it began to pick up mix. Similar to Site 5, the amount was not large. It was more like small popouts. While observing paving, it was noticed that several trucks had mixture sticking to the beds. The contractor was using releasing agents.

<b>Table 6.6: Sampling Times and Dates for Loose Mix From Site 6</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	8/4/97	8/4/97	8/5/97	8/5/97	8/6/97	8/6/97
Time Obtained	10:35am	3:15pm	11:15am	4:15pm	9:50am	1:50pm
Temperature of Mixture in Truck, °F	310	320	305	310	310	310
Day's Tonnage	372	871	N/A	860	185	551
Average Draindown, %	N/A	0.1	0.1	0.03	0.04	0.03

N/A - Not available.

Table 6.7: Gradations For Samples Obtained In-Field

Site: 6  
Sample: 1

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples					
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U	
25.0	100.0					B-F	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	
19.0	100.0						99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1	
12.5	85.0						93.3	93.9	92.5	93.2	0.99	0.1	92.4	90.2	91.3	1.56	2.0	
9.5	66.7						74.7	73.8	77.9	75.9	2.90	-1.1	72.1	69.2	70.7	2.05	4.1	
4.75	26.1	Samples Not Tested						33.9	35.4	36.1	35.8	0.49	-1.8	32.6	31.5	32.1	0.78	1.9
2.36	18.0						22.0	22.1	22.5	22.3	0.26	-0.3	20.7	20.2	20.5	0.35	1.6	
1.18	16.0						19.4	18.7	19.2	19.0	0.35	0.4	18.0	17.6	17.8	0.28	1.6	
0.60	15.8						18.4	17.6	18.0	17.8	0.28	0.6	17.0	16.5	16.8	0.35	1.7	
0.30	15.3						17.9	16.9	17.4	17.2	0.35	0.7	16.4	15.8	16.1	0.42	1.8	
0.150	13.0						16.9	16.2	16.6	16.4	0.28	0.5	15.7	14.7	15.2	0.71	1.7	
0.075	11.1						12.9	13.4	14.0	13.7	0.42	-0.8	12.8	11.4	12.1	0.99	0.8	

Site: 6  
Sample: 2

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
25.0	100.0					B-F	100.0						100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	Samples Destroyed During Extrusion					100.0	100.0	100.0	0.00	-0.1
12.5	85.0	91.7	93.1	92.4	0.99	-7.4	93.3						93.1	91.8	92.5	0.92	0.9
9.5	66.7	73.3	74.9	74.1	1.13	-7.4	74.7						74.0	73.5	73.8	0.35	1.0
4.75	26.1	31.0	31.0	31.0	0.00	-4.9	33.9						33.6	33.3	33.5	0.21	0.6
2.36	18.0	19.4	19.8	19.6	0.28	-1.6	22.0						21.1	21.1	21.1	0.00	0.9
1.18	16.0	17.6	18.0	17.8	0.28	-1.8	19.4						18.0	18.2	18.1	0.14	1.3
0.60	15.8	17.0	17.3	17.2	0.21	-1.4	18.4						17.0	17.2	17.1	0.14	1.3
0.30	15.3	16.6	17.0	16.8	0.28	-1.5	17.9						16.4	16.8	16.5	0.14	1.4
0.150	13.0	16.1	16.7	16.4	0.42	-3.4	16.9						15.9	16.2	16.1	0.21	0.8
0.075	11.1	12.8	13.9	13.4	0.78	-2.3	12.9						12.9	13.2	13.1	0.21	-0.1

Site: 6  
Sample: 3

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples					
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U	
25.0	100.0					B-F	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	
19.0	100.0						99.9	99.8	100.0	99.9	0.14	0.0	100.0	100.0	100.0	0.00	-0.1	
12.5	85.0						93.3	88.3	91.2	89.8	2.05	3.8	92.2	89.3	90.8	2.05	2.8	
9.5	66.7						74.7	67.7	68.8	68.3	0.78	6.5	68.2	66.5	67.4	1.20	7.4	
4.75	26.1	Samples Not Tested						33.9	31.6	32.3	32.0	0.49	2.0	30.5	30.3	30.4	0.14	3.5
2.36	18.0						22.0	20.5	21.0	20.8	0.35	1.3	20.0	19.8	19.9	0.14	2.1	
1.18	16.0						19.4	17.7	18.2	18.0	0.35	1.5	17.3	17.2	17.3	0.07	2.2	
0.60	15.8						18.4	16.7	17.1	16.9	0.28	1.5	16.3	16.3	16.3	0.00	2.1	
0.30	15.3						17.9	16.2	16.6	16.4	0.28	1.5	15.6	15.8	15.7	0.14	2.2	
0.150	13.0						16.9	15.8	16.2	15.9	0.42	1.0	14.5	15.4	15.0	0.64	1.9	
0.075	11.1						12.9	12.9	13.6	13.3	0.49	-0.3	10.9	12.8	11.9	1.34	1.1	

Table 6.7(Continued): Gradations For Samples Obtained In-Field

Site: 6  
 Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	100.0	0.00	-0.1	100.0	100.0	100.0	0.00	-0.1
12.5	85.0	90.7	90.9	90.8	0.14	-5.8	93.3	92.9	91.6	92.3	0.92	1.1	89.3	90.0	89.7	0.49	3.7
9.5	66.7	69.3	70.6	70.0	0.92	-3.2	74.7	72.9	71.6	72.3	0.92	2.5	68.5	67.2	67.9	0.92	6.9
4.75	26.1	29.5	30.4	30.0	0.64	-3.9	33.9	32.6	31.7	32.2	0.64	1.8	30.6	30.3	30.5	0.21	3.5
2.36	18.0	19.1	20.1	19.6	0.71	-1.6	22.0	20.7	20.1	20.4	0.42	1.6	19.7	19.9	19.8	0.14	2.2
1.18	16.0	17.2	18.2	17.7	0.71	-1.7	19.4	17.7	17.1	17.4	0.42	2.0	17.0	17.2	17.1	0.14	2.3
0.60	15.8	16.6	17.6	17.1	0.71	-1.3	18.4	16.6	16.1	16.4	0.35	2.1	16.0	16.2	16.1	0.14	2.3
0.30	15.3	16.2	17.2	16.7	0.71	-1.4	17.9	16.0	15.6	15.8	0.28	2.1	15.4	15.7	15.6	0.21	2.3
0.150	13.0	15.7	16.7	16.2	0.71	-3.2	16.9	15.7	15.2	15.5	0.35	1.4	15.0	15.3	15.2	0.21	1.7
0.075	11.1	12.6	13.5	13.1	0.64	-2.0	12.9	13.4	12.5	13.0	0.64	0.0	12.2	12.6	12.4	0.28	0.5

Site: 6  
 Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	99.9	100.0	0.07	0.0	100.0	100.0	100.0	0.00	-0.1
12.5	85.0	90.9	90.5	90.7	0.28	-5.7	93.3	88.9	92.6	90.8	2.62	2.6	90.4	90.1	90.3	0.21	3.1
9.5	66.7	67.7	67.3	67.5	0.28	-0.8	74.7	73.6	75.0	74.3	0.99	0.4	68.9	69.1	69.0	0.14	5.7
4.75	26.1	29.6	28.3	29.0	0.92	-2.9	33.9	33.9	33.5	33.7	0.28	0.2	31.0	30.9	31.0	0.07	3.0
2.36	18.0	19.1	18.4	18.8	0.49	-0.8	22.0	21.5	21.2	21.4	0.21	0.7	20.4	20.0	20.2	0.28	1.8
1.18	16.0	17.3	16.6	17.0	0.49	-1.0	19.4	18.4	18.1	18.3	0.21	1.2	17.7	17.4	17.6	0.21	1.9
0.60	15.8	16.7	16.1	16.4	0.42	-0.6	18.4	17.3	17.0	17.2	0.21	1.3	16.7	16.4	16.6	0.21	1.9
0.30	15.3	16.3	15.7	16.0	0.42	-0.7	17.9	16.7	16.4	16.6	0.21	1.3	16.1	15.9	16.0	0.14	1.9
0.150	13.0	15.8	15.3	15.6	0.35	-2.6	16.9	16.1	15.9	16.0	0.14	0.9	15.2	15.1	15.2	0.07	1.7
0.075	11.1	12.2	11.7	12.0	0.35	-0.9	12.9	12.5	12.4	12.5	0.07	0.5	11.4	11.4	11.4	0.00	1.5

Site: 6  
 Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
		B-F					I-M					I-S					
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	99.4	99.7	0.42	0.2	100.0	100.0	100.0	0.00	-0.1
12.5	85.0	93.1	90.8	92.0	1.63	-6.9	93.3	89.0	93.7	91.4	3.32	2.0	87.8	92.2	90.0	3.11	3.3
9.5	66.7	72.7	68.3	70.5	3.11	-3.8	74.7	68.0	75.5	71.8	5.30	3.0	64.8	70.4	67.6	3.96	7.1
4.75	26.1	31.6	29.6	30.6	1.41	-4.5	33.9	31.5	35.4	33.5	2.76	0.5	29.3	30.9	30.1	1.13	3.8
2.36	18.0	21.0	19.3	20.2	1.20	-2.2	22.0	19.6	22.1	20.9	1.77	1.2	18.7	19.6	19.2	0.64	2.9
1.18	16.0	19.0	17.4	18.2	1.13	-2.2	19.4	16.6	18.7	17.7	1.48	1.8	16.1	16.7	16.4	0.42	3.0
0.60	15.8	18.3	16.8	17.6	1.06	-1.8	18.4	15.5	17.5	16.5	1.41	1.9	15.1	15.6	15.4	0.35	3.1
0.30	15.3	17.9	16.4	17.2	1.06	-1.9	17.9	14.9	18.9	15.9	1.41	2.0	14.4	14.9	14.7	0.35	3.2
0.150	13.0	17.2	15.9	16.6	0.92	-3.6	16.9	14.2	16.2	15.2	1.41	1.7	13.2	13.9	13.6	0.49	3.3
0.075	11.1	13.1	12.4	12.8	0.49	-1.7	12.9	10.5	12.5	11.5	1.41	1.4	8.9	9.8	9.4	0.64	3.6

Table 6.8: Results of Marshall Hammer Compactions

Marshall Hammer: 50 Blows per Side																	
SITE NUMBER: 6			MATERIALS: Rhyolite/LMS Dust/Cellulose Pellets/Multigrade						COARSE AGGREGATE INFORMATION					Percent Coarse Aggregate: 73.9		DATE: 4/15/98	
AC Sp. Gr. (Gb) = 1.030			Effective Specific Gravity of the Agg. (Gsa) = 2.752			Bulk Specific Gravity of the Agg. (Gsb) = 2.752								Bulk Sp. Gravity of CA (Gca): 2.724			
														Unit Wt. Of CA in DRC (pcf): 97.9			
														Unit Wt. Of CA in DRC (kg/m3) 1568.8			
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES		VOIDS					
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	Unit Weight pcf	VTM %	VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
						F-E	$\frac{D}{G}$		$\frac{(100-C) \cdot H}{Gsb}$	$\frac{C \cdot H}{Gb}$	$H \cdot 62.4$	$100(1-H/I)$	$100 - J$	$100 \cdot \frac{(N-M)}{N}$			
1	1	7.3	1188.0	694.4	1190.1	495.7	2.397	2.480	80.7	17.0	149.5	3.4	19.3	82.6	39.7	42.3	0.938
1	2	7.3	1187.4	694.9	1189.8	494.9	2.399	2.480	80.8	17.0	149.7	3.3	19.2	83.0	39.7	42.3	0.937
1	3	7.3	1181.0	687.4	1183.2	495.8	2.382	2.480	80.2	16.9	148.6	4.0	19.8	80.0	40.1	42.3	0.947
2	1	6.7	1199.3	694.3	1202.2	507.9	2.361	2.513	80.1	15.4	147.3	6.0	19.9	69.7	40.2	42.3	0.950
2	2	Sample destroyed during extruding															
2	3	Sample destroyed during extruding															
3	1	7.1	1207.7	705.7	1210.5	504.8	2.392	2.492	80.8	16.5	149.3	4.0	19.2	79.2	39.7	42.3	0.938
3	2	7.1	1230.4	722.0	1233.9	511.9	2.404	2.492	81.1	16.6	150.0	3.5	18.9	81.2	39.4	42.3	0.931
3	3	7.1	1190.3	692.2	1194.3	502.1	2.371	2.492	80.0	16.3	147.9	4.9	20.0	75.6	40.3	42.3	0.951
4	1	7.0	1173.0	677.5	1178.0	498.5	2.353	2.506	79.5	16.0	146.8	6.1	20.5	70.2	40.6	42.3	0.959
4	2	7.0	1186.3	685.7	1190.5	504.8	2.350	2.506	79.4	16.0	146.6	6.2	20.6	69.8	40.7	42.3	0.961
4	3	7.0	1194.0	689.4	1197.3	507.9	2.351	2.506	79.4	16.0	146.7	6.2	20.6	69.9	40.7	42.3	0.961
5	1	7.3	1183.3	684.0	1186.6	502.6	2.354	2.488	79.3	16.7	146.9	5.4	20.7	74.0	40.8	42.3	0.963
5	2	7.3	1187.6	687.2	1190.1	502.9	2.362	2.488	79.5	16.7	147.4	5.1	20.5	75.1	40.6	42.3	0.959
5	3	7.3	1208.6	691.0	1216.0	525.0	2.302	2.488	77.5	16.3	143.7	7.5	22.5	66.7	42.1	42.3	0.994
6	1	7.4	1192.8	691.7	1197.7	506.0	2.357	2.502	79.3	16.9	147.1	5.8	20.7	72.0	40.8	42.3	0.963
6	2	7.4	1195.7	697.7	1198.5	500.8	2.388	2.502	80.3	17.2	149.0	4.6	19.7	76.7	40.0	42.3	0.945
6	3	7.4	1170.7	680.4	1173.4	493.0	2.375	2.502	79.9	17.1	148.2	5.1	20.1	74.7	40.3	42.3	0.953

Input By:										Checked By: A. Cooley							
SSD = Saturated Surface Dry	cc = cubic centimeter	Gmb = Bulk Specific Gravity of Compacted Mixture	Gsb = Bulk Specific Gravity of Aggregate	VTM = Voids in Total Mix													
TMD = Theoretical Maximum Density	AC = Asphalt Cement	Gmm = Theoretical Maximum Density of Mixture	Gb = Specific Gravity of Asphalt Cement	VMA = Voids in Mineral Aggregate													
gm = gram	pcf = pounds per cubic foot	Gsa = Apparent Specific Gravity of Aggregate	VCA = Voids in Coarse Aggregate	VFA = Voids Filled With Asphalt Cement													

Table 6.9: Results of SGC Compactions

SITE NUMBER: 6			MATERIALS: Rhyolite/LMS Dust/Celulose Pellets/Multigrade							COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 73.9		DATE: 4/15/98																
AC Sp Gr. (Gsb) = 1.030			Effective Specific Gravity of the Agg. (Gsa) = 2.752				Bulk Specific Gravity of the Agg. (Gsb) = 2.752													Bulk Sp. Gravity of CA (Gca): 2.724		Unit Wt. Of CA in DRC (pcf): 97.9																
			WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES			CORR. % Gmm			VOLUMES AT Ndes			VOIDS																	
Sample Number	Replicate	Asphalt Content %	In Air gms	In Water gms	SSD gms	Nini (8 Gyr) mm	Ndes (100 Gyr) mm	Nmax (158 Gyr) mm	Nini (8 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	Nini %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA drc													
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z													
									G*17.67			H*17.67			I*17.67			J*O			K*O			L*O			M*O			N*O			O*O					
									Gmb Est.			Gmb Meas.			J*O			K*O			L*O			(100-C)*K*O (Gsb)			C*K*O (Gb)			100-Q			100-S			100(V-U) V		
1	1	7.3	4607.2	2656.7	4612.7	123.2	111.4		2.116	2.340		2.355	2.480	1.006	85.9	95.0		79.3	16.7	5.0	20.7	75.7	40.8	42.4	0.962													
1	2	7.3	4569.9	2624.8	4579.1	123.4	112.1		2.096	2.307		2.338	2.480	1.014	85.7	94.3		78.8	16.6	5.7	21.2	73.1	41.2	42.4	0.972													
1	3	7.3	4544.1	2655.7	4550.0	121.3	111.7		2.120	2.302		2.399	2.480	1.042	89.1	96.7		80.8	17.0	3.3	19.2	82.9	38.7	42.4	0.936													
2	1	6.7	4602.1	2651.9	4622.2	126.1	114.3		2.065	2.278		2.336	2.525	1.025	83.8	92.5		79.2	15.2	7.5	20.8	64.0	40.9	42.4	0.965													
2	2	6.7	4650.0	2681.9	4681.7	127.3	114.9		2.067	2.290		2.349	2.525	1.026	84.0	93.0		79.6	15.3	7.0	20.4	65.7	40.8	42.4	0.957													
2	3	6.7	4699.0	2740.6	4708.0	127.2	114.8		2.090	2.316		2.388	2.525	1.031	85.4	94.6		81.0	15.5	5.4	19.0	71.6	39.5	42.4	0.933													
3	1	7.1	4648.1	2718.7	4659.5	125.5	114.8		2.096	2.291		2.395	2.482	1.045	87.9	96.1		80.8	16.5	3.5	19.2	79.7	39.8	42.4	0.936													
3	2	7.1	4639.0	2714.6	4649.0	127.6	114.9		2.057	2.285		2.398	2.482	1.050	86.7	96.2		81.0	16.5	3.8	19.0	80.2	39.8	42.4	0.934													
3	3	7.1	4769.5	2796.4	4779.8	129.5	116.8		2.084	2.311		2.405	2.482	1.041	87.0	96.5		81.2	16.8	3.5	18.8	81.4	39.4	42.4	0.930													
4	1	7.0	4574.8	2627.8	4595.1	124.2	112.4		2.084	2.303		2.325	2.506	1.010	84.0	92.8		78.8	15.8	7.2	21.4	66.4	41.3	42.4	0.975													
4	2	7.0	4413.7	2529.4	4441.8	119.3	108.2		2.094	2.306		2.306	2.506	1.000	83.5	92.1		78.0	15.7	7.9	22.0	64.1	41.8	42.4	0.966													
4	3																																					
5	1	7.3	4582.5	2682.7	4588.2	123.9	112.1		2.093	2.313		2.405	2.488	1.040	87.5	96.7		81.0	17.0	3.3	19.0	82.4	39.5	42.4	0.933													
5	2	7.3	4601.9	2685.4	4606.9	124.2	112.9		2.097	2.307		2.392	2.488	1.037	87.4	96.2		80.8	17.0	3.8	19.4	80.2	39.8	42.4	0.940													
5	3	7.3	4606.9	2707.4	4614.0	125.7	113.6	112.4	2.074	2.295	2.319	2.416	2.488	1.042	86.8	96.1	97.1	80.5	16.9	3.9	19.5	79.9	39.9	42.4	0.941													
6	1	7.4	4622.2	2661.0	4648.9	126.7	114.6		2.064	2.282		2.325	2.502	1.019	84.1	92.9		78.2	16.7	7.1	21.8	67.5	41.8	42.4	0.981													
6	2	7.4	4352.3	2516.1	4385.7	117.9	106.7		2.089	2.308		2.353	2.502	1.019	85.1	94.0		79.2	16.9	6.0	20.8	71.4	40.9	42.4	0.965													
6	3	7.4	4365.3	2552.7	4373.8	120.1	108.2	107.0	2.057	2.283	2.309	2.397	2.502	1.038	85.4	94.8	95.8	79.8	17.0	5.2	20.2	74.1	40.4	42.4	0.954													

Input By: \_\_\_\_\_ Checked By: A. Cooley  
 SSD = Saturated Surface Dry cc = cubic centimeter Gmb = Bulk Specific Gravity of Compacted Mixture Gsb = Bulk Specific Gravity of Aggregate VTM = Voids in Total Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gmm = Theoretical Maximum Density of Mixture Gc = Specific Gravity of Asphalt Cement VMA = Voids in Mineral Aggregate  
 gm = gram pcf = pounds per cubic foot Gsa = Apparent Specific Gravity of Aggregate VCA = Voids in Coarse Aggregate VFA = Voids Filled With Asphalt Cement

Table 6.10: Results of Loaded Wheel Testing

Site No.: 6

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	2.4	2.01	3.54	4.03
R2	2.8	2.68	4.28	5.15
R3	2.1	2.85	4.88	5.65
R4	2.7	2.85	5.15	5.25
Average	2.5	2.60	4.46	5.02
Std. Dev.	0.29	0.400	0.714	0.694

Table 6.11: Results of Superpave Analysis Testing

Site No.: 6

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @		G*				
Constant Height		Delta				
Simple Shear Test @		Strain Rate, mm/mm				
Constant Height		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

Table 6.12: Results of Testing on Cores Obtained In-Field

Site No.: 6

Sieve mm	Percent Passing						
	Core 1	Core 2	Core 3	Core 4	Core 5	Average	Std. Dev.
25.0	100.0	100.0	100.0	100.0	100.0	100.0	0.00
19.0	100.0	99.8	99.9	99.9	100.0	99.9	0.08
12.5	92.4	93.3	95.3	92.1	93.5	93.3	1.25
9.5	73.8	73.1	77.4	74.7	74.7	74.7	1.63
4.75	33.5	33.6	34.2	33.8	34.6	33.9	0.46
2.36	21.5	21.5	22.2	22.3	22.6	22.0	0.50
1.18	18.9	18.9	19.5	19.8	19.9	19.4	0.48
0.60	17.9	17.9	18.4	18.9	19.0	18.4	0.53
0.30	17.3	17.4	17.8	18.4	18.5	17.9	0.55
0.150	16.5	16.4	16.8	17.1	17.6	16.9	0.49
0.075	13.0	12.8	12.8	12.4	13.6	12.9	0.44
Gmb	2.329	2.345	2.309	2.371	2.357	2.342	0.02
Unit Weight, pcf	145.3	146.3	144.1	148.0	147.1	146.2	1.51
VTM, %	6.0	5.4	6.8	4.3	4.9	5.5	0.97



**Figure 6.1: Bags of Fiber Pellets Used At Site No. 6**

**NCHRP 9-8 II - Task 8**  
**SMA Construction Project No. 7**

**Location and Background**

Construction Project No. 7 was constructed in August of 1997. NCAT representatives were on-site from August 18 to August 20, 1997. Placement of the SMA consisted of milling an existing asphalt concrete layer down to a Portland cement concrete pavement and filling with 50 mm (2 in) of conventional binder course and 44 mm (1¾ in) of SMA.

**SMA Mixture Information**

The SMA mixture used for this project was a 19.0 mm nominal maximum aggregate mixture. Information about the mixture is presented in Table 7.1. Limestone and traprock were the aggregates used to produce the mixture. Table 7.2 presents the design gradation. Tables 7.3 and 7.4 provide the properties of the aggregates used in the mixture. The asphalt binder used for this project was a PG 64-28. Properties of this binder are presented in Table 7.5. Values in this table represent testing performed by NCAT on samples of the binder obtained from the job-site. Based on this testing, the asphalt binder was a PG 64-22.

**Plant Information**

The plant used for this project was a Standard Havens 4-ton batch plant. This facility utilized a storage silo for the storing and introduction of the mineral filler. The

mineral filler was blown from a truck into the silo where it was augered into the weigh hopper above the pugmill. The fiber was in a loose form as bales. It was blown from a fiber hopper into the weigh hopper above the pugmill. This facility did not use storage silos for the completed mixture.

### **Laydown Procedures**

Paving operations were not observed for this project.

### **Problems Encountered On-Site**

No problems were encountered.

### **Sampling**

Samples obtained while at this project included: each aggregate used to produce the mixture, mineral filler, fiber, asphalt binder, and loose mixture. Table 7.6 presents the times and dates that the loose mix samples were obtained along with the average draindown values. Testing results completed on samples obtained from the project are presented in Tables 7.7 through 7.11.

<b>Table 7.1: Site 7 SMA Mixture Information</b>	
JMF I.D. Number:	
Dates on Project:	August 18 - 20, 1997
Number of Aggregate Stockpiles Used:	3
Design Voids in Coarse Aggregate:	44.0*
Type Asphalt Binder Used:	PG 64-28
Modifier Type:	SBS
Design Asphalt Binder Content:	6.5 percent
Supplier of Asphalt Binder:	Polymer Asphalt Products
Type Fiber Used:	Cellulose
Form of Fiber:	Loose
Design Percentage of Fiber:	0.3 percent
Type Mineral Filler Used:	Limestone dust
Design Percentage of Mineral Filler:	9.2 percent
Type Anti-Strip Additive Used:	None
Design Percentage of Anti-Strip:	N/A
Compaction Method:	Marshall Hammer
Compactive Effort:	50 Blows per Side
Laboratory Mixing Temperature:	330-340°F
Laboratory Compaction Temperature:	312-324°F
Design Voids in Total Mix:	4.3 percent
Design Mixture Density:	142.2 pcf
Design Voids in Mineral Aggregate:	17.5 percent
Design Voids Filled With Asphalt:	75.5 percent
Design Marshall Stability:	2182 lbs
Design Laboratory Draindown:	
Loaded Wheel Test @ Design Asphalt Content:	

\* Determined at NCAT laboratory on materials obtained from project.

<b>Table 7.2: Design Gradation for Site 7</b>			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
¾ in.	19.0	100	100.0
½ in.	12.5	85-95	87.0
⅜ in.	9.5	75 max.	63.1
No. 4	4.75	20-28	27.5
No. 8	2.36	16-24	20.0
No. 16	1.18	----	16.3
No. 30	0.600	12-16	14.1
No. 50	0.300	12-15	13.1
No. 100	0.150	----	11.4
No. 200	0.075	8-10	8.9

<b>Table 7.3: Coarse Aggregate Properties for Site 7</b>		
Test	Limestone	Traprock
Los Angeles Abrasion, % Loss	23	19
Flat & Elongated, %		
3 to 1	27.6*	43.3*
5 to 1	9.9*	17.5*
Bulk/Apparent Specific Gravity	2.616/2.734*	2.610/2.645*
Absorption, %	1.7*	0.5*
Soundness (5 Cycles), % Loss		
Method Similar to AASHTO T103	2.7-6.2	0.1
Crushed Content, %		
One Face	100*	100*
Two Face	100*	100*

Data not provided by agency is presented by blank data field.

\* Determined at NCAT laboratory on materials obtained from project.

<b>Table 7.4: Fine Aggregate Properties for Site 7</b>	
Test	Traprock
Bulk/Apparent Specific Gravity	2.499/2.652*
Absorption, %	2.3*
Soundness (5 Cycles), % Loss	
Method Similar to AASHTO T103	0.1
Angularity, %	45.7*
Liquid Limit, %	
Plasticity Index, %	NP
Data not provided by agency is represented by blank data fields.	

\* Determined at NCAT laboratory on materials obtained from project.

Table 7.5: Site 7 Asphalt Binder Properties

### SHRP ASPHALT BINDER GRADING SUMMARY

**ASPHALT:** Site 7  
**OPERATOR:** Wilson  
**PROJECT:** NCHRP 9-8  
**DATE:** 10/21/97

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: 0.56 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135: 608 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
GRADE	TEMP °C	ORIGINAL	RTFOT	GRADE	TEMP °C	RTFOT + PAV	TEMP °C	RTFOT + PAV		
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		DT (1mm/min)
		G' / sinδ (kPa) ≥ 1.00 kPa	G' / sinδ (kPa) ≥ 2.20 kPa			G' / sinδ (MPa) ≤ 5000 kPa		S, Stiffness (MPa) ≤ 300 MPa	m, Slope ≥ 0.300	Failure Strain ≥ 1.0%
94	94			-10	31		0			
88	88			-16	28		-6			
82	82			-22	25	1150	-12	126	0.371	2.1738
76	76			-28	22	3250	-18	192	0.283	
70	70	0.6960	1.6431	-34	19	4454	-24			
64	64	1.3103	3.0086	-40	16	6241	-30			
58	58			-46	13		-36			
52	52			-52	10		-42			
46	46			-58	7		-48			

**GRADE: PG 64-22**

<b>Table 7.6: Sampling Times and Dates for Loose Mix Samples From Site 7</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	8/18/97	8/19/97	8/19/97	8/20/97	8/20/97	8/20/97
Time Obtained	9:09pm	1:15am	2:18am	6:14pm	8:25pm	10:35pm
Temperature of Mixture in Truck, °F	351	350	351	371	395	345
Truck Load of the Day's Production	1068	1560	1790	864	1021	1383
Average Draindown, %	N/A	N/A	N/A	0.03	0.05	0.05

N/A - Not available.

Table 7.7: Gradations For Samples Obtained In-Field

Site: 7  
Sample: 1

Sieve mm	JMF % Passing	Loose Mix Samples					Marshall Compacted Samples				Gyratory Compacted Samples			
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T
						B-F								
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00
12.5	87.0	89.1	91.4	90.3	1.63	-3.3	90.5	91.8	91.2	0.92	92.0	90.5	91.3	1.06
9.5	63.1	70.5	72.5	71.5	1.41	-8.4	74.3	74.4	74.4	0.07	73.7	73.6	73.7	0.07
4.75	27.5	34.1	33.8	34.0	0.21	-6.5	39.6	40.8	40.2	0.85	38.9	37.1	38.0	1.27
2.36	20.0	25.0	24.5	24.8	0.35	-4.8	27.2	27.7	27.5	0.35	27.6	26.5	27.1	0.78
1.18	16.3	20.1	19.8	20.0	0.21	-3.7	20.8	21.0	20.9	0.14	21.9	20.9	21.4	0.71
0.60	14.1	17.2	16.8	17.0	0.28	-2.9	17.1	17.3	17.2	0.14	18.4	17.5	18.0	0.64
0.30	13.1	15.4	15.0	15.2	0.28	-2.1	14.9	15.0	15.0	0.07	16.1	15.3	15.7	0.57
0.150	11.4	14.3	13.6	14.0	0.49	-2.6	13.5	13.4	13.5	0.07	14.7	13.8	14.3	0.64
0.075	8.9	12.5	11.6	12.1	0.64	-3.2	11.6	11.3	11.5	0.21	12.6	11.7	12.2	0.64

Site: 7  
Sample: 2

Sieve mm	JMF % Passing	Loose Mix Samples					Marshall Compacted Samples				Gyratory Compacted Samples			
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T
						B-F								
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00
19.0	100.0	100.0	99.7	99.9	0.21	0.2	99.7	100.0	99.9	0.21	100.0	100.0	100.0	0.00
12.5	87.0	87.8	89.3	88.6	1.06	-1.6	89.6	92.6	91.1	2.12	91.0	91.2	91.1	0.14
9.5	63.1	68.3	67.0	67.7	0.92	-4.6	72.7	76.9	74.8	2.97	70.2	74.0	72.1	2.69
4.75	27.5	30.9	29.8	30.4	0.78	-2.9	37.9	40.5	39.2	1.84	36.5	36.5	36.5	0.00
2.36	20.0	22.1	21.3	21.7	0.57	-1.7	24.2	27.0	25.6	1.98	25.2	24.6	24.9	0.42
1.18	16.3	18.8	18.0	18.4	0.57	-2.1	18.7	21.3	20.0	1.84	20.1	19.8	20.0	0.21
0.60	14.1	16.8	16.0	16.4	0.57	-2.3	15.7	18.5	17.1	1.98	17.3	17.1	17.2	0.14
0.30	13.1	15.6	14.9	15.3	0.49	-2.2	14.1	17.0	15.6	2.05	15.7	15.5	15.6	0.14
0.150	11.4	14.5	13.8	14.2	0.49	-2.8	13.0	15.6	14.3	1.84	14.4	14.3	14.4	0.07
0.075	8.9	12.7	12.0	12.4	0.49	-3.5	11.1	13.7	12.4	1.84	12.4	12.4	12.4	0.00

Site: 7  
Sample: 3

Sieve mm	JMF % Passing	Loose Mix Samples					Marshall Compacted Samples				Gyratory Compacted Samples			
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T
						B-F								
25.0	100.0						100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00
19.0	100.0						100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00
12.5	87.0						92.5	93.4	93.0	0.64	91.9	91.5	91.7	0.28
9.5	63.1						75.4	76.3	75.9	0.64	74.9	73.0	74.0	1.34
4.75	27.5						40.0	40.5	40.3	0.35	36.9	36.0	36.4	0.57
2.36	20.0						26.3	26.3	26.3	0.00	24.7	24.2	24.5	0.35
1.18	16.3						20.3	20.5	20.4	0.14	19.8	19.4	19.6	0.28
0.60	14.1						17.1	17.5	17.3	0.28	17.0	16.6	16.8	0.28
0.30	13.1						15.3	15.9	15.6	0.42	15.5	14.9	15.2	0.42
0.150	11.4						13.9	14.5	14.2	0.42	14.4	13.5	14.0	0.64
0.075	8.9						11.8	12.5	12.2	0.49	12.5	11.6	12.1	0.64

Table 7.7(Continued): Gradations For Samples Obtained In-Field

Site: 7  
 Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples					Diff. From JMF	Marshall Compacted Samples				Gyratory Compacted Samples			
		Rep 1	Rep 2	Average	Std. Deviation	Std. Deviation		Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T	
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00	
19.0	100.0	99.7	100.0	99.9	0.21	0.2	99.2	100.0	99.6	0.57	100.0	100.0	100.0	0.00	
12.5	87.0	89.5	90.3	89.9	0.57	-2.9	92.1	92.8	92.5	0.49	91.0	86.6	88.8	3.11	
9.5	63.1	68.3	69.0	68.7	0.49	-5.6	76.8	76.8	76.8	0.00	71.9	69.3	70.6	1.84	
4.75	27.5	32.8	31.8	32.3	0.71	-4.8	41.6	41.9	41.8	0.21	36.9	36.9	36.9	0.00	
2.36	20.0	22.9	22.1	22.5	0.57	-2.5	26.5	27.8	27.2	0.92	24.5	25.7	25.1	0.85	
1.18	16.3	18.7	18.0	18.4	0.49	-2.1	20.2	21.5	20.9	0.92	19.2	20.3	19.8	0.78	
0.60	14.1	16.5	15.8	16.2	0.49	-2.1	16.9	18.3	17.6	0.99	16.3	17.4	16.9	0.78	
0.30	13.1	15.3	14.5	14.9	0.57	-1.8	15.2	16.7	16.0	1.06	14.5	15.8	15.2	0.92	
0.150	11.4	14.1	13.5	13.8	0.42	-2.4	13.8	15.4	14.6	1.13	13.1	14.5	13.8	0.99	
0.075	8.9	12.0	11.7	11.9	0.21	-3.0	11.7	13.4	12.6	1.20	11.1	12.5	11.8	0.99	

Site: 7  
 Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples					Diff. From JMF	Marshall Compacted Samples				Gyratory Compacted Samples			
		Rep 1	Rep 2	Average	Std. Deviation	Std. Deviation		Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T	
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00	
19.0	100.0	99.8	100.0	99.9	0.14	0.1	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00	
12.5	87.0	87.3	83.8	85.6	2.47	1.5	87.9	91.4	89.7	2.47	90.3	87.7	89.0	1.84	
9.5	63.1	64.2	59.8	62.0	3.11	1.1	66.9	70.0	68.5	2.19	66.9	64.3	65.6	1.84	
4.75	27.5	28.0	27.0	27.5	0.71	0.0	33.5	32.7	33.1	0.57	31.4	31.9	31.7	0.35	
2.36	20.0	19.8	19.2	19.5	0.42	0.5	21.6	21.2	21.4	0.28	22.0	21.8	21.9	0.14	
1.18	16.3	16.1	15.7	15.9	0.28	0.4	16.4	16.2	16.3	0.14	17.2	17.0	17.1	0.14	
0.60	14.1	14.5	14.2	14.4	0.21	-0.3	13.9	13.9	13.9	0.00	14.8	14.6	14.7	0.14	
0.30	13.1	13.6	13.4	13.5	0.14	-0.4	12.6	12.6	12.6	0.00	13.5	13.2	13.4	0.21	
0.150	11.4	12.8	12.6	12.7	0.14	-1.3	11.6	11.8	11.7	0.14	12.6	12.1	12.4	0.35	
0.075	8.9	11.3	11.1	11.2	0.14	-2.3	9.9	10.2	10.1	0.21	11.0	10.3	10.7	0.49	

Site: 7  
 Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples					Diff. From JMF	Marshall Compacted Samples				Gyratory Compacted Samples			
		Rep 1	Rep 2	Average	Std. Deviation	Std. Deviation		Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T	
25.0	100.0						100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00	
19.0	100.0						99.3	100.0	99.7	0.49	100.0	99.6	99.8	0.28	
12.5	87.0						91.9	91.1	91.5	0.57	90.1	89.5	89.8	0.42	
9.5	63.1						73.6	73.5	73.6	0.07	71.2	69.0	70.1	1.56	
4.75	27.5	Samples Not Tested						40.1	38.8	39.5	0.92	37.3	36.4	36.9	0.64
2.36	20.0							27.1	26.1	26.6	0.71	26.3	25.7	26.0	0.42
1.18	16.3							20.7	19.8	20.3	0.64	20.4	20.1	20.3	0.21
0.60	14.1							17.2	16.4	16.8	0.57	17.0	16.9	17.0	0.07
0.30	13.1							15.2	14.5	14.9	0.49	15.0	14.9	15.0	0.07
0.150	11.4							13.9	13.1	13.5	0.57	13.5	13.4	13.5	0.07
0.075	8.9							12.1	11.3	11.7	0.57	11.2	11.5	11.4	0.21

Table 7.8: Results of Marshall Hammer Compactions

Marshall Hammer: 50 Blows per Side																		
SITE NUMBER: 7			MATERIALS: Limestone/Traprock/Limestone Dust/Cellulose/PG64-28						COARSE AGGREGATE INFORMATION				Percent Coarse Aggregate: 72.5			DATE: 4/15/98		
AC Sp. Gr. (Gb) = 1.023			Apparent Specific Gravity of the Agg. (Gsa) = 2.694			Bulk Specific Gravity of the Agg. (Gsb) = 2.569							Bulk Sp. Gravity of CA (Gca): 2.612			Unit Wt. Of CA in DRC (pcf): 91.2		
													Unit Wt. Of CA in DRC (kg/m3): 1461.4					
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	Unit Weight pcf	VTM %	VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
						F-E	$\frac{D}{G}$		$\frac{(100-C) \cdot H}{Gsb}$	$\frac{C \cdot H}{Gb}$	H * 62.4	$100(1-H/I)$	100 - J	$\frac{100(N-M)}{N}$				
1	1	6.4	1188.4	682.1	1189.0	506.9	2.344	2.390	85.4	14.7	146.3	1.9	14.6	86.9	39.1	44.0	0.889	
1	2	6.4	1202.1	687.6	1203.2	515.6	2.331	2.390	84.9	14.6	145.5	2.4	15.1	83.7	39.4	44.0	0.896	
1	3	6.4	1206.6	692.4	1207.8	515.4	2.341	2.390	85.3	14.6	146.1	2.0	14.7	86.1	39.2	44.0	0.890	
2	1	6.3	1185.5	669.7	1186.5	516.8	2.294	2.384	83.7	14.1	143.1	3.8	16.3	76.9	40.3	44.0	0.917	
2	2	6.3	1191.4	676.0	1192.8	516.8	2.305	2.384	84.1	14.2	143.9	3.3	15.9	79.3	40.0	44.0	0.910	
2	3	6.3	1200.6	681.0	1202.2	521.2	2.304	2.384	84.0	14.2	143.7	3.4	16.0	78.9	40.1	44.0	0.911	
3	1	6.4	1190.1	673.0	1191.3	518.3	2.296	2.380	83.7	14.4	143.3	3.5	16.3	78.4	40.3	44.0	0.917	
3	2	6.4	1188.1	675.2	1189.5	514.3	2.310	2.380	84.2	14.5	144.2	2.9	15.8	81.5	40.0	44.0	0.909	
3	3	6.4	1200.3	683.2	1202.4	519.2	2.312	2.380	84.2	14.5	144.3	2.9	15.8	81.8	39.9	44.0	0.908	
4	1	6.1	1196.3	682.0	1196.9	514.9	2.323	2.388	84.9	13.9	145.0	2.7	15.1	82.0	39.4	44.0	0.897	
4	2	6.1	1196.5	682.9	1197.3	514.4	2.326	2.388	85.0	13.9	145.1	2.6	15.0	82.7	39.4	44.0	0.895	
4	3	6.1	1190.1	679.4	1191.0	511.6	2.326	2.388	85.0	13.9	145.2	2.6	15.0	82.7	39.4	44.0	0.885	
5	1	6.1	1188.2	676.3	1191.4	515.1	2.307	2.405	84.3	13.8	143.9	4.1	15.7	74.0	39.9	44.0	0.906	
5	2	6.1	1175.3	664.4	1179.1	514.7	2.283	2.405	83.5	13.6	142.5	5.1	16.5	69.4	40.5	44.0	0.920	
5	3	6.1	1200.7	676.6	1206.3	529.7	2.267	2.405	82.9	13.5	141.4	5.7	17.1	66.5	40.9	44.0	0.930	
6	1	6.1	1191.9	680.6	1193.0	512.4	2.326	2.392	85.0	13.9	145.1	2.8	15.0	81.6	39.4	44.0	0.895	
6	2	6.1	1196.3	684.2	1198.0	513.8	2.328	2.392	85.1	13.9	145.3	2.7	14.9	82.1	39.3	44.0	0.894	
6	3	6.1	1187.4	680.8	1188.9	508.1	2.337	2.392	85.4	13.9	145.8	2.3	14.6	84.2	39.1	44.0	0.889	
							$\frac{2.330}{2.362}$		$\frac{85.2}{85.2}$	$\frac{13.9}{13.9}$	$\frac{145.3}{145.3}$	$\frac{2.6}{2.6}$	$\frac{14.6}{14.6}$	$\frac{82.7}{82.7}$	$\frac{39.3}{39.3}$	$\frac{44.0}{44.0}$	$\frac{0.892}{0.892}$	
Input By: A. Cooley																		
Checked By: A. Cooley																		
SSD = Saturated Surface Dry			cc = cubic centimeter			Gmb = Bulk Specific Gravity of Compacted Mixture			Gsb = Bulk Specific Gravity of Aggregate			VTM = Voids in Total Mix						
TMD = Theoretical Maximum Density			AC = Asphalt Cement			Gmm = Theoretical Maximum Density of Mixture			Gb = Specific Gravity of Asphalt Cement			VMA = Voids in Mineral Aggregate						
gm = gram			pcf = pounds per cubic foot			Gsa = Apparent Specific Gravity of Aggregate			VCA = Voids in Coarse Aggregate			VFA = Voids Filled With Asphalt Cement						

Table 7.10: Results of Loaded Wheel Testing

Site No.: 7

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	2.3	0.82	1.51	2.22
R2	2.5	1.57	2.13	2.70
R3	2.0	0.84	1.41	1.80
R4	2.7	0.78	1.79	2.25
<b>Average</b>	<b>2.4</b>	<b>1.00</b>	<b>1.71</b>	<b>2.24</b>
<b>Std. Dev.</b>	<b>0.31</b>	<b>0.379</b>	<b>0.323</b>	<b>0.368</b>

Table 7.11: Results of Superpave Analysis Testing

Site No.: 7

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @		G*				
Constant Height		Delta				
Simple Shear Test @		Strain Rate, mm/mm				
Constant Height		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				



## **NCHRP 9-8 II - Task 8 SMA Construction Project No. 8**

### **Location and Background**

Construction Project No. 8 was constructed in August of 1997. NCAT representatives were on-site from August 21 to August 23, 1997. Placement of the SMA consisted of milling an existing asphalt concrete layer down to a Portland cement concrete pavement and filling with 100 mm (4 in) of conventional binder course and 44 mm (1¾ in) of SMA.

### **SMA Mixture Information**

The SMA mixture used for this project was a 19.0 mm nominal maximum aggregate size mixture. Information about the mixture is presented in Table 8.1. Limestone and traprock were the predominant aggregates used to produce the mixture. Table 8.2 presents the design gradation. Tables 8.3 and 8.4 provide the properties of these aggregates. The asphalt binder used for this project was a PG 64-28. Properties of this binder are presented in Table 8.5.

### **Plant Information**

The plant used for this project was a batch plant. This facility utilized a storage silo for the mineral filler. The filler was blown from a truck into the silo where it was augered into the weigh hopper of the plant. The fiber was in a loose form as bales. It was blown from a fiber hopper into the weigh hopper above the pugmill.

### **Laydown Procedures**

Paving operations were not observed for this project.

### **Problems Encountered On-Site**

No problems were encountered.

### **Sampling**

Samples obtained while at this project included: each aggregate used to produce the mixture, mineral filler, fiber, asphalt binder, and loose mixture along with average draindown values for each sample. Table 8.6 presents the times and dates that the loose mix samples were obtained. Tables 8.7 through 8.11 present testing results accomplished on samples obtained from this site.

<b>Table 8.1: Site 8 SMA Mixture Information</b>	
JMF I.D. Number:	
Dates on Project:	August 21 - 23, 1997
Number of Aggregate Stockpiles Used:	3
Design Voids in Coarse Aggregate:	42.6*
Type Asphalt Binder Used:	PG 64-28
Modifier Type:	SBS
Design Asphalt Binder Content:	6.0 percent
Supplier of Asphalt Binder:	Koch
Type Fiber Used:	Cellulose
Form of Fiber:	Loose
Design Percentage of Fiber:	0.3 percent
Type Mineral Filler Used:	Limestone dust
Design Percentage of Mineral Filler:	10.0 percent
Type Anti-Strip Additive Used:	None
Design Percentage of Anti-Strip:	
Compaction Method:	Marshall Hammer
Compactive Effort:	50 Blows per Side
Laboratory Mixing Temperature:	368 °F
Laboratory Compaction Temperature:	340 °F
Design Voids in Total Mix:	4.3 percent
Design Mixture Density:	144.3 pcf
Design Voids in Mineral Aggregate:	17.7 percent
Design Voids Filled With Asphalt:	75.9 percent
Design Marshall Stability:	1801 lbs
Design Laboratory Draindown:	
Loaded Wheel Test @ Design Asphalt Content:	

\* Determined at NCAT laboratory on materials obtained from project.

<b>Table 8.2: Design Gradation for Site 8</b>			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
¾ in.	19.0	100	100.0
½ in.	12.5	85-95	89.9
⅜ in.	9.5	75 max.	63.3
No. 4	4.75	20-28	26.2
No. 8	2.36	16-24	19.5
No. 16	1.18	----	16.0
No. 30	0.600	12-16	14.3
No. 50	0.300	12-15	13.5
No. 100	0.150	----	11.9
No. 200	0.075	8-10	9.5

<b>Table 8.3: Coarse Aggregate Properties for Site 8</b>		
Test	Limestone	Traprock
Los Angeles Abrasion, % Loss	28	19
Flat & Elongated, %		
3 to 1	16.0*	43.5*
5 to 1	0.0*	11.2*
Bulk/Apparent Specific Gravity	2.640/2.733*	2.604*
Absorption, %	1.3*	2.671*
Soundness (5 Cycles), % Loss		1.0*
Method Similar to AASHTO T103	0.1	0.1
Crushed Content, %		
One Face	100*	100*
Two Face	100*	100*
Data not provided by agency is presented by blank data field.		

\* Determined at NCAT laboratory on materials obtained from project.

<b>Table 8.4: Fine Aggregate Properties for Site 8</b>	
Test	Traprock
Bulk/Apparent Specific Gravity	2.401/2.658*
Absorption, %	4.0*
Soundness (5 Cycles), % Loss	
Method Similar to AASHTO T103	0.1
Angularity, %	42.3*
Liquid Limit, %	
Plasticity Index, %	NP
Data not provided by agency is represented by blank data fields.	

\* Determined at NCAT laboratory on materials obtained from project.

<b>Table 8.6: Sampling Times and Dates for Loose Mix Samples From Site 8</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	8/21/97	8/22/97	8/22/97	8/23/97	8/23/97	8/23/97
Time Obtained	7:30pm	9:05pm	11:40pm	12:10am	7:30pm	10:00pm
Temperature of Mixture in Truck, °F	365	360	350	350	335	
Truck Load of the Day's Production	125	358	644	924	137	420
Draindown, %	0.02	0.00	0.1	0.00	0.02	0.1

Table 8.5: Site 8 Asphalt Binder Properties

### SHRP ASPHALT BINDER GRADING SUMMARY

**ASPHALT: Site 8**  
**OPERATOR: Wilson**  
**PROJECT: NCHRP 9-8**  
**DATE: 10/21/97**

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: 0.90 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135: 891 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
G R A D E	T E M P °C	ORIGINAL	RTFOT	G R A D E	T E M P °C	RTFOT + PAV	T E M P °C	RTFOT + PAV		
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		DT (1mm/min)
		$G^* \sin \delta$ (kPa) ≥ 1.00 kPa	$G^* \sin \delta$ (kPa) ≥ 2.20 kPa			$G^* \sin \delta$ (MPa) ≤ 5000 kPa		S, Stiffness(MPa) ≤ 300 MPa	m, Slope ≥ 0.300	Failure Strain ≥ 1.0%
94	94			-10	31		0			
88	88			-16	28		-6			
82	82			-22	25		-12			
76	76			-28	22	1722	-18	132	0.304	3658
70	70	0.8058	1.7782	-34	19	2475	-24			
64	64	1.4557	3.3475	-40	16	3410	-30			
58	58			-46	13	4717	-36			
52	52			-52	10	6361	-42			
46	46			-58	7		-48			

**GRADE: PG 64-28**

Table 8.7: Gradations For Samples Obtained In-Field

Site: 8  
Sample: 1

Sieve mm	JMF % Passing	Loose Mix Samples					Marshall Compacted Samples				Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation	
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T	
		B-F													
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00	
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00	
12.5	89.9	93.0	91.8	92.4	0.85	-2.5	95.1	95.1	95.1	0.00	94.0	91.2	92.6	1.98	
9.5	63.3	67.5	69.6	68.6	1.48	-5.3	75.7	74.7	75.2	0.71	69.5	70.6	70.1	0.78	
4.75	26.2	29.8	29.8	29.8	0.00	-3.6	37.7	38.6	38.2	0.64	34.4	34.4	34.4	0.00	
2.36	19.5	21.7	21.9	21.8	0.14	-2.3	25.6	25.8	25.7	0.14	24.7	24.6	24.7	0.07	
1.18	16.0	18.1	18.2	18.2	0.07	-2.2	20.1	20.3	20.2	0.14	19.9	19.7	19.8	0.14	
0.60	14.3	16.2	16.3	16.3	0.07	-2.0	17.3	17.5	17.4	0.14	17.3	17.2	17.3	0.07	
0.30	13.5	15.1	15.2	15.2	0.07	-1.7	15.7	15.8	15.8	0.14	15.8	15.8	15.7	0.14	
0.150	11.9	14.1	14.1	14.1	0.00	-2.2	14.5	14.6	14.6	0.07	14.5	14.3	14.4	0.14	
0.075	9.5	12.1	11.8	12.0	0.21	-2.5	12.3	12.2	12.3	0.07	11.9	12.0	12.0	0.07	

Site: 8  
Sample: 2

Sieve mm	JMF % Passing	Loose Mix Samples					Marshall Compacted Samples				Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation	
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T	
		B-F													
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00	
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00	
12.5	89.9	89.8	92.5	91.2	1.91	-1.3	94.2	95.0	94.6	0.57	94.8	92.7	93.8	1.48	
9.5	63.3	64.9	65.7	65.3	0.57	-2.0	76.9	74.0	75.5	2.05	76.1	72.3	74.2	2.69	
4.75	26.2	25.9	27.8	26.9	1.34	-0.7	37.3	35.2	36.3	1.48	33.2	33.4	33.3	0.14	
2.36	19.5	18.5	20.0	19.3	1.06	0.3	25.0	23.7	24.4	0.92	22.8	23.0	22.9	0.14	
1.18	16.0	15.5	17.0	16.3	1.08	-0.3	19.9	18.7	19.3	0.85	18.4	18.5	18.5	0.07	
0.60	14.3	13.8	15.3	14.6	1.06	-0.3	17.4	16.1	16.8	0.92	16.0	16.0	16.0	0.00	
0.30	13.5	12.8	14.3	13.6	1.06	-0.1	16.1	14.6	15.4	1.06	14.6	14.6	14.6	0.00	
0.150	11.9	11.9	13.4	12.7	1.06	-0.8	15.4	13.6	14.5	1.27	13.5	13.3	13.4	0.14	
0.075	9.5	9.5	11.4	10.5	1.34	-0.9	13.2	11.4	12.3	1.27	11.3	10.8	11.1	0.35	

Site: 8  
Sample: 3

Sieve mm	JMF % Passing	Loose Mix Samples					Marshall Compacted Samples				Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation	
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T	
		B-F													
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00	
19.0	100.0	99.8	100.0	99.9	0.14	0.1	100.0	100.0	100.0	0.00	99.6	100.0	99.8	0.28	
12.5	89.9	91.3	92.8	92.1	1.06	-2.1	93.7	92.5	93.1	0.85	93.0	94.0	93.5	0.71	
9.5	63.3	65.4	67.8	66.6	1.70	-3.3	74.4	72.6	73.5	1.27	67.5	71.7	69.6	2.97	
4.75	26.2	29.9	30.4	30.2	0.35	-4.0	38.1	38.1	37.1	1.41	33.9	35.7	34.8	1.27	
2.36	19.5	22.3	22.7	22.5	0.28	-3.0	25.9	24.8	25.4	0.78	24.5	26.0	25.3	1.06	
1.18	16.0	18.7	18.8	18.8	0.07	-2.8	20.5	19.7	20.1	0.57	20.1	21.1	20.6	0.71	
0.60	14.3	16.7	16.8	16.8	0.07	-2.5	17.7	17.0	17.4	0.49	17.7	18.4	18.1	0.49	
0.30	13.5	15.7	15.6	15.7	0.07	-2.2	16.3	15.7	16.0	0.42	16.5	17.1	16.8	0.42	
0.150	11.9	14.6	14.5	14.6	0.07	-2.7	15.4	14.8	15.1	0.42	15.2	15.8	15.5	0.42	
0.075	9.5	12.1	11.9	12.0	0.14	-2.5	13.4	12.7	13.1	0.49	13.0	13.6	13.3	0.42	

Table 8.7(Continued): Gradations For Samples Obtained In-Field

Site: 8  
Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples					Marshall Compacted Samples				Gyratory Compacted Samples			
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.9	100.0	100.0	0.07	100.0	99.8	99.9	0.14
12.5	89.9	94.4	91.9	93.2	1.77	-3.3	93.9	94.2	94.1	0.21	92.8	93.2	93.0	0.28
9.5	63.3	71.3	68.4	69.9	2.05	-6.6	75.5	74.0	74.8	1.06	71.8	68.9	70.4	2.05
4.75	26.2	30.5	28.0	29.3	1.77	-3.1	36.3	36.9	36.6	0.42	32.3	31.8	32.1	0.35
2.36	19.5	22.0	19.9	21.0	1.48	-1.5	24.0	24.1	24.1	0.07	23.0	22.0	22.5	0.71
1.18	16.0	18.7	16.6	17.7	1.48	-1.7	18.7	18.9	18.8	0.14	18.6	17.7	18.2	0.64
0.60	14.3	17.0	15.0	16.0	1.41	-1.7	16.2	16.3	16.3	0.07	16.3	15.5	15.9	0.57
0.30	13.5	16.0	14.0	15.0	1.41	-1.5	14.7	14.9	14.8	0.14	15.1	14.2	14.7	0.64
0.150	11.9	15.0	13.1	14.1	1.34	-2.2	13.7	13.7	13.7	0.00	14.1	13.1	13.6	0.71
0.075	9.5	12.7	10.8	11.8	1.34	-2.3	10.9	10.6	10.8	0.21	11.7	10.8	11.3	0.64

Site: 8  
Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples					Marshall Compacted Samples				Gyratory Compacted Samples			
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00
19.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00
12.5	89.9	93.2	93.5	93.4	0.21	-3.4	93.6	94.9	94.3	0.92	95.0	94.8	94.9	0.14
9.5	63.3	69.9	69.6	69.8	0.21	-6.5	74.2	75.9	75.1	1.20	71.1	71.3	71.2	0.14
4.75	26.2	29.8	30.2	30.0	0.28	-3.8	36.5	37.6	37.1	0.78	33.2	33.9	33.6	0.49
2.36	19.5	21.4	21.5	21.5	0.07	-2.0	24.4	24.6	24.5	0.14	23.3	23.6	23.5	0.21
1.18	16.0	18.4	18.3	18.4	0.07	-2.4	19.6	19.9	19.8	0.21	19.4	19.7	19.6	0.21
0.60	14.3	17.0	16.8	16.9	0.14	-2.6	17.4	17.8	17.5	0.14	17.3	17.6	17.5	0.21
0.30	13.5	16.1	15.9	16.0	0.14	-2.5	16.2	16.4	16.3	0.14	16.2	16.6	16.4	0.28
0.150	11.9	15.2	14.9	15.1	0.21	-3.2	15.4	15.5	15.5	0.07	15.4	15.9	15.7	0.35
0.075	9.5	12.8	12.5	12.7	0.21	-3.2	13.4	13.4	13.4	0.00	13.3	14.1	13.7	0.57

Site: 8  
Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples					Marshall Compacted Samples				Gyratory Compacted Samples			
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF	Rep 1	Rep 2	Average	Std. Deviation	Rep 1	Rep 2	Average	Std. Deviation
A	B	C	D	F	G	H	J	K	M	N	P	Q	S	T
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	100.0	100.0	100.0	0.00
19.0	100.0	99.7	99.7	99.7	0.00	0.3	100.0	100.0	100.0	0.00	100.0	99.9	100.0	0.07
12.5	89.9	89.5	91.9	90.7	1.70	-0.8	93.5	93.9	93.7	0.28	90.4	92.6	91.5	1.56
9.5	63.3	64.1	66.0	65.1	1.34	-1.8	72.2	72.6	72.4	0.28	69.9	69.9	69.9	0.00
4.75	26.2	27.1	27.3	27.2	0.14	-1.0	34.4	35.8	35.1	0.99	32.2	34.0	33.1	1.27
2.36	19.5	20.0	20.0	20.0	0.00	-0.5	23.0	23.7	23.4	0.49	22.4	23.9	23.2	1.08
1.18	16.0	16.9	16.7	16.8	0.14	-0.8	18.3	18.7	18.5	0.28	18.2	19.4	18.8	0.85
0.60	14.3	15.2	15.1	15.2	0.07	-0.8	16.0	16.2	16.1	0.14	15.8	17.0	16.4	0.85
0.30	13.5	14.3	14.2	14.3	0.07	-0.8	14.8	14.9	14.9	0.07	14.5	15.5	15.0	0.71
0.150	11.9	13.4	13.5	13.5	0.07	-1.6	13.9	13.7	13.8	0.14	13.6	14.4	14.0	0.57
0.075	9.5	11.6	11.5	11.6	0.07	-2.1	12.0	11.5	11.8	0.35	11.6	12.2	11.9	0.42

Table 8.8: Results of Marshall Hammer Compactions

SITE NUMBER: 8			MATERIALS: Limestone/Traprock/Limestone Dust/Cellulose/PG64-28					COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 73.8		DATE: 4/15/98	
AC Sp. Gr. (Gb) = 1.025			Apparent Specific Gravity of the Agg. (Gsa) = 2.705			Bulk Specific Gravity of the Agg. (Gsb) = 2.578												Bulk Sp. Gravity of CA (Gca): 2.625		Unit Wt. Of CA in DRC (pcf): 93.9	
			WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES				VOIDS							
Sample Number	Replicate	Asphalt Content %	In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	Unit Weight pcf	VTM %	VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %				
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R				
						F-E	D G		(100-C) * H Gsb	C * H Gb	H * 62.4	100(1-H/I)	100 - J	100 (N-M) N							
1	1	6.3	1207.4	696.0	1209.3	513.3	2.352	2.447	85.5	14.3	146.8	3.9	14.5	73.2	38.0	42.6	0.891				
1	2	6.3	1197.8	687.7	1199.3	511.6	2.341	2.447	85.1	14.3	146.1	4.3	14.9	70.9	38.3	42.6	0.898				
1	3	6.3	1199.1	689.5	1202.2	512.7	2.339	2.447	85.1	14.3	145.9	4.4	14.9	70.4	38.4	42.6	0.899				
2	1	5.7	1227.6	699.0	1230.6	531.6	2.309	2.436	84.4	12.9	144.1	5.2	15.6	66.6	38.8	42.6	0.910				
2	2	5.7	1208.2	686.2	1211.1	524.9	2.302	2.436	84.2	12.9	143.6	5.5	15.8	65.2	39.0	42.6	0.915				
2	3	5.7	1200.1	682.7	1204.0	521.3	2.302	2.436	84.2	12.9	143.7	5.5	15.8	65.3	39.0	42.6	0.914				
3	1	6.3	1191.8	684.5	1194.5	510.0	2.337	2.432	85.0	14.2	145.8	3.9	15.0	74.0	38.4	42.6	0.901				
3	2	6.3	1193.9	684.1	1196.8	512.7	2.329	2.432	84.7	14.2	145.3	4.2	15.3	72.3	38.6	42.6	0.906				
3	3	6.3	1197.2	686.2	1200.1	513.9	2.330	2.432	84.7	14.2	145.4	4.2	15.3	72.5	38.6	42.6	0.905				
4	1	6.1	1187.7	675.5	1191.5	516.0	2.302	2.433	83.8	13.7	143.6	5.4	16.2	66.6	39.2	42.6	0.920				
4	2	6.1	1185.7	674.4	1189.1	514.7	2.304	2.433	83.9	13.7	143.7	5.3	16.1	67.0	39.2	42.6	0.919				
4	3	6.1	1199.9	682.5	1202.8	520.3	2.306	2.433	84.0	13.7	143.9	5.2	16.0	67.4	39.1	42.6	0.917				
5	1	6.1	1189.7	682.3	1192.1	509.8	2.334	2.428	85.0	13.9	145.6	3.9	15.0	74.1	38.4	42.6	0.901				
5	2	6.1	1187.0	680.4	1189.8	509.4	2.330	2.428	84.9	13.9	145.4	4.0	15.1	73.4	38.5	42.6	0.903				
5	3	6.1	1188.4	680.7	1191.8	510.9	2.326	2.428	84.7	13.9	145.1	4.2	15.3	72.6	38.6	42.6	0.905				
6	1	6.0	1193.5	682.8	1197.3	514.5	2.320	2.433	84.6	13.6	144.8	4.7	15.4	69.8	38.7	42.6	0.907				
6	2	6.0	1196.8	681.8	1203.2	521.4	2.295	2.433	83.7	13.4	143.2	5.7	16.3	65.3	39.3	42.6	0.923				
6	3	6.0	1221.2	692.2	1228.3	536.1	2.278	2.433	83.1	13.3	142.1	6.4	16.9	62.4	39.8	42.6	0.933				
Input By:			SSD = Saturated Surface Dry					cc = cubic centimeter			Gmb = Bulk Specific Gravity of Compacted Mixture			Gsb = Bulk Specific Gravity of Aggregate			Checked By: A. Cooley				
			TMD = Theoretical Maximum Density					AC = Asphalt Cement			Gmm = Theoretical Maximum Density of Mixture			Gb = Specific Gravity of Asphalt Cement			VTM = Voids in Total Mix				
			gm = gram					pcf = pounds per cubic foot			Gsa = Apparent Specific Gravity of Aggregate			VCA = Voids in Coarse Aggregate			VMA = Voids in Mineral Aggregate				
																	VFA = Voids Filled With Asphalt Cement				

Table 8.9: Results of SGC Compactions

SITE NUMBER: 8		MATERIALS: Limestone/Traprock/Limestone Dust/Cellulose/PG64-28										COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 73.8		DATE: 4/15/98					
AC Sp. Gr. (G <sub>b</sub> ) = 1.025		Apparent Specific Gravity of the Agg. (G <sub>sa</sub> ) = 2.705					Bulk Specific Gravity of the Agg. (G <sub>sb</sub> ) = 2.578					Bulk Sp. Gravity of CA (G <sub>ca</sub> ): 2.625					Unit Wt. Of CA in DRC (pcf): 93.9					Unit Wt. Of CA in DRC (kg/m <sup>3</sup> ): 1503.8							
Sample Number	Replicate	Asphalt Content %	WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES			CORR. % Gmm			VOLUMES AT Ndes		VOIDS									
			In Air gms	In Water gms	SSD gms	Nini (8 Gyr) mm	Ndes (100 Gyr) mm	Nmax (158 Gyr) mm	Nini (8 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	Nini %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA drc %				
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z				
									D G*17.67			D H*17.67			D F-E			Gmb Est. J*O Gmb Meas. K*O			L*O (100-C)*K*O (Gsb)		C*K*O (G)		100-Q 100-S 100(V-U) V				
1	1	6.3	4558.7	2847.9	4563.8	127.9	111.8		2.017	2.307		2.380	2.447	1.031	85.0	97.2		86.5	14.5	2.8	13.5	78.6	37.3	42.7	0.874				
1	2	6.3	4571.0	2851.2	4576.1	127.8	112.1		2.024	2.307		2.375	2.447	1.029	85.1	97.0		86.4	14.5	3.0	13.6	78.3	37.4	42.7	0.877				
1	3	6.3	4617.1	2881.6	4621.6	129.2	113.0		2.022	2.312		2.380	2.447	1.029	85.1	97.3		86.5	14.5	2.7	13.5	78.6	37.3	42.7	0.874				
2	1	5.7	4625.7	2860.5	4634.2	133.2	115.6		1.965	2.264		2.344	2.436	1.035	83.5	96.2		85.7	13.1	3.8	14.3	73.5	37.9	42.7	0.888				
2	2	5.7	4593.8	2856.4	4598.7	130.7	113.1		1.989	2.298		2.365	2.436	1.029	84.0	97.1		86.5	13.2	2.9	13.5	78.5	37.3	42.7	0.875				
2	3	5.7	4606.5	2867.3	4614.4	131.5	113.8		1.983	2.296		2.367	2.436	1.031	83.9	97.2		86.5	13.3	2.8	13.5	78.9	37.3	42.7	0.874				
3	1	6.3	4612.7	2883.3	4615.6	128.4	111.9		2.033	2.333		2.387	2.432	1.023	85.5	98.2		86.6	14.6	1.8	13.2	86.0	37.1	42.7	0.869				
3	2	6.3	4543.2	2843.7	4548.4	125.9	109.9		2.042	2.339		2.388	2.432	1.021	85.7	98.2		86.8	14.6	1.8	13.2	86.2	37.1	42.7	0.869				
3	3	6.3	4485.0	2804.7	4489.1	123.6	109.5		2.053	2.318		2.390	2.432	1.027	86.7	97.9		86.6	14.5	2.1	13.4	84.1	37.3	42.7	0.874				
4	1	6.1	4599.8	2833.8	4575.2	130.0	113.0		1.989	2.288		2.354	2.433	1.029	84.1	96.7		85.7	14.0	3.3	14.3	77.2	37.9	42.7	0.888				
4	2	6.1	4597.1	2844.3	4601.3	130.6	114.0		1.992	2.282		2.349	2.433	1.029	84.3	96.5		85.6	14.0	3.5	14.4	76.1	38.0	42.7	0.891				
4	3	6.1	4484.7	2581.9	4491.4	128.4	111.4		1.976	2.278		2.349	2.433	1.031	83.8	96.5		85.5	14.0	3.5	14.5	76.0	38.0	42.7	0.891				
5	1	6.1	4588.0	2865.1	4593.3	128.1	111.8		2.027	2.322		2.379	2.428	1.025	85.5	98.0		86.6	14.2	2.0	13.4	85.0	37.2	42.7	0.872				
5	2	6.1	4544.4	2826.1	4551.0	127.4	112.5		2.019	2.286		2.361	2.428	1.033	85.9	97.2		86.0	14.1	2.8	14.0	80.3	37.7	42.7	0.884				
5	3	6.1																											
6	1	6.0	4514.8	2592.3	4524.3	130.3	113.4		1.961	2.253		2.337	2.433	1.037	83.6	96.0		85.2	13.7	4.0	14.8	73.3	38.2	42.7	0.897				
6	2	6.0	4600.5	2848.6	4609.0	130.5	114.2		1.995	2.280		2.347	2.433	1.029	84.4	96.5		85.6	13.7	3.5	14.4	75.4	38.0	42.7	0.890				
6	3	6.0	4583.3	2816.4	4574.2	131.1	114.4		1.970	2.257		2.331	2.433	1.033	83.6	95.8		85.0	13.6	4.2	15.0	72.0	38.4	42.7	0.900				

Input By: \_\_\_\_\_ Checked By: A. Cooley  
 SSD = Saturated Surface Dry cc = cubic centimeter Gmb = Bulk Specific Gravity of Compacted Mixture Gsb = Bulk Specific Gravity of Aggregate VTM = Voids in Total Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gmm = Theoretical Maximum Density of Mixture Gc = Specific Gravity of Asphalt Cement VMA = Voids in Mineral Aggregate  
 gm = gram pcf = pounds per cubic foot Gsa = Apparent Specific Gravity of Aggregate VCA = Voids in Coarse Aggregate VFA = Voids Filled With Asphalt Cement

Table 8.10: Results of Loaded Wheel Testing

Site No.: 8

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	2.3	0.34	1.32	1.83
R2	2.6	0.15	0.97	1.67
R3	2.7	0.71	1.69	2.22
R4	3.3	1.03	3.06	3.78
Average	2.7	0.56	1.76	2.38
Std. Dev.	0.44	0.392	0.915	0.965

Table 8.11: Results of Superpave Analysis Testing

Site No.: 8

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @ Constant Height		G*				
		Delta				
Simple Shear Test @ Constant Height		Strain Rate, mm/mm				
		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

## **NCHRP 9-8 II - Task 8 SMA Construction Project No. 9**

### **Location and Background**

Construction Project No. 9 was constructed in September of 1997. NCAT personnel were on-site from September 10 to September 15, 1997. This project consisted of placing approximately 4000 tons of SMA. Within the extent of this project, the interstate was a divided four-lane roadway.

This was the first SMA project performed by this state DOT, therefore the mix design for this project was conducted by NCAT using the SMA mixture design method developed under Phase I of NCHRP Project 9-8. In addition to the mixture design, NCAT was responsible for the quality control testing for this project.

Field construction for this project consisted of overlaying an existing roadway with 44 mm (1.75 in) of SMA.

### **SMA Mixture Information**

The SMA mixture used for this project was a 12.5 mm nominal maximum aggregate size mixture. Constituents of the mixture included crushed granite, agricultural lime filler, hydrated lime, cellulose fiber, and a PG 76-22 asphalt binder. Additional information about the mixture is presented in Table 9.1. The design gradation is shown in Table 9.2. Properties of the coarse and fine aggregate are presented in Table 9.3 and 9.4, respectively.

The mineral filler used for this project (agricultural lime) did not conform to

AASHTO M17 (as specified by the mixture design procedure developed under Phase I). Table 9.5 shows that the gradation of this filler is outside the recommended limits of AASHTO M17. As can be seen from this table, the agricultural lime was coarser than the recommended grading. The contractor wished to use this source of mineral filler because it was coarse enough to be fed to the mixture from an aggregate bin. Since the filler could be fed from an aggregate bin, a separate silo did not have to be constructed to store and introduce the mineral filler. Because of the filler's coarseness, some concerns were expressed prior to the mix design about using this source of filler. Therefore, NCAT contacted the Virginia Asphalt Pavement Association (VAPA). This source of filler had been used on numerous projects within the state of Virginia. Based on this contact, NCAT was informed that the filler had been used successfully on projects within Virginia and therefore was selected for SMA construction project No. 9.

The asphalt binder used for this project was a PG 76-22 modified with Stylink. Properties of this binder are presented in Table 9.6

### **Plant Information**

The facility used to produce the SMA mixture was a GenCor-Bituma drum plant. The only modification made to this plant was the addition of a hopper for the introduction of the fiber (Figure 9.1). This hopper used weight loss over time to keep the amount of fiber entering the production process consistent.

The mineral filler used for this project was introduced via an aggregate bin. To ensure the mineral filler stayed dry, the contractor stored it in a large shop building on the

plant yard. The front-end operator transferred the mineral filler directly to the aggregate bin as required. By storing the mineral filler in the large shop building, the contractor assured it was kept dry.

### **Laydown Procedures**

Paving operations were observed each day that the project was on-going. For this project, the contractor used a Material Transfer Device (MTV) between the unloading trucks and the paver. During the project, the MTV did break down for several hours. The contractor decided to continue placement of the SMA without the MTV by dumping the SMA directly into the paver. While this occurred, segregation problems did occur. Based on a visual inspection by NCAT personnel, it appeared that the segregation occurred at the end of each truck load. Small segregated spots (several 1 to 1.3 meter (3 to 4 feet) diameter spots transversely across the pavement) occurred at approximately every 36 to 43 meters (120 to 140 feet). After discussing the segregation problems with the contractor, a mutual decision was made to stop placement until the MTV was repaired.

Paving speeds of between 6.1 and 11.6 m/min (20 to 38 ft/min) were used during this project. The paving speed of 6.1 m/min was used on the first day of placement and subsequently increased every day to the 11.6 m/min as the contractor gained confidence with placing the SMA mixture. Based on visual observations by NCAT representatives, it appeared that the surface texture of the completed mat became rougher as the paver speed increased. It appeared that portions of the mat were coarser than others

(segregation of the mortar from the coarse aggregate) along with spots that looked like the mixture had pulled under the screed. This was probably due to mortar sticking to the screed. As the amount of mortar would build up on the screed, it would form a “clump.” Before the clumps would break off, they would pull mixture forming small trenches in the mat. When the clumps of mortar would break off the screed, it would form small fat spots of between 8 and 15 cm (3 and 6 inches) in diameter.

Four rollers were used for compacting the placed mat. Each weighing 10 to 12 tons. The breakdown roller would make 5 passes, with the first pass for the outside, middle and inside of the lane being in vibratory mode. The remaining 2 passes were in static mode. The contractor did do a good job of keeping the breakdown roller right behind the paver. After the breakdown roller finished, the second roller would make 7 passes, again with the first pass for each third of the lane in vibratory mode. Both the third roller and finish roller made 9 passes, all in static mode.

### **Problems Encountered On-Site**

Besides the problem described concerning the breakdown of the MTV, no problems were encountered.

### **Sampling**

Samples obtained while at this project included: each aggregate used to produce the mixture, mineral filler, fiber, asphalt binder, loose mixtures, and ten cores. Table 9.7 presents the times and dates that each loose mix sample was obtained along with the average draindown value for each sample. Tables 9.8 through 9.13 present testing results

accomplished on samples obtained from this site.

<b>Table 9.1: Site 9 SMA Mixture Information</b>	
JMF I.D. Number:	97606
Dates on Project:	9/10/97 through 9/15/97
Number of Aggregate Stockpiles Used:	3
Design Voids in Coarse Aggregate:	40.9 percent
Type Asphalt Binder Used:	PG 76-22
Modifier Type:	Stylink
Design Asphalt Binder Content:	6.0 percent
Supplier of Asphalt Binder:	Koch
Type Fiber Used:	Cellulose
Form of Fiber:	Loose
Design Percentage of Fiber:	0.3 percent
Type Mineral Filler Used:	Agricultural Lime
Design Percentage of Mineral Filler:	10.0 percent
Type Anti-Strip Additive Used:	Hydrated Lime
Design Percentage of Anti-Strip:	1.0 percent
Compaction Method:	Marshall Hammer
Compactive Effort:	50 Blows per Side
Laboratory Mixing Temperature:	307 to 320 °F
Laboratory Compaction Temperature:	268 to 282 °F
Design Voids in Total Mix:	3.6 percent
Design Mixture Density:	152.6 pcf
Design Voids in Mineral Aggregate:	17.4 percent
Design Voids Filled With Asphalt:	79.2 percent
Design Marshall Stability:	2183 lbs
Design Flow (0.01 in):	13.2
Loaded Wheel Test @ Design Asphalt Content:	

<b>Table 9.2: Design Gradation for Site 9</b>			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
¾ in.	19.0	100	100.0
½ in.	12.5	85-95	100.0
⅜ in.	9.5	75 max.	75.5
No. 4	4.75	20-28	27.5
No. 8	2.36	16-24	20.7
No. 16	1.18	----	17.1
No. 30	0.600	12-16	15.2
No. 50	0.300	12-15	13.7
No. 100	0.150	----	11.4
No. 200	0.075	8-10	8.5

<b>Table 9.3: Coarse Aggregate Properties for Site 9</b>	
Test	Source
Los Angeles Abrasion, % Loss	27
Flat & Elongated, %	
3 to 1	0
5 to 1	0
Bulk/Apparent Specific Gravity	---/2.84
Absorption, %	0.3
Soundness (5 Cycles), % Loss	
Sodium Sulfate	1.2
Crushed Content, %	
One Face	100
Two Face	100
Data not provided by the agency represented by blank data fields.	

<b>Table 9.4: Fine Aggregate Properties for Site 9</b>	
Test	Source
Bulk/Apparent Specific Gravity	2.819/2.872*
Absorption, %	0.01*
Soundness (5 Cycles), % Loss	
	Sodium Sulfate
Angularity, %	49.3*
Liquid Limit, %	
Plasticity Index, %	
Data not provided by agency represented by blank data fields.	

\* Determined at NCAT laboratory on materials obtained from project.

<b>Table 9.5: Mineral Filler Gradation and AASHTO M17 Limits</b>		
Sieve Size, mm	Mineral Filler Gradation	AASHTO M17 Limits
4.75	100.0	----
2.36	100.0	----
1.18	96.0	----
0.60	92.6	100
0.30	86.4	95-100
0.16	81.4	----
0.075	52.6	70-100

Table 9.6: Site 9 Asphalt binder Properties

### SHRP ASPHALT BINDER GRADING SUMMARY

**ASPHALT:** Site 9  
**OPERATOR:** Wilson  
**PROJECT:** NCHRP 9-8  
**DATE:** 10/21/97

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: 0.12 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135:2791 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
GRADE	TEMP °C	ORIGINAL	RTFOT	GRADE	TEMP °C	RTFOT + PAV	TEMP °C	RTFOT + PAV		
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		DT (1mm/min)
		$G'/\sin\delta$ (kPa) ≥ 1.00 kPa	$G'/\sin\delta$ (kPa) ≥ 2.20 kPa			$G'/\sin\delta$ (MPa) ≤ 5000 kPa		S, Stiffness(MPa) ≤ 300 MPa	m, Slope ≥ 0.300	Failure Strain ≥ 1.0%
94	94			-10	37		0			
88	88			-16	34		-6			
82	82	0.9414	1.8271	-22	31	1243	-12	122	0.314	.2828
76	76	1.5603	3.0886	-28	28	1797	-18			
70	70			-34	25	2525	-24			
64	64			-40	22	3545	-30			
58	58			-46	19	4978	-36			
52	52			-52	16	6908	-42			
46	46			-58	13		-48			

**GRADE: PG 76-22**

<b>Table 9.7: Sampling Times and Dates for Loose Mix Samples From Site 9</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	9/12/97	9/12/97	9/13/97	9/13/97	9/15/97	9/16/97
Time Obtained	10:55am	2:27pm	10:51am	1:30pm	9:15am	9:20am
Temperature of Mixture in Truck, °F	360	360	370	370	345	355
Truck Load of the Day's Production	10	45	6	NA	6	6
Day's Tonnage	217	977	130	637	132	130
Draindown, %	0.04	0.1	0.1	0.01	0.1	0.00

Table 9.8: Gradations for Samples Obtained In-Field

Site: 9  
 Sample: 1

Sieve mm	JMF % Passing	Loose Mix Samples		Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	H	I	J	K	M	N	O	P	Q	S	T	U
			B-F						I-M					I-S
25.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0					
19.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0					
12.5	100.0	99.5	0.5	99.0	99.8	98.8	99.2	0.85	-0.2					
9.5	75.5	70.4	5.1	78.6	80.8	79.9	80.4	0.64	-1.7					
4.75	27.5	30.5	-3.0	33.5	39.1	38.0	38.6	0.78	-5.1					
2.36	20.7	19.7	1.0	21.8	26.1	25.1	25.6	0.71	-3.9					
1.18	17.1			18.3	21.3	20.5	20.9	0.57	-2.6					
0.60	15.2			16.6	19.4	18.6	19.0	0.57	-2.4					
0.30	13.7	13.7	0.0	15.7	18.3	17.7	18.0	0.42	-2.3					
0.150	11.4			14.0	16.7	16.5	16.6	0.14	-2.6					
0.075	8.5	8.9	-0.4	10.7	13.0	12.9	13.0	0.07	-2.2					

Site: 9  
 Sample: 2

Sieve mm	JMF % Passing	Loose Mix Samples		Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	H	I	J	K	M	N	O	P	Q	S	T	U
			B-F	100.0					I-M					I-S
25.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
12.5	100.0	100.0	0.0	99.0	99.7	98.2	99.0	1.06	0.0	99.4	99.2	99.3	0.14	-0.3
9.5	75.5	72.1	3.4	78.6	79.5	79.4	79.5	0.07	-0.8	81.9	82.7	82.3	0.57	-3.7
4.75	27.5	28.0	-0.5	33.5	37.6	36.4	37.0	0.85	-3.5	36.7	34.2	35.5	1.77	-2.0
2.36	20.7	17.0	3.7	21.8	24.1	23.3	23.7	0.57	-2.0	24.0	22.4	23.2	1.13	-1.5
1.18	17.1			18.3	19.0	18.8	18.9	0.14	-0.6	19.6	18.5	19.1	0.78	-0.7
0.60	15.2			16.6	17.1	17.0	17.1	0.07	-0.4	17.8	16.9	17.4	0.64	-0.8
0.30	13.7	12.0	1.7	15.7	15.8	16.2	16.0	0.28	-0.3	16.8	16.1	16.5	0.49	-0.8
0.150	11.4			14.0	14.1	15.0	14.6	0.64	-0.5	15.7	14.3	15.0	0.99	-1.0
0.075	8.5	7.7	0.8	10.7	10.8	11.6	11.2	0.57	-0.5	12.9	11.4	12.2	1.06	-1.4

Site: 9  
 Sample: 3

Sieve mm	JMF % Passing	Loose Mix Samples		Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	H <td>I</td> <td>J</td> <td>K</td> <td>M</td> <td>N</td> <td>O</td> <td>P</td> <td>Q</td> <td>S</td> <td>T</td> <td>U</td>	I	J	K	M	N	O	P	Q	S	T	U
			B-F						I-M					I-S
25.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	99.8	99.9	0.14	0.1
12.5	100.0	99.5	0.5	99.0	98.4	99.0	98.7	0.42	0.3	98.8	98.7	98.8	0.07	0.2
9.5	75.5	70.4	5.1	78.6	80.5	80.1	80.3	0.28	-1.7	80.3	77.5	78.9	1.98	-0.3
4.75	27.5	30.5	-3.0	33.5	39.7	38.9	39.3	0.57	-5.8	38.0	37.3	37.7	0.49	-4.2
2.36	20.7	19.7	1.0	21.8	25.8	26.3	26.6	0.35	-4.8	25.7	25.9	25.8	0.14	-4.1
1.18	17.1			18.3	21.8	21.6	21.7	0.14	-3.4	20.9	21.4	21.2	0.35	-2.8
0.60	15.2			16.6	19.8	19.7	19.8	0.07	-3.2	18.9	19.7	19.3	0.57	-2.7
0.30	13.7	13.7	0.0	15.7	18.6	18.8	18.7	0.14	-3.0	17.5	18.9	18.2	0.99	-2.5
0.150	11.4			14.0	16.5	17.3	16.9	0.57	-2.9	15.4	16.7	16.1	0.92	-2.0
0.075	8.5	8.9	-0.4	10.7	12.9	13.5	13.2	0.42	-2.5	12.0	13.1	12.6	0.78	-1.8

Table 9.8 (Continued): Gradations For Samples Obtained In-Field

Site: 9  
 Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples		Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples								
		Rep 1	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores				
															C	H	J	K
			B-F														I-S	
25.0	100.0	100.0	0.0	100.0													0.0	0.0
19.0	100.0	100.0	0.0	100.0													0.00	0.0
12.5	100.0	99.3	0.7	99.0													0.57	-0.4
9.5	75.5	74.4	1.1	78.6													0.35	1.2
4.75	27.5	27.5	0.0	33.5													1.13	1.7
2.36	20.7	17.0	3.7	21.8													2.26	0.6
1.18	17.1			18.3													2.47	1.2
0.60	15.2			16.6													2.82	1.1
0.30	13.7	11.8	1.9	15.7													2.99	1.0
0.150	11.4			14.0													3.61	0.6
0.075	8.5	7.7	0.8	10.7													3.61	0.3

Site: 9  
 Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples		Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples								
		Rep 1	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores				
															C	H	J	K
			B-F															
25.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	0.0	0.0	0.0	0.0
19.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	0.0	0.0	0.0	0.0
12.5	100.0	98.9	1.1	99.0	99.4	99.6	99.5	0.14	-0.5	98.6	99.4	99.0	0.57	0.0	0.0	0.0	0.57	0.0
9.5	75.5	72.7	2.8	78.6	80.4	82.8	81.6	1.70	-3.0	78.6	75.2	76.9	2.40	1.7	1.7	1.7	2.40	1.7
4.75	27.5	26.1	1.4	33.5	37.3	37.6	37.5	0.21	-4.0	35.3	35.1	35.2	0.14	-1.7	-1.7	0.14	-1.7	
2.36	20.7	16.6	4.1	21.8	24.3	24.1	24.2	0.14	-2.5	23.5	23.7	23.6	0.14	-1.9	-1.9	0.14	-1.9	
1.18	17.1			18.3	19.5	19.2	19.4	0.21	-1.0	19.4	19.6	19.5	0.14	-1.2	-1.2	0.14	-1.2	
0.60	15.2			16.6	17.6	17.1	17.4	0.35	-0.8	17.7	17.7	17.7	0.00	-1.1	-1.1	0.00	-1.1	
0.30	13.7	11.9	1.8	15.7	16.4	15.8	16.1	0.42	-0.4	16.6	16.4	16.5	0.14	-0.8	-0.8	0.14	-0.8	
0.150	11.4			14.0	14.5	13.9	14.2	0.42	-0.2	14.9	14.5	14.7	0.28	-0.7	-0.7	0.28	-0.7	
0.075	8.5	7.7	0.8	10.7	11.3	10.8	11.1	0.35	-0.3	11.7	11.4	11.6	0.21	-0.8	-0.8	0.21	-0.8	

Site: 9  
 Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples		Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples								
		Rep 1	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores				
															C	H	J	K
			B-F															
25.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	0.0	0.0	0.0	0.0
19.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0	0.0	0.0	0.00	0.0
12.5	100.0	100.0	0.0	99.0	98.9	99.4	99.2	0.35	-0.2	99.1	99.4	99.3	0.21	-0.3	-0.3	0.21	-0.3	
9.5	75.5	77.8	-2.3	78.6	81.8	81.5	81.7	0.21	-3.0	79.8	79.3	79.6	0.35	-0.9	-0.9	0.35	-0.9	
4.75	27.5	32.1	-4.6	33.5	39.9	39.1	39.6	0.57	-6.0	36.7	37.7	37.2	0.71	-3.7	-3.7	0.71	-3.7	
2.36	20.7	21.0	-0.3	21.8	26.4	25.4	25.9	0.71	-4.2	24.9	24.7	24.8	0.14	-3.1	-3.1	0.14	-3.1	
1.18	17.1			18.3	21.2	20.3	20.8	0.64	-2.4	20.2	20.1	20.2	0.07	-1.8	-1.8	0.07	-1.8	
0.60	15.2			16.6	19.1	18.2	18.7	0.64	-2.1	18.2	18.1	18.2	0.07	-1.6	-1.6	0.07	-1.6	
0.30	13.7	14.2	-0.5	15.7	17.8	16.8	17.4	0.64	-1.7	16.9	16.9	16.9	0.00	-1.2	-1.2	0.00	-1.2	
0.150	11.4			14.0	16.1	15.0	15.6	0.78	-1.5	14.9	15.1	15.0	0.14	-1.0	-1.0	0.14	-1.0	
0.075	8.5	9.2	-0.7	10.7	12.6	11.3	12.0	0.92	-1.2	11.7	11.8	11.8	0.07	-1.0	-1.0	0.07	-1.0	

Table 9.8: Results of Marshall Hammer Compactions

Marshall Hammer: 50 Blows per Side																		
SITE NUMBER: 9			MATERIALS: Granite\PG 76-22\Agricultural Lime/Cellulose					COARSE AGGREGATE INFORMATION					Percent Coarse Aggregate: 72.5		DATE: 4/15/98			
AC Sp. Gr. (Gb) = 1.028			Apparent Specific Gravity of the Agg. (Gsa) = 2.831			Bulk Specific Gravity of the Agg. (Gsb) = 2.785							Bulk Sp. Gravity of CA (Gca): 2.790		Unit Wt. Of CA in DRC (pcf): 102.8			
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			Unit Weight pcf	VOIDS					
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	VTM %		VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
						F-E	$\frac{D}{G}$		$\frac{(100-C) \cdot H}{Gsb}$	$\frac{C \cdot H}{Gb}$	$H \cdot 62.4$	$100(1-H/I)$	$100 - J$	$\frac{100(N-M)}{N}$				
1	1	6.3	1227.3	730.1	1229.9	499.8	2.456	2.552	82.6	15.0	153.2	3.8	17.4	78.2	40.2	40.9	0.982	
1	2	6.3	1255.4	745.7	1257.6	511.9	2.452	2.552	82.5	15.0	153.0	3.9	17.5	77.7	40.3	40.9	0.984	
1	3	6.3	1235.0	733.7	1237.7	504.0	2.450	2.552	82.5	14.9	152.9	4.0	17.6	77.3	40.3	40.9	0.985	
2	1	6.0	1235.8	734.1	1238.9	504.8	2.448	2.548	82.6	14.4	152.8	3.9	17.4	77.5	40.2	40.9	0.983	
2	2	6.0	1228.4	729.7	1231.5	501.8	2.448	2.548	82.6	14.4	152.8	3.9	17.4	77.5	40.2	40.9	0.983	
2	3	6.0	1234.5	732.0	1237.4	505.4	2.443	2.548	82.4	14.4	152.4	4.1	17.6	76.5	40.4	40.9	0.986	
3	1	5.9	1238.3	741.7	1240.0	496.3	2.485	2.552	83.9	14.3	155.1	2.6	16.1	83.7	39.3	40.9	0.959	
3	2	5.9	1247.7	747.2	1249.2	502.0	2.485	2.552	84.0	14.3	155.1	2.6	16.0	83.8	39.2	40.9	0.959	
3	3	5.9	1224.4	733.5	1226.5	493.0	2.484	2.552	83.9	14.3	155.0	2.7	16.1	83.4	39.3	40.9	0.960	
4	1	6.6	1237.4	734.2	1240.3	506.1	2.445	2.558	82.0	15.6	152.6	4.4	18.0	75.4	40.6	40.9	0.993	
4	2	6.6	1246.6	740.4	1250.1	509.7	2.446	2.558	82.0	15.7	152.6	4.4	18.0	75.6	40.6	40.9	0.993	
4	3	6.6	1234.7	734.5	1237.5	503.0	2.455	2.558	82.3	15.7	153.2	4.0	17.7	77.1	40.4	40.9	0.988	
5	1	6.3	1271.7	753.9	1274.8	520.9	2.441	2.550	82.1	15.0	152.3	4.3	17.9	76.2	40.6	40.9	0.991	
5	2	6.3	1218.2	723.9	1220.7	496.8	2.452	2.550	82.5	15.1	153.0	3.8	17.5	78.1	40.3	40.9	0.985	
5	3	6.3	1236.2	732.4	1238.9	506.5	2.441	2.550	82.1	15.0	152.3	4.3	17.9	76.0	40.6	40.9	0.992	
6	1	6.1	1194.3	713.9	1199.1	485.2	2.461	2.558	83.0	14.6	153.6	3.8	17.0	77.8	39.9	40.9	0.976	
6	2	6.1	1229.6	736.3	1231.3	495.0	2.484	2.558	83.8	14.7	155.0	2.9	16.2	82.2	39.4	40.9	0.962	
6	3	6.1	1204.3	720.4	1206.4	486.0	2.478	2.558	83.6	14.7	154.6	3.1	16.4	81.0	39.5	40.9	0.966	

Input By: \_\_\_\_\_ Checked By: A. Cooley

SSD = Saturated Surface Dry      cc = cubic centimeter      Gmb = Bulk Specific Gravity of Compacted Mixture      Gsb = Bulk Specific Gravity of Aggregate      VTM = Voids in Total Mix

TMD = Theoretical Maximum Density      AC = Asphalt Cement      Gmm = Theoretical Maximum Density of Mixture      Gb = Specific Gravity of Asphalt Cement      VMA = Voids in Mineral Aggregate

gm = gram      pcf = pounds per cubic foot      Gsa = Apparent Specific Gravity of Aggregate      VCA = Voids in Coarse Aggregate      VFA = Voids Filled With Asphalt Cement

Table 9.10: Results of SCG Compactions

SITE NUMBER: 9			MATERIALS: Granite/PG 76-22/Agricultural Lime/Cellulose							COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 72.5		DATE: 4/15/98						
AC Sp. Gr. (Gb) = 1.028			Apparent Specific Gravity of the Agg. (Gsa) = 2.831				Bulk Specific Gravity of the Agg. (Gsb) = 2.785													Bulk Sp. Gravity of CA (Gca): 2.790		Unit Wt. Of CA in DRC (pcf): 1648.7						
Sample Number	Replicate	Asphalt Content %	WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES			CORR. % Gmm			VOLUMES AT Ndes				VOIDS						
			In Air gms	In Water gms	SSD gms	Nini (8 Gyr) mm	Ndes (100 Gyr) mm	Nmax (158 Gyr) mm	Nini (8 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	Nini %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA drc			
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z			
									G <sup>17.67</sup> D <sup>17.67</sup> L <sup>17.67</sup>			D <sup>17.67</sup> E <sup>17.67</sup>			Gmb Est. Gmb Meas			J*O K*O L*O			(100-C)/K*O (Gsb) C/K*O (Gb) 100-Q 100-S 100(V-U) V							
1	1	6.3	4897.5	2955.1	4802.3	127.0	111.4		2.182	2.488		2.515	2.552	1.011	86.4	98.6		84.6	15.4	1.4	15.4	90.6	38.8	40.9	0.947			
1	2	6.3	4910.4	2964.2	4914.0	128.8	112.3		2.157	2.474		2.518	2.552	1.018	86.0	98.7		84.7	15.4	1.3	15.3	91.4	38.7	40.9	0.945			
1	3	6.3	4860.6	2961.9	4863.3	129.2	112.8		2.173	2.489		2.516	2.552	1.011	86.1	98.6		84.7	15.4	1.4	15.3	90.9	38.7	40.9	0.947			
2	1	6.0	4949.8	2976.9	4954.0	133.0	114.9		2.106	2.438		2.504	2.548	1.027	84.9	98.3		84.5	14.6	1.7	15.5	88.7	38.8	40.9	0.949			
2	2	6.0	4924.0	2961.4	4928.0	131.8	114.0		2.114	2.444		2.504	2.548	1.024	85.0	98.3		84.5	14.6	1.7	15.5	88.8	38.8	40.9	0.949			
2	3	6.0	4924.2	2961.8	4929.8	131.9	114.7		2.113	2.429		2.502	2.548	1.030	85.4	98.2		84.5	14.6	1.8	15.5	88.5	38.9	40.9	0.950			
3	1	5.9	4897.9	2966.2	4899.3	124.5	110.3		2.226	2.513		2.534	2.552	1.008	88.0	99.3		85.6	14.5	0.7	14.4	95.0	38.0	40.9	0.930			
3	2	5.9	4914.0	2974.7	4915.8	125.5	110.9		2.218	2.507		2.532	2.552	1.010	87.7	98.2		85.5	14.5	0.8	14.5	94.5	38.1	40.9	0.931			
3	3	5.9	4906.7	2971.8	4910.8	124.1	110.8		2.239	2.512		2.532	2.552	1.008	88.4	99.2		85.6	14.5	0.8	14.4	94.6	38.1	40.9	0.931			
4	1	6.6	4935.7	2960.5	4942.8	134.4	118.1		2.078	2.408		2.490	2.558	1.035	84.1	97.3		83.5	16.0	2.7	16.5	83.9	39.6	40.9	0.967			
4	2	6.6	4914.2	2954.4	4920.2	132.1	114.3		2.105	2.433		2.500	2.558	1.027	84.6	97.7		83.8	16.0	2.3	16.2	85.9	39.3	40.9	0.961			
4	3	6.6	4884.7	2950.5	4888.2	130.5	112.8	110.8	2.118	2.451	2.495	2.521	2.558	1.010	83.7	96.8	98.5	83.0	15.9	3.2	17.0	81.1	39.9	40.9	0.975			
5	1	6.3	4873.9	2939.2	4877.0	128.0	111.2		2.155	2.480		2.515	2.550	1.014	85.7	98.6		84.6	15.4	1.4	15.4	91.1	38.8	40.9	0.947			
5	2	6.3	4838.0	2979.1	4940.1	129.0	112.1		2.186	2.483		2.518	2.550	1.010	85.8	98.7		84.7	15.4	1.3	15.3	91.8	38.7	40.9	0.945			
5	3	6.3	4883.8	2953.7	4885.6	128.7	111.6	110.4	2.147	2.476	2.503	2.528	2.550	1.010	85.0	98.1	99.1	84.1	15.3	1.9	15.9	87.8	39.1	40.9	0.956			
6	1	6.1	4817.2	3004.5	4902.9	127.0	112.1		2.148	2.432		2.480	2.558	1.012	84.9	96.2		82.9	14.6	3.8	17.1	77.5	40.0	40.9	0.977			
6	2	6.1	4781.5	2966.2	4906.4	128.2	111.1		2.135	2.425		2.454	2.558	1.012	84.5	95.9		82.7	14.6	4.1	17.3	76.5	40.1	40.9	0.980			
6	3	6.1	4785.8	2972.2	4910.4	128.8	110.9		2.127	2.432		2.459	2.558	1.011	84.1	96.1		82.9	14.6	3.9	17.1	77.3	40.0	40.9	0.978			

Input By: A. Keeter  
 SSS = Saturated Surface Dry  
 TMD = Theoretical Maximum Density  
 gm = gram  
 cc = cubic centimeter  
 AC = Asphalt Cement  
 pcf = pounds per cubic foot  
 Gmb = Bulk Specific Gravity of Compacted Mixture  
 Gmm = Theoretical Maximum Density of Mixture  
 Gsa = Apparent Specific Gravity of Aggregate  
 Gsb = Bulk Specific Gravity of Aggregate  
 Gb = Specific Gravity of Asphalt Cement  
 VCA = Voids in Coarse Aggregate  
 Checked By: A. Cooley  
 VTM = Voids in Total Mix  
 VMA = Voids in Mineral Aggregate  
 VFA = Voids Filled With Asphalt Cement

Table 9.11: Results of Loaded Wheel Testing

Site No.: 9

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	0.6	0.78	1.32	1.53
R2	0.6	0.80	1.06	1.23
R3	0.8	1.96	2.33	2.59
R4	0.8	0.79	1.29	1.55
Average	0.7	1.08	1.50	1.73
Std. Dev.	0.09	0.585	0.565	0.595

Table 9.12: Results of Superpave Analysis Testing

Site No.: 9

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @ Constant Height		G*				
		Delta				
Simple Shear Test @ Constant Height		Strain Rate, mm/mm				
		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

Table 9.13: Results of Testing on Cores Obtained In-Field

Site No.: 9

Sieve mm	Percent Passing											Average	Std. Dev.
	Core 1	Core 2	Core 3	Core 4	Core 5	Core 6	Core 7	Core 8	Core 9	Core 10			
25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.00
19.0	100.0	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.03
12.5	98.5	99.6	98.3	98.7	99.5	99.1	97.7	99.2	99.6	99.4	99.0	99.0	0.64
9.5	76.9	78.8	78.4	80.7	79.5	79.0	77.9	77.3	78.9	79.0	78.6	78.6	1.09
4.75	34.2	35.6	35.3	34.9	32.8	32.4	30.1	33.1	32.3	33.9	33.5	33.5	1.67
2.36	22.7	22.8	22.6	22.7	21.4	21.1	20.1	21.5	20.7	21.9	21.8	21.8	0.95
1.18	18.8	18.7	18.5	18.5	17.7	17.7	19.8	18.0	17.2	18.4	18.3	18.3	0.73
0.60	17.1	16.9	16.8	16.5	16.0	16.0	18.1	16.3	15.5	16.8	16.6	16.6	0.72
0.30	16.0	16.0	15.8	15.5	15.1	15.2	17.3	15.4	14.6	16.0	15.7	15.7	0.73
0.150	14.0	14.2	13.9	13.8	13.4	13.9	15.8	13.8	12.9	14.6	14.0	14.0	0.77
0.075	10.5	10.8	10.4	10.7	10.2	10.8	12.7	10.4	9.6	11.1	10.7	10.7	0.81
Gmb	2.414	2.348	2.409	2.327	2.355	2.357	2.345	2.389	2.332	2.412	2.369	2.369	0.03
Unit Weight, pcf	150.6	146.5	150.3	145.2	147.0	147.1	146.3	149.1	145.5	150.5	147.8	147.8	2.12
VTM, %	5.3	7.9	5.5	8.7	7.6	7.5	8.0	6.3	8.5	5.4	7.1	7.1	1.32

## **NCHRP 9-8 II - Task 8 SMA Construction Project No. 10**

### **Location and Background**

Construction project 10 was constructed during September and October of 1997. NCAT staff were on-site between September 29 and October 1, 1997.

The contractor for this project had two plants within the vicinity of the project. For the northern end of the project, one plant produce the mixture and while on the southern end another plant was to produce the SMA. NCAT personnel were scheduled to arrive at the project as the contractor switched to the southern plant. Upon arrival, the contractor was having difficulty producing the proper gradation for the SMA mixture. Several control strips were placed to try and produce the proper gradation. Eventually, production of the SMA mixture had to be moved back to the northern plant. Sampling and testing were conducted at this northern plant.

### **SMA Mixture Information**

The SMA mixture used for this project was a 12.5 mm nominal maximum aggregate size mixture. Information about the mixture is presented in Table 10.1. Aggregates used for this project consisted of a traprock and natural sand. The design gradation for the mixture is presented in Table 10.2. Properties of the coarse and fine aggregates are presented in Tables 10.3 and 10.4, respectively. A PG 76-22 asphalt binder was used for this mixture. This binder was air-blown to achieve the PG 76-22 grading. Properties of this binder are presented in Table 10.5.

### **Plant Information**

The plant used to produce the SMA for this project was an Astec drum plant. The dust collection system consisted of a vertical cyclone and a baghouse. The collected dust was returned to the mixture and therefore constituted a portion of the filler.

Mineral filler for the mixture was stored in a silo. This storage silo was located directly above the cold feed conveyor belt. A rotary valve allowed the mineral filler to fall onto the cold feed belt at a controlled rate. The fiber was introduced to the mixture from a hopper similar to the hopper used at sites 4 and 9. Bales of fiber were introduced into the hopper where the bales were broken up into a form that could be blown. Once broken up the fibers were blown to a coater for mixing with the SMA mixture. The contractor said that the fiber was introduced in a uniform manner. The hopper would use a mass loss versus time to introduce the desired amount of fiber.

### **Laydown Procedures**

Paving operations were observed on the night of October 1, 1997. The ambient temperature was 55°F. Additional information about the laydown procedures are presented in Table 10.6

### **Problems Encountered On-Site**

No problems were encountered while producing the SMA mixture besides the aforementioned problems with the SMA gradation at the second plant.

### **Sampling**

Samples obtained from this project included: each aggregate used in the mixture, mineral filler, fiber, asphalt binder, loose mix, and ten cores. Table 10.7 presents the times and dates that the loose mix samples were obtained along with average draindown values. Tables 10.8 through 10.13 presents testing results from samples obtained from this site.

<b>Table 10.1: Site 10 SMA Mixture Information</b>	
JMF I.D. Number:	7006-97-26
Dates on Project:	9/29 to 10/1/97
Number of Aggregate Stockpiles Used:	3
Design Voids in Coarse Aggregate:	42.9*
Type Asphalt Binder Used:	PG 76-22
Modifier Type:	Air-Blown
Design Asphalt Binder Content:	6.10 percent
Supplier of Asphalt Binder:	Koch
Type Fiber Used:	Cellulose
Form of Fiber:	Loose
Design Percentage of Fiber:	0.3 percent of total mixture
Type Mineral Filler Used:	Limestone dust
Design Percentage of Mineral Filler:	9.0 percent
Type Anti-Strip Additive Used:	Liquid
Design Percentage of Anti-Strip:	0.5 percent
Compaction Method:	Marshall
Compactive Effort:	50 Blows per face
Laboratory Mixing Temperature:	
Laboratory Compaction Temperature:	
Design Voids in Total Mix:	3.2 percent
Design Mixture Density:	156 pcf
Design Voids in Mineral Aggregate:	18.9 percent
Design Voids Filled With Asphalt:	83.1 percent
Design Marshall Stability:	
Design Flow (0.01 in):	
Loaded Wheel Test @ Design Asphalt Content:	

\* Determined at NCAT laboratory on materials obtained from project.

Sieve Size	Sieve Size, mm	Percent Passing
¾ in.	19.0	100
½ in.	12.5	86
⅜ in.	9.5	74
No. 4	4.75	28
No. 8	2.36	19
No. 16	1.18	----
No. 30	0.600	15
No. 50	0.300	----
No. 100	0.150	----
No. 200	0.075	8

Test	68's Traprock	8's Traprock
Los Angeles Abrasion, % Loss	13.0	17.4
Flat & Elongated, %		
3 to 1	21.2*	16.9*
5 to 1	3.1*	0.4*
Bulk/Apparent Specific Gravity	2.930/3.006	2.920/3.004
Absorption, %	0.9	1.0
Soundness (5 Cycles), % Loss		
Sodium Sulfate		
Crushed Content, %		
One Face	100*	100*
Two Face	100*	100*

Data not provided by the agency represented by blank data fields.

\* Determined at NCAT laboratory on materials obtained from project.

Table 10.4: Fine Aggregate Properties for Site 10	
Test	Natural Sand
Bulk/Apparent Specific Gravity	2.610/2.846*
Absorption, %	3.2*
Soundness (5 Cycles), % Loss	
	Sodium Sulfate
Angularity, %	47.1*
Liquid Limit, %	
Plasticity Index, %	
Data not provided by agency represented by blank data fields.	

\* Determined at NCAT laboratory on materials obtained from project.

<b>Table 10.6: Laydown Information from Site 10</b>	
Manufacturer of Paver:	Roadtec
Other Equipment Used:	Shuttlebuggy
Number of Rollers Used:	3
Temperature of Mixture When Delivered (Truck):	320°F
Temperature of Mixture After Finish Roller Ended Compaction:	275°F
Comments:	The mixture was noticed to be sticking to trucks. Releasing Agents were used.

<b>Table 10.7: Sampling Times and Dates for Loose Mix Samples From Site 10</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	9/29/97	9/30/97	9/30/97	9/30/97	10/1/97	10/1/97
Time Obtained	10:30pm	12:30am	2:30am	10:30pm	9:27pm	11:20pm
Temperature of Mixture in Truck, °F	325	330	335	340	310	320
Draindown, %	1.1	1.1	3.6	0.6	0.5	0.5

Table 10.8: Gradations for Samples Obtained In-field

Site: 11  
Sample: 1

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
						B-F						I-M					I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	98.2	99.9	99.1	1.20	0.9	99.2	98.4	99.2	98.8	0.57	0.4	100.0	98.8	99.4	0.85	-0.2
12.5	90.0	89.9	92.0	91.0	1.48	-1.0	91.3	89.6	89.4	89.5	0.14	1.8	93.0	90.3	91.7	1.91	-0.4
9.5	59.2	60.7	60.6	60.7	0.07	-1.5	67.1	66.0	67.3	66.7	0.92	0.5	66.7	62.3	64.5	3.11	2.6
4.75	27.0	29.1	28.2	28.7	0.64	-1.7	33.4	36.3	36.3	36.3	0.00	-2.9	34.8	31.9	33.4	2.05	0.0
2.36	21.5	22.0	20.0	21.0	1.41	0.5	23.4	25.4	24.5	25.0	0.64	-1.6	24.2	23.0	23.6	0.86	-0.2
1.18	17.4	18.6	16.2	17.4	1.70	0.0	18.5	20.2	18.9	19.6	0.92	-1.1	19.0	18.1	18.6	0.64	-0.1
0.60	12.7	17.0	14.2	15.6	1.98	-2.9	15.8	17.7	16.2	17.0	1.06	-1.2	16.1	15.4	15.8	0.49	0.0
0.30	10.7	15.9	12.7	14.3	2.26	-3.6	13.4	16.1	14.2	15.2	1.34	-1.8	13.9	13.3	13.6	0.42	-0.2
0.150	8.8	13.6	10.7	12.2	2.05	-3.4	10.9	14.5	12.1	13.3	1.70	-2.4	11.7	11.2	11.5	0.35	-0.5
0.075	7.5	11.6	9.1	10.4	1.77	-2.9	8.7	12.1	10.0	11.1	1.48	-2.3	9.8	9.2	9.5	0.42	-0.8

Site: 11  
Sample: 2

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
						B-F	100.0					I-M					I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	99.9	99.9	99.9	0.00	0.1	99.2	98.9	98.8	98.9	0.07	0.3	99.4	100.0	99.7	0.42	-0.5
12.5	90.0	94.0	94.1	94.1	0.07	-4.1	91.3	93.8	91.1	92.5	1.91	-1.2	93.9	93.9	93.9	0.00	-2.6
9.5	59.2	64.0	62.1	63.1	1.34	-3.8	67.1	69.4	70.5	70.0	0.78	-2.8	64.5	67.1	65.8	1.84	1.3
4.75	27.0	29.6	28.9	29.3	0.49	-2.3	33.4	36.1	36.3	36.2	0.14	-2.8	33.5	33.5	33.5	0.00	-0.1
2.36	21.5	20.4	19.9	20.2	0.35	1.4	23.4	24.3	24.6	24.5	0.21	-1.1	23.6	23.2	23.4	0.28	0.0
1.18	17.4	16.3	16.1	16.2	0.14	1.2	18.5	18.9	19.3	19.1	0.28	-0.6	18.9	18.0	18.5	0.64	0.1
0.60	12.7	14.3	14.1	14.2	0.14	-1.5	15.8	16.3	16.8	16.6	0.35	-0.8	16.4	15.5	16.0	0.64	-0.2
0.30	10.7	12.6	12.6	12.6	0.00	-1.9	13.4	14.5	15.1	14.8	0.42	-1.4	14.8	13.6	14.2	0.85	-0.8
0.150	8.8	10.6	10.6	10.6	0.00	-1.8	10.9	12.5	13.2	12.9	0.49	-2.0	13.5	11.6	12.6	1.34	-1.7
0.075	7.5	8.9	9.0	9.0	0.07	-1.5	8.7	10.3	10.9	10.6	0.42	-1.9	11.5	9.7	10.6	1.27	-1.9

Site: 11  
Sample: 3

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
						B-F						I-M					I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	97.7	99.9	98.8	1.56	1.2	99.2	98.3	99.3	98.8	0.71	0.4	100.0	97.6	98.8	1.70	0.4
12.5	90.0	86.9	93.0	90.0	4.31	0.0	91.3	92.4	88.9	90.7	2.47	0.6	94.1	88.4	91.3	4.03	0.0
9.5	59.2	54.4	63.6	59.0	6.51	0.2	67.1	66.5	66.8	66.7	0.21	0.5	64.5	63.1	63.8	0.99	3.3
4.75	27.0	27.0	30.4	28.7	2.40	-1.7	33.4	34.4	35.5	35.0	0.78	-1.6	33.3	32.5	32.9	0.57	0.5
2.36	21.5	19.6	22.1	20.9	1.77	0.6	23.4	23.5	24.2	23.9	0.49	-0.5	23.7	23.4	23.6	0.21	-0.2
1.18	17.4	15.9	18.1	17.0	1.56	0.4	18.5	17.8	18.8	18.3	0.71	0.2	18.4	18.5	18.5	0.07	0.1
0.60	12.7	14.0	16.2	15.1	1.56	-2.4	15.8	15.0	16.3	15.7	0.92	0.1	15.8	15.9	15.9	0.07	-0.1
0.30	10.7	12.5	14.9	13.7	1.70	-3.0	13.4	12.9	14.8	13.9	1.34	-0.5	13.8	13.9	13.9	0.07	-0.5
0.150	8.8	10.5	12.7	11.6	1.56	-2.8	10.9	10.7	13.2	12.0	1.77	-1.1	11.8	12.0	11.9	0.14	-1.0
0.075	7.5	8.8	10.8	9.8	1.41	-2.3	8.7	9.1	11.1	10.1	1.41	-1.4	10.0	10.3	10.2	0.21	-1.4

Table 10.8(Continued): Gradations For Samples Obtained In-Field

Site: 11  
Sample: 4

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
		C	D	F	G	H		J	K	M	N	O	P	Q	S	T	U
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
						B-F						I-M					I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	100.0	100.0	100.0	0.00	0.0	99.2	100.0	100.0	100.0	0.00	-0.8	98.8	99.4	99.1	0.42	0.1
12.5	90.0	86.1	89.5	87.8	2.40	2.2	91.3	90.4	93.0	91.7	1.84	-0.4	84.8	88.8	86.8	2.83	4.5
9.5	59.2	52.1	57.0	54.8	3.46	4.7	67.1	69.0	66.7	67.9	1.63	-0.7	58.2	64.2	61.2	4.24	5.9
4.75	27.0	25.1	27.9	26.5	1.98	0.5	33.4	36.8	36.5	36.7	0.21	-3.3	30.8	33.2	32.0	1.70	1.4
2.36	21.5	18.5	21.0	19.8	1.77	1.8	23.4	26.1	25.0	25.6	0.78	-2.2	22.5	25.1	23.8	1.84	-0.4
1.18	17.4	15.5	16.9	16.2	0.99	1.2	18.5	20.8	19.6	20.2	0.85	-1.7	18.0	20.9	19.5	2.05	-0.9
0.60	12.7	14.1	14.6	14.4	0.35	-1.7	15.8	18.2	17.0	17.6	0.85	-1.8	15.4	18.8	17.1	2.40	-1.3
0.30	10.7	12.3	12.5	12.4	0.14	-1.7	13.4	16.1	14.9	15.5	0.85	-2.1	13.3	17.3	15.3	2.83	-1.9
0.150	8.8	10.4	10.2	10.3	0.14	-1.5	10.9	13.9	12.8	13.4	0.78	-2.5	11.3	15.3	13.3	2.83	-2.4
0.075	7.5	8.7	8.3	8.5	0.28	-1.0	8.7	11.5	10.4	11.0	0.78	-2.2	9.2	12.6	10.9	2.40	-2.2

Site: 11  
Sample: 5

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
		C	D	F	G	H		J	K	M	N	O	P	Q	S	T	U
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
						B-F						I-M					I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	97.7	99.4	98.6	1.20	1.4	99.2	97.8	100.0	98.9	1.56	0.3	99.0	99.9	99.5	0.64	-0.3
12.5	90.0	86.8	89.1	88.0	1.63	2.1	91.3	91.0	91.5	91.3	0.35	0.0	92.8	90.9	91.9	1.34	-0.6
9.5	59.2	55.8	53.4	54.6	1.70	4.6	67.1	67.6	66.9	67.3	0.49	-0.1	65.2	64.2	64.7	0.71	2.4
4.75	27.0	25.0	25.2	25.1	0.14	1.9	33.4	35.2	35.0	35.1	0.14	-1.7	33.5	32.4	33.0	0.78	0.4
2.36	21.5	18.1	18.3	18.2	0.14	3.3	23.4	23.9	24.5	24.2	0.42	-0.8	23.4	23.1	23.3	0.21	0.1
1.18	17.4	14.8	14.7	14.7	0.07	2.8	18.5	18.6	19.1	18.9	0.35	-0.4	18.5	18.2	18.4	0.21	0.1
0.60	12.7	13.0	12.9	13.0	0.07	-0.3	15.8	16.0	16.5	16.3	0.35	-0.5	16.0	15.7	15.9	0.21	-0.1
0.30	10.7	11.8	11.5	11.7	0.21	-1.0	13.4	14.2	14.5	14.4	0.21	-0.9	14.2	13.8	14.0	0.28	-0.6
0.150	8.8	9.9	9.6	9.8	0.21	-0.9	10.9	12.2	12.4	12.3	0.14	-1.4	12.0	12.1	12.1	0.07	-1.2
0.075	7.5	8.0	8.1	8.1	0.07	-0.6	8.7	9.9	10.2	10.1	0.21	-1.3	9.8	10.2	10.0	0.28	-1.3

Site: 11  
Sample: 6

Sieve mm	JMF % Passing	Loose Mix Samples					Average Core Gradation	Marshall Compacted Samples					Gyratory Compacted Samples				
		Rep 1	Rep 2	Average	Std. Deviation	Diff. From JMF		Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores	Rep 1	Rep 2	Average	Std. Deviation	Diff. From Cores
		C	D	F	G	H		J	K	M	N	O	P	Q	S	T	U
A	B	C	D	F	G	H	I	J	K	M	N	O	P	Q	S	T	U
						B-F						I-M					I-S
25.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	100.0	0.00	0.0	100.0	100.0	100.0	0.00	0.0
19.0	100.0	99.5	98.8	99.2	0.57	0.8	99.2	100.0	100.0	100.0	0.00	-0.8	99.0	99.3	99.2	0.21	0.0
12.5	90.0	90.8	89.2	90.0	1.13	0.0	91.3	89.1	90.8	90.0	1.20	1.3	88.1	88.7	88.4	0.42	2.9
9.5	59.2	61.8	56.9	59.4	3.46	-0.1	67.1	62.7	64.0	63.4	0.92	3.8	62.0	62.2	62.1	0.14	5.0
4.75	27.0	29.1	27.3	28.2	1.27	-1.2	33.4	33.0	31.4	32.2	1.13	1.2	31.9	32.6	32.3	0.49	1.1
2.36	21.5	20.9	19.8	20.4	0.78	1.2	23.4	23.4	21.4	22.4	1.41	1.0	23.1	23.8	23.5	0.49	-0.1
1.18	17.4	16.8	15.8	16.3	0.71	1.1	18.5	18.4	16.5	17.5	1.34	1.1	18.0	19.3	18.7	0.92	-0.1
0.60	12.7	14.9	13.7	14.3	0.85	-1.6	15.8	15.9	14.1	15.0	1.27	0.8	15.2	16.9	16.1	1.20	-0.3
0.30	10.7	13.4	12.1	12.8	0.92	-2.1	13.4	14.0	12.6	13.3	0.99	0.1	13.0	15.4	14.2	1.70	-0.8
0.150	8.8	11.3	10.3	10.8	0.71	-2.0	10.9	12.1	10.9	11.5	0.85	-0.6	10.6	13.9	12.3	2.33	-1.4
0.075	7.5	9.5	8.7	9.1	0.57	-1.6	8.7	9.9	8.4	9.2	1.06	-0.4	8.7	11.6	10.2	2.05	-1.4

Table 10.9: Results of Marshall Hammer Compactions

Marshall Hammer: 50 Blows per Side																		
SITE NUMBER: 10		MATERIALS: Traprock/Natural Sand/PG 76-22/Limestone Dust/Cellulo								COARSE AGGREGATE INFORMATION				Percent Coarse Aggregate: 72.0		DATE: 4/15/98		
AC Sp. Gr. (Gb) = 1.028		Apparent Specific Gravity of the Agg. (Gsa) = 2.903				Bulk Specific Gravity of the Agg. (Gsb) = 2.894				Bulk Sp. Gravity of CA (Gca): 3.005				Unit Wt. Of CA in DRC (pcf): 107.0		Unit Wt. Of CA in DRC (kg/m3) 1714.4		
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			Unit Weight pcf	VOIDS					
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	VTM %		VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
						F-E	$\frac{D}{G}$		$\frac{(100-C) \cdot H}{Gsb}$	$\frac{C \cdot H}{Gb}$	$H \cdot 62.4$	$100(1-H/I)$	$100 - J$	$\frac{100(N-M)}{N}$				
1	1	6.7	1226.5	725.8	1230.1	504.3	2.432	2.596	78.4	15.9	151.8	6.3	21.6	70.8	45.6	42.9	1.064	
1	2	6.7	1227.2	726.7	1231.5	504.8	2.431	2.596	78.4	15.8	151.7	6.4	21.6	70.6	45.7	42.9	1.064	
1	3	6.7	1217.9	719.0	1222.4	503.4	2.419	2.596	78.0	15.8	151.0	6.8	22.0	69.1	45.9	42.9	1.071	
2	1	6.5	1208.8	725.8	1212.0	486.2	2.486	2.589	80.3	15.7	155.1	4.0	19.7	79.8	44.3	42.9	1.033	
2	2	6.5	1196.8	719.9	1200.0	480.1	2.493	2.589	80.5	15.8	155.6	3.7	19.5	80.9	44.2	42.9	1.029	
2	3	6.5	1219.6	731.9	1224.1	492.2	2.478	2.589	80.1	15.7	154.6	4.3	19.9	78.5	44.5	42.9	1.037	
3	1	6.9	1222.5	732.3	1225.3	493.0	2.480	2.568	79.8	16.6	154.7	3.4	20.2	83.1	44.7	42.9	1.042	
3	2	6.9	1237.3	739.6	1239.7	500.1	2.474	2.568	79.6	16.6	154.4	3.6	20.4	82.2	44.8	42.9	1.045	
3	3	6.9	1201.8	717.7	1205.7	488.0	2.463	2.568	79.2	16.5	153.7	4.1	20.8	80.4	45.1	42.9	1.051	
4	1	6.3	1209.2	721.6	1214.8	493.2	2.452	2.560	79.4	15.0	153.0	4.2	20.6	79.5	45.0	42.9	1.048	
4	2	6.3	1212.3	720.6	1218.7	498.1	2.434	2.560	78.8	14.9	151.9	4.9	21.2	76.8	45.4	42.9	1.058	
4	3	6.3	1204.7	716.8	1212.4	495.6	2.431	2.560	78.7	14.9	151.7	5.0	21.3	76.3	45.4	42.9	1.059	
5	1	6.2	1214.2	733.5	1216.2	482.7	2.515	2.593	81.5	15.2	157.0	3.0	18.5	83.8	43.5	42.9	1.013	
5	2	6.2	1220.7	736.5	1223.0	486.5	2.509	2.593	81.3	15.1	156.6	3.2	18.7	82.7	43.6	42.9	1.017	
5	3	6.2	1200.8	724.2	1202.6	478.4	2.510	2.593	81.4	15.1	156.6	3.2	18.6	82.8	43.6	42.9	1.016	
6	1	6.1	1221.3	735.0	1225.7	490.7	2.489	2.604	80.8	14.8	155.3	4.4	19.2	77.0	44.0	42.9	1.026	
6	2	6.1	1241.8	748.1	1245.5	497.4	2.497	2.604	81.0	14.8	155.8	4.1	19.0	78.3	43.8	42.9	1.022	
6	3	6.1	1209.6	722.2	1214.4	492.2	2.468	2.604	79.7	14.6	153.4	5.6	20.3	72.2	44.7	42.9	1.042	

Input By:

SSD = Saturated Surface Dry  
TMD = Theoretical Maximum Density  
gm = gram

cc = cubic centimeter  
AC = Asphalt Cement  
pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mixture  
Gmm = Theoretical Maximum Density of Mixture  
Gsa = Apparent Specific Gravity of Aggregate

Gsb = Bulk Specific Gravity of Aggregate  
Gb = Specific Gravity of Asphalt Cement  
VCA = Voids in Coarse Aggregate

Checked By: A. Cooley

VTM = Voids in Total Mix  
VMA = Voids in Mineral Aggregate  
VFA = Voids Filled With Asphalt Cement

Table 10.10: Results of SGC Compactions

SITE NUMBER: 10			MATERIALS: Traprock/Natural Sand/PG 78-22/Limestone Dust/Celulose									COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 72.0		DATE: 4/15/98		
AC Sp. Gr. (Gb) = 1.028			Apparent Specific Gravity of the Agg. (Gsa) = 2.903						Bulk Specific Gravity of the Agg. (Gsb) = 2.894													Bulk Sp. Gravity of CA (Gca): 3.005				
			WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES			CORR. % Gmm			VOLUMES AT Ndes			VOIDS					
Sample Number	Replicate	Asphalt Content %	In Air gms	In Water gms	SSD gms	Nini (8 Gyr) mm	Ndes (100 Gyr) mm	Nmax (158 Gyr) mm	Nini (8 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction	Nini %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA VCA drc	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
									G*17.67			D			Gmb Est. Gmb Meas			J*O			K*O			L*O		
1	1	6.7	4580.9	2696.5	4598.4	123.6	111.2		2.067	2.331		2.411	2.596	1.034	83.6	92.9		77.7	15.7	7.1	22.3	68.0	46.1	42.9	1.074	
1	2	6.7	4573.8	2688.0	4592.2	120.7	110.7		2.144	2.338		2.402	2.596	1.027	84.9	92.5		77.4	15.7	7.5	22.6	68.9	46.3	42.9	1.079	
1	3	6.7	4582.9	2705.7	4604.3	121.9	111.0		2.127	2.338		2.414	2.596	1.033	84.7	93.0		77.8	15.7	7.0	22.2	68.4	46.0	42.9	1.073	
2	1	6.5	4586.9	2758.1	4595.6	119.2	107.7		2.178	2.410		2.496	2.589	1.036	87.1	96.4		80.7	15.8	3.8	19.3	81.5	44.1	42.9	1.027	
2	2	6.5	4567.0	2745.6	4574.3	118.3	106.8		2.185	2.420		2.497	2.589	1.032	87.1	96.5		80.7	15.8	3.5	19.3	81.7	44.1	42.9	1.027	
2	3	6.5	4605.1	2783.4	4612.6	118.2	106.9		2.205	2.438		2.518	2.589	1.033	87.9	97.2		81.3	15.9	2.8	18.7	85.2	43.6	42.9	1.018	
3	1	6.9	4558.0	2740.5	4564.4	119.5	107.9	106.5	2.158	2.390	2.422	2.499	2.588	1.032	86.7	96.1	97.3	79.4	16.6	3.9	20.6	80.9	45.0	42.9	1.048	
3	2	6.9	4512.7	2713.2	4517.1	116.1	106.9	104.7	2.200	2.389	2.439	2.502	2.588	1.026	87.9	95.4	97.4	78.8	16.4	4.8	21.2	78.3	45.3	42.9	1.057	
3	3	6.9	4509.4	2686.7	4518.5	117.8	107.2		2.166	2.380		2.475	2.588	1.040	87.7	96.4		79.6	16.6	3.8	20.4	82.3	44.8	42.9	1.044	
4	1	6.3	4493.9	2664.5	4508.5	119.7	107.6		2.125	2.383		2.437	2.560	1.031	85.6	95.2		78.9	14.9	4.8	21.1	77.2	45.3	42.9	1.058	
4	2	6.3	4478.3	2640.0	4495.4	119.8	106.5		2.115	2.336		2.414	2.560	1.033	85.4	94.3		78.1	14.8	5.7	21.9	73.8	45.8	42.9	1.068	
4	3	6.3	4619.6	2729.4	4640.1	122.2	111.0		2.139	2.355		2.418	2.560	1.027	85.8	94.4		78.3	14.8	5.6	21.7	74.4	45.7	42.9	1.066	
5	1	6.2	4652.5	2834.5	4657.2	116.9	104.9		2.252	2.510		2.553	2.593	1.017	88.3	98.4		82.7	15.4	1.6	17.3	91.0	42.6	42.9	0.994	
5	2	6.2	4598.0	2801.9	4602.3	116.0	104.0		2.243	2.502		2.554	2.593	1.021	88.3	98.5		82.8	15.4	1.5	17.2	91.2	42.6	42.9	0.993	
5	3	6.2	4624.5	2814.3	4630.1	115.8	104.6		2.280	2.502		2.547	2.593	1.018	88.7	98.2		82.5	15.4	1.8	17.5	89.8	42.8	42.9	0.997	
6	1	6.1	4593.2	2761.7	4592.7	118.0	106.4		2.198	2.438		2.503	2.604	1.027	86.7	96.1		81.2	14.9	3.9	18.8	79.4	43.7	42.9	1.018	
6	2	6.1	4649.8	2802.9	4659.0	119.7	108.2		2.198	2.432		2.505	2.604	1.030	87.0	96.2		81.3	14.9	3.8	18.7	79.7	43.6	42.9	1.017	
6	3	6.1	4581.0	2752.1	4571.9	117.9	106.0		2.189	2.435		2.506	2.604	1.029	86.5	96.2		81.3	14.9	3.8	18.7	79.9	43.6	42.9	1.018	

Input By: \_\_\_\_\_ Checked By: A. Cooley  
 SSD = Saturated Surface Dry cc = cubic centimeter Gmb = Bulk Specific Gravity of Compacted Mixture Gsb = Bulk Specific Gravity of Aggregate VTM = Voids in Total Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gmm = Theoretical Maximum Density of Mixture Gb = Specific Gravity of Asphalt Cement VMA = Voids in Mineral Aggregate  
 gm = gram pcf = pounds per cubic foot Gsa = Apparent Specific Gravity of Aggregate VCA = Voids in Coarse Aggregate VFA = Voids Filled With Asphalt Cement

Table 10.11: Results of Loaded Wheel Testing

Site No.: 10

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	6.6	1.19	2.04	2.66
R2	4.9	2.06	2.89	3.59
R3	4.4	1.65	2.31	2.81
R4	5.2	1.75	2.43	3.04
<b>Average</b>	<b>5.3</b>	<b>1.66</b>	<b>2.42</b>	<b>3.03</b>
<b>Std. Dev.</b>	<b>0.96</b>	<b>0.360</b>	<b>0.355</b>	<b>0.408</b>

Table 10.12: Results of Superpave Analysis Testing

Site No.: 10

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @ Constant Height		G*				
		Delta				
Simple Shear Test @ Constant Height		Strain Rate, mm/mm				
		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

Table 10.13: Results of Testing on Cores Obtained In-Field

Site No.: 10

Sieve mm	Percent Passing										Average	Std. Dev.	
	Core 1	Core 2	Core 3	Core 4	Core 5	Core 6	Core 7	Core 8	Core 9	Core 10			
25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.00
19.0	99.3	100.0	98.8	98.8	99.1	99.1	100.0	100.0	98.8	98.7	99.3	0.54	
12.5	89.1	93.3	88.9	85.8	84.4	87.5	87.2	88.0	93.7	88.6	88.7	2.93	
9.5	78.2	80.1	77.4	77.6	74.3	75.7	75.8	77.4	84.8	77.1	77.8	2.90	
4.75	35.2	31.8	31.9	40.1	32.0	32.5	32.1	31.6	34.5	32.5	33.4	2.64	
2.36	19.0	17.2	18.5	23.2	19.0	19.1	18.5	17.7	18.8	18.0	18.9	1.63	
1.18	15.5	14.3	15.6	19.2	16.5	16.8	15.7	15.2	15.8	15.3	16.0	1.32	
0.60	12.5	11.7	12.7	16.3	14.1	14.2	13.1	12.6	13.1	12.6	13.3	1.29	
0.30	9.5	9.2	10.0	13.3	11.7	11.8	10.5	10.1	10.5	10.0	10.7	1.25	
0.150	7.8	7.5	8.3	11.4	10.1	10.1	8.9	8.5	8.9	8.4	9.0	1.20	
0.075	6.7	6.3	7.1	9.7	8.8	8.8	7.5	7.3	7.7	7.2	7.7	1.06	
Gmb	2.370	2.362	2.345	2.459	2.404	2.367	2.400	2.357	2.291	2.358	2.371	0.04	
Unit Weight, pcf	147.9	147.4	146.3	153.4	150.0	147.7	149.8	147.1	143.0	147.1	148.0	2.73	
VTM, %	9.0	9.3	9.9	5.6	7.7	9.1	7.8	9.5	12.0	9.4	8.9	1.67	

## **NCHRP 9-8 II - Task 8 SMA Construction Project No. 11**

### **Location and Background**

Construction project 11 was constructed during October 1997. NCAT staff were on-site between October 6 and October 7, 1997.

This project was located on a four-lane U.S. highway. During the time spent on this project, the contractor was paving in the southbound lane. Construction consisted of milling 38 mm (1.5 inches) and replacing with 38 mm of SMA. The underlying pavement was an asphalt concrete pavement.

### **SMA Mixture Information**

The SMA mixture used for this project was a 12.5 mm nominal maximum aggregate size mixture. Information about the mixture is presented in Table 11.1. Aggregates used for this project consisted of a limestone and a manufactured sand. The design gradation for the mixture is presented in Table 11.2. Properties of the coarse and fine aggregates are presented in Tables 11.3 and 11.4, respectively. A PG 58-28 asphalt binder was used for this mixture. Properties of this binder are presented in Table 11.5. Cellulose in a loose form was used as a stabilizing additive.

### **Plant Information**

The plant used to produce the SMA for this project was a drum plant. Mineral filler for the mixture was stored in a silo. The mineral filler was augered from the storage silo to the drum. The fiber was introduced to the mixture from a hopper. Bales of fiber

were introduced into the hopper where the bales were broken up into a form that could be blown. Once broken up the fibers were blown to the drum for mixing with the SMA mixture.

### **Laydown Procedures**

Paving operations were observed on the night of October 6, 1997. Additional information about the laydown procedures are presented in Table 11.6

### **Problems Encountered On-Site**

No problems were encountered while producing the SMA mixture.

### **Sampling**

Samples obtained from this project included: each aggregate used to fabricate the mixture, mineral filler, fiber, asphalt binder, loose mix, and ten cores. Table 11.7 presents the times and dates that the loose mix samples were obtained along with the average draindown values for each of the samples. Tables 11.8 through 11.13 presents testing results from samples obtained from this site.

<b>Table 11.1: Site 11 SMA Mixture Information</b>	
JMF I.D. Number:	
Dates on Project:	October 6 and 7, 1997
Number of Aggregate Stockpiles Used:	5
Design Voids in Coarse Aggregate:	40.0 percent
Type Asphalt Binder Used:	PG 58-28
Modifier Type:	None
Design Asphalt Binder Content:	6.7 percent
Supplier of Asphalt Binder:	TM Oil
Type Fiber Used:	Cellulose
Form of Fiber:	Loose
Design Percentage of Fiber:	0.3 percent of total mixture
Type Mineral Filler Used:	Fly Ash
Design Percentage of Mineral Filler:	7.0 percent
Type Anti-Strip Additive Used:	None
Design Percentage of Anti-Strip:	N/A
Compaction Method:	Marshall Hammer
Compactive Effort:	50 Blows per side
Laboratory Mixing Temperature:	315 °F
Laboratory Compaction Temperature:	295 °F
Design Voids in Total Mix:	3.3 percent
Design Mixture Density:	145.0 pcf
Design Voids in Mineral Aggregate:	17.2 percent
Design Voids Filled With Asphalt:	80.8 percent
Design Marshall Stability:	
Design Flow (0.01 in):	
Loaded Wheel Test @ Design Asphalt Content:	

<b>Table 11.2: Design Gradation for Site 11</b>		
Sieve Size	Sieve Size, mm	Percent Passing
¾ in.	19.0	100.0
½ in.	12.5	90.0
⅜ in.	9.5	59.2
No. 4	4.75	27.0
No. 8	2.36	21.5
No. 16	1.18	17.4
No. 30	0.600	12.7
No. 50	0.300	10.7
No. 100	0.150	8.8
No. 200	0.075	7.5

<b>Table 11.3: Coarse Aggregate Properties for Site 11</b>	
Test	Limestone
Los Angeles Abrasion, % Loss	33.0
Flat & Elongated, %	
3 to 1	7.0*
5 to 1	1.0*
Bulk/Apparent Specific Gravity	2.625/2.783*
Absorption, %	2.2*
Soundness (5 Cycles), % Loss	
Sodium Sulfate	
Crushed Content, %	
One Face	100*
Two Face	100*
Data not provided by the agency represented by blank data fields.	

\* Determined at NCAT laboratory on materials obtained from project.

<b>Table 11.4: Fine Aggregate Properties for Site 11</b>		
Test	Manufactured Sand	Fines Crushed
Bulk/Apparent Specific Gravity	2.560/2.673*	2.481/2.740*
Absorption, %	1.7*	3.8*
Soundness (5 Cycles), % Loss		
Sodium Sulfate		
Angularity, %	43.5*	41.4*
Liquid Limit, %		
Plasticity Index, %		
Data not provided by agency represented by blank data fields.		

\* Determined at NCAT laboratory on materials obtained from project.

Table 10.5: Site 10 Asphalt Binder Properties

**SHRP ASPHALT BINDER GRADING SUMMARY**

**ASPHALT: Site 10**  
**OPERATOR: Wilson**  
**PROJECT: NCHRP 9-8**  
**DATE: 10/21/97**

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: 0.25 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135: 1033 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
GRADE	TEMP °C	ORIGINAL	RTFOT	GRADE	TEMP °C	RTFOT + PAV	TEMP °C	RTFOT + PAV		
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		DT (1mm/mm)
		G' / sinδ (kPa) ≥ 1.00 kPa	G' / sinδ (kPa) ≥ 2.20 kPa			G' sinδ (MPa) ≤ 5000 kPa		S, Stiffness (MPa) ≤ 300 MPa	m, Slope ≥ 0.300	Failure Strain ≥ 1.0%
94	94			-10	37		0			
88	88			-16	34		-6			
82	82	0.6435	1.9361	-22	31	1638	-12	226	0.347	0.2153
76	76	1.2762	3.8814	-28	28	2264	-18			
70	70			-34	25	3081	-24			
64	64			-40	22	4126	-30			
58	58			-46	19	5082	-36			
52	52			-52	16	6908	-42			
46	46			-58	13		-48			

**GRADE: PG 76-22**

Table 11.5: Site 11 Asphalt Binder Properties

### SHRP ASPHALT BINDER GRADING SUMMARY

**ASPHALT: Site 11**  
**OPERATOR: Wilson**  
**PROJECT: NCHRP 9-8**  
**DATE: 10/17/97**

Original	RTFOT	RTFOT + PAV residue
Flash Pt: --- °C	Loss: 0.23 %	Time/Temp after PAV: 20 HRS AT 100°C
Vis@135: 479 cP		Physical Hardening Index: ---

HIGH TEMPERATURE GRADING				LOW TEMPERATURE GRADING						
GRADE	TEMP °C	ORIGINAL	RTFOT	GRADE	TEMP °C	RTFOT + PAV	TEMP °C	RTFOT + PAV		
		Dynamic Shear 10 rad/s (1.5 Hz)	Dynamic Shear 10 rad/s (1.5 Hz)			Dynamic Shear 10 rad/s (1.5 Hz)		Flexural Creep (at 60 sec)		DT (1mm/min)
		$G^*/\sin\delta$ (kPa) ≥ 1.00 kPa	$G^*/\sin\delta$ (kPa) ≥ 2.20 kPa			$G^*\sin\delta$ (MPa) ≤ 5000 kPa		S, Stiffness (MPa) ≤ 300 MPa	m, Slope ≥ 0.300	Failure Strain ≥ 1.0%
94	94			-10	28		0			
88	88			-16	25		-6			
82	82			-22	22	3176	-12			
76	76			-28	19	4739	-18	288	0.307	.3241
70	70			-34	16	6624	-24			
64	64	0.6791	1.6682	-40	13		-30			
58	58	1.5108	3.7873	-46	10		-36			
52	52			-52	7		-42			
46	46			-58	4		-48			

**GRADE: PG 58-28**

<b>Table 11.6: Laydown Information from Site 11</b>	
Manufacturer of Paver:	Blaw Knox
Other Equipment Used:	Material Transfer Device
Number of Rollers Used:	3 (2 Vibratory and 1 static)
Temperature of Mixture When Delivered (Truck):	290°F
Temperature of Mixture When Compaction Begins:	280°F
Comments:	No mixture was observed sticking to the trucks.

<b>Table 11.7: Sampling Times and Dates for Loose Mix Samples From Site 11</b>						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Date Obtained	10/6/97	10/6/97	10/6/97	10/7/97	10/7/97	10/7/97
Time Obtained	6:50pm	8:50pm	11:05pm	7:30pm	10:00pm	11:30pm
Temperature of Mixture in Truck, °F	300	300	296	296	294	290
Day's Tonnage	250	605	1023	N/A	760	1078
Draindown, %	0.03	0.00	0.02	0.04	0.00	0.02

N/A - Not Available

Table 11.9: Results of Marshall Hammer Compaction

Marshall Hammer: 50 Blows per Side																		
SITE NUMBER: 11		MATERIALS: Limestone/Fly Ash/Cellulose/PG 58-28							COARSE AGGREGATE INFORMATION				Percent Coarse Aggregate: 73.0		DATE: 4/15/98			
AC Sp. Gr. (Gb) = 1.027		Effective Specific Gravity of the Agg. (Gsa) = 2.650					Bulk Specific Gravity of the Agg. (Gsb) = 2.620							Bulk Sp. Gravity of CA (Gca): 2.611		Unit Wt. Of CA in DRC (pcf): 97.7		
Sample Number	Replicate	Asphalt Content %	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air gms	In Water gms	SSD gms	Volume cc	Bulk Gmb	TMD Gmm	Aggregate Volume cc	AC by Volume %	Unit Weight pcf	VTM %	VMA %	VFA %	VCA %	VCA drc %	VCA/VCA drc %	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
						F-E	$\frac{D}{G}$		$\frac{(100-C) \cdot H}{Gsb}$	$\frac{C \cdot H}{Gb}$	$H \cdot 62.4$	$100(1-H/I)$	$100 - J$	$\frac{100(N-M)}{N}$				
1	1	6.8	1191.5	682.0	1192.4	510.4	2.334	2.412	83.0	15.5	145.7	3.2	17.0	81.0	39.2	40.0	0.979	
1	2	6.8	1196.8	687.6	1196.0	510.4	2.345	2.412	83.4	15.5	146.3	2.8	16.6	83.2	38.9	40.0	0.972	
1	3	6.8	1191.4	686.4	1193.1	506.7	2.351	2.412	83.6	15.6	146.7	2.5	16.4	84.6	38.7	40.0	0.968	
2	1	7.2	1207.9	694.1	1210.0	515.9	2.341	2.415	82.9	16.4	146.1	3.0	17.1	82.1	39.3	40.0	0.981	
2	2	7.2	1194.0	687.8	1195.5	507.7	2.352	2.415	83.3	16.5	146.8	2.6	16.7	84.3	39.0	40.0	0.975	
2	3	7.2	1213.3	698.0	1216.0	518.0	2.342	2.415	83.0	16.4	146.2	3.0	17.0	82.3	39.2	40.0	0.981	
3	1	7.0	1187.2	682.2	1189.5	507.3	2.340	2.425	83.1	16.0	146.0	3.5	16.9	79.4	39.2	40.0	0.979	
3	2	7.0	1209.4	694.8	1211.9	517.1	2.339	2.425	83.0	15.9	145.9	3.6	17.0	79.1	39.2	40.0	0.980	
3	3	7.0	1219.9	700.7	1221.2	520.5	2.344	2.425	83.2	16.0	146.2	3.4	16.8	80.1	39.1	40.0	0.976	
4	1	7.2	1184.0	682.2	1185.4	503.2	2.353	2.423	83.3	16.5	146.6	2.9	16.7	82.6	39.0	40.0	0.974	
4	2	7.2	1214.4	702.3	1216.4	514.1	2.362	2.423	83.7	16.6	147.4	2.5	16.3	84.6	38.7	40.0	0.968	
4	3	7.2	1153.2	660.7	1154.2	493.5	2.337	2.423	82.8	16.4	145.8	3.6	17.2	79.3	39.4	40.0	0.984	
5	1	7.1	1210.4	696.8	1212.8	516.0	2.346	2.427	83.2	16.2	146.4	3.3	16.8	80.1	39.1	40.0	0.977	
5	2	7.1	1184.5	683.2	1186.3	503.1	2.354	2.427	83.5	16.3	146.9	3.0	16.5	81.9	38.8	40.0	0.971	
5	3	7.1	1187.9	683.5	1189.8	506.3	2.346	2.427	83.2	16.2	146.4	3.3	16.8	80.2	39.1	40.0	0.976	
6	1	6.9	1228.0	705.6	1234.4	526.6	2.322	2.440	82.5	15.6	144.9	4.6	17.5	72.4	39.6	40.0	0.989	
6	2	6.9	1206.3	692.4	1210.6	518.2	2.328	2.440	82.7	15.6	145.3	4.6	17.3	73.4	39.4	40.0	0.985	
6	3	6.9	1204.6	692.4	1208.1	515.7	2.336	2.440	83.0	15.7	145.8	4.3	17.0	74.9	39.2	40.0	0.980	

Input By:	Checked By: A. Cooley					
SSD = Saturated Surface Dry	cc = cubic centimeter	Gmb = Bulk Specific Gravity of Compacted Mixture	Gsb = Bulk Specific Gravity of Aggregate	VTM = Voids in Total Mix		
TMD = Theoretical Maximum Density	AC = Asphalt Cement	Gmm = Theoretical Maximum Density of Mixture	Gc = Specific Gravity of Asphalt Cement	VMA = Voids in Mineral Aggregate		
gm = gram	pcf = pounds per cubic foot	Gsa = Apparent Specific Gravity of Aggregate	VCA = Voids in Coarse Aggregate	VFA = Voids Filled With Asphalt Cement		

Table 11.10: Results of SGC Compactions

SITE NUMBER: 11			MATERIALS: Limestone/Fly Ash/Cellulosa/PG 58-28									COARSE AGGREGATE INFORMATION										Percent Coarse Aggregate: 73.0	DATE: 4/15/98		
AC Sp. Gr. (Gb) = 1.027			Effective Specific Gravity of the Agg. (Gsa) = 2.650						Bulk Specific Gravity of the Agg. (Gsb) = 2.620													Bulk Sp. Gravity of CA (Gca): 2.611			
			WEIGHTS			HEIGHTS			EST. BULK GRAVITIES			SPECIFIC GRAVITIES			CORR. % Grmm			VOLUMES AT Ndes				VOIDS			
Sample Number	Replicate	Asphalt Content %	In Air gms	In Water gms	SSD gms	Nini (8 Gyr) mm	Ndes (100 Gyr) mm	Nmax (158 Gyr) mm	Nint (8 Gyr)	Ndes (100 Gyr)	Nmax (158 Gyr)	Bulk Gmb	TMD Gmm	Correction Factor	Nini %	Ndes %	Nmax %	Aggregate Volume cc	AC by Volume %	VTM at Ndes %	VMA at Ndes %	VFA at Ndes %	VCA %	VCA drc %	VCA drc %
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
									D G*17.67	D H*17.67	D I*17.67	D F-E		Gmb Est. Gmb Meas.	J*O	K*O	L*O	(100-C)*K*O (Gsb)	C*K*O (Gb)	100-Q	100-S	100(V-U) V			
1	1	6.8	4578.0	2848.3	4579.6	127.4	111.1		2.033	2.331		2.369	2.412	1.017	85.7	98.2		84.3	15.7	1.8	15.7	88.8	38.3	40.0	0.956
1	2	6.8	4554.4	2650.7	4556.2	123.2	109.6		2.092	2.352		2.390	2.412	1.016	86.2	99.1		85.0	15.8	0.9	15.0	93.9	37.7	40.0	0.943
1	3	6.8	4563.4	2648.0	4567.0	127.8	111.2		2.021	2.322		2.378	2.412	1.024	85.8	98.6		84.6	15.7	1.4	15.4	90.9	38.0	40.0	0.951
2	1	7.2	4649.0	2720.7	4652.2	125.1	112.6	110.7	2.103	2.336	2.377	2.407	2.415	1.013	88.2	98.0	99.7	83.8	16.6	2.0	16.2	87.5	38.6	40.0	0.965
2	2	7.2	4654.4	2709.6	4660.1	128.9	112.4		2.043	2.343		2.386	2.415	1.018	86.2	98.8		84.5	16.7	1.2	15.5	92.3	38.1	40.0	0.952
2	3	7.2	4656.9	2714.9	4662.5	129.0	112.1		2.044	2.352		2.392	2.415	1.017	86.1	99.1		84.7	16.8	0.9	15.3	93.8	37.9	40.0	0.948
3	1	7.0	4644.9	2707.1	4647.6	129.0	113.0	111.5	2.038	2.326	2.357	2.394	2.425	1.015	85.3	97.4	98.7	83.8	16.1	2.6	16.2	83.9	38.6	40.0	0.965
3	2	7.0	4655.5	2701.2	4658.5	128.0	112.5		2.058	2.342		2.379	2.425	1.016	86.2	98.1		84.4	16.2	1.9	15.6	87.7	38.2	40.0	0.954
3	3	7.0	4641.7	2692.4	4646.3	130.2	113.0		2.017	2.324		2.376	2.425	1.022	85.0	98.0		84.3	16.2	2.0	15.7	87.0	38.2	40.0	0.950
4	1	7.2	4652.4	2709.9	4657.2	129.8	112.8		2.031	2.338		2.389	2.423	1.022	85.7	98.6		84.6	16.7	1.4	15.4	90.9	38.0	40.0	0.950
4	2	7.2	4616.7	2691.7	4620.5	127.1	111.1		2.055	2.352		2.394	2.423	1.018	86.3	98.8		84.8	16.8	1.2	15.2	92.0	37.9	40.0	0.947
4	3	7.2	4739.9	2761.7	4747.9	133.4	115.6		2.011	2.320		2.386	2.423	1.029	85.3	98.5		84.5	16.7	1.5	15.5	90.2	38.1	40.0	0.952
5	1	7.1	4593.6	2673.6	4598.3	128.4	111.1		2.024	2.340		2.387	2.427	1.020	85.1	98.3		84.6	16.5	1.7	15.4	89.2	38.0	40.0	0.950
5	2	7.1	4682.7	2724.3	4687.6	130.9	113.8		2.024	2.329		2.385	2.427	1.024	85.4	98.3		84.6	16.5	1.7	15.4	88.8	38.0	40.0	0.951
5	3	7.1	4706.6	2742.2	4712.7	131.0	113.6		2.033	2.345		2.389	2.427	1.019	85.3	98.4		84.7	16.5	1.6	15.3	89.6	38.0	40.0	0.949
6	1	6.9	4674.3	2720.3	4682.8	131.6	114.0		2.010	2.320		2.382	2.440	1.027	84.6	97.6		84.6	16.0	2.4	15.4	84.5	38.0	40.0	0.950
6	2	6.9	4643.2	2698.6	4653.2	131.6	114.0		1.997	2.305		2.376	2.440	1.031	84.3	97.4		84.4	16.0	2.6	15.6	83.0	38.2	40.0	0.954
6	3	6.9	4748.9	2780.3	4758.4	133.2	115.9		2.018	2.319		2.377	2.440	1.025	84.8	97.4		84.5	16.0	2.6	15.5	83.3	38.1	40.0	0.953

Input By: \_\_\_\_\_ Checked By: A. Cooley  
SSD = Saturated Surface Dry cc = cubic centimeter Gmb = Bulk Specific Gravity of Compacted Mixture Gsb = Bulk Specific Gravity of Aggregate VTM = Voids in Total Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gmm = Theoretical Maximum Density of Mixture Gb = Specific Gravity of Asphalt Cement VMA = Voids in Mineral Aggregate  
gm = gram pcf = pounds per cubic foot Gsa = Apparent Specific Gravity of Aggregate VCA = Voids in Coarse Aggregate VFA = Voids Filled With Asphalt Cement

Table 11.11: Results of Loaded Wheel Testing

Site No.: 11

Specimen No.	VTM %	Rut Depth at 1000 Cycles (mm)	Rut Depth at 4000 Cycles (mm)	Rut Depth at 8000 Cycles (mm)
R1	1.7	1.16	2.70	3.73
R2	2.2	2.43	3.91	4.46
R3	2.4	2.16	4.00	5.27
R4	2.5	2.28	4.78	5.78
Average	2.2	2.01	3.85	4.81
Std. Dev.	0.33	0.576	0.859	0.902

Table 11.12: Results of Superpave Analysis Testing

Site No.: 11

Test	Test Temp. deg. C	Test Result	Rep. 1	Rep. 2	Average	Std. Dev.
Frequency Sweep @ Constant Height		G*				
		Delta				
Simple Shear Test @ Constant Height		Strain Rate, mm/mm				
		Final Strain, mm				
Creep Compliance		Strain Rate, mm/mm				
		Final Strain, mm				
Tensile Strength		Strength				

Figure 11.13: Results of Testing on Cores Obtained In-Field

Site No.: 11

Sieve mm	Percent Passing											Average	Std. Dev.
	Core 11	Core 27	Core 28	Core 29	Core 30	Core 12	Core 32	Core 33	Core 34	Core 35			
25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.00
19.0	99.3	98.6	99.3	99.3	100.0	99.4	98.7	99.0	100.0	98.2	99.2	99.2	0.58
12.5	90.8	93.2	92.1	92.7	91.3	89.6	90.5	92.4	92.0	88.2	91.3	91.3	1.54
9.5	69.0	67.5	67.6	70.1	66.8	65.9	64.9	68.1	67.2	64.0	67.1	67.1	1.83
4.75	35.4	33.2	33.2	32.9	32.6	33.6	33.0	33.6	33.7	32.5	33.4	33.4	0.82
2.36	24.5	23.2	23.0	22.5	22.0	23.8	23.1	24.2	23.8	23.5	23.4	23.4	0.76
1.18	19.4	18.3	18.4	17.7	17.3	18.8	18.2	19.3	18.9	18.7	18.5	18.5	0.66
0.60	16.5	15.6	15.9	15.3	14.9	15.9	15.5	16.2	16.0	15.8	15.8	15.8	0.46
0.30	14.1	13.3	14.0	13.3	13.0	13.2	13.2	13.3	13.4	13.2	13.4	13.4	0.36
0.150	11.4	10.9	11.8	11.1	10.9	10.4	10.7	10.5	10.8	10.5	10.9	10.9	0.44
0.075	9.2	8.7	9.6	9.0	9.0	8.2	8.5	8.2	8.5	8.3	8.7	8.7	0.47
Gmb	2.317	2.329	2.295	2.287	2.292	2.335	2.303	2.343	2.367	2.351	2.322	2.322	0.03
Unit Weight, pcf	144.6	145.3	143.2	142.7	143.0	145.7	143.7	146.2	147.7	146.7	144.9	144.9	1.71
VTM, %	4.2	3.8	5.2	5.5	5.3	4.0	5.3	3.7	2.7	3.4	4.3	4.3	0.96

**Table B1: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary**  
**Mix: 4.75 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

**GRADATION A--20% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:						Percent Coarse Aggregate:		DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.963		Effective Sp. Gr. of Agg. (Gse) = 2.918		Bulk Sp. Gr. of Agg. (Gsb) = 2.887									80		10-Feb-99
			WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N)				
						(F-E)	(F-E)		(Gsb)	(Gb)			O					
4/2-A1	6.0	117.4	4559.1	2637.0	4677.6	2040.6	2.234	2.628	72.7	13.1	139.4	15.0	27.3	45.0	41.8	47.1	0.887	
4/2-A2	6.0	117.5	4555.3	2680.1	4680.0	1999.9	2.278	2.628	74.2	13.3	142.1	13.3	25.8	48.4	40.7	47.1	0.863	
4/2-A3	6.0	117.0	4562.1	2680.7	4684.1	2003.4	2.277	2.628	74.1	13.3	142.1	13.3	25.9	48.4	40.7	47.1	0.863	
AVG												13.9	26.3	47.3	41.1	47.1	0.871	

Computed By: G. FLOWERS  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches  
 TMD = Theoretical Maximum Density AC = Asphalt Cement  
 Checked By: T. LYNN  
 Gmb = Bulk Specific Gravity of Compacted Mix  
 Gmm = Theoretical Maximum Specific Gravity of Mix  
 Gsa = Apparent Specific Gravity of Aggregate  
 Gsb = Bulk Specific Gravity of Aggregate  
 Gse = Effective Specific Gravity of Aggregate  
 Gb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:						Percent Coarse Aggregate:		DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.963		Effective Sp. Gr. of Agg. (Gse) = 2.924		Bulk Sp. Gr. of Agg. (Gsb) = 2.887									76		10-Feb-99
			WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N)				
						(F-E)	(F-E)		(Gsb)	(Gb)			O					
4/2-B1	6.0	114.0	4561.2	2664.8	4645.9	1981.1	2.302	2.633	75.0	13.4	143.7	12.6	25.0	49.8	43.0	47.1	0.913	
4/2-B2	6.0	114.5	4569.3	2674.8	4659.2	1984.4	2.303	2.633	75.0	13.4	143.7	12.5	25.0	49.9	43.0	47.1	0.913	
4/2-B3	6.0	114.6	4575.7	2681.7	4667.1	1985.4	2.305	2.633	75.0	13.5	143.8	12.5	25.0	50.0	43.0	47.1	0.912	
AVG												12.5	25.0	49.9	43.0	47.1	0.913	

Computed By: G. FLOWERS  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches  
 TMD = Theoretical Maximum Density AC = Asphalt Cement  
 Checked By: T. LYNN  
 Gmb = Bulk Specific Gravity of Compacted Mix  
 Gmm = Theoretical Maximum Specific Gravity of Mix  
 Gsa = Apparent Specific Gravity of Aggregate  
 Gsb = Bulk Specific Gravity of Aggregate  
 Gse = Effective Specific Gravity of Aggregate  
 Gb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:						Percent Coarse Aggregate:		DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.963		Effective Sp. Gr. of Agg. (Gse) = 2.913		Bulk Sp. Gr. of Agg. (Gsb) = 2.887									72		10-Feb-99
			WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N)				
						(F-E)	(F-E)		(Gsb)	(Gb)			O					
4/2-C1	6.0	112.5	4564.5	2666.9	4628.2	1961.3	2.327	2.624	75.8	13.6	145.2	11.3	24.2	53.3	45.5	47.1	0.964	
4/2-C2	6.0	112.5	4574.7	2678.9	4635.9	1957.0	2.338	2.624	76.1	13.6	145.9	10.9	23.9	54.3	45.2	47.1	0.959	
4/2-C3	6.0	111.6	4572.8	2673.1	4619.0	1945.9	2.350	2.624	76.5	13.7	146.6	10.4	23.5	55.5	44.9	47.1	0.953	
AVG												10.9	23.9	54.4	45.2	47.1	0.959	

Computed By: G. FLOWERS  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches  
 TMD = Theoretical Maximum Density AC = Asphalt Cement  
 Checked By: T. LYNN  
 Gmb = Bulk Specific Gravity of Compacted Mix  
 Gmm = Theoretical Maximum Specific Gravity of Mix  
 Gsa = Apparent Specific Gravity of Aggregate  
 Gsb = Bulk Specific Gravity of Aggregate  
 Gse = Effective Specific Gravity of Aggregate  
 Gb = Specific Gravity of Asphalt Cement

**Table B2: SMA Mix Designs for NMA SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary (Continued)**  
**Mix: 4.75 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

**GRADATION D--32% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:									
AC Sp. Gr. (G <sub>b</sub> ) = 1.028			Apparent Sp. Gr. of Agg. (G <sub>sa</sub> ) = 2.963		Effective Sp. Gr. of Agg. (G <sub>se</sub> ) = 2.875		Bulk Sp. Gr. of Agg. (G <sub>sb</sub> ) = 2.887			Percent Coarse Aggregate: 68			Bulk Specific Gravity of CA (G <sub>ca</sub> ): 2.888				DATE: 10-Feb-99	
			Unit wt. of CA in DRC (pcf): 95.2								Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1525.0							
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (G <sub>mb</sub> )	TMD (G <sub>mm</sub> )	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-IJ)	(100-K)	100(O-N)				
						(F-E)	(F-E)		(G <sub>sb</sub> )	(G <sub>b</sub> )				O				
4/2-D1	6.0	110.4	4595.1	2691.9	4624.6	1932.7	2.378	2.595	77.4	13.9	148.4	8.4	22.6	62.9	47.4	47.1	1.005	
4/2-D2	6.0	109.7	4562.0	2685.2	4605.1	1919.9	2.376	2.595	77.4	13.9	148.3	8.4	22.6	62.7	47.4	47.1	1.006	
4/2-D3	6.0	110.6	4563.5	2696.2	4623.9	1927.7	2.367	2.595	77.1	13.9	147.7	8.8	22.9	61.7	47.6	47.1	1.010	
AVG												8.5	22.7	62.5	47.5	47.1	1.007	
Computed By: G. FLOWERS			Checked By: T. LYNN															
SSD = Saturated Surface Dry			gm = gram			pcf = pounds per cubic foot			G <sub>mb</sub> = Bulk Specific Gravity of Compacted Mix			G <sub>sb</sub> = Bulk Specific Gravity of Aggregate						
Sp. Gr. = Specific Gravity			cc = cubic centimeter			in = inches			G <sub>mm</sub> = Theoretical Maximum Specific Gravity of Mix			G <sub>se</sub> = Effective Specific Gravity of Aggregate						
TMD = Theoretical Maximum Density			AC = Asphalt Cement						G <sub>sa</sub> = Apparent Specific Gravity of Aggregate			G <sub>b</sub> = Specific Gravity of Asphalt Cement						

**Table B3: SMA Mix Designs for NMA SubTask  
National Center for Asphalt Technology**

**SMA Mix Design Summary**

**Mix: 4.75 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

**OPTIMUM GRADATION - - 31% Passing 2.36 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:				Percent Coarse Aggregate:			DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.963		Effective Sp. Gr. of Agg. (Gse) = 2.925		Bulk Sp. Gr. of Agg. (Gsb) = 2.887						69			10-Feb-99	
													2.888				
													95.20				
													1525.0				
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N)			
							(F-E)		(Gsb)	(Gb)				O			
5.5-1	5.5	110.5	4547.6	2700.6	4623.8	1923.2	2.365	2.656	77.4	12.7	147.6	11.0	22.6	51.5	46.6	47.1	0.989
5.5-2	5.5	111.1	4547.6	2682.1	4621.9	1939.8	2.344	2.656	76.7	12.5	146.3	11.7	23.3	49.6	47.1	47.1	0.998
5.5-3	5.5	110.5	4542.6	2677.0	4601.9	1924.9	2.360	2.656	77.2	12.6	147.3	11.1	22.8	51.0	46.7	47.1	0.991
AVG												11.3	22.9	50.7	46.8	47.1	0.993
6.0-1	6.0	110.1	4566.6	2670.7	4591.7	1921.0	2.377	2.634	77.4	13.9	148.3	9.7	22.6	56.9	46.6	47.1	0.989
6.0-2	6.0	110.2	4564.8	2675.4	4596.2	1920.8	2.377	2.634	77.4	13.9	148.3	9.8	22.6	56.8	46.6	47.1	0.989
6.0-3	6.0	109.8	4568.6	2678.3	4591.0	1912.7	2.389	2.634	77.8	13.9	149.0	9.3	22.2	58.1	46.4	47.1	0.983
AVG												9.6	22.5	57.2	46.5	47.1	0.987
6.5-1	6.5	109.4	4581.5	2684.8	4591.5	1906.7	2.403	ERR	77.8	15.2	149.9	ERR	22.2	ERR	46.3	47.1	0.983
6.5-2	6.5	110.0	4587.8	2686.3	4603.1	1916.8	2.393	ERR	77.5	15.1	149.4	ERR	22.5	ERR	46.5	47.1	0.987
6.5-3	6.5	108.8	4578.3	2685.0	4585.1	1900.1	2.410	ERR	78.0	15.2	150.4	ERR	22.0	ERR	46.2	47.1	0.979
AVG												ERR	22.2	ERR	46.3	47.1	0.983
7.0-1	7.0	109.2	4621.5	2725.3	4627.0	1901.7	2.430	2.591	78.3	16.5	151.6	6.2	21.7	71.4	46.0	47.1	0.976
7.0-2	7.0	109.6	4607.3	2706.0	4614.6	1908.6	2.414	2.591	77.8	16.4	150.6	6.8	22.2	69.3	46.4	47.1	0.983
7.0-3	7.0	109.9	4608.9	2704.1	4617.8	1913.7	2.408	2.591	77.6	16.4	150.3	7.0	22.4	68.6	46.5	47.1	0.986
AVG												6.7	22.1	69.8	46.3	47.1	0.982
7.5-1	7.5	108.4	4596.6	2707.8	4601.0	1893.2	2.428	2.570	77.8	17.7	151.5	5.5	22.2	75.1	46.3	47.1	0.983
7.5-2	7.5	107.7	4548.9	2675.0	4553.6	1878.6	2.421	2.570	77.6	17.7	151.1	5.8	22.4	74.2	46.5	47.1	0.986
7.5-3	7.5	107.8	4580.8	2707.2	4586.7	1879.5	2.437	2.570	78.1	17.8	152.1	5.2	21.9	76.4	46.1	47.1	0.979
AVG												5.5	22.2	75.2	46.3	47.1	0.983

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B4: SMA Mix Designs for NMA SubTask**  
**National Center for Asphalt Technology**  
**SMA Mix Design Summary (Continued)**  
**Mix: 4.75 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

**OPTIMUM GRADATION - - 31% Passing 2.36 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:				Percent Coarse Aggregate: 69			DATE: 10-Feb-99	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.963		Effective Sp. Gr. of Agg. (Gse) = 2.922		Bulk Sp. Gr. of Agg. (Gsb) = 2.887		Bulk Specific Gravity of CA (Gca): 2.888				Unit wt. of CA in DRC (pcf): 95.20		Unit wt. of CA in DRC (kg/m3): 1525.0		
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D (F-E)	J	(100-B) x I (Gsb)	B x I (Gb)	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N) O			
8.0-1	8.0	109.6	4656.4	2748.7	4661.0	1912.3	2.435	2.547	77.6	18.9	151.9	4.4	22.4	80.4	46.5	47.1	0.986
8.0-2	8.0	109.4	4635.4	2728.4	4639.3	1910.9	2.426	2.547	77.3	18.9	151.4	4.8	22.7	79.0	46.7	47.1	0.990
8.0-3	8.0	109.7	4631.2	2723.5	4635.9	1912.4	2.422	2.547	77.2	18.8	151.1	4.9	22.8	78.4	46.8	47.1	0.992
AVG												4.7	22.6	79.3	46.6	47.1	0.989
8.5-1	8.5	109.6	4661.5	2754.6	4664.6	1910.0	2.441	2.527	77.4	20.2	152.3	3.4	22.6	84.9	46.6	47.1	0.989
8.5-2	8.5	109.7	4666.5	2759.4	4670.7	1911.3	2.442	2.527	77.4	20.2	152.4	3.4	22.6	85.0	46.6	47.1	0.989
8.5-3	8.5	109.3	4655.1	2755.0	4658.9	1903.9	2.445	2.527	77.5	20.2	152.6	3.2	22.5	85.6	46.5	47.1	0.987
AVG												3.3	22.6	85.2	46.6	47.1	0.989
9.0-1	9.0	109.4	4665.7	2758.5	4668.2	1909.7	2.443	2.507	77.0	21.4	152.5	2.5	23.0	88.9	46.9	47.1	0.994
9.0-2	9.0	109.3	4678.9	2773.1	4681.6	1908.5	2.452	2.507	77.3	21.5	153.0	2.2	22.7	90.3	46.7	47.1	0.991
9.0-3	9.0	109.5	4664.1	2754.1	4667.8	1913.7	2.437	2.507	76.8	21.3	152.1	2.8	23.2	88.0	47.0	47.1	0.997
AVG												2.5	23.0	89.1	46.9	47.1	0.994

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry      gm = gram      pcf = pounds per cubic foot      Gmb = Bulk Specific Gravity of Compacted Mix      Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity      cc = cubic centimeter      in = inches      Gmm = Theoretical Maximum Specific Gravity of Mix      Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density      AC = Asphalt Cement      Gsa = Apparent Specific Gravity of Aggregate      Gb = Specific Gravity of Asphalt Cement

**Table B5: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Optimum Mix Summary**  
**Mix: 4.75 mm Nominal Maximum Size/ 2.36 mm Break Point Sieve**

**OPTIMUM GRADATION - - 31% Passing 2.36 mm Sieve/OPTIMUM ASPHALT CONTENT- - 8.3%**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:										
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.963		Effective Sp. Gr. of Agg. (Gse) = 2.925		Bulk Sp. Gr. of Agg. (Gsb) = 2.887		Percent Coarse Aggregate: 69			Bulk Specific Gravity of CA (Gca): 2.888			Unit wt. of CA in DRC (pcf): 95.20			DATE: 10-Feb-99	
			Unit wt. of CA in DRC (kg/m3): 1525.0																
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	$\frac{D}{(F-E)}$		$\frac{(100-B) \times I}{(Gsb)}$	$\frac{B \times I}{(Gb)}$	(I x 62.4)	100(1-I/J)	(100-K)	$\frac{100(O-N)}{O}$					
RUT 1	8.3	75.0	3214.3	1906.1	3216.0	1309.9	2.454	ERR	77.9	19.8	153.1	ERR	22.1	ERR	46.2	47.1	0.981		
RUT 2	8.3	75.0	3201.3	1897.3	3206.8	1309.5	2.445	ERR	77.7	19.7	152.5	ERR	22.3	ERR	46.4	47.1	0.985		
RUT 3	8.3	75.1	3197.3	1893.0	3199.3	1306.3	2.448	ERR	77.7	19.8	152.7	ERR	22.3	ERR	46.4	47.1	0.984		
RUT 4	8.3	74.6	3195.2	1898.7	3197.4	1298.7	2.460	ERR	78.1	19.9	153.5	ERR	21.9	ERR	46.1	47.1	0.978		
RUT 5	8.3	75.0	3200.7	1898.0	3202.5	1304.5	2.454	ERR	77.9	19.8	153.1	ERR	22.1	ERR	46.2	47.1	0.981		
RUT 6	8.3	75.1	3199.3	1893.6	3201.2	1307.6	2.447	ERR	77.7	19.8	152.7	ERR	22.3	ERR	46.4	47.1	0.984		
RUT 7	8.3	75.0	3200.8	1898.0	3202.6	1304.6	2.453	ERR	77.9	19.8	153.1	ERR	22.1	ERR	46.2	47.1	0.981		
RUT 8	8.3	75.0	3198.4	1894.7	3200.3	1305.6	2.450	ERR	77.8	19.8	152.9	ERR	22.2	ERR	46.3	47.1	0.983		
AVG												ERR	22.1	ERR	46.3	47.1	0.982		
10-1																			
10-2																			
AVG																			
30-1																			
30-2																			
AVG																			
50-1																			
50-2																			
AVG																			

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B6: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary**  
**Mix: 4.75 mm Nominal Maximum Size/1.18 mm Break Point Sieve**

**GRADATION A--20% Passing 1.18 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate: 80		DATE: 10-Feb-99		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.960		Effective Sp. Gr. of Agg. (Gse) = 2.881		Bulk Sp. Gr. of Agg. (Gsb) = 2.887								Bulk Specific Gravity of CA (Gca): 2.888			
															Unit wt. of CA in DRC (pcf): 96.9			
															Unit wt. of CA in DRC (kg/m3): 1552.2			
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	$\frac{D}{(F-E)}$		$\frac{(100-B) \times I}{(Gsb)}$	$\frac{B \times I}{(Gb)}$	(I x 62.4)	$\frac{100(1-I/J)}{(100-K)}$	$\frac{100(O-N)}{O}$					
4/1-A1	6.0	116.5	4659.4	2708.3	4735.8	2027.5	2.298	2.600	74.8	13.5	143.4	11.6	25.2	53.9	40.2	46.2	0.869	
4/1-A2	6.0	116.5	4664.3	2710.1	4748.7	2038.6	2.288	2.600	74.5	13.4	142.8	12.0	25.5	52.9	40.4	46.2	0.875	
4/1-A3	6.0	116.7	4661.5	2711.0	4751.9	2040.9	2.284	2.600	74.4	13.4	142.5	12.2	25.6	52.6	40.5	46.2	0.877	
AVG												11.9	25.4	53.1	40.4	46.2	0.874	

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gsb = Bulk Specific Gravity of Aggregate Gca = Bulk Specific Gravity of CA Gcb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 1.18 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate: 76		DATE: 10-Feb-99		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.960		Effective Sp. Gr. of Agg. (Gse) = 2.889		Bulk Sp. Gr. of Agg. (Gsb) = 2.887								Bulk Specific Gravity of CA (Gca): 2.888			
															Unit wt. of CA in DRC (pcf): 97.2			
															Unit wt. of CA in DRC (kg/m3): 1557.0			
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	$\frac{D}{(F-E)}$		$\frac{(100-B) \times I}{(Gsb)}$	$\frac{B \times I}{(Gb)}$	(I x 62.4)	$\frac{100(1-I/J)}{(100-K)}$	$\frac{100(O-N)}{O}$					
4/1-B1	6.0	113.9	4674.2	2725.2	4718.1	1992.9	2.345	2.606	76.4	13.7	146.4	10.0	23.6	57.7	42.0	46.0	0.912	
4/1-B2	6.0	113.7	4666.7	2722.8	4713.6	1990.8	2.344	2.606	76.3	13.7	146.3	10.0	23.7	57.6	42.0	46.0	0.913	
4/1-B3	6.0	113.6	4666.6	2721.9	4709.5	1987.6	2.348	2.606	76.4	13.7	146.5	9.9	23.6	57.9	41.9	46.0	0.911	
AVG												10.0	23.6	57.7	42.0	46.0	0.912	

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gsb = Bulk Specific Gravity of Aggregate Gca = Bulk Specific Gravity of CA Gcb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 1.18 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate: 72		DATE: 10-Feb-99		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.960		Effective Sp. Gr. of Agg. (Gse) = 2.889		Bulk Sp. Gr. of Agg. (Gsb) = 2.887								Bulk Specific Gravity of CA (Gca): 2.888			
															Unit wt. of CA in DRC (pcf): 96.5			
															Unit wt. of CA in DRC (kg/m3): 1545.8			
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	$\frac{D}{(F-E)}$		$\frac{(100-B) \times I}{(Gsb)}$	$\frac{B \times I}{(Gb)}$	(I x 62.4)	$\frac{100(1-I/J)}{(100-K)}$	$\frac{100(O-N)}{O}$					
4/1-C1	6.0	111.8	4666.2	2743.3	4699.4	1956.1	2.385	2.606	77.7	13.9	148.9	8.5	22.3	62.1	44.1	46.4	0.950	
4/1-C2	6.0	112.0	4712.9	2777.4	4737.4	1960.0	2.405	2.606	78.3	14.0	150.0	7.7	21.7	64.4	43.6	46.4	0.940	
4/1-C3	6.0	112.2	4718.8	2780.4	4741.8	1961.4	2.406	2.606	78.3	14.0	150.1	7.7	21.7	64.5	43.6	46.4	0.940	
AVG												8.0	21.9	63.7	43.8	46.4	0.943	

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gsb = Bulk Specific Gravity of Aggregate Gca = Bulk Specific Gravity of CA Gcb = Specific Gravity of Asphalt Cement

**Table B7: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary (continued)**  
**Mix: 4.75 mm Nominal Maximum Size/1.18 mm Break Point Sieve**

**GRADATION C2--28% Passing 1.18 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:				Percent Coarse Aggregate:			DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.960		Effective Sp. Gr. of Agg. (Gse) = 2.889		Bulk Sp. Gr. of Agg. (Gsb) = 2.887						Bulk Specific Gravity of CA (Gca): 2.888			72	10-Feb-99
													Unit wt. of CA in DRC (pcf): 96.5			2.888	
													Unit wt. of CA in DRC (kg/m3): 1545.8			1545.8	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N)			
							(F-E)		(Gsb)	(G)				O			
4/I-C2-1	6.0	111.0	4662.9	2736.4	4685.0	1948.6	2.393	2.606	77.9	14.0	149.3	8.2	22.1	63.0	43.9	46.4	0.946
4/I-C2-2	6.0	110.7	4660.8	2740.8	4678.9	1938.1	2.405	2.606	78.3	14.0	150.1	7.7	21.7	64.4	43.6	46.4	0.940
4/I-C2-3	6.0	111.0	4662.7	2736.0	4681.5	1945.5	2.397	2.606	78.0	14.0	149.6	8.0	22.0	63.4	43.8	46.4	0.944
AVG												8.0	21.9	63.6	43.8	46.4	0.944

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gsb = Bulk Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION D--32% Passing 1.18 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:				Percent Coarse Aggregate:			DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.960		Effective Sp. Gr. of Agg. (Gse) = 2.890		Bulk Sp. Gr. of Agg. (Gsb) = 2.887						Bulk Specific Gravity of CA (Gca): 2.888			68	10-Feb-99
													Unit wt. of CA in DRC (pcf): 97.2			2.888	
													Unit wt. of CA in DRC (kg/m3): 1557.0			1557.0	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N)			
							(F-E)		(Gsb)	(G)				O			
4/I-D1	6.0	108.8	4667.3	2769.8	4675.4	1905.6	2.449	2.606	79.7	14.3	152.8	6.0	20.3	70.3	45.8	46.0	0.995
4/I-D2	6.0	109.0	4669.8	2769.2	4679.9	1910.7	2.444	2.606	79.6	14.3	152.5	6.2	20.4	69.6	45.9	46.0	0.997
4/I-D3	6.0	108.7	4663.5	2769.3	4673.1	1903.8	2.450	2.606	79.8	14.3	152.9	6.0	20.2	70.3	45.8	46.0	0.995
AVG												6.1	20.3	70.1	45.8	46.0	0.996

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gsb = Bulk Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B8: SMA Mix Designs for NMA SubTask**  
**National Center for Asphalt Technology**  
**SMA Mix Design Summary**

**Mix: 4.75 mm Nominal Maximum Size/1.18 mm Break Point Sieve**

**OPTIMUM GRADATION - - 32% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:				Percent Coarse Aggregate: 68			DATE: 10-Feb-99	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.960		Effective Sp. Gr. of Agg. (Gse) = 2.932		Bulk Sp. Gr. of Agg. (Gsb) = 2.887		Bulk Specific Gravity of CA (Gca): 2.888				Unit wt. of CA in DRC (pcf): 97.2				
									Unit wt. of CA in DRC (kg/m3): 1557.0								
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA d
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D (F-E)		(100-B) x I (Gsb)	B x I (Gb)	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N) O			
5.5-1	5.5	109.3	4654.6	2767.5	4681.2	1913.7	2.432	2.661	79.6	13.0	151.8	8.6	20.4	57.8	45.9	46.0	0.997
5.5-2	5.5	109.6	4640.2	2749.2	4673.4	1924.2	2.411	2.661	78.9	12.9	150.5	9.4	21.1	55.5	46.3	46.0	1.007
5.5-3	5.5	109.7	4635.7	2744.5	4667.3	1922.8	2.411	2.661	78.9	12.9	150.4	9.4	21.1	55.4	46.4	46.0	1.007
AVG												9.1	20.8	56.2	46.2	46.0	1.003
4/1-D1	6.0	108.8	4667.3	2769.8	4675.4	1905.6	2.449	2.639	79.7	14.3	152.8	7.2	20.3	64.5	45.8	46.0	0.995
4/1-D2	6.0	109.0	4669.8	2769.2	4679.9	1910.7	2.444	2.639	79.6	14.3	152.5	7.4	20.4	63.8	45.9	46.0	0.997
4/1-D3	6.0	108.7	4663.5	2769.3	4673.1	1903.8	2.450	2.639	79.8	14.3	152.9	7.2	20.2	64.5	45.8	46.0	0.995
AVG												7.3	20.3	64.3	45.8	46.0	0.996
6.5-1	6.5	109.6	4672.0	2764.1	4682.8	1918.7	2.435	2.617	78.9	15.4	151.9	7.0	21.1	67.1	46.4	46.0	1.008
6.5-2	6.5	109.2	4696.1	2792.0	4703.1	1911.1	2.457	2.617	79.6	15.5	153.3	6.1	20.4	70.1	45.9	46.0	0.997
6.5-3	6.5	109.5	4695.1	2788.5	4703.8	1915.3	2.451	2.617	79.4	15.5	153.0	6.3	20.6	69.3	46.0	46.0	1.000
AVG												6.5	20.7	68.8	46.1	46.0	1.002
7.0-1	7.0	108.4	4720.5	2810.4	4723.9	1913.5	2.467	2.596	79.5	16.8	153.9	5.0	20.5	75.8	46.0	46.0	0.999
7.0-2	7.0	108.9	4717.2	2822.4	4720.3	1897.9	2.485	2.596	80.1	16.9	155.1	4.3	19.9	78.6	45.6	46.0	0.990
7.0-3	7.0	108.9	4726.2	2820.8	4730.2	1909.4	2.475	2.596	79.7	16.9	154.5	4.7	20.3	77.0	45.8	46.0	0.995
AVG												4.6	20.2	77.2	45.8	46.0	0.995
7.5-1	7.5	109.1	4746.4	2842.9	4749.3	1906.4	2.490	2.575	79.8	18.2	155.4	3.3	20.2	83.6	45.8	46.0	0.994
7.5-2	7.5	108.5	4749.2	2846.0	4751.4	1905.4	2.492	2.575	79.9	18.2	155.5	3.2	20.1	84.1	45.7	46.0	0.993
7.5-3	7.5	109.3	4734.3	2837.0	4736.3	1899.3	2.493	2.575	79.9	18.2	155.5	3.2	20.1	84.1	45.7	46.0	0.993
AVG												3.2	20.2	83.9	45.7	46.0	0.993

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B9: SMA Mix Designs for NMA SubTask**  
**National Center for Asphalt Technology**  
**SMA Optimum Mix Summary**

**Mix: 4.75 mm Nominal Maximum Size/1.18 mm Break Point Sieve**

**OPTIMUM GRADATION - - 32% Passing 1.18 mm Sieve/OPTIMUM ASPHALT CONTENT- - 7.3%**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose					COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			68	DATE:	
AC Sp. Gr. (G <sub>b</sub> ) = 1.028			Apparent Sp. Gr. of Agg. (G <sub>sa</sub> ) = 2.960		Effective Sp. Gr. of Agg. (G <sub>se</sub> ) = 2.932		Bulk Sp. Gr. of Agg. (G <sub>sb</sub> ) = 2.887			Bulk Specific Gravity of CA (G <sub>ca</sub> ): 2.888			Unit wt. of CA in DRC (pcf): 97.2			1557.0		10-Feb-99
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (G <sub>mb</sub> )	TMD (G <sub>mm</sub> )	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D (F-E)		$\frac{(100-B) \times I}{G_{sb}}$	$\frac{B \times I}{G_b}$	(I x 62.4)	100(1-I/J)	(100-K)	$\frac{100(O-N)}{O}$				
RUT 1	7.3	74.9	3244.9	1939.3	3249.5	1310.2	2.477	2.583	79.5	17.6	154.5	4.1	20.5	79.9	45.9	46.0	0.998	
RUT 2	7.3	75.0	3251.6	1945.4	3255.2	1309.8	2.483	2.583	79.7	17.6	154.9	3.9	20.3	80.8	45.8	46.0	0.995	
RUT 3	7.3	75.0	3240.0	1931.0	3242.3	1311.3	2.471	2.583	79.3	17.5	154.2	4.3	20.7	79.0	46.1	46.0	1.001	
RUT 4	7.3	75.0	3242.9	1933.8	3245.4	1311.6	2.472	2.583	79.4	17.6	154.3	4.3	20.6	79.2	46.0	46.0	1.000	
RUT 5	7.3	75.0	3230.5	1924.8	3232.4	1307.6	2.471	2.583	79.3	17.5	154.2	4.4	20.7	78.9	46.1	46.0	1.001	
RUT 6	7.3	75.0	3241.6	1931.7	3246.3	1314.6	2.466	2.583	79.2	17.5	153.9	4.5	20.8	78.2	46.2	46.0	1.003	
RUT 7	7.3	75.0	3242.5	1933.5	3244.1	1310.6	2.474	2.583	79.4	17.6	154.4	4.2	20.6	79.5	46.0	46.0	0.999	
RUT 8	7.3	75.0	3241.5	1931.2	3244.0	1312.8	2.469	2.583	79.3	17.5	154.1	4.4	20.7	78.7	46.1	46.0	1.002	
AVG												4.3	20.6	* 79.3	* 46.0	46.0	1.000	
10-1	7.3	82.7	3208.3	1834.0	3279.8	1445.8	2.219	2.583	71.3	15.8	138.5	14.1	28.7	51.0	51.6	46.0	1.120	
10-1	7.3	82.5	3218.3	1838.5	3280.4	1441.9	2.232	2.583	71.7	15.8	139.3	13.6	28.3	52.0	51.3	46.0	1.114	
AVG							2.226	2.583	71.5	15.8		13.8	28.5	* 51.5	51.4	46.0	1.117	
30-1	7.3	78.6	3217.8	1852.3	3231.7	1379.4	2.333	2.583	74.9	16.6	145.6	9.7	25.1	61.4	49.1	46.0	1.066	
30-1	7.3	79.0	3222.0	1858.5	3240.1	1381.6	2.332	2.583	74.9	16.6	145.5	9.7	25.1	61.3	49.1	46.0	1.067	
AVG							2.332	2.583	74.9	16.6		9.7	25.1	* 61.4	49.1	46.0	1.066	
50-1	7.3	77.4	3212.4	1873.8	3217.8	1344.0	2.390	2.583	76.7	17.0	149.1	7.5	23.3	67.9	47.8	46.0	1.039	
50-1	7.3	77.3	3216.9	1878.6	3222.9	1344.3	2.393	2.583	76.8	17.0	149.3	7.4	23.2	68.2	47.8	46.0	1.038	
AVG							2.392	2.583	76.8	17.0		7.4	23.2	* 68.1	47.8	46.0	1.038	

Computed By: G. FLOWERS Checked By: T. LYNN

SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B10: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary**  
**Mix: 9.5 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

**GRADATION A--20% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcico/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.972		Effective Sp. Gr. of Agg. (Gse) = 2.955		Bulk Sp. Gr. of Agg. (Gsb) = 2.907								Bulk Specific Gravity of CA (Gca): 2.960			05-Aug-98
			Unit wt. of CA in DRC (pcf): 102.0											Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1633.9				
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N)				
						(F-E)	D		(Gsb)	(Gb)				O				
9/4 A1	6.0	119.4	4827.4	2845.4	4865.8	2020.4	2.389	2.656	77.3	14.0	149.1	10.0	22.7	55.8	39.3	44.7	0.878	
9/4 A2	6.0	118.2	4834.2	2842.1	4864.1	2022.0	2.391	2.656	77.3	14.0	149.2	10.0	22.7	56.0	39.3	44.7	0.877	
9/4 A3	6.0	119.2	4842.3	2844.7	4876.6	2031.9	2.383	2.656	77.1	14.0	148.7	10.3	22.9	55.2	39.5	44.7	0.882	
AVG												10.1	22.8	55.7	39.3	44.7	0.879	

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcico/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.971		Effective Sp. Gr. of Agg. (Gse) = 2.957		Bulk Sp. Gr. of Agg. (Gsb) = 2.906								Bulk Specific Gravity of CA (Gca): 2.960			05-Aug-98
			Unit wt. of CA in DRC (pcf): 102.0											Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1633.9				
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N)				
						(F-E)	D		(Gsb)	(Gb)				O				
9/4 B1	6.0	117.6	4904.4	2912.1	4930.1	2018.0	2.430	2.658	78.6	14.2	151.7	8.6	21.4	60.0	41.3	44.7	0.924	
9/4 B2	6.0	116.5	4878.0	2900.9	4894.5	1993.6	2.447	2.658	79.1	14.3	152.7	7.9	20.9	62.0	40.9	44.7	0.915	
9/4 B3	6.0	117.8	4862.7	2894.6	4898.5	2003.9	2.427	2.658	78.5	14.2	151.4	8.7	21.5	59.6	41.4	44.7	0.926	
AVG												8.4	21.3	60.5	41.2	44.7	0.922	

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcico/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.971		Effective Sp. Gr. of Agg. (Gse) = 2.948		Bulk Sp. Gr. of Agg. (Gsb) = 2.905								Bulk Specific Gravity of CA (Gca): 2.960			05-Aug-98
			Unit wt. of CA in DRC (pcf): 102.0											Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1633.9				
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N)				
						(F-E)	D		(Gsb)	(Gb)				O				
9/4 C1	6.0	112.2	4870.7	2955.4	4879.4	1924.0	2.532	2.651	81.9	14.8	158.0	4.5	18.1	75.2	42.1	44.7	0.941	
9/4 C2	6.0	112.4	4846.9	2940.5	4858.4	1917.9	2.527	2.651	81.7	14.8	157.7	4.7	18.3	74.5	42.2	44.7	0.943	
9/4 C3	6.0	112.6	4881.8	2956.0	4892.6	1936.6	2.521	2.651	81.5	14.7	157.3	4.9	18.5	73.4	42.4	44.7	0.947	
AVG												4.7	18.3	74.4	42.2	44.7	0.944	

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B11: SMA Mix Designs for NMA SubTask**

**National Center for Asphalt Technology**

**SMA Trial Gradation Summary**

**Mix: 9.5 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

**GRADATION A--32% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:											
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.972		Effective Sp. Gr. of Agg. (Gse) = 2.955		Bulk Sp. Gr. of Agg. (Gsb) = 2.907		Percent Coarse Aggregate: 68				Bulk Specific Gravity of CA (Gca): 2.960		Unit wt. of CA in DRC (pcf): 102.0		Unit wt. of CA in DRC (kg/m3): 1633.9		DATE: 05-Aug-98	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc			
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S			
						(F-E)	$\frac{D}{(F-E)}$		$\frac{(100-B) \times I}{(Gsb)}$	$\frac{B \times I}{(Gb)}$	(I x 62.4)	100(I-I/J)	(100-K)	$\frac{100(O-N)}{O}$						
9/4 D1	6.0	111.3	4904.4	3003.5	4911.5	1908.0	2.570	2.629	83.1	15.0	160.4	2.2	16.9	86.8	44.5	44.7	0.994			
9/4 D2	6.0	109.8	4862.0	2980.4	4866.5	1886.1	2.578	2.629	83.4	15.1	160.9	1.9	16.6	88.3	44.3	44.7	0.991			
9/4 D3	6.0	110.3	4867.7	2987.4	4873.7	1886.3	2.581	2.629	83.4	15.1	161.0	1.8	16.6	88.9	44.3	44.7	0.989			
AVG												2.0	16.7	88.0	44.4	44.7	0.992			

Computed By: G. FLOWERS	Checked By: T. LYNN			
SSD = Saturated Surface Dry	gm = gram	pcf = pounds per cubic foot	Gmb = Bulk Specific Gravity of Compacted Mix	Gsb = Bulk Specific Gravity of Aggregate
Sp. Gr. = Specific Gravity	cc = cubic centimeter	in = inches	Gmm = Theoretical Maximum Specific Gravity of Mix	Gse = Effective Specific Gravity of Aggregate
TMD = Theoretical Maximum Density	AC = Asphalt Cement		Gsa = Apparent Specific Gravity of Aggregate	Gb = Specific Gravity of Asphalt Cement

**Table B12: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Mix Design Summary**  
**Mix: 9.5 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

**OPTIMUM GRADATION - - 30% Passing 4.75 mm Sieve** **Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:								Percent Coarse Aggregate: 72		DATE: 05-Aug-98
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.972		Effective Sp. Gr. of Agg. (Gse) = 2.905		Bulk Sp. Gr. of Agg. (Gsb) = 2.904			Bulk Specific Gravity of CA (Gca): 2.960				Unit wt. of CA in DRC (pcf): 104.40				Unit wt. of CA in DRC (kg/m3): 1672.3	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES				VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D (F-E)		(100-B) x I (Gsb)	B x I (Gb)	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N) O					
5.5-1	5.5	112.7	4853.6	2947.5	4870.3	1922.8	2.524	2.640	82.1	13.5	157.5	4.4	17.9	75.5	42.0	43.4	0.966		
5.5-2	5.5	111.4	4856.8	2959.0	4865.4	1906.4	2.548	2.640	82.9	13.6	159.0	3.5	17.1	79.6	41.4	43.4	0.954		
5.5-3	5.5	112.2	4850.7	2954.5	4865.6	1911.1	2.538	2.640	82.6	13.6	158.4	3.8	17.4	77.9	41.7	43.4	0.959		
AVG												3.9	17.5	77.7	41.7	43.4	0.960		
6.0-1	6.0	110.8	4842.4	2953.2	4849.9	1896.7	2.553	2.618	82.6	14.9	159.3	2.5	17.4	85.7	41.6	43.4	0.958		
6.0-2	6.0	111.0	4852.8	2936.6	4857.9	1921.3	2.526	2.618	81.8	14.7	157.6	3.5	18.2	80.7	42.2	43.4	0.972		
6.0-3	6.0	111.2	4887.1	2989.7	4895.4	1905.7	2.564	2.618	83.0	15.0	160.0	2.0	17.0	88.0	41.4	43.4	0.952		
AVG												2.7	17.5	84.8	41.7	43.4	0.961		
6.5-1	6.5	108.6	4555.5	2790.3	4566.3	1776.0	2.565	2.597	82.6	16.2	160.1	1.2	17.4	93.0	41.7	43.4	0.959		
6.5-2	6.5	109.0	4579.4	2809.9	4594.7	1784.8	2.566	2.597	82.6	16.2	160.1	1.2	17.4	93.2	41.6	43.4	0.959		
6.5-3	6.5	108.4	4561.4	2791.0	4573.2	1782.2	2.559	2.597	82.4	16.2	159.7	1.4	17.6	91.9	41.8	43.4	0.962		
AVG												1.3	17.5	92.7	41.7	43.4	0.960		

Computed By: G. FLOWERS Checked By: T. LYNN

SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B13: SMA Mix Designs for NMA SubTask**  
**National Center for Asphalt Technology**  
**SMA Optimum Mix Summary**

**Mix: 9.5 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

**OPTIMUM GRADATION - - 30% Passing 4.75 mm Sieve/OPTIMUM ASPHALT CONTENT- - 5.6%**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:						Percent Coarse Aggregate: 72		DATE: 05-Aug-98		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.972		Effective Sp. Gr. of Agg. (Gse) = 2.905		Bulk Sp. Gr. of Agg. (Gsb) = 2.904								Bulk Specific Gravity of CA (Gca): 2.960				
																Unit wt. of CA in DRC (pcf): 104.40			
																Unit wt. of CA in DRC (kg/m3): 1672.3			
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D (F-E)		(100-B) x I (Gsb)	B x I (Gb)	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N) O					
RUT 1	5.6	75.0	3263.2	1987.5	3272.8	1285.3	2.539	2.635	82.4	13.8	158.4	3.7	17.6	79.1	41.7	44.7	0.932		
RUT 2	5.6	75.0	3256.4	1992.9	3267.3	1274.4	2.555	2.635	83.0	13.9	159.4	3.0	17.0	82.1	41.3	44.7	0.924		
RUT 3	5.6	75.0	3259.5	1996.0	3270.9	1274.9	2.557	2.635	83.0	13.9	159.5	3.0	17.0	82.4	41.3	44.7	0.923		
RUT 4	5.6	75.0	3262.5	1992.4	3271.1	1278.7	2.551	2.635	82.9	13.9	159.2	3.2	17.1	81.4	41.4	44.7	0.926		
RUT 5	5.6	75.0	3266.7	1999.0	3272.5	1273.5	2.565	2.635	83.3	14.0	160.1	2.7	16.7	84.0	41.1	44.7	0.918		
RUT 6	5.6	75.0	3265.3	1995.7	3270.7	1275.0	2.561	2.635	83.2	14.0	159.8	2.8	16.8	83.2	41.2	44.7	0.921		
RUT 7	5.6	75.0	3264.5	1997.2	3269.0	1271.8	2.567	2.635	83.4	14.0	160.2	2.6	16.6	84.4	41.1	44.7	0.918		
RUT 8	5.6	75.0	3266.2	1997.5	3272.9	1275.4	2.561	2.635	83.2	14.0	159.8	2.8	16.8	83.2	41.2	44.7	0.921		
AVG												3.0	17.0	82.5	41.3	44.7	0.923		
RUT 1A	5.6	75.6	3241.7	1977.5	3248.8	1271.3	2.550	2.635	82.8	13.9	159.1	3.2	17.2	81.1	41.4	44.7	0.926		
RUT 2A	5.6	75.1	3234.4	1970.6	3241.2	1270.6	2.546	2.635	82.7	13.9	158.8	3.4	17.3	80.4	41.5	44.7	0.929		
RUT 3A	5.6	75.0	3232.0	1969.6	3241.3	1271.7	2.541	2.635	82.5	13.8	158.6	3.6	17.5	79.6	41.6	44.7	0.931		
RUT 4A	5.6	75.0	3233.8	1975.5	3247.6	1272.1	2.542	2.635	82.6	13.8	158.6	3.5	17.4	79.7	41.6	44.7	0.930		
RUT 5A	5.6	75.0	3233.9	1965.8	3245.0	1279.2	2.528	2.635	82.1	13.8	157.8	4.1	17.9	77.3	42.0	44.7	0.938		
RUT 6A	5.6	75.0	3230.8	1965.8	3242.4	1276.6	2.531	2.635	82.2	13.8	157.9	4.0	17.8	77.7	41.9	44.7	0.936		
AVG												3.6	17.5	79.3	41.7	44.7	0.932		
10-1	5.6	79.8	3149.4	1904.6	3213.5	1308.9	2.406	2.635	78.1	13.1	150.1	8.7	21.9	60.2	44.7	44.7	1.000		
10-2	5.6	82.0	3163.1	1910.3	3239.0	1328.7	2.381	2.635	77.3	13.0	148.5	9.7	22.7	57.4	45.3	44.7	1.013		
AVG												9.2	22.3	58.8	45.0	44.7	1.007		
30-1	5.6	76.9	3153.2	1892.3	3184.3	1292.0	2.441	2.635	79.3	13.3	152.3	7.4	20.7	64.4	44.0	44.7	0.982		
30-2	5.6	77.8	3148.8	1896.1	3195.6	1299.5	2.423	2.635	78.7	13.2	151.2	8.1	21.3	62.2	44.4	44.7	0.991		
AVG												7.7	21.0	63.3	44.2	44.7	0.987		
50-1	5.6		3161.6	1913.9	3246.0	1332.1	2.373	2.635	77.1	12.9	148.1	9.9	22.9	56.6	45.5	44.7	1.017		
50-2	5.6	75.6	3137.2	1888.3	3163.8	1275.5	2.460	2.635	79.9	13.4	153.5	6.7	20.1	66.9	43.5	44.7	0.973		
AVG												8.3	21.5	61.8	44.5	44.7	0.995		

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B14: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary**  
**Mix: 9.5 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

**GRADATION A--20% Passing 2.36 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:						Percent Coarse Aggregate:		80	DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.967			Effective Sp. Gr. of Agg. (Gse) = 2.934			Bulk Sp. Gr. of Agg. (Gsb) = 2.899			Bulk Specific Gravity of CA (Gca): 2.960			Unit wt. of CA in DRC (pcf): 104.0		Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1665.9		05-Aug-98
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA dre (%)	VCA / VCA dre		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D	J	(100-B) x I	B x I	(I x 62.4)	100(1-J)	(100-K)	100(O-N)					
						(F-E)	(F-E)	(F-E)	(Gsb)	(Gsb)	(Gsb)	(Gsb)	(Gsb)	O					
9/2 A1	6.0	108.4	4653.5	2797.0	4661.0	1864.0	2.497	2.639	80.9	14.6	155.8	5.4	19.1	71.7	36.6	43.7	0.838		
9/2 A2	6.0	107.1	4649.7	2800.8	4654.9	1854.1	2.508	2.639	81.3	14.7	156.5	5.0	18.7	73.4	36.3	43.7	0.831		
9/2 A3	6.0	107.8	4661.0	2806.9	4667.3	1860.4	2.505	2.639	81.2	14.7	156.3	5.1	18.8	73.0	36.3	43.7	0.833		
AVG												5.1	18.8	72.7	36.4	43.7	0.834		

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 2.36 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:						Percent Coarse Aggregate:		76	DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.967			Effective Sp. Gr. of Agg. (Gse) = 2.925			Bulk Sp. Gr. of Agg. (Gsb) = 2.898			Bulk Specific Gravity of CA (Gca): 2.960			Unit wt. of CA in DRC (pcf): 104.0		Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1665.9		05-Aug-98
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA dre (%)	VCA / VCA dre		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D	J	(100-B) x I	B x I	(I x 62.4)	100(1-J)	(100-K)	100(O-N)					
						(F-E)	(F-E)	(F-E)	(Gsb)	(Gsb)	(Gsb)	(Gsb)	(Gsb)	O					
9/2 B1	6.0	105.5	4692.3	2861.3	4695.5	1834.2	2.558	2.632	83.0	14.9	159.6	2.8	17.0	83.6	38.3	43.7	0.876		
9/2 B2	6.0	105.7	4663.1	2848.9	4670.0	1821.1	2.561	2.632	83.0	14.9	159.8	2.7	17.0	84.0	38.2	43.7	0.875		
9/2 B3	6.0	105.6	4661.0	2838.4	4665.7	1827.3	2.551	2.632	82.7	14.9	159.2	3.1	17.3	82.1	38.4	43.7	0.880		
AVG												2.9	17.1	83.2	38.3	43.7	0.877		

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 2.36 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:						Percent Coarse Aggregate:		72	DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.966			Effective Sp. Gr. of Agg. (Gse) = 2.926			Bulk Sp. Gr. of Agg. (Gsb) = 2.897			Bulk Specific Gravity of CA (Gca): 2.960			Unit wt. of CA in DRC (pcf): 104.0		Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1665.9		05-Aug-98
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA dre (%)	VCA / VCA dre		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D	J	(100-B) x I	B x I	(I x 62.4)	100(1-J)	(100-K)	100(O-N)					
						(F-E)	(F-E)	(F-E)	(Gsb)	(Gsb)	(Gsb)	(Gsb)	(Gsb)	O					
9/2 C1	6.0	103.9	4646.2	2848.1	4649.6	1801.5	2.579	2.633	83.6	15.1	160.9	2.0	16.4	87.5	41.0	43.7	0.940		
9/2 C2	6.0	103.8	4639.8	2846.9	4644.5	1797.6	2.581	2.633	83.7	15.1	161.1	2.0	16.3	87.9	41.0	43.7	0.939		
9/2 C3	6.0	103.4	4632.9	2841.4	4636.9	1795.5	2.580	2.633	83.7	15.1	161.0	2.0	16.3	87.7	41.0	43.7	0.939		
AVG												2.0	16.3	87.7	41.0	43.7	0.939		

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B15: SMA Mix Designs for NMAS SubTask**

**National Center for Asphalt Technology**

**SMA Mix Design Summary**

**Mix: 9.5 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

**OPTIMUM GRADATION - - 23% Passing 2.36 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:								Percent Coarse Aggregate: 77	DATE: 05-Aug-98		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.967		Effective Sp. Gr. of Agg. (Gse) = 2.918		Bulk Sp. Gr. of Agg. (Gsb) = 2.898		Bulk Specific Gravity of CA (Gca): 2.960								Unit wt. of CA in DRC (pcf): 104.40		Unit wt. of CA in DRC (kg/m3): 1672.3	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc			
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S			
						(F-E)	D (F-E)		(100-B) x I (Gsb)	B x I (Gb)	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N) O						
5.5-1	5.5	106.3	4650.1	2825.7	4656.4	1830.7	2.540	2.650	82.8	13.6	158.5	4.2	17.2	75.8	37.6	43.4	0.864			
5.5-2	5.5	106.6	4660.5	2824.7	4666.1	1841.4	2.531	2.650	82.5	13.5	157.9	4.5	17.5	74.2	37.8	43.4	0.870			
5.5-3	5.5	106.2	4658.7	2824.6	4672.4	1847.8	2.521	2.650	82.2	13.5	157.3	4.9	17.8	72.6	38.0	43.4	0.875			
AVG												4.5	17.5	74.2	37.8	43.4	0.870			
6.0-1	6.0	106.3	4671.3	2845.7	4674.8	1829.1	2.554	2.628	82.8	14.9	159.4	2.8	17.2	83.5	37.6	43.4	0.864			
6.0-2	6.0	106.5	4648.4	2816.9	4651.9	1835.0	2.533	2.628	82.2	14.8	158.1	3.6	17.8	79.7	38.1	43.4	0.876			
6.1-3	6.0	107.2	4675.5	2835.2	4687.3	1852.1	2.524	2.628	81.9	14.7	157.5	4.0	18.1	78.2	38.3	43.4	0.881			
AVG												3.5	17.7	80.5	38.0	43.4	0.874			
6.5-1	6.5	108.6	4555.5	2790.3	4566.3	1776.0	2.565	2.607	82.8	16.2	160.1	1.6	17.2	90.7	37.6	43.4	0.866			
6.5-2	6.5	109.0	4579.4	2809.9	4594.7	1784.8	2.566	2.607	82.8	16.2	160.1	1.6	17.2	90.9	37.6	43.4	0.865			
6.5-3	6.5	108.4	4561.4	2791.0	4573.2	1782.2	2.559	2.607	82.6	16.2	159.7	1.8	17.4	89.6	37.7	43.4	0.869			
AVG												1.7	17.3	90.4	37.7	43.4	0.867			

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B16: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Optimum Mix Summary**  
**Mix: 9.5 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

**OPTIMUM GRADATION - - 23% Passing 2.36 mm Sieve/OPTIMUM ASPHALT CONTENT - - 5.8%**

**Troxler SGC: 100 Gyration**

PROJECT NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:										DATE: 05-Aug-98	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.967		Effective Sp. Gr. of Agg. (Gse) = 2.918		Bulk Sp. Gr. of Agg. (Gsb) = 2.898		Percent Coarse Aggregate: 77										Bulk Specific Gravity of CA (Gca): 2.960	
									Unit wt. of CA in DRC (pcf): 104.40										Unit wt. of CA in DRC (kg/m3): 1672.3	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS								
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc			
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S			
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N)						
							(F-E)		(Gsb)	(Gb)		O								
RUT 1	5.8	75.0	3272.1	1988.9	3278.1	1289.2	2.538	2.637	82.5	14.3	158.4	3.8	17.5	78.6	37.8	43.7	0.866			
RUT 2	5.8	75.0	3272.6	1989.6	3277.0	1287.4	2.542	2.637	82.6	14.3	158.6	3.6	17.4	79.3	37.7	43.7	0.864			
RUT 3	5.8	75.0	3271.6	1983.4	3275.5	1292.1	2.532	2.637	82.3	14.3	158.0	4.0	17.7	77.5	38.0	43.7	0.869			
RUT 4	5.8	75.0	3270.9	1987.2	3274.3	1287.1	2.541	2.637	82.6	14.3	158.6	3.6	17.4	79.2	37.7	43.7	0.864			
RUT 5	5.8	75.0	3266.7	1990.3	3274.5	1284.2	2.544	2.637	82.7	14.4	158.7	3.5	17.3	79.6	37.7	43.7	0.863			
RUT 6	5.8	75.0	3272.9	1992.3	3278.8	1286.5	2.544	2.637	82.7	14.4	158.7	3.5	17.3	79.6	37.7	43.7	0.863			
RUT 7	5.8	75.0	3284.4	2000.2	3288.7	1288.5	2.549	2.637	82.8	14.4	159.1	3.3	17.2	80.6	37.5	43.7	0.860			
RUT 8	5.8	75.0	3265.4	1981.7	3270.4	1288.7	2.534	2.637	82.3	14.3	158.1	3.9	17.7	77.8	37.9	43.7	0.868			
AVG												3.7	17.4	79.0	37.7	43.7	0.864			
10-1	5.8	80.8	3158.1	1894.7	3254.5	1359.8	2.322	2.637	75.5	13.1	144.9	11.9	24.5	51.4	43.1	43.7	0.987			
10-2	5.8	81.3	3141.0	1889.9	3241.0	1351.1	2.325	2.637	75.5	13.1	145.1	11.8	24.5	51.6	43.0	43.7	0.986			
AVG												11.9	24.5	51.5	43.1	43.7	0.986			
30-1	5.8	76.9	3155.7	1884.2	3198.3	1314.1	2.401	2.637	78.0	13.5	149.8	8.9	22.0	59.3	41.2	43.7	0.943			
30-2	5.8	76.4	3145.3	1878.1	3185.9	1307.8	2.405	2.637	78.1	13.6	150.1	8.8	21.9	59.7	41.1	43.7	0.941			
AVG												8.9	21.9	59.5	41.1	43.7	0.942			
50-1	4.8	75.0	3167.8	1897.2	3185.7	1288.5	2.459	2.637	80.7	11.5	153.4	6.8	19.3	64.9	39.1	43.7	0.896			
50-2	4.8	75.2	3162.8	1892.7	3190.5	1297.8	2.437	2.637	80.0	11.4	152.1	7.6	20.0	62.0	39.6	43.7	0.908			
AVG												7.2	19.6	63.4	39.4	43.7	0.902			

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B17: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary**  
**Mix: 12.5 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

**GRADATION A--20% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcico/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			80	DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.974		Effective Sp. Gr. of Agg. (Gse) = 2.947		Bulk Sp. Gr. of Agg. (Gsb) = 2.917								Bulk Specific Gravity of CA (Gca): 2.924		104.7	1677.1	05-Aug-98
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES					VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA dre (%)	VCA / VCA dre		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(1-IJ)	(100-K)	100(O-N)					
						(F-E)	(F-E)		(Gsb)	(Gb)			O						
1/9 A1	6.0	114.3	4445.6	2657.9	4498.7	1840.8	2.415	2.650	77.8	14.1	150.7	8.9	22.2	60.0	37.9	42.6	0.890		
1/9 A2	6.0	114.6	4573.7	2722.1	4609.3	1887.2	2.424	2.650	78.1	14.2	151.2	8.5	21.9	61.0	37.7	42.6	0.885		
1/9 A3	6.0	114.5	4496.3	2671.2	4534.5	1863.3	2.413	2.650	77.8	14.1	150.6	8.9	22.2	59.8	37.9	42.6	0.891		
AVG												8.8	22.1	60.3	37.8	42.6	0.888		

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcico/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			76	DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.973		Effective Sp. Gr. of Agg. (Gse) = 2.928		Bulk Sp. Gr. of Agg. (Gsb) = 2.916								Bulk Specific Gravity of CA (Gca): 2.924		104.7	1677.1	05-Aug-98
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES					VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA dre (%)	VCA / VCA dre		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(1-IJ)	(100-K)	100(O-N)					
						(F-E)	(F-E)		(Gsb)	(Gb)			O						
1/9 B1	6.0	112.2	4563.2	2738.8	4587.0	1848.2	2.469	2.636	79.6	14.4	154.1	6.3	20.4	69.0	39.7	42.6	0.932		
1/9 B2	6.0	111.9	4513.0	2670.9	4535.3	1864.4	2.421	2.636	78.0	14.1	151.0	8.2	22.0	62.9	40.9	42.6	0.959		
1/9 B3	6.0	111.2	4497.0	2686.9	4526.7	1839.8	2.444	2.636	78.8	14.3	152.5	7.3	21.2	65.7	40.3	42.6	0.946		
AVG												7.3	21.2	65.9	40.3	42.6	0.946		

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcico/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			72	DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.973		Effective Sp. Gr. of Agg. (Gse) = 2.928		Bulk Sp. Gr. of Agg. (Gsb) = 2.915								Bulk Specific Gravity of CA (Gca): 2.924		104.7	1677.1	05-Aug-98
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES					VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA dre (%)	VCA / VCA dre		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(1-IJ)	(100-K)	100(O-N)					
						(F-E)	(F-E)		(Gsb)	(Gb)			O						
1/9 C1	6.0	108.5	4548.6	2744.1	4566.4	1822.3	2.496	2.637	80.4	14.6	155.8	5.3	19.6	72.7	42.2	42.6	0.992		
1/9 C2	6.0	108.4	4530.0	2727.6	4547.7	1820.1	2.489	2.637	80.2	14.5	155.3	5.6	19.8	71.6	42.4	42.6	0.995		
1/9 C3	6.0	108.7	4570.9	2772.6	4589.7	1817.1	2.515	2.637	81.1	14.7	157.0	4.6	18.9	75.7	41.8	42.6	0.981		
AVG												5.2	19.4	73.3	42.1	42.6	0.989		

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement



**Table B19: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**

**SMA Mix Design Summary**

**Mix: 12.5 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

**OPTIMUM GRADATION - - 28% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:								DATE: 05-Aug-98	
AC Sp. Gr. (G <sub>b</sub> ) = 1.028			Apparent Sp. Gr. of Agg. (G <sub>sa</sub> ) = 2.975		Effective Sp. Gr. of Agg. (G <sub>se</sub> ) = 2.955		Bulk Sp. Gr. of Agg. (G <sub>sb</sub> ) = 2.915		Percent Coarse Aggregate: 72				Bulk Specific Gravity of CA (G <sub>ca</sub> ): 2.924		Unit wt. of CA in DRC (pcf): 104.7		Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1677.1	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	$\frac{D}{(F-E)}$		$\frac{(100-B) \times I}{(Gsb)}$	$\frac{B \times I}{(Gb)}$	(I x 62.4)	100(1-I/J)	(100-K)	$\frac{100(O-N)}{O}$				
1/9 C1	6.0	108.5	4548.6	2744.1	4566.4	1822.3	2.496	2.658	80.5	14.6	155.8	6.1	19.5	68.8	42.2	42.6	0.992	
1/9 C2	6.0	108.4	4530.0	2727.6	4547.7	1820.1	2.489	2.658	80.3	14.5	155.3	6.4	19.7	67.8	42.4	42.6	0.995	
1/9 C3	6.0	108.7	4570.9	2772.6	4589.7	1817.1	2.515	2.658	81.1	14.7	157.0	5.4	18.9	71.6	41.8	42.6	0.981	
AVG												5.9	19.4	69.4	42.1	42.6	0.989	
6.5-1	6.5	108.6	4521.4	2722.5	4537.2	1814.7	2.492	2.636	79.9	15.8	155.5	5.5	20.1	72.7	42.6	42.6	1.001	
6.5-2	6.5	108.0	4545.1	2741.5	4555.5	1814.0	2.506	2.636	80.4	15.8	156.3	4.9	19.6	74.8	42.3	42.6	0.994	
6.5-3	6.5	108.7	4520.2	2714.6	4535.4	1820.8	2.483	2.636	79.6	15.7	154.9	5.8	20.4	71.4	42.8	42.6	1.006	
AVG												5.4	20.0	73.0	42.6	42.6	1.000	
7.0-1	7.0	108.9	4503.5	2701.0	4522.3	1821.3	2.473	2.614	78.9	16.8	154.3	5.4	21.1	74.4	43.4	42.6	1.019	
7.0-2	7.0	108.5	4533.3	2728.8	4546.4	1817.6	2.494	2.614	79.6	17.0	155.6	4.6	20.4	77.5	42.9	42.6	1.007	
7.0-3	7.0	108.2	4518.0	2722.3	4530.5	1808.2	2.499	2.614	79.7	17.0	155.9	4.4	20.3	78.2	42.8	42.6	1.005	
AVG												4.8	20.6	76.7	43.0	42.6	1.010	

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry      gm = gram      pcf = pounds per cubic foot      Gmb = Bulk Specific Gravity of Compacted Mix      Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity      cc = cubic centimeter      in = inches      Gmm = Theoretical Maximum Specific Gravity of Mix      Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density      AC = Asphalt Cement      Gsa = Apparent Specific Gravity of Aggregate      Gb = Specific Gravity of Asphalt Cement



**Table B21: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Mix Design Summary 3**  
**Mix: 12.5 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

**OPTIMUM GRADATION - - 24% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:											
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.975		Effective Sp. Gr. of Agg. (Gse) = 2.955		Bulk Sp. Gr. of Agg. (Gsb) = 2.915			Percent Coarse Aggregate: 76			Bulk Specific Gravity of CA (Gca): 2.924				Unit wt. of CA in DRC (pcf): 104.7		DATE: 05-Aug-98	
			Unit wt. of CA in DRC (kg/m3): 1677.1																	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS								
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc			
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S			
						(F-E)	$\frac{D}{(F-E)}$		$\frac{(100-B) \times I}{(Gsb)}$	$\frac{B \times I}{(Gb)}$	(I x 62.4)	100(1-I/J)	(100-K)	$\frac{100(O-N)}{O}$						
1/9 B1	6.0	112.2	4563.2	2738.8	4587.0	1848.2	2.469	2.659	79.6	14.4	154.1	7.1	20.4	64.9	39.7	42.6	0.932			
1/9 B2	6.0	111.9	4513.0	2670.9	4535.3	1864.4	2.421	2.659	78.1	14.1	151.0	9.0	21.9	59.1	40.9	42.6	0.959			
1/9 B3	6.0	111.2	4497.0	2686.9	4526.7	1839.8	2.444	2.659	78.8	14.3	152.5	8.1	21.2	61.9	40.3	42.6	0.946			
AVG												8.1	21.2	62.0	40.3	42.6	0.946			
6.5-1C	6.5	110.6	4522.5	2710.6	4553.2	1842.6	2.454	2.637	78.7	15.5	153.2	6.9	21.3	67.5	40.4	42.6	0.948			
6.5-2C	6.5	111.7	4536.6	2699.0	4557.5	1858.5	2.441	2.637	78.3	15.4	152.3	7.4	21.7	65.8	40.7	42.6	0.955			
6.5-3C	6.5	111.4	4537.8	2702.3	4561.5	1859.2	2.441	2.637	78.3	15.4	152.3	7.4	21.7	65.7	40.7	42.6	0.955			
AVG												7.3	21.6	66.3	40.6	42.6	0.953			
7.0-1C	7.0	111.4	4525.6	2683.4	4543.9	1860.5	2.432	2.615	77.6	16.6	151.8	7.0	22.4	68.8	41.2	42.6	0.967			
7.0-2C	7.0	110.6	4514.3	2701.0	4534.0	1833.0	2.463	2.615	78.6	16.8	153.7	5.8	21.4	72.8	40.5	42.6	0.950			
7.0-3C	7.0	110.3	4436.0	2641.1	4463.4	1822.3	2.434	2.615	77.7	16.6	151.9	6.9	22.3	69.1	41.2	42.6	0.966			
AVG												6.6	22.1	70.2	40.9	42.6	0.961			

Computed By: G. FLOWERS Checked By: T. LYNN

SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B22: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Optimum Mix Summary**

**Mix: 12.5 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

**OPTIMUM GRADATION - - 26% Passing 9.5 mm Sieve/OPTIMUM ASPHALT CONTENT - - 8.0%**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:											
AC Sp. Gr. (G <sub>b</sub> ) = 1.028			Apparent Sp. Gr. of Agg. (G <sub>sa</sub> ) = 2.975		Effective Sp. Gr. of Agg. (G <sub>se</sub> ) = 2.955		Bulk Sp. Gr. of Agg. (G <sub>sb</sub> ) = 2.915		Percent Coarse Aggregate: 74				Bulk Specific Gravity of CA (G <sub>ca</sub> ): 2.924		Unit wt. of CA in DRC (pcf): 104.70		Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1677.1		DATE: 05-Aug-98	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc			
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S			
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N)						
						(F-E)			(Gsb)	(Gb)				O						
RUT 1	8.0	75.2	3048.5	1816.1	3061.3	1245.2	2.448	2.569	77.2	19.1	152.8	4.7	22.8	79.3	0.0	42.6	0.000			
RUT 2	8.0	75.2	3080.4	1844.5	3094.3	1249.8	2.465	2.569	77.7	19.2	153.8	4.1	22.3	81.7	42.6	42.6	1.001			
RUT 3	8.0	75.2	3084.1	1845.2	3090.6	1245.4	2.476	2.569	78.1	19.3	154.5	3.6	21.9	83.5	42.3	42.6	0.994			
RUT 4	8.0	75.2	3096.1	1854.2	3103.9	1249.7	2.477	2.569	78.1	19.3	154.6	3.6	21.9	83.6	42.3	42.6	0.994			
RUT 5	8.0	75.2	3086.7	1847.7	3095.5	1247.8	2.474	2.569	78.0	19.3	154.4	3.7	22.0	83.1	42.4	42.6	0.996			
RUT 6	8.0	75.2	3131.3	1877.1	3142.0	1264.9	2.476	2.569	78.1	19.3	154.5	3.7	21.9	83.3	42.4	42.6	0.995			
RUT 7	8.0	75.2	3105.4	1858.2	3113.6	1255.4	2.474	2.569	78.0	19.3	154.4	3.7	22.0	83.0	42.4	42.6	0.996			
RUT 8	8.0	75.2	3114.6	1870.6	3121.3	1250.7	2.490	2.569	78.5	19.4	155.4	3.1	21.5	85.6	42.0	42.6	0.987			
AVG												3.8	22.0	82.9	*	37.1	42.6	0.870		
10-1	8.0	84.1	3169.5	1855.7	3206.8	1351.1	2.346	2.569	74.0	18.3	146.4	8.7	26.0	66.6	45.4	42.6	1.066			
10-2	8.0	85.2	3177.6	1871.0	3214.7	1343.7	2.365	2.569	74.6	18.4	147.6	8.0	25.4	68.7	44.9	42.6	1.055			
AVG												8.3	25.7	67.6	*	45.2	42.6	1.060		
30-1	8.0	81.2	3144.5	1846.3	3157.4	1311.1	2.398	2.569	75.6	18.7	149.7	6.7	24.4	72.7	44.2	42.6	1.037			
30-2	8.0	80.9	3196.1	1896.0	3211.5	1315.5	2.430	2.569	76.6	18.9	151.6	5.4	23.4	76.7	43.4	42.6	1.020			
AVG												6.1	23.9	74.7	*	43.8	42.6	1.028		
50-1	8.0	77.5	3166.6	1881.0	3179.6	1298.6	2.438	2.569	76.9	19.0	152.2	5.1	23.1	77.9	43.2	42.6	1.015			
50-2	8.0	77.7	3191.2	1902.5	3204.4	1301.9	2.451	2.569	77.3	19.1	153.0	4.6	22.7	79.7	42.9	42.6	1.008			
AVG												4.8	22.9	78.8	*	43.1	42.6	1.012		

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry  
 Sp. Gr. = Specific Gravity  
 TMD = Theoretical Maximum Density

gm = gram  
 cc = cubic centimeter  
 AC = Asphalt Cement

pcf = pounds per cubic foot  
 in = inches

Gmb = Bulk Specific Gravity of Compacted Mix  
 Gmm = Theoretical Maximum Specific Gravity of Mix  
 Gsa = Apparent Specific Gravity of Aggregate

Gsb = Bulk Specific Gravity of Aggregate  
 Gse = Effective Specific Gravity of Aggregate  
 Gb = Specific Gravity of Asphalt Cement

**Table B23: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**

**SMA Trial Gradation Summary**

**Mix: 12.5 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

**GRADATION A--20% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS Traprock/Dolceto/Ergon PG64-22/Cellulose					COARSE AGGREGATE INFORMATION:							Percent Coarse Aggregate: 80		DATE: 06-Aug-98
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = Effective Sp. Gr. of Agg. (Gse) = Bulk Sp. Gr. of Agg. (Gsb) =												Bulk Specific Gravity of CA (Gca): 2.917		
			2.972 2.939 2.910												Unit wt. of CA in DRC (pcf): 103.4		
															Unit wt. of CA in DRC (kg/m3): 1656.3		
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(1-IJ)	(100-K)	100(O-N)			
						(F-E)	(F-E)		(Gsb)	(Gb)				Q			
124 A-1	6.0	115.7	4732.5	2791.2	4767.5	1976.3	2.395	2.644	77.4	14.0	149.4	5.0	22.6	77.9	38.3	43.2	0.887
124 A-2	6.0	115.4	4737.7	2819.6	4764.4	1944.8	2.436	2.644	78.7	14.3	152.0	4.6	21.3	78.4	37.2	43.2	0.862
124 A-3	6.0	116.5	4737.3	2829.1	4768.1	1939.0	2.443	2.644	78.9	14.3	152.5	5.3	21.1	74.9	37.0	43.2	0.858
AVG												5.0	21.7	77.1	37.5	43.2	0.869

Computed By: G. FLOWERS Checked By: T. LYNN  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gsb = Bulk Specific Gravity of Aggregate  
 Gse = Effective Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS Traprock/Dolceto/Ergon PG64-22/Cellulose					COARSE AGGREGATE INFORMATION:							Percent Coarse Aggregate: 76		DATE: 06-Aug-98
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = Effective Sp. Gr. of Agg. (Gse) = Bulk Sp. Gr. of Agg. (Gsb) =												Bulk Specific Gravity of CA (Gca): 2.917		
			2.972 2.87 2.909												Unit wt. of CA in DRC (pcf): 103.9		
															Unit wt. of CA in DRC (kg/m3): 1664.3		
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(1-IJ)	(100-K)	100(O-N)			
						(F-E)	(F-E)		(Gsb)	(Gb)				Q			
124 B-1	6.0	112.9	4756.6	2867.9	4774.7	1906.8	2.495	2.591	80.6	14.3	145.0	3.7	19.4	80.9	38.9	42.9	0.907
124 B-2	6.0	113.0	4763.6	2870.9	4778.2	1907.3	2.498	2.591	80.7	14.4	146.2	2.9	19.3	85.0	38.8	42.9	0.905
124 B-3	6.0	112.6	4760.4	2875.3	4777.6	1902.3	2.502	2.591	80.8	14.4	146.0	3.1	19.2	83.8	38.7	42.9	0.903
AVG												3.2	19.3	83.3	38.8	42.9	0.905

Computed By: G. FLOWERS Checked By: T. LYNN  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gsb = Bulk Specific Gravity of Aggregate  
 Gse = Effective Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS Traprock/Dolceto/Ergon PG64-22/Cellulose					COARSE AGGREGATE INFORMATION:							Percent Coarse Aggregate: 72		DATE: 06-Aug-98
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = Effective Sp. Gr. of Agg. (Gse) = Bulk Sp. Gr. of Agg. (Gsb) =												Bulk Specific Gravity of CA (Gca): 2.917		
			2.971 2.927 2.908												Unit wt. of CA in DRC (pcf): 104.4		
															Unit wt. of CA in DRC (kg/m3): 1672.3		
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(1-IJ)	(100-K)	100(O-N)			
						(F-E)	(F-E)		(Gsb)	(Gb)				Q			
124 C-1	6.0	109.5	4775.1	2919.5	4782.4	1862.9	2.563	2.635	82.8	15.0	159.9	2.7	17.2	84.2	40.5	42.6	0.951
124 C-2	6.0	109.3	4772.1	2919.2	4780.7	1861.5	2.564	2.635	82.8	15.0	160.0	2.7	17.2	84.2	40.5	42.6	0.951
124 C-3	6.0	109.5	4763.9	2907.2	4771.1	1863.9	2.556	2.635	82.6	14.9	159.5	3.0	17.4	82.8	40.7	42.6	0.955
AVG												2.8	17.3	83.7	40.6	42.6	0.952

Computed By: G. FLOWERS Checked By: T. LYNN  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gsb = Bulk Specific Gravity of Aggregate  
 Gse = Effective Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B24: SMA Mix Designs for NMA SubTask**  
**National Center for Asphalt Technology**  
**SMA Mix Design Summary**  
**Mix: 12.5 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

**OPTIMUM GRADATION - - 27% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:									
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = Effective Sp. Gr. of Agg. (Gse) = 2.971						Bulk Sp. Gr. of Agg. (Gsb) = 2.939			Percent Coarse Aggregate: 73			DATE: 06-Aug-98			
												Bulk Specific Gravity of CA (Gca): 2.917						
												Unit wt. of CA in DRC (pcf): 104.40						
												Unit wt. of CA in DRC (kg/m3): 1672.3						
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc (%)	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N)				
5.5-1	5.5	109.9	4722.6	2874.2	4741.1	1866.9	2.530	2.667	82.2	13.5	157.9	5.1	17.8	71.1	40.2	42.6	0.943	
5.5-2	5.5	109.8	4727.3	2874.4	4742.9	1868.5	2.530	2.667	82.2	13.5	157.9	5.1	17.8	71.2	40.2	42.6	0.943	
5.5-3	5.5	110.1	4741.8	2884.8	4761.0	1876.2	2.527	2.667	82.1	13.5	157.7	5.2	17.9	70.8	40.2	42.6	0.944	
AVG												5.2	17.8	71.0	40.2	42.6	0.943	
6.0-1	6.0	110.4	4754.9	2891.4	4767.8	1876.4	2.534	2.644	81.9	14.8	158.1	4.2	18.1	76.9	40.4	42.6	0.948	
6.0-2	6.0	110.6	4755.7	2894.2	4769.5	1875.3	2.536	2.644	82.0	14.8	158.2	4.1	18.0	77.3	40.3	42.6	0.947	
6.0-3	6.0	109.7	4761.1	2897.6	4770.5	1872.9	2.542	2.644	82.2	14.8	158.6	3.9	17.8	78.3	40.2	42.6	0.943	
AVG												4.0	18.0	77.5	40.3	42.6	0.946	
6.5-1	6.5	109.6	4784.8	2914.9	4792.8	1877.9	2.548	2.622	81.9	16.1	159.0	2.8	18.1	84.3	40.4	42.6	0.948	
6.5-2	6.5	109.5	4755.6	2892.3	4767.4	1875.1	2.536	2.622	81.5	16.0	158.3	3.3	18.5	82.2	40.7	42.6	0.954	
6.5-3	6.5	109.4	4759.8	2898.4	4770.0	1871.6	2.543	2.622	81.8	16.1	158.7	3.0	18.2	83.4	40.5	42.6	0.950	
AVG												3.0	18.3	83.3	40.5	42.6	0.951	

Computed By: G. FLOWERS      Checked By: T. LYNN

SSD = Saturated Surface Dry      gm = gram      pcf = pounds per cubic foot      Gmb = Bulk Specific Gravity of Compacted Mix      Gsb = Bulk Specific Gravity of Aggregate  
Sp. Gr. = Specific Gravity      cc = cubic centimeter      in = inches      Gmm = Theoretical Maximum Specific Gravity of Mix      Gse = Effective Specific Gravity of Aggregate  
TMD = Theoretical Maximum Density      AC = Asphalt Cement      Gsa = Apparent Specific Gravity of Aggregate      Gb = Specific Gravity of Asphalt Cement

**Table B25: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Optimum Mix Summary**  
**Mix: 12.5 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

**OPTIMUM GRADATION - - 27% Passing 4.75 mm Sieve/OPTIMUM ASPHALT CONTENT- - 6.1%**

**Troxler SGC: 100 Gyration**

PROJECT NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = Effective Sp. Gr. of Agg. (Gse) = 2.971			Bulk Sp. Gr. of Agg. (Gsb) = 2.939						Bulk Specific Gravity of CA (Gca): 2.917			73		06-Aug-98	
												Unit wt. of CA in DRC (pcf): 104.40						
												Unit wt. of CA in DRC (kg/m3): 1672.3						
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA d	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D (F-E)		(100-B) x I (Gsb)	B x I (Gb)	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N) O				
RUT 1	6.1	75.0	3205.3	1948.8	3210.2	1261.4	2.541	2.640	82.0	15.1	158.6	3.7	18.0	79.2	40.3	43.2	0.934	
RUT 2	6.1	75.0	3204.4	1944.3	3212.3	1268.0	2.527	2.640	81.5	15.0	157.7	4.3	18.5	76.8	40.6	43.2	0.941	
RUT 3	6.1	75.0	3110.3	1869.1	3123.0	1253.9	2.481	2.640	80.0	14.7	154.8	6.0	20.0	69.7	41.7	43.2	0.966	
RUT 4	6.1	75.0	3112.3	1875.5	3130.1	1254.6	2.481	2.640	80.0	14.7	154.8	6.0	20.0	69.8	41.7	43.2	0.966	
RUT 5	6.1	75.0	3107.1	1868.4	3121.8	1253.4	2.479	2.640	80.0	14.7	154.7	6.1	20.0	69.5	41.7	43.2	0.967	
RUT 6	6.1	75.0	3209.3	1950.0	3216.2	1266.2	2.535	2.640	81.8	15.0	158.2	4.0	18.2	78.1	40.4	43.2	0.937	
RUT 7	6.1	75.0	3206.7	1952.4	3216.0	1263.6	2.538	2.640	81.9	15.1	158.4	3.9	18.1	78.6	40.4	43.2	0.935	
RUT 8	6.1	75.0	3208.8	1949.2	3216.5	1267.3	2.532	2.640	81.7	15.0	158.0	4.1	18.3	77.7	40.5	43.2	0.938	
RUT 9	6.1	74.8	3213.4	1955.8	3228.0	1272.2	2.526	2.640	81.5	15.0	157.6	4.3	18.5	76.6	40.6	43.2	0.942	
RUT 10	6.1	75.0	3207.2	1948.2	3220.9	1272.7	2.520	2.640	81.3	15.0	157.2	4.5	18.7	75.7	40.8	43.2	0.945	
RUT 11	6.1	75.0	3214.7	1957.7	3228.9	1271.2	2.529	2.640	81.6	15.0	157.8	4.2	18.4	77.1	40.6	43.2	0.940	
AVG												4.7	18.8	75.4	37.2	43.2	0.947	
10-1	6.1		3173.5	1889.4	3227.2	1337.8	2.372	2.640	76.5	14.1	148.0	10.1	23.5	56.8	44.3	43.2	1.025	
10-2	6.1	82.1	3168.7	1896.0	3230.6	1334.6	2.374	2.640	76.6	14.1	148.2	10.1	23.4	57.0	44.2	43.2	1.024	
AVG												10.1	23.4	56.9	44.2	43.2	1.025	
30-1	6.1	78.0	3166.3	1896.6	3193.6	1297.0	2.441	2.640	78.8	14.5	152.3	7.5	21.2	64.5	42.6	43.2	0.988	
30-2	6.1	77.2	3168.8	1903.4	3199.3	1295.9	2.445	2.640	78.9	14.5	152.6	7.4	21.1	65.0	42.5	43.2	0.986	
AVG												7.4	21.2	64.8	42.6	43.2	0.987	
50-1	6.1	75.5	3152.8	1898.6	3165.4	1266.8	2.489	2.640	80.3	14.8	155.3	5.7	19.7	70.9	41.5	43.2	0.962	
50-2	6.1	75.8	3172.3	1915.3	3187.7	1272.4	2.493	2.640	80.4	14.8	155.6	5.6	19.6	71.6	41.4	43.2	0.959	
AVG												5.6	19.6	71.2	41.5	43.2	0.961	

Computed By: G. FLOWERS Checked By: T. LYNN

SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B26: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary**  
**Mix: 19.0 mm Nominal Maximum Size/4.75 mm Break Point Sieve - Phase II**

**GRADATION A--20% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:							DATE: 06-Aug-98		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.979		Effective Sp. Gr. of Agg. (Gse) = 2.931		Bulk Sp. Gr. of Agg. (Gsb) = 2.922			Percent Coarse Aggregate: Bulk Specific Gravity of CA (Gca): 2.929 Unit wt. of CA in DRC (pcf): 102.0 Unit wt. of CA in DRC (kg/m3): 1633.9								
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(1-I)	(100-K)	100(O-N)				
						(F-E)	D	J	(Gsb)	(Gib)			O					
20-1	6.0		4691.4	2846.7	4713.0	1866.3	2.514	2.638	80.9	14.7	156.9	4.7	19.1	75.4	35.5	44.2	0.803	
20-2	6.0		4676.4	2833.0	4703.0	1870.0	2.501	2.638	80.4	14.6	156.0	5.2	19.6	73.4	35.8	44.2	0.811	
20-3	6.0		4683.0	2837.2	4703.6	1866.4	2.509	2.638	80.7	14.7	156.6	4.9	19.3	74.7	35.6	44.2	0.806	
AVG												4.9	19.3	74.5	35.6	44.2	0.806	

Computed By: G. FLOWERS Checked By: T. LYNN  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
 Gsb = Bulk Specific Gravity of Aggregate Gca = Bulk Specific Gravity of CA Gcb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:							DATE: 06-Aug-98		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.978		Effective Sp. Gr. of Agg. (Gse) = 2.925		Bulk Sp. Gr. of Agg. (Gsb) = 2.920			Percent Coarse Aggregate: Bulk Specific Gravity of CA (Gca): 2.922 Unit wt. of CA in DRC (pcf): 102.0 Unit wt. of CA in DRC (kg/m3): 1633.9								
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(1-I)	(100-K)	100(O-N)				
						(F-E)	D	J	(Gsb)	(Gib)			O					
24-1	6.0		4746.4	2905.3	4759.9	1854.6	2.559	2.633	82.3	14.9	159.7	2.8	17.7	84.1	37.4	44.0	0.850	
24-2	6.0		4744.9	2903.1	4760.1	1857.0	2.555	2.633	80.9	14.7	159.4	3.0	17.8	83.4	37.5	44.0	0.852	
24-3	6.0		4759.7	2914.8	4771.0	1856.2	2.564	2.633	82.5	15.0	160.0	2.6	17.5	85.1	37.3	44.0	0.847	
AVG												2.8	17.7	84.2	37.4	44.0	0.850	

Computed By: G. FLOWERS Checked By: T. LYNN  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
 Gsb = Bulk Specific Gravity of Aggregate Gca = Bulk Specific Gravity of CA Gcb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:							DATE: 06-Aug-98		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.977		Effective Sp. Gr. of Agg. (Gse) = 2.926		Bulk Sp. Gr. of Agg. (Gsb) = 2.919			Percent Coarse Aggregate: Bulk Specific Gravity of CA (Gca): 2.929 Unit wt. of CA in DRC (pcf): 102.0 Unit wt. of CA in DRC (kg/m3): 1633.9								
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(1-I)	(100-K)	100(O-N)				
						(F-E)	D	J	(Gsb)	(Gib)			O					
28-1	6.0		4765.0	2941.0	4769.7	1828.7	2.606	2.634	83.8	15.2	162.6	1.1	16.2	93.4	39.8	44.2	0.901	
28-2	6.0		4736.1	2922.5	4741.9	1819.4	2.603	2.634	83.7	15.2	162.4	1.2	16.3	92.8	39.9	44.2	0.902	
28-3	6.0		4752.2	2932.0	4758.3	1826.3	2.602	2.634	83.7	15.2	162.4	1.2	16.3	92.6	39.9	44.2	0.903	
AVG												1.2	16.2	92.9	39.8	44.2	0.902	

Computed By: G. FLOWERS Checked By: T. LYNN  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
 Gsb = Bulk Specific Gravity of Aggregate Gca = Bulk Specific Gravity of CA Gcb = Specific Gravity of Asphalt Cement

**Table B27: SMA Mix Designs for NMAS SubTask  
National Center for Asphalt Technology**

**SMA Mix Design Summary**

**Mix: 19.0 mm Nominal Maximum Size/4.75 mm Break Point Sieve - Phase II**

**OPTIMUM GRADATION - - 24% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:										
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.978		Effective Sp. Gr. of Agg. (Gse) = 2.925		Bulk Sp. Gr. of Agg. (Gsb) = 2.920			Percent Coarse Aggregate: 76				DATE: 06-Aug-98					
										Bulk Specific Gravity of CA (Gca): 2.922				Unit wt. of CA in DRC (pcf): 102.00		Unit wt. of CA in DRC (kg/m3): 1633.9			
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N)					
						(F-E)	(F-E)		(Gsb)	(Gb)			O						
5.0-1	5.0	108.6	4687.2	2881.4	4703.8	1822.4	2.572	2.710	83.7	12.5	160.5	5.1	16.3	68.8	36.4	44.0	0.828		
5.0-2	5.0	108.8	4707.8	2898.8	4724.5	1825.7	2.579	2.710	83.9	12.5	160.9	4.8	16.1	69.9	36.3	44.0	0.824		
5.0-3	5.0	108.2	4710.8	2903.8	4727.9	1824.1	2.583	2.710	84.0	12.6	161.2	4.7	16.0	70.6	36.2	44.0	0.822		
AVG												4.9	16.1	69.8	36.3	44.0	0.825		
5.5-1	5.5	107.7	4714.6	2903.1	4726.1	1823.0	2.586	2.687	83.7	13.8	161.4	3.8	16.3	77.0	36.4	44.0	0.828		
5.5-2	5.5	108.7	4717.1	2905.2	4729.4	1824.2	2.586	2.687	83.7	13.8	161.4	3.8	16.3	76.9	36.4	44.0	0.828		
5.5-3	5.5	108.0	4739.8	2925.9	4749.9	1824.0	2.599	2.687	84.1	13.9	162.2	3.3	15.9	79.3	36.1	44.0	0.821		
AVG												3.6	16.2	77.7	36.3	44.0	0.825		
6.0-1	6.0	107.5	4714.2	2905.0	4724.9	1819.9	2.590	2.664	83.4	15.1	161.6	2.8	16.6	83.4	36.7	44.0	0.833		
6.0-2	6.0	108.0	4754.3	2934.8	4763.0	1828.2	2.601	2.664	83.7	15.2	162.3	2.4	16.3	85.4	36.4	44.0	0.827		
6.0-3	6.0	107.1	4736.3	2923.3	4743.1	1819.8	2.603	2.664	83.8	15.2	162.4	2.3	16.2	85.8	36.4	44.0	0.826		
AVG												2.5	16.4	84.8	36.5	44.0	0.829		

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B28: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary**  
**Mix: 25.0 mm Nominal Maximum Size/12.5 mm Break Point Sieve**

**GRADATION A--20% Passing 12.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:							Percent Coarse Aggregate: 80		DATE: 06-Aug-98
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = Effective Sp. Gr. of Agg. (Gse) = Bulk Sp. Gr. of Agg. (Gsb) = 2.989 2.982 2.945													Bulk Specific Gravity of CA (Gca): 2.960		
																Unit wt. of CA in DRC (pcf): 106.1		
																Unit wt. of CA in DRC (kg/m3): 1699.6		
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(I-J)	(100-K)	100(O-N)				
						(F-E)	(F-E)	(F-E)	(Gsb)	(Gsb)			O					
25/12 A1	6.0	113.6	4538.4	2765.2	4568.1	1802.9	2.517	2.677	80.3	14.7	157.1	6.0	19.7	69.6	36.0	42.5	0.848	
25/12 A2	6.0	113.0	4559.1	2781.2	4591.5	1810.3	2.518	2.677	80.4	14.7	157.1	5.9	19.6	69.8	36.0	42.5	0.847	
25/12 A3	6.0	113.2	4577.6	2791.8	4598.0	1806.2	2.534	2.677	80.9	14.8	158.1	5.3	19.1	72.1	35.6	42.5	0.837	
AVG												5.7	19.5	70.5	35.9	42.5	0.844	

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gc = Bulk Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 12.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:							Percent Coarse Aggregate: 76		DATE: 06-Aug-98
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = Effective Sp. Gr. of Agg. (Gse) = Bulk Sp. Gr. of Agg. (Gsb) = 2.988 2.986 2.943													Bulk Specific Gravity of CA (Gca): 2.960		
																Unit wt. of CA in DRC (pcf): 105.3		
																Unit wt. of CA in DRC (kg/m3): 1686.7		
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(I-J)	(100-K)	100(O-N)				
						(F-E)	(F-E)	(F-E)	(Gsb)	(Gsb)			O					
25/12 B1	6.0	110.6	4582.4	2794.5	4602.1	1807.6	2.535	2.680	80.9	14.8	158.2	5.4	19.1	71.7	38.8	43.0	0.904	
25/12 B2	6.0	109.8	4568.1	2804.9	4586.7	1781.8	2.564	2.680	81.8	15.0	160.0	4.3	18.2	76.1	38.1	43.0	0.887	
25/12 B3	6.0	110.1	4581.8	2803.7	4601.2	1797.5	2.549	2.680	81.4	14.9	159.1	4.9	18.6	73.8	38.5	43.0	0.896	
AVG												4.9	18.6	73.9	38.5	43.0	0.896	

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gc = Bulk Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 12.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:							Percent Coarse Aggregate: 72		DATE: 06-Aug-98
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = Effective Sp. Gr. of Agg. (Gse) = Bulk Sp. Gr. of Agg. (Gsb) = 2.987 2.965 2.940													Bulk Specific Gravity of CA (Gca): 2.960		
																Unit wt. of CA in DRC (pcf): 104.4		
																Unit wt. of CA in DRC (kg/m3): 1672.3		
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D	J	(100-B) x I	B x I	(1 x 62.4)	100(I-J)	(100-K)	100(O-N)				
						(F-E)	(F-E)	(F-E)	(Gsb)	(Gsb)			O					
25/12 C1	6.0	107.0	4592.0	2829.7	4606.0	1776.3	2.585	2.664	82.5	15.1	161.3	3.0	17.5	83.1	40.9	43.4	0.941	
25/12 C2	6.0	107.4	4592.9	2823.2	4606.0	1782.8	2.576	2.664	82.2	15.0	160.8	3.3	17.8	81.5	41.1	43.4	0.946	
25/12 C3	6.0	107.2	4576.2	2820.5	4595.6	1775.1	2.578	2.664	82.3	15.0	160.9	3.2	17.7	81.8	41.1	43.4	0.945	
AVG												3.2	17.7	82.1	41.0	43.4	0.944	

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gc = Bulk Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gb = Specific Gravity of Asphalt Cement

**Table B29: SMA Mix Designs for NMAAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Mix Design Summary**

Mix: 25.0 mm Nominal Maximum Size/12.5 mm Break Point Sieve

**OPTIMUM GRADATION - - 28% Passing 12.5 mm Sieve**

Troxler SGC: 100 Gyration

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:				Percent Coarse Aggregate: 72		DATE: 06-Aug-98		
AC Sp. Gr. (G <sub>b</sub> ) = 1.028			Apparent Sp. Gr. of Agg. (G <sub>sa</sub> ) = 2.987		Effective Sp. Gr. of Agg. (G <sub>se</sub> ) = 2.964		Bulk Sp. Gr. of Agg. (G <sub>sb</sub> ) = 2.940		Bulk Specific Gravity of CA (G <sub>ca</sub> ): 2.960				Unit wt. of CA in DRC (pcf): 104.40		Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1672.3		
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D (F-E)		(100-B) x I (Gsb)	B x I (Gb)	(1 x 62.4)	100(1-I/J)	(100-K)	100(O-N) O			
5.5-1	5.5	108.9	4578.4	2822.6	4594.4	1771.8	2.584	2.686	83.1	13.8	161.2	3.8	16.9	77.6	40.6	43.4	0.935
5.5-2	5.5	109.0	4623.6	2849.5	4639.8	1790.3	2.583	2.686	83.0	13.8	161.2	3.9	17.0	77.3	40.6	43.4	0.935
5.5-3	5.5	108.0	4576.6	2819.2	4592.3	1773.1	2.581	2.686	83.0	13.8	161.1	3.9	17.0	77.1	40.7	43.4	0.936
AVG												3.9	17.0	77.3	40.6	43.4	0.935
25/12 C1	6.0	107.0	4592.0	2829.7	4606.0	1776.3	2.585	2.663	82.7	15.1	161.3	2.9	17.3	83.1	40.9	43.4	0.941
25/12 C2	6.0	107.4	4592.9	2823.2	4606.0	1782.8	2.576	2.663	82.4	15.0	160.8	3.3	17.6	81.4	41.1	43.4	0.946
25/12 C3	6.0	107.2	4576.2	2820.5	4595.6	1775.1	2.578	2.663	82.4	15.0	160.9	3.2	17.6	81.8	41.1	43.4	0.945
AVG												3.1	17.5	82.1	41.0	43.4	0.944
6.5-1	6.5	108.6	4555.5	2790.3	4566.3	1776.0	2.565	2.641	81.6	16.2	160.1	2.9	18.4	84.4	41.7	43.4	0.959
6.5-2	6.5	109.0	4579.4	2809.9	4594.7	1784.8	2.566	2.641	81.6	16.2	160.1	2.8	18.4	84.5	41.6	43.4	0.959
6.5-3	6.5	108.4	4561.4	2791.0	4573.2	1782.2	2.559	2.641	81.4	16.2	159.7	3.1	18.6	83.4	41.8	43.4	0.962
AVG												2.9	18.5	84.1	41.7	43.4	0.960

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B30: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Optimum Mix Summary**  
**Mix: 25.0 mm Nominal Maximum Size/12.5 mm Break Point Sieve**

**OPTIMUM GRADATION - - 28% Passing 12.5 mm Sieve/OPTIMUM ASPHALT CONTENT- - 5.6%**

**Troxler SGC: 100 Gyration**

PROJECT NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:								Percent Coarse Aggregate: 72		DATE: 06-Aug-98	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.987		Effective Sp. Gr. of Agg. (Gse) = 2.964		Bulk Sp. Gr. of Agg. (Gsb) = 2.940			Bulk Specific Gravity of CA (Gca): 2.960				Unit wt. of CA in DRC (pcf): 104.40		Unit wt. of CA in DRC (kg/m3): 1672.3				
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc			
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S			
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N)						
						(F-E)			(Gsb)	(Gsb)				O						
RUT 1	5.6	74.9	3135.1	1942.9	3145.0	1202.1	2.608	2.681	83.6	14.2	162.7	2.7	16.4	83.3	40.1	42.5	0.943			
RUT 2	5.6	74.5	3127.0	1931.0	3138.4	1207.4	2.590	2.681	83.0	14.1	161.6	3.4	17.0	79.9	40.5	42.5	0.953			
RUT 3	5.6	75.0	3145.5	1938.6	3154.0	1215.4	2.588	2.681	83.0	14.1	161.5	3.5	17.0	79.6	40.6	42.5	0.954			
RUT 4	5.6	75.0	3116.5	1914.4	3130.8	1216.4	2.562	2.681	82.1	14.0	159.9	4.5	17.9	75.1	41.2	42.5	0.968			
RUT 5	5.6	75.1	3153.8	1947.7	3161.2	1213.5	2.599	2.681	83.3	14.2	162.2	3.1	16.7	81.6	40.3	42.5	0.948			
RUT 6	5.6	75.0	3133.1	1928.7	3143.8	1215.1	2.578	2.681	82.7	14.0	160.9	3.8	17.3	77.9	40.8	42.5	0.959			
RUT 7	5.6	75.0	3152.9	1944.9	3162.9	1218.0	2.589	2.681	83.0	14.1	161.5	3.5	17.0	79.7	40.6	42.5	0.954			
RUT 8	5.6	75.1	3149.6	1944.3	3160.5	1216.2	2.590	2.681	83.0	14.1	161.6	3.4	17.0	79.9	40.5	42.5	0.953			
AVG												3.5	17.0	79.6	40.6	42.5	0.954			
10-1	5.6	84.8	3106.5	1912.0	3146.4	1234.4	2.517	2.681	80.7	13.7	157.0	6.1	19.3	68.2	42.2	42.5	0.993			
10-2	5.6	84.8	3140.6	1932.2	3178.9	1246.7	2.519	2.681	80.7	13.7	157.2	6.1	19.3	68.5	42.2	42.5	0.991			
AVG												6.1	19.3	68.4	42.2	42.5	0.992			
30-1	5.6	79.3	3121.7	1926.9	3145.4	1218.5	2.562	2.681	82.1	14.0	159.9	4.5	17.9	75.1	41.2	42.5	0.968			
30-2	5.6	79.8	3126.5	1919.3	3151.5	1232.2	2.537	2.681	81.3	13.8	158.3	5.4	18.7	71.2	41.7	42.5	0.981			
AVG												4.9	18.3	73.1	41.5	42.5	0.975			
50-1	5.6	77.4	3111.9	1908.9	3131.3	1222.4	2.546	2.681	81.6	13.9	158.9	5.1	18.4	72.5	41.5	42.5	0.977			
50-2	5.6	77.2	3113.0	1910.2	3132.5	1222.3	2.547	2.681	81.6	13.9	158.9	5.0	18.4	72.7	41.5	42.5	0.976			
AVG												5.0	18.4	72.6	41.5	42.5	0.977			

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B31: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary**  
**Mix: 25.0 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

**GRADATION A--20% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			80	DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.985		Effective Sp. Gr. of Agg. (Gse) = 2.998		Bulk Sp. Gr. of Agg. (Gsb) = 2.938								Bulk Specific Gravity of CA (Gca): 2.951			105.4	06-Aug-98
															Unit wt. of CA in DRC (pcf): 1688.3			1688.3	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-IJ)	(100-K)	100(O-N)					
						(F-E)	D		(Gsb)	(Gb)				O					
25/9 A-1	6.0	117.8	4670.2	2832.4	4700.8	1868.4	2.500	2.689	80.0	14.6	156.0	7.0	20.0	64.8	36.3	42.7	0.850		
25/9 A-2	6.0	116.2	4717.5	2841.5	4737.4	1895.9	2.488	2.689	79.6	14.6	155.3	7.5	20.4	63.4	36.6	42.7	0.856		
25/9 A-3	6.0	114.4	4702.2	2857.8	4720.3	1862.5	2.525	2.689	80.8	14.8	157.5	6.1	19.2	68.2	35.7	42.7	0.835		
AVG												6.9	19.9	65.5	36.2	42.7	0.847		

Computed By: G. FLOWERS  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			76	DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.984		Effective Sp. Gr. of Agg. (Gse) = 2.922		Bulk Sp. Gr. of Agg. (Gsb) = 2.936								Bulk Specific Gravity of CA (Gca): 2.951			105.2	06-Aug-98
															Unit wt. of CA in DRC (pcf): 1685.1			1685.1	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-IJ)	(100-K)	100(O-N)					
						(F-E)	D		(Gsb)	(Gb)				O					
25/9 B-1	6.0	112.5	4715.8	2874.0	4727.9	1853.9	2.544	2.660	81.4	14.8	158.7	4.4	18.6	76.5	38.4	42.8	0.897		
25/9 B-2	6.0	111.6	4668.3	2835.2	4687.2	1852.0	2.521	2.660	80.6	14.7	157.3	5.2	19.4	72.9	39.0	42.8	0.910		
25/9 B-3	6.0	111.7	4748.8	2917.7	4758.8	1841.1	2.579	2.660	82.5	15.1	161.0	3.0	17.5	82.6	37.6	42.8	0.877		
AVG												4.2	18.5	77.4	38.3	42.8	0.894		

Computed By: G. FLOWERS  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			72	DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.983		Effective Sp. Gr. of Agg. (Gse) = 2.960		Bulk Sp. Gr. of Agg. (Gsb) = 2.934								Bulk Specific Gravity of CA (Gca): 2.951			105.1	06-Aug-98
															Unit wt. of CA in DRC (pcf): 1683.5			1683.5	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc		
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S		
						(F-E)	D		(100-B) x I	B x I	(1 x 62.4)	100(1-IJ)	(100-K)	100(O-N)					
						(F-E)	D		(Gsb)	(Gb)				O					
25/9 C-1	6.0	108.9	4733.1	2911.5	4740.5	1829.0	2.588	2.660	82.8	15.1	161.5	2.7	17.2	84.2	40.6	42.9	0.948		
25/9 C-2	6.0	109.5	4685.7	2875.1	4699.3	1824.2	2.569	2.660	82.2	15.0	160.3	3.4	17.8	80.7	41.1	42.9	0.958		
25/9 C-3	6.0	109.2	4689.9	2879.3	4701.3	1822.0	2.574	2.660	82.4	15.0	160.6	3.2	17.6	81.7	41.0	42.9	0.955		
AVG												3.1	17.6	82.2	40.9	42.9	0.954		

Computed By: G. FLOWERS  
 SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B32: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**

**SMA Mix Design Summary**

**Mix: 25.0 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

**OPTIMUM GRADATION - - 28% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose					COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate: 72		DATE: 06-Aug-98		
AC Sp. Gr. (G <sub>b</sub> ) = 1.028			Apparent Sp. Gr. of Agg. (G <sub>sa</sub> ) = 2.983		Effective Sp. Gr. of Agg. (G <sub>se</sub> ) = 2.940		Bulk Sp. Gr. of Agg. (G <sub>sb</sub> ) = 2.934			Bulk Specific Gravity of CA (G <sub>ca</sub> ): 2.951		Unit wt. of CA in DRC (pcf): 105.10		Unit wt. of CA in DRC (kg/m <sup>3</sup> ): 1683.5			
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (G <sub>mb</sub> )	TMD (G <sub>mm</sub> )	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N)			
						(F-E)			(G <sub>sb</sub> )	(G <sub>b</sub> )				O			
5.0-1	5.0	109.4	4674.6	2893.4	4690.3	1796.9	2.601	2.704	84.2	12.7	162.3	3.8	15.8	76.0	39.7	42.9	0.926
5.0-2	5.0	109.6	4684.4	2897.4	4700.5	1803.1	2.598	2.704	84.1	12.6	162.1	3.9	15.9	75.3	39.8	42.9	0.927
5.0-3	5.0	107.4	4687.6	2907.7	4698.9	1791.2	2.617	2.704	84.7	12.7	163.3	3.2	15.3	78.9	39.3	42.9	0.917
AVG												3.6	15.6	76.7	39.6	42.9	0.923
5.5-1	5.5	109.0	4690.4	2901.0	4703.2	1802.2	2.603	2.681	83.8	13.9	162.4	2.9	16.2	81.9	40.0	42.9	0.932
5.5-2	5.5	109.3	4729.2	2925.4	4740.4	1815.0	2.606	2.681	83.9	13.9	162.6	2.8	16.1	82.5	39.9	42.9	0.931
5.5-3	5.5	108.3	4725.9	2923.2	4735.1	1811.9	2.608	2.681	84.0	14.0	162.8	2.7	16.0	83.0	39.9	42.9	0.929
AVG												2.8	16.1	82.5	39.9	42.9	0.931
25/9 C-1	6.0	108.9	4733.1	2911.5	4740.5	1829.0	2.588	2.658	82.9	15.1	161.5	2.6	17.1	84.5	40.6	42.9	0.948
25/9 C-2	6.0	109.5	4685.7	2875.1	4699.3	1824.2	2.569	2.658	82.3	15.0	160.3	3.4	17.7	81.0	41.1	42.9	0.958
25/9 C-3	6.0	109.2	4689.9	2879.3	4701.3	1822.0	2.574	2.658	82.5	15.0	160.6	3.2	17.5	82.0	41.0	42.9	0.955
AVG												3.1	17.4	82.5	40.9	42.9	0.954
6.5-1	6.5	108.5	4721.3	2886.3	4729.9	1843.6	2.561	2.636	81.6	16.2	159.8	2.8	18.4	84.5	41.6	42.9	0.969
6.5-2	6.5	109.9	4692.2	2865.9	4702.4	1836.5	2.555	2.636	81.4	16.2	159.4	3.1	18.6	83.5	41.7	42.9	0.973
6.5-3	6.5	107.9	4701.3	2887.4	4710.4	1823.0	2.579	2.636	82.2	16.3	160.9	2.2	17.8	87.8	41.2	42.9	0.960
AVG												2.7	18.3	85.3	41.5	42.9	0.967

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry  
 Sp. Gr. = Specific Gravity  
 TMD = Theoretical Maximum Density

gm = gram  
 cc = cubic centimeter  
 AC = Asphalt Cement  
 pcf = pounds per cubic foot  
 in = inches

G<sub>mb</sub> = Bulk Specific Gravity of Compacted Mix  
 G<sub>mm</sub> = Theoretical Maximum Specific Gravity of Mix  
 G<sub>sa</sub> = Apparent Specific Gravity of Aggregate

G<sub>sb</sub> = Bulk Specific Gravity of Aggregate  
 G<sub>se</sub> = Effective Specific Gravity of Aggregate  
 G<sub>b</sub> = Specific Gravity of Asphalt Cement

**Table B33: SMA Mix Designs for NMA SubTask**  
**National Center for Asphalt Technology**

**SMA Mix Design Summary 2**

**Mix: 25.0 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

**OPTIMUM GRADATION - - 26% Passing 9.5 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:								Percent Coarse Aggregate: 74		DATE: 06-Aug-98		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.983		Effective Sp. Gr. of Agg. (Gse) = 2.940		Bulk Sp. Gr. of Agg. (Gsb) = 2.934											Bulk Specific Gravity of CA (Gca): 2.951		Unit wt. of CA in DRC (pcf): 105.10	
																		Unit wt. of CA in DRC (kg/m3): 1683.5			
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS								
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc				
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S				
						(F-E)	D (F-E)		(100-B) x I (Gsb)	B x I (Gb)	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N) O							
5.0-1B	5.0	111.1	4672.5	2879.6	4691.5	1811.9	2.579	2.690	83.5	12.5	160.9	4.1	16.5	75.0	38.6	42.9	0.899				
5.0-2B	5.0	111.4	4678.9	2885.9	4698.1	1812.2	2.582	2.690	83.6	12.6	161.1	4.0	16.4	75.6	38.5	42.9	0.897				
5.0-3B	5.0	109.8	4670.7	2872.1	4688.8	1816.7	2.571	2.690	83.2	12.5	160.4	4.4	16.8	73.7	38.8	42.9	0.903				
AVG												4.2	16.6	74.7	38.6	42.9	0.900				
5.5-1B	5.5	111.3	4673.3	2868.3	4691.2	1822.9	2.564	2.667	82.6	13.7	160.0	3.9	17.4	77.8	39.2	42.9	0.915				
5.5-2B	5.5	110.7	4703.7	2905.6	4720.3	1814.7	2.592	2.667	83.5	13.9	161.7	2.8	16.5	83.0	38.6	42.9	0.899				
5.5-3B	5.5	111.1	4690.7	2879.2	4708.1	1828.9	2.565	2.667	82.6	13.7	160.0	3.8	17.4	78.0	39.2	42.9	0.914				
5.5-4B	5.5	109.8	4607.6	2843.9	4628.4	1784.5	2.582	2.667	83.2	13.8	161.1	3.2	16.8	81.1	38.8	42.9	0.905				
5.5-5B	5.5	111.4	4709.8	2893.5	4726.6	1833.1	2.569	2.667	82.8	13.7	160.3	3.7	17.2	78.8	39.1	42.9	0.912				
5.5-6B	5.5	111.4	4690.2	2881.9	4709.8	1827.9	2.566	2.667	82.6	13.7	160.1	3.8	17.4	78.2	39.2	42.9	0.914				
5.5-7B	5.5	109.5	4612.2	2841.3	4625.7	1784.4	2.585	2.667	83.3	13.8	161.3	3.1	16.7	81.6	38.7	42.9	0.903				
5.5-8B	5.5	109.7	4705.7	2890.9	4718.3	1827.4	2.575	2.667	82.9	13.8	160.7	3.4	17.1	79.8	39.0	42.9	0.909				
AVG												3.5	17.1	79.8	39.0	42.9	0.909				
6.0-1B	6.0	110.8	4688.7	2882.2	4701.2	1819.0	2.578	2.645	82.6	15.0	160.8	2.5	17.4	85.4	39.2	42.9	0.915				
6.0-2B	6.0	111.2	4685.1	2865.5	4700.6	1835.1	2.553	2.645	81.8	14.9	159.3	3.5	18.2	81.0	39.8	42.9	0.928				
6.0-3B	6.0	112.4	4694.8	2865.0	4712.4	1847.4	2.541	2.645	81.4	14.8	158.6	3.9	18.6	79.0	40.1	42.9	0.935				
6.0-4B	6.0	111.5	4634.8	2835.2	4649.6	1814.4	2.554	2.645	81.8	14.9	159.4	3.4	18.2	81.2	39.8	42.9	0.928				
6.0-5B	6.0	111.0	4666.1	2853.3	4684.4	1831.1	2.548	2.645	81.6	14.9	159.0	3.6	18.4	80.1	39.9	42.9	0.931				
AVG												3.4	18.1	81.5	39.8	42.9	0.927				

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry      gm = gram      pcf = pounds per cubic foot      Gmb = Bulk Specific Gravity of Compacted Mix      Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity      cc = cubic centimeter      in = inches      Gmm = Theoretical Maximum Specific Gravity of Mix      Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density      AC = Asphalt Cement      Gsa = Apparent Specific Gravity of Aggregate      Gb = Specific Gravity of Asphalt Cement

**Table B34: SMA Mix Designs for NMA SubTask**  
**National Center for Asphalt Technology**  
**SMA Optimum Mix Summary**  
**Mix: 25.0 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

**OPTIMUM GRADATION - - 26% Passing 9.5 mm Sieve/OPTIMUM ASPHALT CONTENT- - 5.5%**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate: 74			DATE: 06-Aug-98	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.983		Effective Sp. Gr. of Agg. (Gse) = 2.940		Bulk Sp. Gr. of Agg. (Gsb) = 2.934			Bulk Specific Gravity of CA (Gca): 2.951					Unit wt. of CA in DRC (pcf): 105.10		Unit wt. of CA in DRC (kg/m3): 1683.5	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS					
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	D	(100-B) x I			B x I	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N)			
						(F-E)	D	(Gsb)	(Gb)						O			
RUT 1	5.5	75.0	3181.8	1976.5	3196.0	1219.5	2.609	2.667	83.9	14.0	162.8	2.2	16.1	86.5	38.2	42.7	0.893	
RUT 2	5.5	75.1	3116.7	1926.5	3130.1	1203.6	2.589	2.667	83.3	13.9	161.6	2.9	16.7	82.6	38.6	42.7	0.904	
RUT 3	5.5	75.1	3034.6	1860.1	3061.4	1201.3	2.526	2.667	81.3	13.5	157.6	5.3	18.7	71.8	40.1	42.7	0.939	
RUT 4	5.5	75.0	3129.9	1914.6	3127.2	1212.6	2.567	2.667	82.6	13.7	160.2	3.7	17.4	78.5	39.2	42.7	0.917	
RUT 5	5.5	75.1	3117.2	1918.1	3131.4	1213.3	2.569	2.667	82.6	13.7	160.3	3.7	17.4	78.9	39.1	42.7	0.915	
RUT 6	5.5	75.0	3119.5	1927.9	3135.7	1207.8	2.583	2.667	83.1	13.8	161.2	3.2	16.9	81.3	38.8	42.7	0.908	
RUT 7	5.5	75.0	3121	1935.2	3138.3	1203.1	2.594	2.667	83.4	13.9	161.9	2.7	16.6	83.5	38.5	42.7	0.902	
RUT 8	5.5	75.0	3119.5	1926.2	3133.8	1207.6	2.583	2.667	83.1	13.8	161.2	3.1	16.9	81.4	38.8	42.7	0.908	
AVG												3.4	17.1	80.6	38.9	42.7	0.911	
RUT 1A	5.5	74.9	3117.0	1915.9	3127.0	1211.1	2.574	2.667	82.8	13.8	160.6	3.5	17.2	79.7	39.0	42.7	0.913	
RUT 2A	5.5	74.9	3115.3	1921.0	3127.0	1206.0	2.583	2.667	83.1	13.8	161.2	3.1	16.9	81.4	38.8	42.7	0.908	
RUT 3A	5.5	75.0	3124.9	1920.1	3136.7	1216.6	2.569	2.667	82.6	13.7	160.3	3.7	17.4	78.8	39.1	42.7	0.916	
RUT 4A	5.5	75.0	3122.3	1920.0	3135.3	1215.3	2.569	2.667	82.6	13.7	160.3	3.7	17.4	78.9	39.1	42.7	0.915	
AVG												3.5	17.2	79.7	39.0	42.7	0.913	
10-1	5.5	83.7	3137.8	1922.9	3169.2	1246.3	2.518	2.667	81.0	13.5	157.1	5.6	19.0	70.6	40.3	42.7	0.944	
10-2	5.5	83.2	3128.8	1914.7	3162.4	1247.7	2.508	2.667	80.7	13.4	156.5	6.0	19.3	69.1	40.6	42.7	0.950	
AVG												5.8	19.2	69.8	40.5	42.7	0.947	
30-1	5.5	78.1	3132.5	1922.1	3154.2	1232.1	2.542	2.667	81.8	13.6	158.6	4.7	18.2	74.4	39.8	42.7	0.930	
30-2	5.5	77.0	3131.5	1920.5	3148.7	1228.2	2.550	2.667	82.0	13.6	159.1	4.4	18.0	75.5	39.6	42.7	0.926	
AVG												4.5	18.1	75.0	39.7	42.7	0.928	
50-1	5.5	76.0	3127.7	1921.2	3141.2	1220.0	2.564	2.667	82.5	13.7	160.0	3.9	17.5	77.9	39.2	42.7	0.919	
50-2	5.5	76.9	3146.0	1935.0	3161.5	1226.5	2.565	2.667	82.5	13.7	160.1	3.8	17.5	78.1	39.2	42.7	0.918	
AVG												3.8	17.5	78.0	39.2	42.7	0.918	

Computed By: G. FLOWERS Checked By: T. LYNN

SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix Gsb = Bulk Specific Gravity of Aggregate  
 Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix Gse = Effective Specific Gravity of Aggregate  
 TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gb = Specific Gravity of Asphalt Cement

**Table B35: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Trial Gradation Summary**  
**Mix: 25.0 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

**GRADATION A--20% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:								Percent Coarse Aggregate: 80		DATE: 06-Aug-98				
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.980		Effective Sp. Gr. of Agg. (Gse) = 2.938		Bulk Sp. Gr. of Agg. (Gsb) = 2.927											Bulk Specific Gravity of CA (Gca): 2.937		Unit wt. of CA in DRC (pcf): 106.8		Unit wt. of CA in DRC (kg/m3): 1710.8	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS											
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc						
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S						
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(I-J)	(100-K)	100(O-N)									
25/A A1	6.0	113.7	4833.7	2935.4	4851.5	1916.1	2.523	2.643	81.0	14.8	157.4	4.6	19.0	76.0	35.4	41.7	0.849						
25/A A2	6.0	112.3	4870.0	2993.6	4876.6	1883.0	2.586	2.643	83.1	15.1	161.4	2.1	16.9	87.3	33.8	41.7	0.810						
25/A A3	6.0	113.9	4826.5	2926.5	4839.1	1912.6	2.524	2.643	81.0	14.8	157.5	4.5	19.0	76.2	35.4	41.7	0.849						
AVG												3.7	18.3	79.8	34.9	41.7	0.836						

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gsb = Bulk Specific Gravity of Aggregate Gca = Bulk Specific Gravity of CA  
Gce = Effective Specific Gravity of Aggregate Gcb = Specific Gravity of Asphalt Cement

**GRADATION B--24% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:								Percent Coarse Aggregate: 76		DATE: 06-Aug-98				
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.979		Effective Sp. Gr. of Agg. (Gse) = 2.948		Bulk Sp. Gr. of Agg. (Gsb) = 2.925											Bulk Specific Gravity of CA (Gca): 2.937		Unit wt. of CA in DRC (pcf): 106.7		Unit wt. of CA in DRC (kg/m3): 1709.2	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS											
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc						
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S						
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(I-J)	(100-K)	100(O-N)									
25/B B1	6.0	110.4	4871.9	3008.1	4877.4	1869.3	2.606	2.651	85.7	15.2	162.6	1.7	16.3	89.6	36.6	41.7	0.877						
25/B B2	6.0	109.5	4824.8	2975.7	4833.0	1857.3	2.598	2.651	83.4	15.2	162.1	2.0	16.6	87.9	36.8	41.7	0.882						
25/B B3	6.0	108.9	4834.8	2983.0	4841.5	1858.5	2.601	2.651	85.5	15.2	162.3	1.9	16.5	88.6	36.7	41.7	0.880						
AVG												1.9	16.4	88.7	36.7	41.7	0.879						

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gsb = Bulk Specific Gravity of Aggregate Gca = Bulk Specific Gravity of CA  
Gce = Effective Specific Gravity of Aggregate Gcb = Specific Gravity of Asphalt Cement

**GRADATION C--28% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:								Percent Coarse Aggregate: 72		DATE: 06-Aug-98				
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.978		Effective Sp. Gr. of Agg. (Gse) = 2.960		Bulk Sp. Gr. of Agg. (Gsb) = 2.923											Bulk Specific Gravity of CA (Gca): 2.937		Unit wt. of CA in DRC (pcf): 106.1		Unit wt. of CA in DRC (kg/m3): 1699.6	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS											
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc						
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S						
						(F-E)	D		(100-B) x I	B x I	(I x 62.4)	100(I-J)	(100-K)	100(O-N)									
25/C C1	6.0	107.0	4853.3	3002.9	4856.8	1853.9	2.618	2.660	84.1	15.3	163.4	1.6	15.9	90.1	39.7	42.1	0.943						
25/C C2	6.0	108.1	4825.3	2979.5	4832.3	1852.8	2.604	2.660	83.6	15.2	162.5	2.1	16.4	87.2	40.0	42.1	0.950						
25/C C3	6.0	107.1	4840.0	2998.9	4847.6	1848.7	2.618	2.660	84.1	15.3	163.4	1.6	15.9	90.1	39.7	42.1	0.943						
AVG												1.8	16.1	89.1	39.8	42.1	0.945						

Computed By: G. FLOWERS Checked By: T. LYNN  
SSD = Saturated Surface Dry gm = gram pcf = pounds per cubic foot Gmb = Bulk Specific Gravity of Compacted Mix  
Sp. Gr. = Specific Gravity cc = cubic centimeter in = inches Gmm = Theoretical Maximum Specific Gravity of Mix  
TMD = Theoretical Maximum Density AC = Asphalt Cement Gsa = Apparent Specific Gravity of Aggregate Gse = Effective Specific Gravity of Aggregate  
Gsb = Bulk Specific Gravity of Aggregate Gca = Bulk Specific Gravity of CA  
Gce = Effective Specific Gravity of Aggregate Gcb = Specific Gravity of Asphalt Cement

**Table B36: SMA Mix Designs for NMA SubTask**  
**National Center for Asphalt Technology**

**SMA Mix Design Summary**

**Mix: 25.0 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

**OPTIMUM GRADATION - - 21% Passing 4.75 mm Sieve**

**Troxler SGC: 100 Gyration**

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose					COARSE AGGREGATE INFORMATION:										DATE: 06-Aug-98		
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.980		Effective Sp. Gr. of Agg. (Gse) = 2.965		Bulk Sp. Gr. of Agg. (Gsb) = 2.927			Percent Coarse Aggregate: 79			Bulk Specific Gravity of CA (Gca): 2.937			Unit wt. of CA in DRC (pcf): 106.80			Unit wt. of CA in DRC (kg/m3): 1710.8	
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES			VOLUMES			VOIDS							
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc			
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S			
						(F-E)	D (F-E)		(100-B) x I (Gsb)	B x I (Gb)	(I x 62.4)	100(1-I/J)	(100-K)	100(O-N) O						
5.5-1	5.5	112.3	4787.0	2924.9	4820.9	1896.0	2.525	2.687	81.5	13.5	157.5	6.0	18.5	67.4	35.8	41.7	0.859			
5.5-2	5.5	111.9	4820.9	2963.3	4833.7	1870.4	2.577	2.687	83.2	13.8	160.8	4.1	16.8	75.8	34.5	41.7	0.827			
5.5-3	5.5	113.2	4815.8	2948.7	4835.8	1887.1	2.552	2.687	82.4	13.7	159.2	5.0	17.6	71.5	35.1	41.7	0.843			
AVG												5.0	17.6	71.6	35.1	41.7	0.843			
6.0-1	6.0	113.5	4810.4	2941.9	4823.8	1881.9	2.556	2.664	82.1	14.9	159.5	4.0	17.9	77.4	35.4	41.7	0.848			
6.0-2	6.0	112.7	4825.6	2947.8	4840.7	1892.9	2.549	2.664	81.9	14.9	159.1	4.3	18.1	76.3	35.5	41.7	0.852			
6.0-3	6.0	112.8	4831.0	2946.4	4846.3	1899.9	2.543	2.664	81.7	14.8	158.7	4.6	18.3	75.2	35.7	41.7	0.856			
AVG												4.3	18.1	76.3	35.5	41.7	0.852			
6.5-1	6.5	112.5	4827.2	2948.3	4836.3	1888.0	2.557	2.642	81.7	16.2	159.5	3.2	18.3	82.5	35.7	41.7	0.856			
6.5-2	6.5	111.8	4806.4	2949.8	4833.4	1883.6	2.552	2.642	81.5	16.1	159.2	3.4	18.5	81.6	35.8	41.7	0.859			
6.5-3	6.5	111.9	4807.3	2934.3	4819.6	1885.3	2.550	2.642	81.5	16.1	159.1	3.5	18.5	81.3	35.9	41.7	0.860			
AVG												3.4	18.5	81.8	35.8	41.7	0.859			

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table B37: SMA Mix Designs for NMAS SubTask**  
**National Center for Asphalt Technology**  
**SMA Optimum Mix Summary**  
**Mix: 25.0 mm Nominal Maximum Size/ 4.75 mm Break Point Sieve**

**OPTIMUM GRADATION - - 21% Passing 4.75 mm Sieve/OPTIMUM ASPHALT CONTENT- - 6.3%**

Troxler SGC: 100 Gyration

PROJECT: NCHRP9-8-II			MATERIALS: Traprock/Dolcito/Ergon PG64-22/Cellulose						COARSE AGGREGATE INFORMATION:					Percent Coarse Aggregate:			DATE:	
AC Sp. Gr. (Gb) = 1.028			Apparent Sp. Gr. of Agg. (Gsa) = 2.98		Effective Sp. Gr. of Agg. (Gse) = 2.965		Bulk Sp. Gr. of Agg. (Gsb) = 2.927								79		06-Aug-98	
															2.937			
															106.80			
															1710.8			
Specimen Number	Asphalt Content (%)	Average Thickness (mm)	WEIGHTS			MIX VOLUME	SPECIFIC GRAVITIES		VOLUMES			VOIDS						
			In Air (gm)	In Water (gm)	SSD (gm)	Volume (cc)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume (cc)	AC by Volume (%)	Unit Weight (pcf)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA drc (%)	VCA / VCA drc	
A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	
						(F-E)	$\frac{D}{(F-E)}$		$\frac{(100-B) \times I}{(Gsb)}$	$\frac{B \times I}{(Gb)}$	(I x 62.4)	100(1-I/J)	(100-K)	$\frac{100(O-N)}{O}$				
RUT 1	6.3	75.0	3193.1	1967.0	3202.6	1235.6	2.584	2.651	82.7	15.8	161.3	2.5	17.3	85.5	34.9	41.7	0.836	
RUT 2	6.3	75.0	3159.5	1926.5	3168.9	1242.4	2.543	2.651	81.4	15.6	158.7	4.1	18.6	78.2	35.9	41.7	0.861	
RUT 3	6.3	75.0	3121.3	1906.4	3131.5	1225.1	2.548	2.651	81.6	15.6	159.0	3.9	18.4	79.0	35.8	41.7	0.858	
RUT 4	6.3	75.0	3114.9	1904.0	3125.5	1221.5	2.550	2.651	81.6	15.6	159.1	3.8	18.4	79.4	35.7	41.7	0.857	
RUT 5	6.3	75.0	3132.5	1910.2	3141.5	1231.3	2.544	2.651	81.4	15.6	158.7	4.0	18.6	78.4	35.9	41.7	0.861	
RUT 6	6.3	75.0	3129.3	1906.8	3139.0	1232.2	2.540	2.651	81.3	15.6	158.5	4.2	18.7	77.6	36.0	41.7	0.863	
RUT 7	6.3	75.6	3134.3	1903.4	3153.8	1250.4	2.507	2.651	80.2	15.4	156.4	5.4	19.8	72.5	36.8	41.7	0.883	
RUT 8	6.3	75.0	3125.5	1916.3	3137.9	1221.6	2.559	2.651	81.9	15.7	159.7	3.5	18.1	80.8	35.5	41.7	0.852	
AVG												3.9	18.5	78.9	35.8	41.7	0.859	
10-1	6.3	83.1	3123.1	1890.6	3160.6	1270.0	2.459	2.651	78.7	15.1	153.4	7.2	21.3	66.1	38.0	41.7	0.912	
10-2	6.3	81.7	3154.4	1902.1	3193.0	1290.9	2.444	2.651	78.2	15.0	152.5	7.8	21.8	64.1	38.4	41.7	0.921	
AVG												7.5	21.5	65.1	38.2	41.7	0.917	
30-1	6.3	78.1	3140.5	1895.9	3157.0	1261.1	2.490	2.651	79.7	15.3	155.4	6.0	20.3	70.2	37.2	41.7	0.893	
30-2	6.3	77.4	3137.9	1889.5	3155.4	1265.9	2.479	2.651	79.4	15.2	154.7	6.5	20.6	68.6	37.5	41.7	0.900	
AVG												6.3	20.5	69.4	37.4	41.7	0.897	
50-1	6.3	75.5	3117.6	1896.2	3128.4	1232.2	2.530	2.651	81.0	15.5	157.9	4.5	19.0	76.1	36.2	41.7	0.869	
50-2	6.3	75.9	3171.9	1933.1	3183.0	1249.9	2.538	2.651	81.2	15.6	158.4	4.3	18.8	77.3	36.0	41.7	0.864	
AVG												4.4	18.9	76.7	36.1	41.7	0.867	

Computed By: G. FLOWERS

Checked By: T. LYNN

SSD = Saturated Surface Dry

gm = gram

pcf = pounds per cubic foot

Gmb = Bulk Specific Gravity of Compacted Mix

Gsb = Bulk Specific Gravity of Aggregate

Sp. Gr. = Specific Gravity

cc = cubic centimeter

in = inches

Gmm = Theoretical Maximum Specific Gravity of Mix

Gse = Effective Specific Gravity of Aggregate

TMD = Theoretical Maximum Density

AC = Asphalt Cement

Gsa = Apparent Specific Gravity of Aggregate

Gb = Specific Gravity of Asphalt Cement

**Table C1: Rut Depth Measurements For NMAS Subtask**

**National Center for Asphalt Technology**

**SMA Rut Testing Data**

**Mix: 4.75 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

Optimum Gradation -- 31% Passing 2.36 mm Sieve - 8.3% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 2				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.26	7.15	7.21	0.00
1000	9.90	9.34	9.62	2.42
4000	10.72	10.98	10.85	3.65
8000	11.24	11.68	11.46	4.26

Location: Center Rear				
Specimen: 3				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.74	6.77	6.76	0.00
1000	8.89	9.36	9.13	2.37
4000	10.81	10.64	10.73	3.97
8000	10.96	10.95	10.96	4.20

Location: Right Rear				
Specimen: 7				
VTM: 3.3				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.78	7.75	7.77	0.00
1000	10.03	9.98	10.01	2.24
4000	10.94	11.71	11.33	3.56
8000	11.37	12.36	11.87	4.10

Location: Left Front				
Specimen: 5				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.41	7.29	7.35	0.00
1000	9.73	9.25	9.49	2.14
4000	10.71	10.51	10.61	3.26
8000	11.40	11.07	11.24	3.89

Location: Center Front				
Specimen: 6				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.80	6.97	6.89	0.00
1000	9.73	9.36	9.55	2.66
4000	10.22	10.47	10.35	3.46
8000	10.76	11.17	10.97	4.08

Location: Right Front				
Specimen: 8				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.46	7.39	7.43	0.00
1000	9.69	10.27	9.98	2.56
4000	11.15	11.44	11.30	3.87
8000	12.28	12.05	12.17	4.74

Passes	Average	STD Dev
0	0.00	0.00
1000	2.40	0.19
4000	3.63	0.26
8000	4.21	0.29

**Table C2: Rut Depth Measurements For NMAS Subtask**

**National Center for Asphalt Technology**

**SMA Rut Testing Data**

**Mix: 4.75 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

Optimum Gradation -- 31% Passing 2.36 mm Sieve - 8.3% Asphalt

Test Temperature: 64C

Location: Left Rear				
Specimen: 2				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.75	7.19	6.97	0.00
1000	9.07	9.26	9.17	2.20
4000	10.90	11.11	11.01	4.04
8000	12.23	12.04	12.14	5.17

Location: Center Rear				
Specimen: 6				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.68	7.40	7.54	0.00
1000	10.12	9.82	9.97	2.43
4000	11.46	10.96	11.21	3.67
8000	12.33	12.10	12.22	4.68

Location: Right Rear				
Specimen: 7				
VTM: 3.3				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.93	6.73	6.83	0.00
1000	9.31	9.20	9.26	2.43
4000	11.39	11.16	11.28	4.45
8000	12.25	12.17	12.21	5.38

Location: Left Front				
Specimen: 3				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.01	6.63	6.82	0.00
1000	9.25	9.10	9.18	2.36
4000	11.21	11.07	11.14	4.32
8000	12.15	12.37	12.26	5.44

Location: Center Front				
Specimen: 5				
VTM: 3.3				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.72	6.63	6.68	0.00
1000	8.80	8.92	8.86	2.19
4000	10.90	11.04	10.97	4.30
8000	12.18	12.07	12.13	5.45

Location: Right Front				
Specimen: 8				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.47	6.49	6.48	0.00
1000	9.23	9.28	9.26	2.78
4000	11.13	11.20	11.17	4.69
8000	12.21	12.12	12.17	5.69

Passes	Average	STD Dev
0	0.00	0.00
1000	2.39	0.22
4000	4.24	0.35
8000	5.30	0.35

**Table C3: Rut Depth Measurements For NMAS Subtask**

**National Center for Asphalt Technology**

**SMA Rut Testing Data**

**Mix: 4.75 mm Nominal Maximum Size/1.18 mm Break Point Sieve**

Optimum Gradation -- 32% Passing 1.18 mm Sieve - 7.3% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 2				
VTM: 3.9				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.16	7.73	7.45	0.00
1000	9.19	9.32	9.26	1.81
4000	10.07	10.32	10.20	2.75
8000	10.60	10.72	10.66	3.22

Location: Center Rear				
Specimen: 1				
VTM: 4.1				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.77	7.57	7.67	0.00
1000	9.64	9.49	9.57	1.90
4000	10.07	10.01	10.04	2.37
8000	10.41	10.39	10.40	2.73

Location: Right Rear				
Specimen: 5				
VTM: 4.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.12	8.17	8.15	0.00
1000	9.97	9.90	9.94	1.79
4000	10.80	10.33	10.57	2.42
8000	11.27	10.83	11.05	2.91

Location: Left Front				
Specimen: 3				
VTM: 4.3				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.27	7.16	7.22	0.00
1000	8.73	8.57	8.65	1.44
4000	9.47	9.24	9.36	2.14
8000	9.89	9.64	9.77	2.55

Location: Center Front				
Specimen: 7				
VTM: 4.2				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.14	7.98	8.06	0.00
1000	9.27	9.18	9.23	1.17
4000	9.62	9.73	9.68	1.62
8000	9.93	9.94	9.94	1.88

Location: Right Front				
Specimen: 4				
VTM: 4.3				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.45	8.79	8.62	0.00
1000	9.94	10.06	10.00	1.38
4000	10.77	10.89	10.83	2.21
8000	11.64	11.43	11.54	2.92

Passes	Average	STD Dev
0	0.00	0.00
1000	1.58	0.29
4000	2.25	0.38
8000	2.70	0.46

**Table C4: Rut Depth Measurements For NMAS Subtask**

**National Center for Asphalt Technology**

**SMA Rut Testing Data**

**Mix: 4.75 mm Nominal Maximum Size/1.18 mm Break Point Sieve**

Optimum Gradation -- 32% Passing 1.18 mm Sieve - 7.3% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 5				
VTM: 4.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	5.20	5.07	5.14	0.00
1000	9.17	9.31	9.24	4.11
4000	11.27	11.55	11.41	6.28
8000	12.47	12.55	12.51	7.38

Location: Center Rear				
Specimen: 7				
VTM: 4.2				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.71	7.70	7.71	0.00
1000	10.56	10.36	10.46	2.76
4000	11.37	11.21	11.29	3.59
8000	11.83	11.80	11.82	4.11

Location: Right Rear				
Specimen: 4				
VTM: 4.3				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.55	7.42	7.49	0.00
1000	10.27	10.51	10.39	2.91
4000	11.45	11.42	11.44	3.95
8000	12.05	12.33	12.19	4.71

Location: Left Front				
Specimen: 2				
VTM: 3.9				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	5.36	5.87	5.62	0.00
1000	8.78	9.11	8.95	3.33
4000	10.97	11.00	10.99	5.37
8000	12.30	12.40	12.35	6.74

Location: Center Front				
Specimen: 1				
VTM: 4.1				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.52	7.36	6.94	0.00
1000	9.57	9.51	9.54	2.60
4000	10.65	10.60	10.63	3.69
8000	11.10	11.33	11.22	4.28

Location: Right Front				
Specimen: 3				
VTM: 4.3				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.75	7.15	6.95	0.00
1000	10.22	10.53	10.38	3.43
4000	11.41	11.75	11.58	4.63
8000	12.04	12.15	12.10	5.15

Passes	Average	STD Dev
0	0.00	0.00
1000	3.19	0.55
4000	4.58	1.07
8000	5.39	1.35

**Table C5: Rut Depth Measurements For NMAS Subtask**  
**National Center for Asphalt Technology**  
**SMA Rut Testing Data**

**Mix: 9.5 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

Optimum Gradation -- 30% Passing 4.75 mm Sieve - 5.6% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 2A				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.94	9.56	8.75	0.00
1000	9.54	11.76	10.65	1.90
4000	10.44	12.33	11.39	2.64
8000	10.95	12.61	11.78	3.03

Location: Center Rear				
Specimen: 3A				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.43	7.67	8.05	0.00
1000	9.63	9.35	9.49	1.44
4000	10.74	9.85	10.30	2.25
8000	11.18	10.18	10.68	2.63

Location: Right Rear				
Specimen: 4				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.83	8.82	8.83	0.00
1000	11.32	10.71	11.02	2.19
4000	11.90	10.21	11.06	2.23
8000	12.22	11.63	11.93	3.10

Location: Left Front				
Specimen: 1A				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.57	7.74	7.66	0.00
1000	9.20	9.56	9.38	1.73
4000	10.06	10.85	10.46	2.80
8000	10.76	10.95	10.86	3.20

Location: Center Front				
Specimen: 4A				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.68	10.57	9.63	0.00
1000	9.44	10.73	10.09	0.46
4000	9.99	11.37	10.68	1.06
8000	10.33	11.70	11.02	1.39

Location: Right Front				
Specimen: 1				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.80	7.67	7.74	0.00
1000	10.27	10.47	10.37	2.64
4000	10.64	10.72	10.68	2.95
8000	10.92	11.23	11.08	3.34

Passes	Average	STD Dev
0	0.00	0.00
1000	1.73	0.74
4000	2.32	0.68
8000	2.78	0.72

**Table C6: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 9.5 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

Optimum Gradation -- 30% Passing 4.75 mm Sieve - 5.6% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 1A				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.62	8.92	9.27	0.00
1000	10.92	10.67	10.80	1.53
4000	11.86	11.82	11.84	2.57
8000	12.79	13.02	12.91	3.64

Location: Center Rear				
Specimen: 4				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.73	8.00	7.87	0.00
1000	10.12	10.29	10.21	2.34
4000	12.50	12.18	12.34	4.48
8000	13.09	13.07	13.08	5.22

Location: Right Rear				
Specimen: 3A				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.53	9.31	9.42	0.00
1000	12.71	11.35	12.03	2.61
4000	13.15	12.61	12.88	3.46
8000	13.42	13.18	13.30	3.88

Location: Left Front				
Specimen: 4A				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.79	7.86	8.33	0.00
1000	10.22	10.44	10.33	2.01
4000	11.61	12.32	11.97	3.64
8000	12.72	13.47	13.10	4.77

Location: Center Front				
Specimen: 2A				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.50	7.87	8.19	0.00
1000	11.50	11.01	11.26	3.07
4000	12.73	12.58	12.66	4.47
8000	13.09	13.18	13.14	4.95

Location: Right Front				
Specimen: 1				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.05	7.90	7.98	0.00
1000	9.51	10.18	9.85	1.87
4000	10.34	11.64	10.99	3.02
8000	11.83	12.37	12.10	4.13

Passes	Average	STD Dev
0	0.00	0.00
1000	2.24	0.55
4000	3.61	0.77
8000	4.43	0.64

**Table C7: Rut Depth Measurements For NMAS Subtask**  
**National Center for Asphalt Technology**  
**SMA Rut Testing Data**

**Mix: 9.5 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

Optimum Gradation -- 23% Passing 2.36 mm Sieve - 5.8% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 1				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.07	7.49	7.78	0.00
1000	9.59	9.05	9.32	1.54
4000	11.11	10.63	10.87	3.09
8000	11.85	11.24	11.55	3.77

Location: Center Rear				
Specimen: 6				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.55	8.10	8.33	0.00
1000	11.02	10.38	10.70	2.38
4000	11.31	10.71	11.01	2.69
8000	12.32	11.10	11.71	3.39

Location: Right Rear				
Specimen: 2				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.30	7.78	7.54	0.00
1000	10.18	10.80	10.49	2.95
4000	11.08	10.96	11.02	3.48
8000	12.12	11.41	11.77	4.23

Location: Left Front				
Specimen: 5				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.47	7.08	7.28	0.00
1000	9.94	9.53	9.74	2.46
4000	10.02	10.22	10.12	2.85
8000	10.40	10.59	10.50	3.22

Location: Center Front				
Specimen: 4				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.94	7.69	8.32	0.00
1000	11.79	11.02	11.41	3.09
4000	11.92	11.39	11.66	3.34
8000	11.83	11.89	11.86	3.55

Location: Right Front				
Specimen: 8				
VTM: 3.9				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.55	7.92	7.74	0.00
1000	9.24	9.58	9.41	1.68
4000	9.69	10.09	9.89	2.16
8000	10.16	10.63	10.40	2.66

Passes	Average	STD Dev
0	0.00	0.00
1000	2.35	0.64
4000	2.93	0.48
8000	3.47	0.53

**Table C8: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 9.5 mm Nominal Maximum Size/2.36 mm Break Point Sieve**

Optimum Gradation -- 23% Passing 2.36 mm Sieve - 5.8% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 4				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.44	7.66	8.05	0.00
1000	11.15	10.79	10.97	2.92
4000	12.36	11.86	12.11	4.06
8000	13.28	12.36	12.82	4.77

Location: Center Rear				
Specimen: 2				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.53	7.47	7.50	0.00
1000	11.47	11.48	11.48	3.98
4000	12.72	12.79	12.76	5.26
8000	13.43	13.47	13.45	5.95

Location: Right Rear				
Specimen: 5				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.62	7.75	7.69	0.00
1000	9.78	10.72	10.25	2.57
4000	11.61	12.01	11.81	4.13
8000	12.19	12.52	12.36	4.67

Location: Left Front				
Specimen: 1				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.58	6.84	7.21	0.00
1000	10.46	10.85	10.66	3.45
4000	11.36	12.26	11.81	4.60
8000	12.20	12.72	12.46	5.25

Location: Center Front				
Specimen: 6				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.23	7.68	7.96	0.00
1000	11.48	11.45	11.47	3.51
4000	12.60	12.62	12.61	4.66
8000	13.42	13.48	13.45	5.50

Location: Right Front				
Specimen: 8				
VTM: 3.9				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.67	6.36	6.52	0.00
1000	10.71	10.68	10.70	4.18
4000	11.26	11.39	11.33	4.81
8000	12.91	12.12	12.52	6.00

Passes	Average	STD Dev
0	0.00	0.00
1000	3.43	0.61
4000	4.58	0.45
8000	5.36	0.57

**Table C9: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 12.5 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

Optimum Gradation -- 26% Passing 9.5 mm Sieve - 8.0% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 2				
VTM: 4.1				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	11.20	11.16	11.18	0.00
1000	13.25	13.08	13.17	1.99
4000	14.35	15.05	14.70	3.52
8000	15.17	15.95	15.56	4.38

Location: Center Rear				
Specimen: 4				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.15	9.81	9.48	0.00
1000	10.65	10.57	10.61	1.13
4000	11.62	12.12	11.87	2.39
8000	13.03	13.93	13.48	4.00

Location: Right Rear				
Specimen: 6				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.91	10.50	10.71	0.00
1000	11.57	11.96	11.77	1.06
4000	13.06	12.66	12.86	2.16
8000	13.58	13.21	13.40	2.69

Location: Left Front				
Specimen: 3				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.82	11.15	10.99	0.00
1000	12.19	11.75	11.97	0.98
4000	13.13	12.85	12.99	2.01
8000	13.68	13.22	13.45	2.47

Location: Center Front				
Specimen: 5				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.73	9.71	10.22	0.00
1000	12.18	10.84	11.51	1.29
4000	13.13	12.22	12.68	2.46
8000	14.05	13.93	13.99	3.77

Location: Right Front				
Specimen: 7				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.18	9.23	9.21	0.00
1000	11.38	10.65	11.02	1.81
4000	13.44	13.39	13.42	4.21
8000	13.52	14.31	13.92	4.71

Passes	Average	STD Dev
0	0.00	0.00
1000	1.38	0.42
4000	2.79	0.88
8000	3.67	0.91

**Table C10: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 12.5 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

Optimum Gradation -- 26% Passing 9.5 mm Sieve - 8.0% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 3				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	13.22	11.58	12.40	0.00
1000	14.50	12.32	13.41	1.01
4000	15.61	14.75	15.18	2.78
8000	16.23	15.05	15.64	3.24

Location: Center Rear				
Specimen: 5				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.88	11.98	11.43	0.00
1000	12.76	13.96	13.36	1.93
4000	13.49	15.18	14.34	2.91
8000	13.88	15.23	14.56	3.13

Location: Right Rear				
Specimen: 7				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.40	10.14	10.27	0.00
1000	14.04	13.75	13.90	3.63
4000	15.22	16.30	15.76	5.49
8000	16.78	17.33	17.06	6.79

Location: Left Front				
Specimen: 2				
VTM: 4.1				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	11.35	12.55	11.95	0.00
1000	14.04	13.79	13.92	1.97
4000	15.41	15.02	15.22	3.27
8000	15.56	15.60	15.58	3.63

Location: Center Front				
Specimen: 4				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	11.16	9.46	10.31	0.00
1000	13.98	12.76	13.37	3.06
4000	15.06	15.47	15.27	4.96
8000	17.05	17.27	17.16	6.85

Location: Right Front				
Specimen: 6				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.56	11.10	10.83	0.00
1000	13.40	12.94	13.17	2.34
4000	13.69	14.30	14.00	3.17
8000	14.33	15.64	14.99	4.16

Passes	Average	STD Dev
0	0.00	0.00
1000	2.32	0.92
4000	3.76	1.16
8000	4.63	1.73

**Table C11: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 12.5 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

Optimum Gradation -- 27% Passing 9.5 mm Sieve - 6.1% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 3				
VTM: 6.0				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.33	7.58	7.46	0.00
1000	11.16	11.48	11.32	3.87
4000	11.64	12.20	11.92	4.47
8000	11.86	12.70	12.28	4.83

Location: Center Rear				
Specimen: 1				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.39	7.16	7.28	0.00
1000	11.12	10.63	10.88	3.60
4000	11.31	10.89	11.10	3.83
8000	11.53	11.25	11.39	4.12

Location: Right Rear				
Specimen: 6				
VTM: 4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.43	7.39	7.41	0.00
1000	10.34	11.05	10.70	3.29
4000	10.68	11.23	10.96	3.55
8000	10.75	11.52	11.14	3.73

Location: Left Front				
Specimen: 4				
VTM: 6.0				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.03	7.33	7.68	0.00
1000	10.94	11.37	11.16	3.48
4000	11.85	12.44	12.15	4.47
8000	12.27	12.50	12.39	4.71

Location: Center Front				
Specimen: 7				
VTM: 3.9				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.82	7.24	7.53	0.00
1000	10.37	9.51	9.94	2.41
4000	10.93	10.17	10.55	3.02
8000	11.27	10.50	10.89	3.36

Location: Right Front				
Specimen: 5				
VTM: 6.1				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.15	8.51	8.33	0.00
1000	10.63	11.15	10.89	2.56
4000	11.34	12.02	11.68	3.35
8000	11.81	12.35	12.08	3.75

Passes	Average	STD Dev
0	0.00	0.00
1000	3.20	0.59
4000	3.78	0.59
8000	4.08	0.58

**Table C12: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 12.5 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

Optimum Gradation -- 27% Passing 9.5 mm Sieve - 6.1% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 3				
VTM: 6.0				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.27	6.10	6.19	0.00
1000	9.68	9.13	9.41	3.22
4000	11.32	11.18	11.25	5.07
8000	12.43	12.45	12.44	6.26

Location: Center Rear				
Specimen: 5				
VTM: 6.1				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.63	7.58	7.61	0.00
1000	10.16	9.97	10.07	2.46
4000	11.02	11.20	11.11	3.51
8000	12.47	12.53	12.50	4.90

Location: Right Rear				
Specimen: 9				
VTM: 4.3				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.53	7.32	7.43	0.00
1000	10.49	10.20	10.35	2.92
4000	11.76	11.57	11.67	4.24
8000	12.53	12.47	12.50	5.08

Location: Left Front				
Specimen: 4				
VTM: 6.0				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.73	6.46	6.60	0.00
1000	9.40	9.32	9.36	2.77
4000	11.15	11.07	11.11	4.52
8000	12.42	12.48	12.45	5.86

Location: Center Front				
Specimen: 8				
VTM: 4.1				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.29	7.23	7.26	0.00
1000	9.86	9.93	9.90	2.64
4000	11.16	11.30	11.23	3.97
8000	12.48	12.57	12.53	5.27

Location: Right Front				
Specimen: 1				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.29	7.31	7.30	0.00
1000	9.47	9.76	9.62	2.32
4000	11.28	11.48	11.38	4.08
8000	12.42	12.47	12.45	5.15

Passes	Average	STD Dev
0	0.00	0.00
1000	2.72	0.33
4000	4.23	0.53
8000	5.42	0.53

**Table C13: Rut Depth Measurements For NMAS Subtask**

**National Center for Asphalt Technology**

**SMA Rut Testing Data**

**Mix: 19 mm Nominal Maximum Size/4.75 mm Break Point Sieve - Phase I**

Optimum Gradation -- 24% Passing 4.75 mm Sieve - 5.6% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 1				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.55	9.75	9.65	0.00
1000	10.12	10.26	10.19	0.54
4000	10.62	10.66	10.64	0.99
8000	10.91	10.95	10.93	1.28

Location: Center Rear				
Specimen: 4				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.46	10.66	10.56	0.00
1000	11.11	10.69	10.90	0.34
4000	11.89	11.68	11.79	1.23
8000	12.10	12.15	12.13	1.57

Location: Right Rear				
Specimen: 6				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.56	9.89	9.73	0.00
1000	10.95	10.49	10.72	0.99
4000	11.32	11.11	11.22	1.49
8000	11.58	11.66	11.62	1.90

Location: Left Front				
Specimen: 3				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.78	9.60	9.69	0.00
1000	10.11	10.30	10.21	0.52
4000	10.46	10.88	10.67	0.98
8000	10.90	10.98	10.94	1.25

Location: Center Front				
Specimen: 5				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.21	9.40	9.31	0.00
1000	9.96	10.12	10.04	0.73
4000	10.61	11.27	10.94	1.64
8000	11.48	12.24	11.86	2.56

Location: Right Front				
Specimen: 7				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.36	9.32	8.84	0.00
1000	9.33	10.15	9.74	0.90
4000	9.89	10.40	10.15	1.31
8000	10.05	10.65	10.35	1.51

Passes	Average	STD Dev
0	0.00	0.00
1000	0.67	0.25
4000	1.27	0.26
8000	1.68	0.49

**Table C14: Rut Depth Measurements For NMAS Subtask**

**National Center for Asphalt Technology**

**SMA Rut Testing Data**

**Mix: 19 mm Nominal Maximum Size/4.75 mm Break Point Sieve - Phase I**

Optimum Gradation -- 24% Passing 4.75 mm Sieve - 5.6% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 1				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.89	10.79	10.84	0.00
1000	11.18	12.57	11.88	1.04
4000	11.61	12.32	11.97	1.13
8000	12.54	12.15	12.35	1.51

Location: Center Rear				
Specimen: 5				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.41	9.67	9.54	0.00
1000	11.26	11.08	11.17	1.63
4000	12.08	13.50	12.79	3.25
8000	12.70	14.75	13.73	4.19

Location: Right Rear				
Specimen: 3				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.30	9.85	10.08	0.00
1000	11.14	10.93	11.04	0.96
4000	11.65	11.64	11.65	1.57
8000	12.03	12.97	12.50	2.43

Location: Left Front				
Specimen: 7				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.86	10.15	10.01	0.00
1000	10.08	10.91	10.50	0.49
4000	11.30	11.54	11.42	1.42
8000	12.23	11.94	12.09	2.08

Location: Center Front				
Specimen: 6				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.01	9.66	9.84	0.00
1000	10.14	10.53	10.34	0.50
4000	11.76	11.81	11.79	1.95
8000	12.19	12.38	12.29	2.45

Location: Right Front				
Specimen: 4				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.79	9.02	8.91	0.00
1000	10.09	9.83	9.96	1.06
4000	11.96	10.68	11.32	2.42
8000	12.09	11.81	11.95	3.05

Passes	Average	STD Dev
0	0.00	0.00
1000	0.95	0.42
4000	1.95	0.78
8000	2.62	0.92

**Table C15: Rut Depth Measurements For NMAS Subtask**

**National Center for Asphalt Technology**

**SMA Rut Testing Data**

**Mix: 19 mm Nominal Maximum Size/4.75 mm Break Point Sieve - Phase II**

Optimum Gradation -- 24% Passing 4.75 mm Sieve - 5.5% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 3				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.42	9.19	8.81	0.00
1000	8.86	9.53	9.20	0.39
4000	10.03	10.20	10.12	1.31
8000	10.16	10.45	10.31	1.50

Location: Center Rear				
Specimen: 7				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.75	9.78	9.77	0.00
1000	10.34	10.12	10.23	0.47
4000	11.12	10.40	10.76	0.99
8000	11.60	10.80	11.20	1.44

Location: Right Rear				
Specimen: 5				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.23	9.55	9.39	0.00
1000	9.87	9.75	9.81	0.42
4000	10.02	10.35	10.19	0.79
8000	10.48	10.80	10.64	1.25

Location: Left Front				
Specimen: 4				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.48	9.38	9.43	0.00
1000	10.35	9.61	9.98	0.55
4000	10.70	10.27	10.49	1.06
8000	11.13	10.40	10.77	1.34

Location: Center Front				
Specimen: 8				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.07	9.09	9.08	0.00
1000	9.60	9.35	9.48	0.40
4000	10.40	9.96	10.18	1.10
8000	11.11	10.60	10.86	1.78

Location: Right Front				
Specimen: 6				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.17	9.28	9.23	0.00
1000	9.33	9.38	9.36	0.13
4000	9.67	9.57	9.62	0.40
8000	10.10	10.08	10.09	0.87

Passes	Average	STD Dev
0	0.00	0.00
1000	0.39	0.14
4000	0.94	0.32
8000	1.36	0.30

**Table C16: Rut Depth Measurements For NMAS Subtask**

**National Center for Asphalt Technology**

**SMA Rut Testing Data**

**Mix: 19 mm Nominal Maximum Size/4.75 mm Break Point Sieve - Phase II**

Optimum Gradation -- 24% Passing 4.75 mm Sieve - 5.5% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 8				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.22	9.18	9.70	0.00
1000	11.75	10.19	10.97	1.27
4000	12.90	11.45	12.18	2.48
8000	13.24	12.00	12.62	2.92

Location: Center Rear				
Specimen: 3				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.69	10.42	10.56	0.00
1000	10.75	11.25	11.00	0.45
4000	11.46	12.35	11.91	1.35
8000	12.02	12.72	12.37	1.82

Location: Right Rear				
Specimen: 6				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	11.03	9.74	10.39	0.00
1000	11.98	11.24	11.61	1.23
4000	12.43	11.54	11.99	1.60
8000	12.78	12.44	12.61	2.23

Location: Left Front				
Specimen: 7				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.57	9.20	9.39	0.00
1000	9.81	9.57	9.69	0.31
4000	10.21	10.78	10.50	1.11
8000	10.62	11.41	11.02	1.63

Location: Center Front				
Specimen: 5				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.78	10.67	10.23	0.00
1000	10.54	11.62	11.08	0.85
4000	10.75	12.62	11.69	1.46
8000	11.65	12.75	12.20	1.98

Location: Right Front				
Specimen: 4				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.30	9.72	9.51	0.00
1000	10.78	11.06	10.92	1.41
4000	11.61	11.93	11.77	2.26
8000	12.15	12.30	12.23	2.72

Passes	Average	STD Dev
0	0.00	0.00
1000	0.92	0.46
4000	1.71	0.54
8000	2.21	0.51

**Table C17: Rut Depth Measurements For NMAAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 25 mm Nominal Maximum Size/12.5 mm Break Point Sieve**

Optimum Gradation -- 28% Passing 4.75 mm Sieve - 5.6% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 6				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.50	7.56	7.53	0.00
1000	10.73	10.36	10.55	3.02
4000	11.99	11.17	11.58	4.05
8000	12.41	11.98	12.20	4.67

Location: Center Rear				
Specimen: 2				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.35	7.97	7.66	0.00
1000	9.95	10.38	10.17	2.51
4000	10.76	10.54	10.65	2.99
8000	11.20	10.93	11.07	3.41

Location: Right Rear				
Specimen: 4				
VTM: 4.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.48	7.46	7.47	0.00
1000	10.80	11.23	11.02	3.55
4000	11.47	11.80	11.64	4.17
8000	11.58	11.90	11.74	4.27

Location: Left Front				
Specimen: 7				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.29	9.07	9.18	0.00
1000	11.83	11.80	11.82	2.64
4000	12.20	12.10	12.15	2.97
8000	15.95	14.21	15.08	5.90

Location: Center Front				
Specimen: 3				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.24	7.01	7.13	0.00
1000	10.92	11.23	11.08	3.95
4000	11.80	11.73	11.77	4.64
8000	12.24	12.01	12.13	5.00

Location: Right Front				
Specimen: 8				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.34	8.13	7.74	0.00
1000	11.34	11.23	11.29	3.55
4000	12.02	11.75	11.89	4.15
8000	12.36	12.39	12.38	4.64

Passes	Average	STD Dev
0	0.00	0.00
1000	3.20	0.57
4000	3.83	0.69
8000	4.65	0.82

**Table C18: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 25 mm Nominal Maximum Size/12.5 mm Break Point Sieve**

Optimum Gradation -- 28% Passing 4.75 mm Sieve - 5.6% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 4				
VTM: 4.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.40	7.23	7.32	0.00
1000	8.93	8.89	8.91	1.60
4000	11.00	10.92	10.96	3.65
8000	15.28	15.31	15.30	7.98

Location: Center Rear				
Specimen: 8				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.23	7.31	7.27	0.00
1000	9.12	9.20	9.16	1.89
4000	10.70	10.81	10.76	3.49
8000	14.55	14.66	14.61	7.34

Location: Right Rear				
Specimen: 6				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.77	6.93	6.85	0.00
1000	8.52	8.62	8.57	1.72
4000	10.41	10.37	10.39	3.54
8000	13.82	13.55	13.69	6.84

Location: Left Front				
Specimen: 7				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.77	6.57	6.67	0.00
1000	8.41	8.57	8.49	1.82
4000	9.87	9.92	9.90	3.23
8000	15.11	15.17	15.14	8.47

Location: Center Front				
Specimen: 2				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.35	7.10	7.23	0.00
1000	9.35	9.14	9.25	2.02
4000	10.94	10.70	10.82	3.60
8000	15.01	14.93	14.97	7.75

Location: Right Front				
Specimen: 8				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.06	6.97	7.02	0.00
1000	9.01	9.04	9.03	2.01
4000	10.81	10.90	10.86	3.84
8000	14.23	14.88	14.56	7.54

Passes	Average	STD Dev
0	0.00	0.00
1000	1.84	0.17
4000	3.56	0.20
8000	7.65	0.56

**Table C19: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 25 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

Optimum Gradation -- 26% Passing 4.75 mm Sieve - 5.5% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 2A				
VTM: 4.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.94	9.56	8.75	0.00
1000	9.54	11.76	10.65	1.90
4000	10.44	12.33	11.39	2.64
8000	10.95	12.61	11.78	3.03

Location: Center Rear				
Specimen: 3A				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.43	7.67	8.05	0.00
1000	9.63	9.35	9.49	1.44
4000	10.74	9.85	10.30	2.25
8000	11.18	10.18	10.68	2.63

Location: Right Rear				
Specimen: 4				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.83	8.82	8.83	0.00
1000	11.32	10.21	10.77	1.94
4000	11.90	10.71	11.31	2.48
8000	12.22	11.63	11.93	3.10

Location: Left Front				
Specimen: 1A				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.57	7.74	7.66	0.00
1000	9.20	9.56	9.38	1.73
4000	10.06	10.85	10.46	2.80
8000	10.76	10.95	10.86	3.20

Location: Center Front				
Specimen: 4A				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.68	10.57	9.63	0.00
1000	9.44	10.73	10.09	0.46
4000	9.99	11.37	10.68	1.06
8000	10.33	11.70	11.02	1.39

Location: Right Front				
Specimen: 1				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.80	7.67	7.74	0.00
1000	10.27	10.47	10.37	2.64
4000	10.64	10.72	10.68	2.95
8000	10.92	11.23	11.08	3.34

Passes	Average	STD Dev
0	0.00	0.00
1000	1.68	0.72
4000	2.36	0.68
8000	2.78	0.72

**Table C20: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 25 mm Nominal Maximum Size/9.5 mm Break Point Sieve**

Optimum Gradation -- 26% Passing 4.75 mm Sieve - 5.5% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 1A				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.62	8.92	9.27	0.00
1000	10.92	10.67	10.80	1.53
4000	11.86	11.82	11.84	2.57
8000	12.79	13.02	12.91	3.64

Location: Center Rear				
Specimen: 4				
VTM: 3.4				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.73	8.00	7.87	0.00
1000	10.12	10.29	10.21	2.34
4000	12.50	12.18	12.34	4.48
8000	13.09	13.07	13.08	5.22

Location: Right Rear				
Specimen: 3A				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.53	9.31	9.42	0.00
1000	12.71	11.35	12.03	2.61
4000	13.15	12.61	12.88	3.46
8000	13.42	13.18	13.30	3.88

Location: Left Front				
Specimen: 4A				
VTM: 3.7				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.79	7.86	8.33	0.00
1000	10.22	10.44	10.33	2.01
4000	11.61	12.32	11.97	3.64
8000	12.72	13.47	13.10	4.77

Location: Center Front				
Specimen: 2A				
VTM: 3.6				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.50	7.87	8.19	0.00
1000	11.50	11.01	11.26	3.07
4000	12.73	12.58	12.66	4.47
8000	13.09	13.18	13.14	4.95

Location: Right Front				
Specimen: 1				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.05	7.90	7.98	0.00
1000	9.51	10.18	9.85	1.87
4000	10.34	11.64	10.99	3.02
8000	11.83	12.37	12.10	4.13

Passes	Average	STD Dev
0	0.00	0.00
1000	2.24	0.55
4000	3.61	0.77
8000	4.43	0.64

**Table C21: Rut Depth Measurements For NMAAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 25 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

Optimum Gradation -- 21% Passing 4.75 mm Sieve - 6.3% Asphalt

Test Temperature: 55 C

Location: Left Rear				
Specimen: 2				
VTM: 4.1				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.35	8.04	8.20	0.00
1000	9.68	9.52	9.60	1.41
4000	11.08	11.02	11.05	2.86
8000	11.70	11.66	11.68	3.49

Location: Center Rear				
Specimen: 3				
VTM: 3.9				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.79	7.53	7.66	0.00
1000	9.05	8.51	8.78	1.12
4000	10.03	9.85	9.94	2.28
8000	10.91	10.89	10.90	3.24

Location: Right Rear				
Specimen: 5				
VTM: 4.0				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.21	8.28	8.25	0.00
1000	9.67	9.68	9.68	1.43
4000	11.03	11.31	11.17	2.93
8000	11.54	11.79	11.67	3.42

Location: Left Front				
Specimen: 4				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.01	7.97	8.49	0.00
1000	10.45	9.06	9.76	1.27
4000	10.55	9.97	10.26	1.77
8000	11.81	11.33	11.57	3.08

Location: Center Front				
Specimen: 6				
VTM: 4.2				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.57	7.82	8.20	0.00
1000	9.91	9.26	9.59	1.39
4000	10.81	10.89	10.85	2.66
8000	11.31	11.39	11.35	3.16

Location: Right Front				
Specimen: 8				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.17	5.92	6.05	0.00
1000	8.68	9.00	8.84	2.80
4000	10.61	10.95	10.78	4.74
8000	11.13	11.28	11.21	5.16

Passes	Average	STD Dev
0	0.00	0.00
1000	1.57	0.61
4000	2.87	1.01
8000	3.59	0.78

**Table C22: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 25 mm Nominal Maximum Size/4.75 mm Break Point Sieve**

Optimum Gradation -- 21% Passing 4.75 mm Sieve - 6.3% Asphalt

Test Temperature: 64 C

Location: Left Rear				
Specimen: 2				
VTM: 4.1				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.55	7.57	7.56	0.00
1000	10.27	10.30	10.29	2.73
4000	11.41	11.89	11.65	4.09
8000	14.52	15.56	15.04	7.48

Location: Center Rear				
Specimen: 3				
VTM: 3.9				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.73	7.97	7.85	0.00
1000	10.20	10.40	10.30	2.45
4000	10.98	11.09	11.04	3.19
8000	14.30	14.20	14.25	6.40

Location: Right Rear				
Specimen: 5				
VTM: 4.0				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.82	8.93	8.88	0.00
1000	10.97	11.12	11.05	2.17
4000	12.27	12.36	12.32	3.44
8000	14.45	14.74	14.60	5.72

Location: Left Front				
Specimen: 4				
VTM: 3.8				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.68	7.59	7.64	0.00
1000	10.23	10.18	10.21	2.57
4000	11.36	11.11	11.24	3.60
8000	14.23	14.27	14.25	6.62

Location: Center Front				
Specimen: 8				
VTM: 3.5				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.89	7.40	7.65	0.00
1000	10.00	9.87	9.94	2.29
4000	11.25	11.19	11.22	3.58
8000	14.55	14.46	14.51	6.86

Location: Right Front				
Specimen: 6				
VTM: 4.2				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.94	8.76	8.85	0.00
1000	11.10	11.22	11.16	2.31
4000	12.31	12.23	12.27	3.42
8000	15.05	14.88	14.97	6.12

Passes	Average	STD Dev
0	0.00	0.00
1000	2.42	0.20
4000	3.55	0.30
8000	6.53	0.61

**Table C23: Rut Depth Measurements For NMA Subtask**  
**National Center for Asphalt Technology**  
**SMA Rut Testing Data**

Mix: 9.5 mm Superpave - Above the Restricted Zone

Test Temperature: 55 C

Location: Left Rear				
Specimen: 1				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.72	7.61	7.67	0.00
1000	8.74	8.84	8.79	1.13
4000	9.56	9.34	9.45	1.79
8000	9.67	9.58	9.63	1.96

Location: Center Rear				
Specimen: 4				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.36	7.65	7.51	0.00
1000	8.60	8.49	8.55	1.04
4000	8.78	8.72	8.75	1.25
8000	9.19	9.09	9.14	1.64

Location: Right Rear				
Specimen: 6				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.31	7.29	7.30	0.00
1000	8.42	8.51	8.47	1.17
4000	8.89	8.91	8.90	1.60
8000	9.11	9.07	9.09	1.79

Location: Left Front				
Specimen: 2				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.87	7.70	7.79	0.00
1000	8.58	8.81	8.70	0.91
4000	8.91	9.18	9.05	1.26
8000	9.41	9.66	9.54	1.75

Location: Center Front				
Specimen: 5				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.58	6.80	6.69	0.00
1000	8.13	8.35	8.24	1.55
4000	8.39	8.58	8.49	1.80
8000	8.58	8.79	8.69	2.00

Location: Right Front				
Specimen: 8				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.81	7.98	7.90	0.00
1000	8.67	8.74	8.71	0.81
4000	9.03	9.13	9.08	1.19
8000	9.16	9.30	9.23	1.34

Passes	Average	STD Dev
0	0.00	0.00
1000	1.10	0.26
4000	1.48	0.28
8000	1.74	0.24

**Table C24: Rut Depth Measurements For NMA Subtask**  
**National Center for Asphalt Technology**  
**SMA Rut Testing Data**

Mix: 9.5 mm Superpave - Below the Restricted Zone

Test Temperature: 55 C

Location: Left Rear				
Specimen: 4				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.79	8.76	8.78	0.00
1000	10.82	10.92	10.87	2.10
4000	12.87	12.85	12.86	4.09
8000	13.29	13.28	13.29	4.51

Location: Center Rear				
Specimen: 7				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.54	7.73	7.64	0.00
1000	9.71	9.18	9.45	1.81
4000	11.03	10.74	10.89	3.25
8000	11.63	11.48	11.56	3.92

Location: Right Rear				
Specimen: 8				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.91	8.33	8.12	0.00
1000	10.01	10.22	10.12	2.00
4000	11.78	11.53	11.66	3.54
8000	13.20	12.26	12.73	4.61

Location: Left Front				
Specimen: 5				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.39	8.21	8.30	0.00
1000	10.28	10.59	10.44	2.14
4000	12.99	11.97	12.48	4.18
8000	13.28	13.38	13.33	5.03

Location: Center Front				
Specimen: 6				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.54	7.60	7.57	0.00
1000	8.52	9.28	8.90	1.33
4000	9.68	10.67	10.18	2.61
8000	11.28	11.16	11.22	3.65

Location: Right Front				
Specimen: 3				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.61	7.47	7.54	0.00
1000	9.58	9.32	9.45	1.91
4000	10.73	10.25	10.49	2.95
8000	11.87	11.05	11.46	3.92

Passes	Average	STD Dev
0	0.00	0.00
1000	1.88	0.29
4000	3.43	0.62
8000	4.27	0.53

**Table C25: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 25 mm Superpave - Above the Restricted Zone**

Test Temperature: 55 C

Location: Left Rear				
Specimen: 1				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	5.59	5.27	5.43	0.00
1000	5.88	5.55	5.72	0.29
4000	6.10	5.92	6.01	0.58
8000	6.36	6.08	6.22	0.79

Location: Center Rear				
Specimen: 4				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	5.41	5.43	5.42	0.00
1000	7.01	6.50	6.76	1.34
4000	7.30	6.96	7.13	1.71
8000	7.52	7.28	7.40	1.98

Location: Right Rear				
Specimen: 6				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.20	6.26	6.23	0.00
1000	7.16	7.25	7.21	0.98
4000	7.63	7.90	7.77	1.54
8000	8.17	8.21	8.19	1.96

Location: Left Front				
Specimen: 2				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.56	6.74	6.65	0.00
1000	7.74	7.85	7.80	1.15
4000	8.06	8.26	8.16	1.51
8000	8.45	8.54	8.50	1.85

Location: Center Front				
Specimen: 5				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	5.47	5.66	5.57	0.00
1000	6.32	6.63	6.48	0.91
4000	6.53	7.13	6.83	1.27
8000	6.88	7.55	7.22	1.65

Location: Right Front				
Specimen: 8				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	6.42	6.56	6.49	0.00
1000	7.55	7.74	7.65	1.16
4000	7.83	8.26	8.05	1.56
8000	8.12	8.51	8.32	1.83

Passes	Average	STD Dev
0	0.00	0.00
1000	0.97	0.37
4000	1.36	0.41
8000	1.68	0.45

**Table C26: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 25 mm Superpave - Below the Restricted Zone**

Test Temperature: 55 C

Location: Left Rear				
Specimen: 2				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.15	10.17	10.16	0.00
1000	11.04	10.79	10.92	0.75
4000	12.17	11.34	11.76	1.60
8000	12.97	11.80	12.39	2.23

Location: Center Rear				
Specimen: 4				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.39	8.82	9.11	0.00
1000	9.75	9.63	9.69	0.59
4000	10.58	10.03	10.31	1.20
8000	11.08	10.85	10.97	1.86

Location: Right Rear				
Specimen: 6				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.13	9.11	9.12	0.00
1000	9.87	9.76	9.82	0.69
4000	10.65	10.70	10.68	1.56
8000	11.37	11.06	11.22	2.10

Location: Left Front				
Specimen: 3				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.90	10.05	9.98	0.00
1000	10.65	10.68	10.67	0.69
4000	11.05	11.48	11.27	1.29
8000	11.94	12.21	12.08	2.10

Location: Center Front				
Specimen: 5				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.85	8.36	8.61	0.00
1000	9.67	8.65	9.16	0.56
4000	10.20	9.05	9.63	1.02
8000	10.81	9.16	9.99	1.38

Location: Right Front				
Specimen: 7				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.47	9.40	9.44	0.00
1000	10.80	11.07	10.94	1.50
4000	11.62	11.10	11.36	1.93
8000	12.20	11.68	11.94	2.51

Passes	Average	STD Dev
0	0.00	0.00
1000	0.80	0.35
4000	1.43	0.33
8000	2.03	0.38

**Table C27: Rut Depth Measurements For NMAS Subtask  
National Center for Asphalt Technology  
SMA Rut Testing Data**

**Mix: 25 mm Superpave - Below the Restricted Zone**

Test Temperature: 64 C

Location: Left Rear				
Specimen: 6				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.00	8.94	8.97	0.00
1000	10.00	9.91	9.96	0.99
4000	10.83	10.56	10.70	1.73
8000	11.30	10.91	11.11	2.14

Location: Center Rear				
Specimen: 4				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.81	10.02	9.92	0.00
1000	11.90	10.77	11.34	1.42
4000	13.10	12.15	12.63	2.71
8000	13.49	13.12	13.31	3.39

Location: Right Rear				
Specimen: 2				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	8.22	7.80	8.01	0.00
1000	9.66	11.13	10.40	2.39
4000	10.44	12.33	11.39	3.38
8000	11.11	13.11	12.11	4.10

Location: Left Front				
Specimen: 7				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	9.11	8.60	8.86	0.00
1000	10.22	10.40	10.31	1.46
4000	11.10	10.95	11.03	2.17
8000	11.49	11.57	11.53	2.68

Location: Center Front				
Specimen: 5				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	7.70	8.59	8.15	0.00
1000	8.53	9.51	9.02	0.88
4000	9.88	10.78	10.33	2.19
8000	11.34	11.68	11.51	3.37

Location: Right Front				
Specimen: 3				
VTM:				
Passes	Reading 1	Reading 2	Average	Rut Depth
0	10.73	8.29	9.51	0.00
1000	10.00	9.96	9.98	0.47
4000	11.98	11.00	11.49	1.98
8000	12.49	11.21	11.85	2.34

Passes	Average	STD Dev
0	0.00	0.00
1000	1.27	0.66
4000	2.36	0.59
8000	3.00	0.75

**NCHRP 9-8 Phase II - Task 13: Verify Density Requirements**

Table D.1: Results of Permeability Testing

Site No.: 2

Location No.	1	2	3	4	5	6	7	8	9	10
Volume of Water at Start of Test, ml	505	Could	500	500	500	500	500	500	500	500
Volume of Water at End of Test, ml	475	Not	495	450	340	365	495	370	500	500
Test Time, sec.	120	Seat	180	180	180	180	180	180	180	180
Volume of Water Lost	30		5	50	160	135	5	130	0	0
Core Density, pcf	142.6	137.7	136.4	138	137.2	138.2	139.7	139.6	145.9	142.8
Theoretical Maximum Density of Core	152.8	152.8	152.8	152.8	152.8	151.4	151.4	151.4	151.4	151.4
Permeability, ml/sec	0.25		0.03	0.28	0.89	0.75	0.03	0.72	0.00	0.00
Air Void Content of Core, %	6.7	9.9	10.7	9.7	10.2	8.7	7.7	7.8	3.6	5.7

**NCHRP 9-8 Phase II - Task 13: Verify Density Requirements**

Table D.2: Results of Permeability Testing

Site No.:     3    

Location No.	1	2	3	4	5	6	7	8	9	10
Volume of Water at Start of Test, ml	500	500	500	500	500	500	500	500	500	500
Volume of Water at End of Test, ml	200	220	420	0	50	253	280	0	227	240
Test Time, sec.	180	180	180	180	180	50	315	180	130	400
Volume of Water Lost	300	280	80	500	450	247	220	500	273	260
Core Density, pcf	127.8	126.6	125.6	127.1	129.0	125.5	124.7	124.5	124.6	126.3
Theoretical Maximum Density of Core	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4	136.4
Permeability, ml/sec	1.67	1.56	0.44	2.78	2.50	4.94	0.70	2.78	2.10	0.65
Air Void Content of Core, %	6.3	7.2	7.9	6.8	5.4	8.0	8.6	8.7	8.7	7.4

**NCHRP 9-8 Phase II - Task 13: Verify Density Requirements**

Table D.3: Results of Permeability Testing

Site No.:     4    

Location No.	1	2	3	4	5	6	7	8	9	10
Volume of Water at Start of Test, ml	500	500	500	500	500	500	500	500	500	500
Volume of Water at End of Test, ml	320	100	100	100	50	253	280	147	227	240
Test Time, sec.	69	84	76	86	51	110	60	32	30	70
Volume of Water Lost	180	400	400	400	450	247	220	353	273	260
Core Density, pcf	136.7	133.7	134.9	135.8	132.5	140.0	138.6	137.9	137.3	136.6
Theoretical Maximum Density of Core	151.3	151.3	151.3	151.3	151.3	151.3	151.3	151.3	151.3	151.3
Permeability, ml/sec	2.61	4.76	5.26	4.65	8.82	2.25	3.67	11.03	9.10	3.71
Air Void Content of Core, %	9.6	11.6	10.8	10.2	12.4	7.5	8.4	8.9	9.3	9.7

**NCHRP 9-8 Phase II - Task 13: Verify Density Requirements**

Table D.4: Results of Permeability Testing

Site No.:     5    

Location No.	1	2	3	4	5	6	7	8	9	10
Volume of Water at Start of Test, ml	500	500	500	500	500	500	500	500	500	500
Volume of Water at End of Test, ml	100	340	100	350	350	260	100	260	100	220
Test Time, sec.	83	107	37	80	106	91	38	144	37	148
Volume of Water Lost	400	160	400	150	150	240	400	240	400	280
Core Density, pcf	136.1	136.5	134.5	136.1	136.2	140.9	136.6	138.5	136.6	137.6
Theoretical Maximum Density of Core	152.0	152.0	152.0	152.0	152.0	152.5	152.5	152.5	152.5	152.5
Permeability, ml/sec	4.82	1.50	10.81	1.89	1.42	2.65	10.67	1.67	10.81	1.89
Air Void Content of Core, %	10.4	10.2	11.5	10.4	10.4	7.6	10.4	9.2	10.4	9.8

**NCHRP 9-8 Phase II - Task 13: Verify Density Requirements**

Table D.5: Results of Permeability Testing

Site No.: 6

Location No.	1	2	3	4	5
Volume of Water at Start of Test, ml	500	500	500	500	500
Volume of Water at End of Test, ml	380	465	465	448	335
Test Time, sec.	150	315	150	120	240
Volume of Water Lost	120	35	35	52	165
Core Density, pcf	145.3	146.3	144.1	148.0	147.1
Theoretical Maximum Density of Core	154.6	154.6	154.6	154.6	154.6
Permeability, ml/sec	0.80	0.11	0.23	0.43	0.69
Air Void Content of Core, %	6.0	5.4	6.8	4.3	4.9

**NCHRP 9-8 Phase II - Task 13: Verify Density Requirements**

Table D.6: Results of Permeability Testing

Site No.:     9    

Location No.	6	7	8	9	10
Volume of Water at Start of Test, ml	500	500	500	500	500
Volume of Water at End of Test, ml	375	350	465	448	335
Test Time, sec.	30	43	150	120	240
Volume of Water Lost	125	150	35	52	165
Core Density, pcf	147.1	146.3	149.1	145.5	150.5
Theoretical Maximum Density of Core	159.1	159.1	159.1	159.1	159.1
Permeability, ml/sec	4.17	3.49	0.23	0.43	0.69
Air Void Content of Core, %	7.5	8.0	6.3	8.5	5.4

**NCHRP 9-8 Phase II - Task 13: Verify Density Requirements**

Table D.7: Results of Permeability Testing

Site No.:     10    

Location No.	1	2	3	4	5	6	7	8	9	10
Volume of Water at Start of Test, ml	500	500	500	500	500	500	500	500	500	500
Volume of Water at End of Test, ml	310	330	340	315	280	340	473	330	350	310
Test Time, sec.	60	60	60	60	60	60	60	60	60	60
Volume of Water Lost	190	170	160	185	220	160	27	170	150	190
Core Density, pcf	2.370	2.362	2.345	2.459	2.404	2.367	2.400	2.357	2.291	2.358
Theoretical Maximum Density of Core	2.604	2.604	2.604	2.604	2.604	2.604	2.604	2.604	2.604	2.604
Permeability, ml/sec	3.17	2.83	2.67	3.08	3.67	2.67	0.45	2.83	2.50	3.17
Air Void Content of Core, %	9.0	9.3	9.9	5.6	7.7	9.1	7.8	9.5	12.0	9.4

**NCHRP 9-8 Phase II - Task 13: Verify Density Requirements**

Table D.8: Results of Permeability Testing

Site No.:     11    

Location No.	11	27	28	29	30	12	32	33	34	35
Volume of Water at Start of Test, ml	500	500	500	500	500	500	500	500	500	500
Volume of Water at End of Test, ml	460	490	500	490	465	460	440	490	490	485
Test Time, sec.	60	60	60	60	60	60	60	60	60	60
Volume of Water Lost	40	10	0	10	35	40	60	10	10	15
Core Density, pcf	144.6	145.3	143.2	142.7	143	145.7	143.7	146.2	147.7	146.7
Theoretical Maximum Density of Core	151.0	151.0	151.0	151.0	151.0	151.8	151.8	151.8	151.8	151.8
Permeability, ml/sec	0.67	0.17	0.00	0.17	0.58	0.67	1.00	0.17	0.17	0.25
Air Void Content of Core, %	4.2	3.8	5.2	5.5	5.3	4.0	5.3	3.7	2.7	3.4

## **APPENDIX E: Laboratory Permeability Test Procedure**

Florida Method of Test  
for

**MEASUREMENT OF WATER PERMEABILITY  
OF COMPACTED ASPHALT PAVING MIXTURES**

Designation: FM 5-565

1. SCOPE

- 1.1 This test method covers the laboratory determination of the water conductivity of a compacted asphalt paving mixture sample. The measurement provides an indication of water permeability of that sample as compared to those of other asphalt samples tested in the same manner.
- 1.2 The procedure uses either laboratory compacted cylindrical specimens or field core samples obtained from existing pavements.
- 1.3 The values stated in metric (SI) units are to be regarded as standard. Values given in parenthesis are for information and reference purposes only.
- 1.4 *This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, and health practices and determine the applicability of regulatory limitations prior to use.*

2. APPLICABLE DOCUMENTS

2.1 AASHTO Standards:

M 231 Weights and Balances Used in the Testing of Highway Materials

2.2 Florida Test Methods

FM 1-T166 Bulk Specific Gravity of Compacted Bituminous Mixtures  
FM 1-T209 Maximum Specific Gravity of Bituminous Paving Mixtures

3. SUMMARY OF TEST METHOD

- 3.1 A falling head permeability test, as shown in Figure 1, is used to determine the rate of flow of water through the specimen. Water from a graduated buret is allowed to flow through a saturated asphalt sample and the interval of time taken to reach a known change in head loss is recorded. The coefficient of permeability of the asphalt sample is then determined based on Darcy's law.

#### 4. SIGNIFICANCE AND USE

- 4.1 This test method provides a means for determining water conductivity of water-saturated asphalt samples. It applies to one-dimensional, laminar flow of water. It is assumed the Darcy's law is valid.

#### 5. APPARATUS

5.1 *Graduated Buret*- A 1000 mL graduated glass buret with a stopcock valve.

5.2 *Buret Stand*- A three or four legged support capable of holding the buret firmly in position. A suitable arrangement is shown in Figure 1 and consists of (1) a cast-iron tripod base support and a rod, 915 mm in length and 12.7 mm in diameter, (2) two three-prong clamps, 270 mm in overall length and 150 mm in arm length, and (3) two connectors, with a 12.7 mm hole, for rod ends.

5.3 *Top and Base Plates*- Impermeable, rigid (PVC or plexi-glass) 300x300x25 mm top and base plates shall be provided to support the sample and provide for transmission of water to and from the specimen. The top plate shall have a central hole to fit a 9.5x9.5 mm hose barb for water transmission to the sample and another 7.9 mm diameter hole to fit an air relieve valve. The base plate shall have a 100 mm diameter central hole for water drainage from the specimen. Both plates shall have a 15 mm diameter hole near the corners to fit a 12.7 mm diameter carriage bolt.

5.4 *Hose Barb*- A 9.5x9.5 mm hose barb for water transmission to the sample.

5.5 *Plastic Hose*- The buret and the hose barb shall be connected using a 9.5 mm inside diameter plastic hose. The length of the hose shall be such that, during testing, the buret and the hose barb are aligned and the plastic hose is straight.

5.6 *O-rings*- The top and base plates shall be sealed to the test sample with rubber O-rings of 6.35 mm minimum thickness. The O-ring diameter shall not be more that 12.7 mm larger than that of the test specimen.

5.7 *Carriage Bolts*- The plates along with the O-rings and the specimen shall be held together as to create a permeameter cell using four 200 mm long bolts.

5.5 *Pan*- A metal or plastic pan of sufficient size to contain the apparatus and catch the water draining from the sample.

- 5.6 *Casting Molds*- Casting molds, consisting of pieces of standard PVC pipe, to allow for easy molding of a sealing ring around the test specimen. The mold diameter shall be approximately 50 mm larger than that of the test sample. The height of the mold shall be at least 10 mm taller than that of the test specimen.
- 5.7 *Flat Metal Plate*- A flat metal plate onto which the molds are placed.
- 5.8 *Timer*- A stop watch or other timing device graduated in divisions of 0.1 s or less and accurate to within 0.05% when tested over intervals of not less than 15 min.
- 5.9 *Measuring Device*-A device used to measure the dimensions of the specimen shall be capable of measuring to the nearest 0.3 mm or better.
- 5.10 *Balance*-The balance shall be suitable for determining the weight of the specimen and shall conform to the requirements of AASHTO M231, Class G2. The weight of the specimens shall be determined to the nearest 0.1 g.
- 5.11 *Saw*-Equipment for wet cutting the specimen to the desired lengths.
- 5.12 *Masking Tape*-A 50 mm-wide masking tape to cover the top and bottom surfaces of the samples to prevent epoxy seepage into those areas.
- 5.13 *Sealing Agent*-Epoxy-like material to seal the sides of samples.

## 6. PREPARATION OF TEST SAMPLES

- 6.1 Saw cut the field cores or the laboratory compacted specimens into the desired test sample thickness.
- NOTE 1: If the total height of the core or the laboratory compacted specimen is to be used for testing, consideration should be given to trimming its top and bottom faces so that the permeability measurement is representative of the internal mixture structure.
- 6.2 Wash the test samples thoroughly with water to remove any loose fine material resulting from saw cutting.
- 6.3 Measure and record the height and diameter of each sample in three different locations to the nearest 0.3 mm or better. The respective length and diameter of the three measurements shall not vary by more than  $\pm 5\%$ . The diameter of the specimen shall be at least 4 times greater than the largest particle size within the sample, and shall not be less than 100 mm.
- 6.4 Determine the specific gravities required to compute the air void content of individual test samples in accordance with the Florida Methods of Test FM 1-T 166 and FM 1-T 209.

- 6.5 Cover the top and bottom surfaces of the dried test specimens using the 50 mm-wide masking tape.
- 6.6 Lubricate the inside of the mold(s) and the metal plate with a release agent. This will prevent the epoxy from adhering to the mold and/or metal plate.

NOTE 2: The size of the metal plate may be such as to accommodate more than one mold. Thus, more than one test sample may be prepared at once.

- 6.7 Center the test specimen(s) in the mold(s).
- 6.8 Prepare the epoxy for the sealing ring according to the manufacturer directions ( a two-part system, Sikadur 32, Hi-Mod, may be used).
- 6.9 Pour the epoxy in a uniform and circular motion into the mold around the test sample up to the top of the sample.
- 6.10 Let the epoxy cure for 24 hours before removing the test sample from the mold.
- 6.11 Remove the masking tape from the top and bottom surfaces of the test sample.

## 7. TEST PROCEDURE

### 7.1 Permeameter Cell Setup

7.1.1 Center one O-ring around the drainage hole of the PVC base plate. Then, place the test specimen on the center of the base plate.

7.1.2 Place another O-ring around the top face of the sample. The top plate is then placed and bolted to the base plate with the four carriage bolts. The nuts shall be tightened firmly in a pattern that assures even torque distribution. Do not over tighten the nuts.

7.1.3 Place the permeameter cell in a pan to collect the water drained during testing.

7.2 Connect the buret to the permeameter cell through the hose barb using a plastic hose. The length of the hose shall be such that the buret and the hose barb are aligned and the plastic hose is straight.

7.3 Measure to the nearest mm and record the height from the top of the base plate to the 400 mL mark in the buret. This is the initial head,  $h_1$ .

7.4 Measure to the nearest mm and record the height from the tip of the base plate to the 900 mL mark in the buret. This is the final head,  $h_2$ .

NOTE 3: Other mL marks may be used to set initial and final heads.

7.5 Fill the buret with water. Release the valve at the base of the buret and let the water flow through the specimen. Make sure that permeameter cell is tight enough as to avoid any water leakage. Remove all air bubbles from the connecting hose.

NOTE 4: To facilitate the removal of any entrapped air in the cell, open the air relieve valve until water starts coming through it. After all visible air has been removed, close the valve.

7.6 Let the water run through the specimen until the saturation state is achieved. This may require filling the buret several times.

NOTE 5: Saturation may be confirmed when the respective recorded times for a change in heads from  $h_1$  to  $h_2$  for three consecutive tests are within 15%.

7.7 Once the saturation of the specimen is achieved, close the valve at the base of the buret and fill the buret.

7.8 To start the test, release the valve at the base of the buret and let the water flow through the specimen. Once the head is at the 400 mL mark (initial head), start the stop watch. Stop the stop watch when the head reaches the 900 mL mark (final head). Record the time shown on the stop watch. Use the average time of three consecutive tests to compute the water conductivity of the specimen.

NOTE 6: If the recorded times for three consecutive tests are not within 15%, the specimen is not saturated enough. Additional water should be run through the sample and the test repeated.

## 8. CALCULATION

8.1 The water conductivity or coefficient of permeability,  $k$ , is determined using the following equation:

$$k = \frac{aL}{At} \ln(h_1/h_2)$$

Where:  $k$ =coefficient of permeability, cm/s;  
 $a$ =inside cross-sectional area of the buret, cm<sup>2</sup>;  
 $L$ =thickness of the test specimen, cm;  
 $A$ =cross-sectional area of the test specimen, cm<sup>2</sup>;

$t$ =elapsed time between  $h_1$  and  $h_2$ , s;  
 $h_1$ =initial head across the test specimen, cm;  
 $h_2$ =final head across the test specimen, cm.

- 8.2 For each sample, the coefficient of permeability is computed for three runs and averaged. The results are reported in whole units  $\times 10^{-5}$  cm/s.

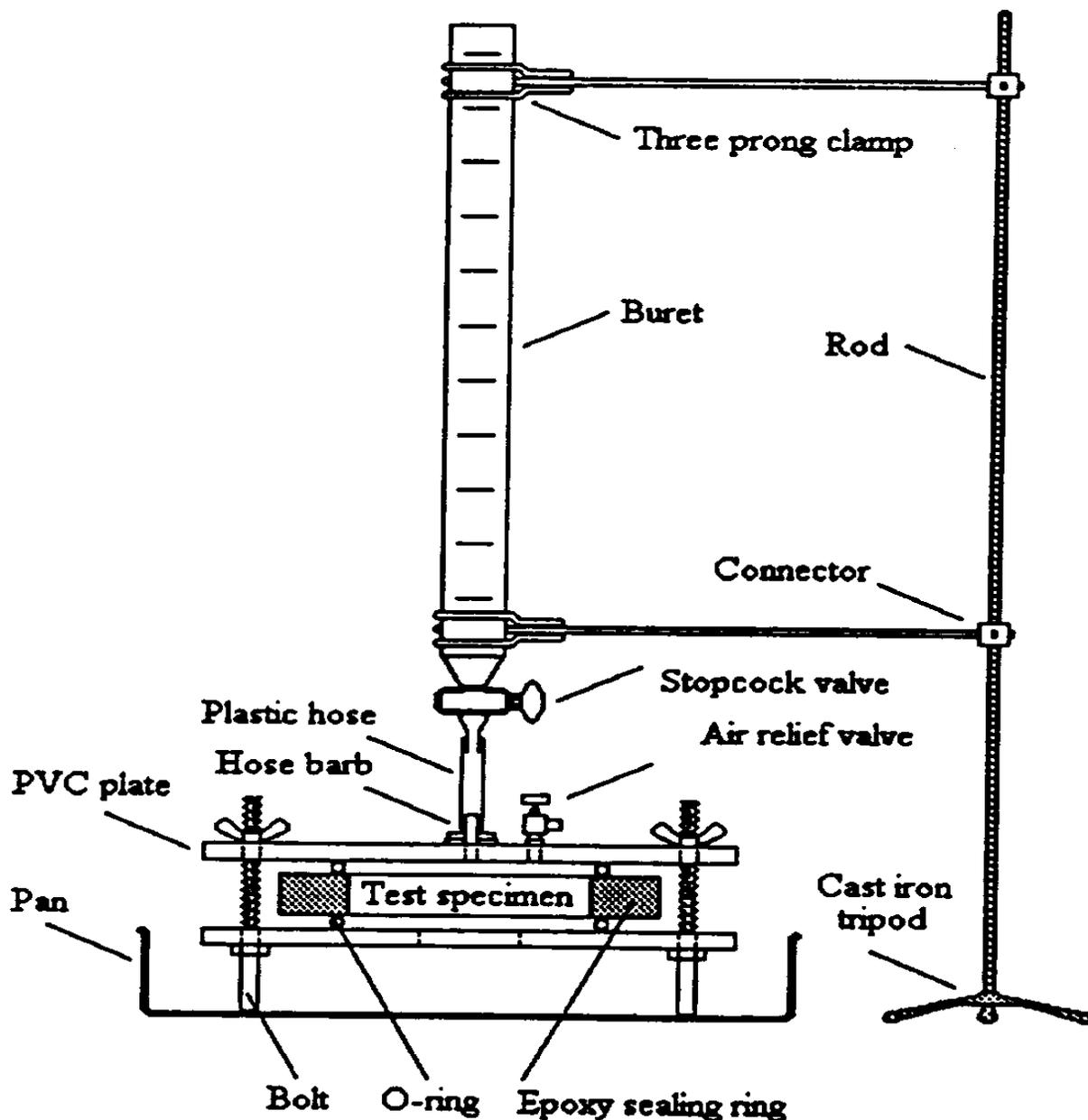


Figure 1. Schematic of Water Permeability Testing Apparatus (not to scale)

## **APPENDIX F: Asphalt Pavement Analyzer Method of Test**

(ASTM Format)  
METHOD OF TEST FOR DETERMINING RUTTING SUSCEPTIBILITY USING THE  
ASPHALT PAVEMENT ANALYZER

1. SCOPE

- 1.1 This method describes a procedure for testing the rutting susceptibility of asphalt aggregate mixtures using the Asphalt Pavement Analyzer (APA).

2. APPARATUS

- 2.1 Asphalt Pavement Analyzer (APA)-A thermostatically controlled device designed to test the rutting susceptibility of hot mix asphalt by applying repetitive linear loads to compacted test specimens through pressurized hoses.
- 2.1.1 The APA shall be thermostatically controlled to maintain the test temperature and conditioning chamber at any setpoint between 30° and 60°C within 1°C.
- 2.1.2 The APA shall be capable of independently applying loads up to 450 N to three wheels. The loads shall be calibrated to the desired test load by an external force transducer.
- 2.1.3 The pressure in the test hoses shall be adjustable and capable of maintaining pressure up to 830 kPa.
- 2.1.4 The APA shall be capable of testing three beam specimens simultaneously.
- 2.1.5 The APA shall have a programmable master cycle counter which can be preset to the desired number of cycles for a test. The APA shall be capable of automatically stopping the test at the completion of the programmed number of cycles.
- 2.2 Balance. 12,000 gram capacity, accurate to 0.1 gram.
- 2.3 Mixing utensils (bowls, spoon, spatula)
- 2.4 Ovens for heating aggregate and asphalt cement.
- 2.5 Compaction device and molds.

3. TEST SPECIMENS:

- 3.1 Number of test specimens-One test will use either three beam (75 mm x 125 mm x 300 mm) specimens or six cylindrical (150 mm diameter x 75 mm) specimens.
- 3.2 Samples of plant produced mixtures shall be obtained in accordance with AASHTO T 169. Mixture samples shall be reduced to the appropriate test size and compacted while the mixture is still hot. Reheating of loose plant mixture should be avoided.
- 3.3 Laboratory Prepared Mixtures
- 3.3.1 Mixture proportions are batched in accordance to the desired Job Mix Formula. Required batch sizes are determined in accordance to Paragraph 12. The voids in total mix (Va) for the compacted specimens shall be 7.0±1.0%.
- 3.3.2 The temperature to which the asphalt binder must be heated to achieve a viscosity

- of  $170 \pm 20$  cSt shall be the mixing temperature. For modified asphalt binders, use the mixing temperature recommended by the binder manufacturer.
- 3.3.3 Dry mix aggregates and hydrated lime (when lime is used) first, then add optimum percentage of asphalt cement. Mix the materials until all aggregates are thoroughly coated.
- 3.3.3 Test samples shall be aged in accordance with the short-term aging procedure in AASHTO PP2 except that the aging period shall be two hours and the spread rate shall be approximately  $50 \text{ kg/m}^2$ .
- 3.3.4 The temperature to which the asphalt binder must be heated to achieve a viscosity of  $290 \pm 30$  cSt shall be the compaction temperature. For modified asphalt binders, use the compaction temperature recommended by the binder manufacturer. The mixture shall not be heated at the compaction temperature for more than one hour.
- 3.4 Roadway Core Specimens
- 3.4.1 Roadway core specimens shall be 150 mm diameter with all surfaces of the perimeter perpendicular to the surface of the core within 5 mm. Cores shall be trimmed with a wet masonry saw to a height of  $75 \pm 3$  mm.

#### 4. COMPACTION OF SPECIMENS

##### METHOD A - Vibrating Compaction

- 4.1 Apparatus-Asphalt Vibratory Compactor, Model AVC II
- 4.2 The following specimen compaction procedures can be used for compacting cylinder specimens and beam specimens.
- 4.3 Place the specimen mold on top of a counter adjacent to the compaction machine. Insert a preheated base plate into the mold. Apply a light coat of oil on the inside surfaces of the mold and the base plate. Cooking oil sprays (available from supermarkets) work well for this purpose. Remove loose HMA from the oven and pour the entire batch into the mold and level the mixture at the top. Measure the temperature in the mixture. Temperature at the starting of the compaction should be within  $5^\circ\text{C}$  of the specified compaction temperature for the mixture.
- 4.4 Transfer the specimen mold to the supporting base of the machine and fit it in the recessed area. Apply a light coat of oil on the surfaces of the compaction head.
- 4.5 Set the control unit CYCLE TIME to 25 seconds (More time may be necessary to compact harsh mixtures). Turn MODE switch to AUTO, VIBRATING switch to AUTO, and pull up (disable) the EMERGENCY STOP.
- 4.6 Press both green palm buttons simultaneously (you do not need to hold down the palm buttons). This will cause the vibrating assembly to move downward automatically and when it gets down to a certain position, the vibrating actions will be activated automatically. Under the static compression force and the vibrating actions, the compaction head will move downward to consolidate and compact the loose asphalt mixture confined in the specimen mold for 25 seconds. For most dense-graded HMA, compaction will be achieved in less than 10 seconds after the

vibration is activated. At this point the bottom surface of the vibrating assembly base plate will be in contact with the top surface of the specimen mold and the compaction head is "bottomed out". After the vibrating time is completed, the vibrating compaction assembly will automatically retract. This completes the compaction operations. If at the end of the time the bottom surface of the vibrating assembly base plate is not in contact with the top surface of the specimen mold, this implies that the specimen has not been compacted to the specified density.

Additional vibrating compaction can be applied by increasing the vibrating time.

- 4.7 Lift the specimen mold from the compaction position, move forward and slide the edges of the specimen mold under the restraining brackets and position the specimen mold in the recessed area at the extruding support base.
- 4.8 On the control unit, turn the MODE switch to EJECT. Press and hold down both green palm buttons to raise the extrusion cylinder head to extrude the specimen out of the mold. Remove the compacted specimen with the base plate together from the rigid bottom of the mold and place them on a firm counter top. Press the OPEN button on the control unit to retract the extrusion cylinder head. Then remove the specimen mold from the extrusion supporting base.
- 4.9 Compacted specimens should be left at room temperature (approximately 25°C) to allow the entire specimen to cool for a minimum of 3 hours.

#### METHOD C-Superpave Gyrotory Compaction

- 5.1 Apparatus (see AASHTO TP4)
- 5.2 Compaction of cylindrical specimens with the Superpave Gyrotory Compactor can be accomplished in several ways. Specimens can be compacted directly to the specified height of 75 mm, or specimens can be compacted to the number of gyrations at which the target air void content of  $7.0 \pm 1.0\%$  has been estimated.
- 5.3 Remove the mold and base plate from the oven set at the compaction temperature. Place a paper disc in the bottom of the mold assembly.
- 5.4 Transfer the mixture to the mold with care to avoid segregation of the mixture. Check the mixture temperature to determine if it is within the range determined from paragraph 3.3.4. Place a paper disk on the top of the mixture.
- 5.5 Place the mold and mixture in the Superpave Gyrotory Compactor and begin compaction as described in the compactor's operation manual.
- 5.6 When the compaction procedure is completed, remove the mold and compacted specimen from the compactor. Extrude the specimen from the mold with care to avoid distorting the specimen until it is cooled.
- 5.7 Compacted specimens should be left at room temperature (approximately 25°C) to allow the entire specimen to cool for a minimum of 3 hours.

#### 6. DETERMINING THE AIR VOID CONTENTS

- 6.1 Determine the bulk specific gravity of the test specimens in accordance with ASTM

- D 2726 (AASHTO T 166).
- 6.2 Determine the maximum specific gravity of the test mixture in accordance with ASTM D2041 (AASHTO T 209).
- 6.3 Determine the air void contents of the test specimens in accordance with ASTM D3203 (AASHTO T 269).

## 7. SELECTING THE TEST TEMPERATURE

- 7.1 The test temperature should be representative of the environment in which the paving mixture will be utilized. The SHRPBIND software or the Superpave software available from the FHWA can be used to determine the pavement temperature for any project location in the United States.
- 7.2 SHRPBIND software version 2.0
  - 7.2.1 Select the depth to surface of layer at 0 mm for surface mixtures. For evaluating other layers in the pavements structure, select the depth in millimeters to the top of the layer. The SHRPBIND software will determine the high pavement design temperature 20 mm below the input depth as used in binder grade selection and mixture performance modeling.
  - 7.2.2 Use the map to select the project location. The high temperature for the nearest weather station will be displayed. For projects with low traffic loads (i.e.<1 million ESAL's) the temperature corresponding to 50 percent reliability should be used; for projects with high traffic loads, the temperature corresponding to 98 percent reliability should be used.
- 7.3 Superpave software (still in development)
- 7.4 Alternatively, the test temperature may be based on the average high pavement temperatures for a geographical area.

## 8. SPECIMEN CONDITIONING

- 8.1 Place the specimens in the testing position and allow the specimens to equalize at the test temperature. A companion dummy specimen with an embedded thermometer or thermocouple may be placed near the test specimens to determine when the test specimens have reached the test temperature. Specimens should not be held at elevated temperatures for more than 24 hours prior to testing.

Note 1-Studies have shown that specimens take five to six hours to achieve a uniform temperature when taken from room temperature and are placed in the APA at the test temperature.

## 9. PROCEDURE

- 9.1 Set the hose pressure gage reading to 700+/-35 kPa (100+/-5 psi). Set the load cylinder pressure reading for each wheel to achieve a load of 534+/-22 N(120+/-5 lb.).

- 9.2 Stabilize the testing chamber temperature at the temperature selected in Paragraph 7.
- 9.3 Place the test specimens into the testing molds and firmly secure in the APA.
- 9.4 Close the chamber doors and start the APA to apply 10 cycles to seat the specimens before the initial measurements. Make adjustments to the hose pressure as needed during the 10 cycles.
- 9.5 Place the rut depth measurement template over the specimen. Make sure that the rut depth measurement template is properly seated and firmly rests on top of the testing mold.
- 9.6 Zero the digital measuring gauge so that the display shows 0.00 mm with the gauge completely extended. The display should also have a bar below the "inc." position. Take initial readings at each of the five locations on the template. (For cylindrical specimens, the center measurement is not used). Measurements shall be determined by placing the digital measuring gauge in the template slots and sliding the gauge slowly across the each slot. Record the smallest measurement for each location to the nearest 0.01 mm.
- 9.7 Repeat steps 9.5 and 9.6 for each beam or set of cylinders in the testing position. All measurements shall be completed within four minutes.
- 9.8 Push the sample holding tray in and secure. Close the chamber doors and allow five minutes for the temperature to equalize.
- 9.8 Set the PRESET COUNTER to the number of cycles for the next interval. Measurements are typically taken at 500, 2000, 4000, and 8000 cumulative cycles.
- 9.9 Start or resume the test. When the test reaches the number of cycles set on the counter, the APA will stop and the load wheels will automatically retract.
- 9.10 Open the chamber doors, unlock and pull out the sample holding tray. Take rut-depth measurements as stated in steps 9.4 through 9.6.

## 10. CALCULATIONS

- 10.1 The rut depth at each location is determined by subtracting the measurement for each interval (500, 2000, 4000, and 8000 cycles) from the initial measurement.
- 10.2 Determine the average rut depth at each interval for each beam specimen or cylinder set. For beams specimens, use only the three center measurements for calculating the average rut depth. For cylindrical specimens, use the average of all four measurements to calculate the average rut depth.
- 10.3 The APA rut depth for the mixture is the average of the three beam specimens or six cylindrical specimens.

## 11. REPORT

- 11.1 The test report shall include the following information:
  - 11.1.1 The laboratory name, technician name, and date of test.

- 11.1.2 The mixture type and description.
- 11.1.3 Specimen type.
- 11.1.4 Average air void content of the test specimens.
- 11.1.5 The test temperature.
- 11.1.6 The average rut depths to the nearest 0.1 mm at 500, 2000, 4000, and 8000 cycles.

## 12. NONMANDATORY INFORMATION Calculation of Specimen Masses

### 12.1 Beam Specimens

- 12.1.1 Volume of specimen= $75 \text{ mm} \times 125 \text{ mm} \times 300 \text{ mm}=2812.5 \text{ cm}^3$ .
  - 12.1.2 Total mass of beam specimen,  $g=\text{Gmm @ Opt. A.C.} \times 0.93 \times 2812.5 \text{ cm}^3$
  - 12.1.3 Beams may be batched in 1, 2 or 3 layers. Divide the total mass by the number of layers.
  - 12.1.4 Individual weights for dry aggregate, lime and liquid A. C. per layer
    - 12.1.4.1 Mass of asphalt cement,  $g=\text{grams/layer} \times \% \text{ of A. C. @ Opt.}$
    - 12.1.4.2 Mass of aggregate,  $g=\text{grams/layer}-\text{grams of A. C.}$  (This includes lime, if used in the mixture).
    - 12.1.4.3 Mass of aggregate excluding lime,  $g=\text{grams of aggregate}/1.01$
    - 12.1.4.4 Mass of lime,  $g=\text{grams of aggregate}-\text{grams of aggregate excluding lime}$
- ### 12.2 Cylindrical Specimens
- 12.2.1 Volume of Specimen= $(\frac{1}{4}\pi \times (150 \text{ mm})^2 \times 75 \text{ mm})/1000=1325.4 \text{ cm}^3$
  - 12.2.2 Total mass of cylindrical specimen,  $g=\text{Gmm @ Opt. A.C.} \times 0.93 \times 1325.4 \text{ cm}^3$
  - 12.2.4 Individual weights for dry aggregate, lime and liquid A. C. @ Opt.
    - 12.2.4.1 Mass of asphalt cement,  $g=\text{grams/layer} \times \% \text{ A. C. @ Opt.}$
    - 12.2.4.2 Mass of aggregate,  $g= \text{grams/layer} - \text{grams of A. C.}$  (This includes lime, if used in the mixture)
    - 12.2.4.3 Mass of aggregate excluding lime,  $g=\text{grams of aggregate}/1.01$
    - 12.2.4.4 Mass of lime,  $g=\text{grams of aggregate}-\text{grams of aggregate excluding lime}$