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FINAL REPORT

U.F. Project No: 49104504-775-12
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EVALUATION OF SUPERPAVE AND MODIFIED SUPERPAVE MIXTURES BY MEANS OF ACCELERATED PAVEMENT TESTING

(PLANNING AND DESIGN PHASE)

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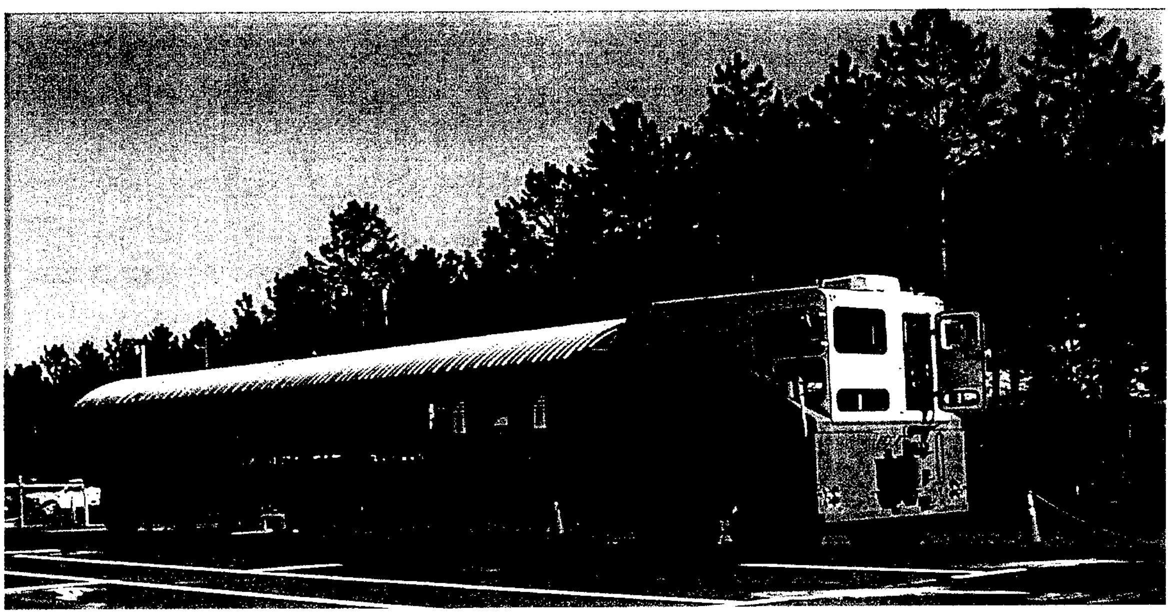
May 2001



Department of Civil & Coastal Engineering
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DISCLAIMER

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	l
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
psi	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	ac
ha	hectares	2.47	acres	mi^2
km^2	square kilometers	0.386	square miles	
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg	megagrams	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	psi

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised August 1992)

ACKNOWLEDGMENTS

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TECHNICAL SUMMARY

A cooperative research study was carried out by the Florida Department of Transportation (FDOT) and the University of Florida to evaluate the long-term rutting performance of Superpave mixtures and SBS-modified Superpave mixtures using the Heavy Vehicle Simulator (HVS) at FDOT's Accelerated Pavement Testing (APT) facility. This report presents the work performed in the planning, design and construction phase of this study.

Three different pavement designs were incorporated in the test pavements constructed for this study. They were (1) two 2-inch lifts of unmodified Superpave mixture, (2) two 2-inch lifts of SBS-modified Superpave mixture, and (3) a 2-inch lift of SBS-modified Superpave mixture placed over a 2-inch lift of unmodified Superpave mixture. All the mixtures were to be compacted to $93 \pm 1\%$ of maximum theoretical density.

The test track consisted of seven test lanes. Each test lane was divided into 3 test sections. One test lane was to be used for trial runs to evaluate the performance characteristics of the HVS and to determine the most effective test configuration to be used in the testing program. Another test lane was set aside for additional testing deemed necessary or desirable at the end of the main testing program. The main testing program was to be run on five test lanes with a total of fifteen test sections. Three different testing temperatures will be incorporated in the testing program.

Type K thermocouples were installed at various locations in the test pavements to monitor the temperature distribution in the test pavements. For each test section, three thermocouples were placed on top of the base course, three were placed on top of the first

lift of asphalt mixture, and two were placed on the surface. These thermocouples were connected to a PC data acquisition system. Temperature readings are to be taken every 15 minutes and recorded in the PC during each test.

The placement of the asphalt mixtures on the test track was started on October 17, 2000 and completed on October 18, 2000. Density measurements from nuclear density gauges and cores taken from the completed test pavements indicated that the density of the compacted mixture was within the target range for all lanes and lifts.

CHAPTER 1
INTRODUCTION

1.1 Background

FDOT started the use of Superpave mixtures on its highway pavements in 1996. Modified binders have also been used in some of the Superpave mixtures in an effort to increase the cracking and rutting resistance of these mixtures. Due to the short history of these mixtures, it is still too early to assess the long-term performance of these Superpave mixtures and the benefits from the use of the modified binders. There is a need to evaluate the long-term performance of these mixtures and the benefits obtained from the use of modified binders, so that the Superpave technology and the selection of modified binders to be used could be effectively applied.

The FDOT Materials Office has recently acquired a Heavy Vehicle Simulator (HVS) and constructed an Accelerated Pavement Testing (APT) facility which uses this Heavy Vehicle Simulator. The HVS can simulate 20 years of interstate traffic on a test pavement within a short period of time. Thus, a research study was started to evaluate the long-term performance of Superpave mixtures and modified Superpave mixtures using the APT facility. This research work is being carried out by a cooperative effort between the FDOT and the University of Florida. The main objectives of this study are as follows:

1. To evaluate the operational performance of the Heavy Vehicle Simulator, and to

determine its most effective test configurations for use in evaluating the long term performance of pavement materials and/or designs under typical Florida traffic and climate conditions.

2. To evaluate the rutting performance of a typical Superpave mixture used in Florida and that of the same Superpave mixture modified with a SBS polymer.
3. To evaluate the relationship between mixture properties and the rutting performance.
4. To evaluate the difference in rutting performance of a pavement using two lifts of modified mixture versus a pavement using one lift of modified mixture on top of one lift of unmodified mixture.

1.2 Scope of Report

This report presents the work which was performed in the planning, design and construction phases of this study. It includes description of (1) the aggregates, binders and mix designs used for the test pavements, (2) the design of experiment, (3) the instrumentation and data acquisition system, and (4) the monitoring of the construction of the test pavements.

CHAPTER 2
MATERIALS

The two asphalt mixtures which were placed in the test pavements were (1) a Superpave mixture using a PG67-22 asphalt and (2) a Superpave mixture using a PG67-22 asphalt modified with a SBS polymer which had an equivalent grading of PG76-22. Both mixtures were made with the same aggregate blend having the same gradation, and had the same effective asphalt content. The types and gradation of the aggregate blend used were similar to those of an actual Superpave mixture which had recently been placed down in Florida. The properties of the aggregates used are shown in Table 2.1. These mixtures can be classified as 12.5 mm fine Superpave mixes, with a nominal maximum aggregate size of 12.5 mm and the gradation plotted above the restricted zone.

Designs for these two mixtures were done by the personnel of the Bituminous Section of the FDOT Materials Office. The optimum binder content was determined according to the Superpave mix design procedure and criteria using a design traffic level of 10 to 30 X 10^6 ESALs. The mix design data for these two mixtures are given in Tables A1 and A2 in the Appendix A. The binder contents and volumetric properties for these two mixtures are shown in Table 2.2.

Table 2.1 Properties of Aggregates used in the Asphalt Mixture

Type Material		FDOT Code	Producer		Pit No		Date Sampled	
1. S-1-A Stone		41	Rinker Mat. Corp		TM-489 87-089		9/11/00	
2. S-1-B Stone		51	Rinker Mat. Corp		TM-489 87-089		9/11/00	
3. Screenings		20	Anderson Mining Corp		29-361		9/11/00	
4. Local Sand			V.E.Whitehurst & Sons, Inc		Starvation Hill		9/11/00	
Percentage by Weight Total Aggregate Passing Sieves								
Blend		12%	25%	48%	15%	JMF	Control	Restricted
Number		1	2	3	4		Points	Zone
S	3/4" 19.0mm	99	100	100	100	100	100	
I	1/2" 12.5mm	45	100	100	100	93	90-100	
E	3/8" 9.5mm	13	99	100	100	89	-90	
V	No. 4 4.75mm	5	49	90	100	71		
E	No. 8 2.36mm	4	10	72	100	53	28-58	39.1-39.1
	No. 16 1.18mm	4	4	54	100	42		25.6-31.6
S	No. 30 600μm	4	3	41	96	35		19.1-23.1
I	No. 50 300μm	4	3	28	52	22		
Z	No. 100 150μm	3	2	14	10	9		
E	No. 200 75μm	2.7	1.9	5.9	2.2	4.5	2-10	
	G_{sb}	2.327	2.337	2.299	2.546	2.346		

Table 2.2 Volumetric Properties of the Asphalt Mixtures

Mix Type	Asphalt Binder	% Binder	V_a @N_{des}	VMA	VFA	P_{be}	G_{mm}
Superpave Mix	PG67-22	8.2	4.0	14.5	72	4.97	2.276
Modified Superpave Mix	PG76-22	7.9	3.8	14.2	73	4.90	2.273

CHAPTER 3
EXPERIMENTAL DESIGN

3.1 Test Track Layout

The layout of the test track, which was constructed at the FDOT APT facility for this study, is shown in Figure 3.1. The test track consisted of seven test lanes. The locations for these test lanes were selected such that they could fit around the two existing concrete conduit boxes. Their widths varied from 12 to 13.5 feet. Each test lane was divided into three test sections. Each test section was to be 30 feet long, with 20 feet of test area and 5 feet at each end for acceleration and deceleration of the test wheel. Adjacent to the test lanes was a 94 feet long area, which was to be used for maneuvering of the HVS.

The test track had a 10.5-inch limerock base placed on top of a 12-inch limerock stabilized subgrade. Lanes 1 and 2 were paved with two 2-inch lifts of the SBS-modified Superpave mixture. Lane 3 had a 2-inch lift of the modified Superpave mix over a 2-inch lift of unmodified Superpave mix. Lanes 4 through 7 were paved with two 2-inch lifts of the unmodified Superpave mix.

3.2 Testing Parameters and Sequence

The main testing program was to be run on Test Lanes 1 through 5, which had a total of 15 test sections. Test Lane 6 was set aside for additional testing deemed necessary or desirable at the end of the main testing program. Test Lane 7 was to be used

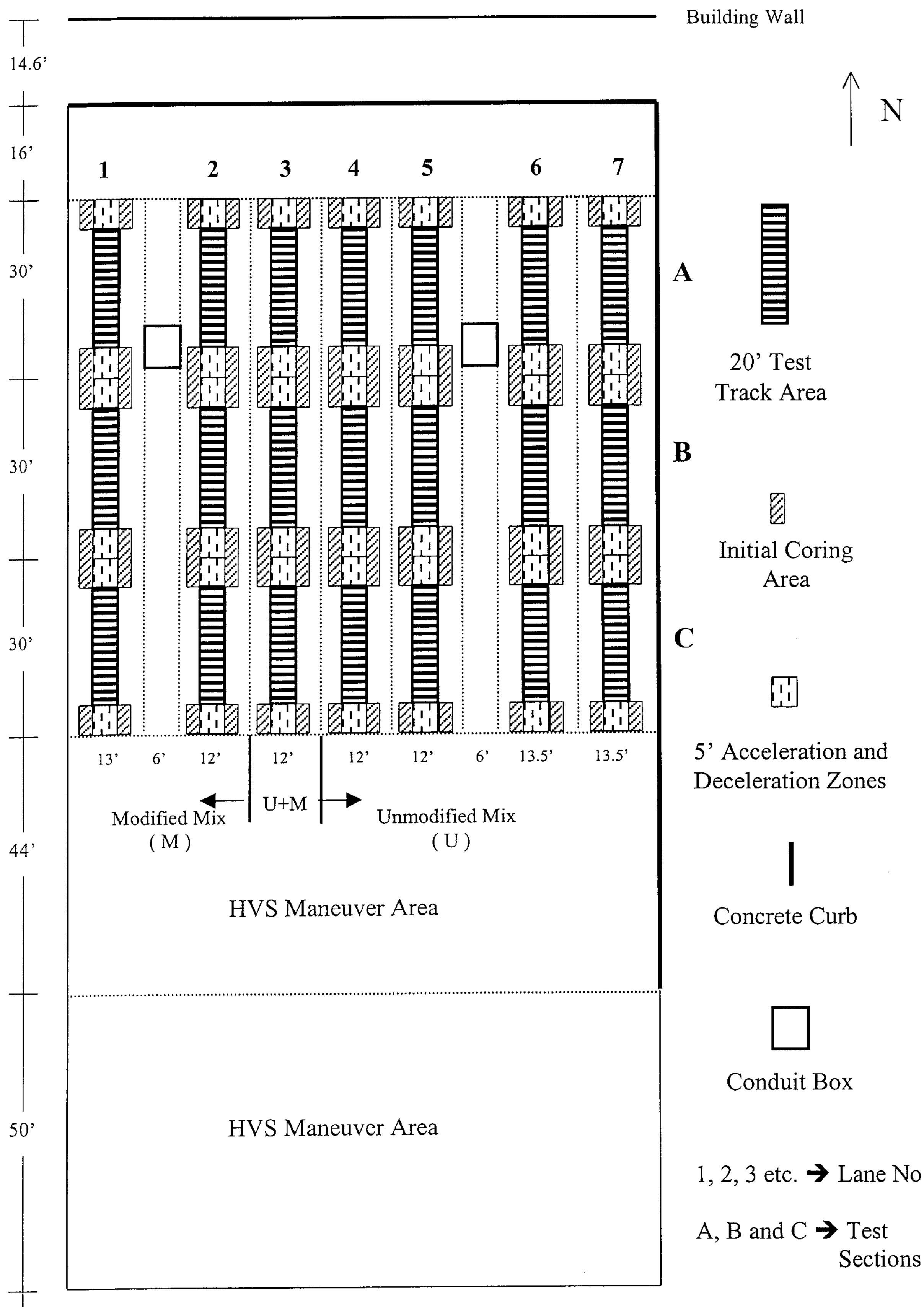


Figure 3.1 APT Test Track Layout (Plan View)

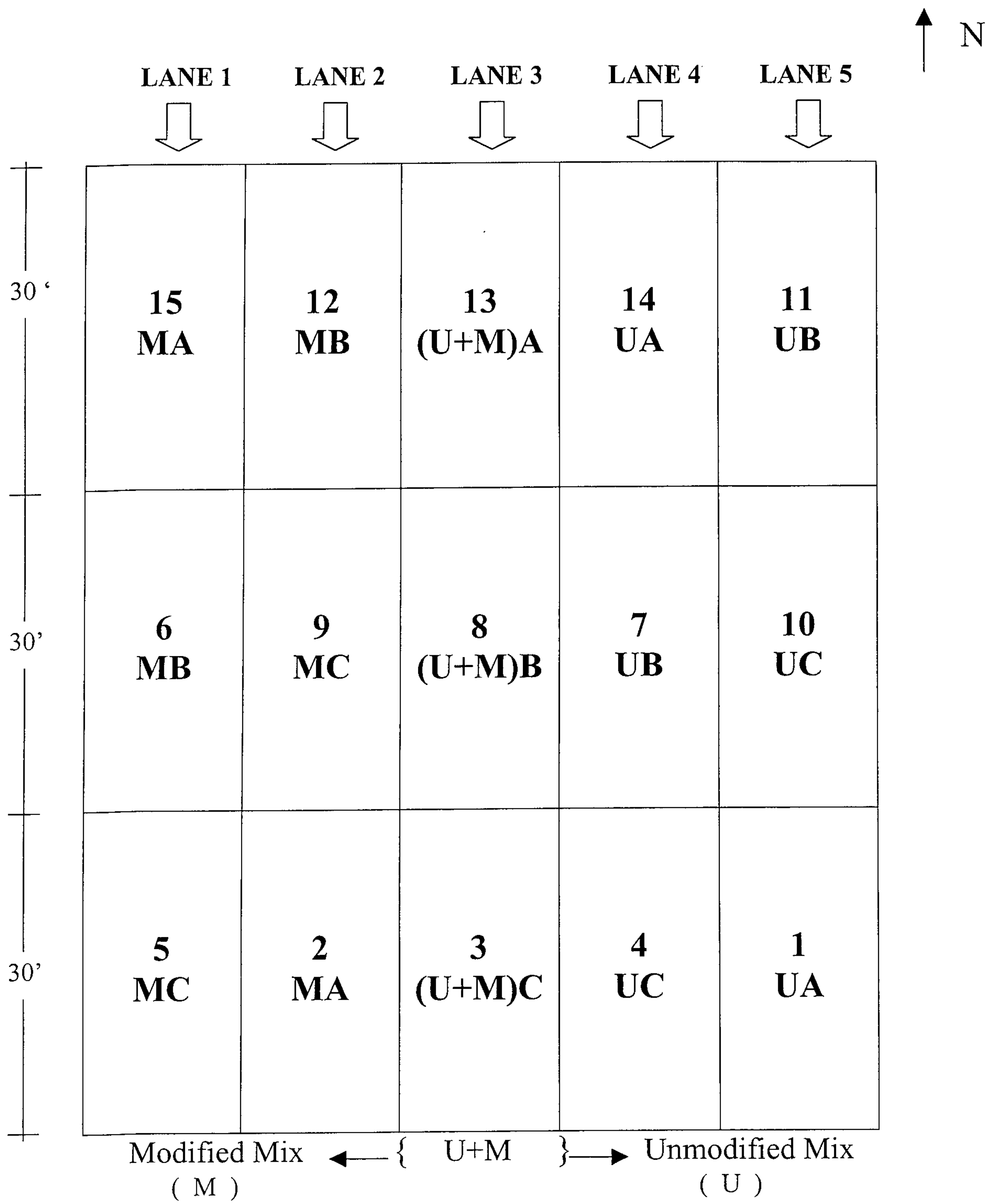
for trial runs to evaluate the performance characteristics of the HVS and to determine the most effective test configuration to be used in the testing program.

The testing parameters and sequence to be used for the main testing program are shown in Figure 3.2. Three testing temperatures will be used. Two replicate tests per testing temperature will be used for Lanes 1 and 2, which have two 2-inch lifts of SBS-modified Superpave mixture, and for Lanes 4 and 5, which have two 2-inch lifts of unmodified Superpave mixture. Only one test per testing temperature will be run on Lane 3, which has one lift of SBS-modified mixture on top of one lift of unmodified mixture. The testing sequence is arranged such that the effects of time on each lane can be averaged out. It is also arranged such that the HVS vehicle would not have to drive over a test section which has not been tested in order to minimize damage to the test sections.

The wheel load to be used is a 9-kip super single tire. The number of load applications, the type and amount of wheel wander, and the three testing temperatures to be used will be determined after all the trial tests on Lane 7 are completed and evaluated.

3.3 Temperature Monitoring System

The temperature distributions in the test pavements are to be monitored by means of Type K thermocouples installed at various depths and locations in the test pavements. Type K thermocouple was selected to be used in consideration of its relatively high sensitivity (40 μV/°C), high range of operation (-200 to 1250 °C), reliability and low cost. Figure 3.3 shows the locations of the thermocouples on the test track. Figure 3.4 shows the plan and cross section views of the thermocouples for each test section. A total



U → Unmodified Mix
M → Modified Mix
U+M → Unmodified +Modified Mix

A → Temperature 1
B → Temperature 2
C→ Temperature 3
1, 2, 3 …→ Testing sequence number

Figure 3.2 Testing Sequence (Plan View)

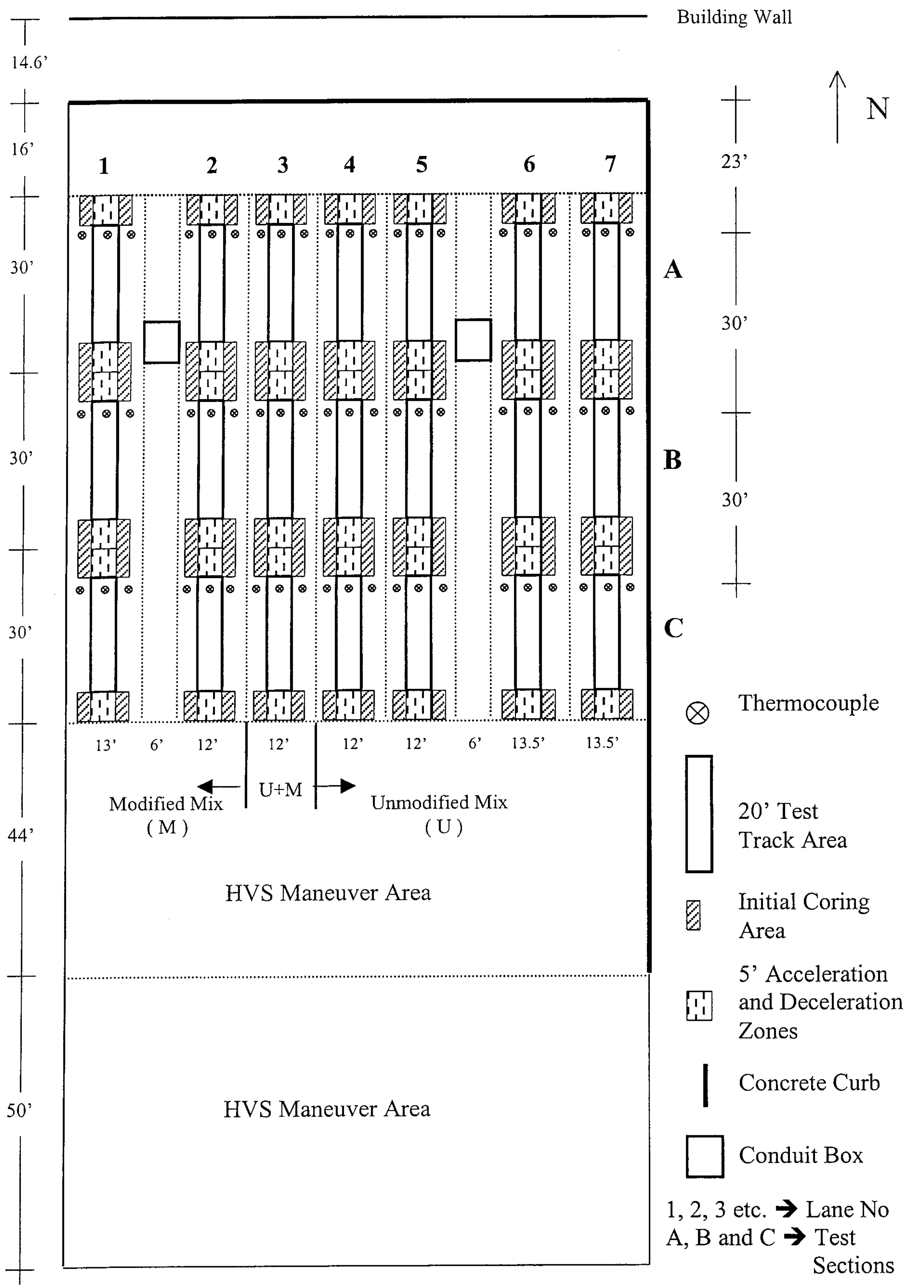


Figure 3.3 Locations of thermocouples

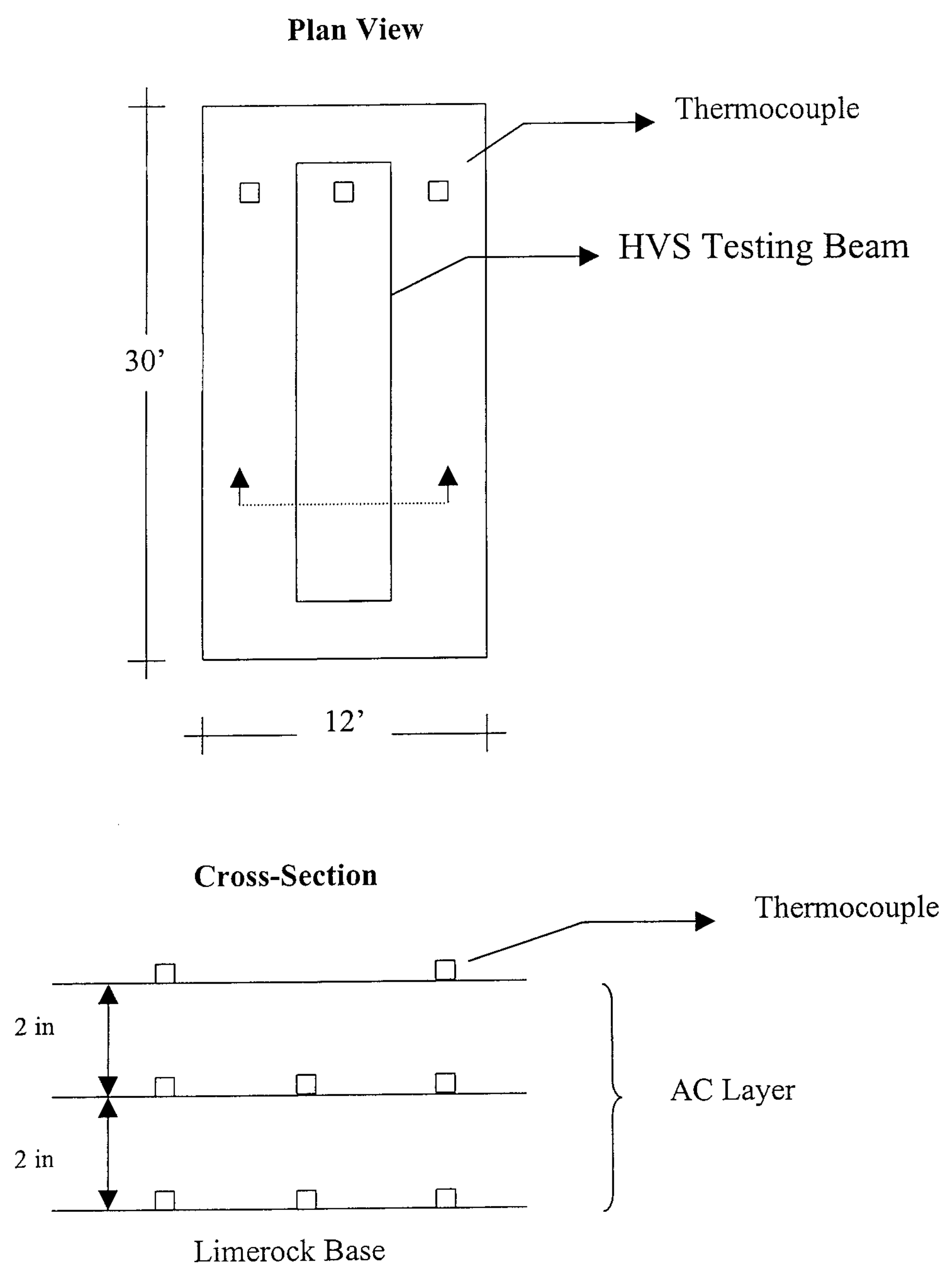


Figure 3.4 Plan and cross section view of thermocouples per test section

of eight thermocouples were installed for each test section. For each test section, three thermocouples were placed on top of the base course, three were placed on top of the first lift of asphalt mixture, and two were placed on the surface. These thermocouples were connected to a PC data acquisition system. Temperature readings are to be taken every 15 minutes and recorded in the PC during each test.

CHAPTER 4
CONSTRUCTION OF THE TEST TRACK

4. 1 Construction of Control Strip

Before the Superpave and the SBS-modified Superpave mixtures were placed on the test track, a control strip was constructed using the Superpave mixture. This was done in order to determine the appropriate rolling pattern needed to achieve the desired density and to calibrate the two nuclear density gauges to be used for checking the density of the test pavements. The target density for the compacted mixture was 93±1% of G_{mm} (maximum theoretical density). The density of the compacted mixture was measured by means of the two nuclear density gauges using a reading time of one minute, and cores taken from the compacted pavement. The density measurements from the cores were used to calibrate the two nuclear density gauges.

The two rollers used by the paving contractor were 25,000-lb steel-wheel rollers, which could be used in either a static mode or a vibratory mode. From the results of the test strip, it was determined that the target density could be achieved by three passes of the vibratory roller followed by three passes of the static roller. This rolling pattern was thus used in the compaction of the asphalt mixtures in the test track.

4.2 Placement of Thermocouples

As described in Section 3.3, for each of the 21 test sections, three thermocouples were to be placed on top the limerock base course, three were to be placed between the two lifts of asphalt layers, and two were to be placed on the surface of the pavement. There were a total of 63 thermocouples to be placed on the limerock base. This task was completed by October 16, 2000, one day before the placement of the asphalt mixture on the test track. The end of each thermocouple wire was placed at its designated location on the limerock base and secured by means of a U-shaped two-ended nail, as shown in Figure 4.1. Each thermocouple wire was run from its designated location to the nearest concrete conduit box. These thermocouple wires were secured to the limerock by means of the U-shaped nails.

There were a total of 63 thermocouples to be placed on top of the first lift of asphalt mixture. This task was done in the afternoon of October 17, 2000 and in the morning of October 18, 2000, between the time of the placement of the first lift and the placement of the second lift. The theromocouples were secured to the asphalt layer by means of the U-shaped nails in a similar fashion as that for the limerock base. Figure 4.2 shows a picture of the thermocouples placed on top of the first lift of asphalt mixture.

4.3 Placement of the Asphalt Mixtures

The placement of the asphalt mixtures on the test track was started on October 17, 2000 and completed on October 18, 2000. The first 2-inch lift of unmodified Superpave mixture was placed on Lanes 3 through 7 on the first day. The second lift of unmodified Superpave mixture was placed on Lanes 4 through 7 on the second day. The bottom lift of SBS-modified Superpave mixture was placed on Lanes 1 and 2 in the morning of the second day. The top lift of SBS-modified Superpave Mixture was placed in the afternoon of the second day.

Each lift of asphalt mixture was compacted by three passes of the vibratory

Figure 4.1 Photo of thermocouple installed on the limerock base

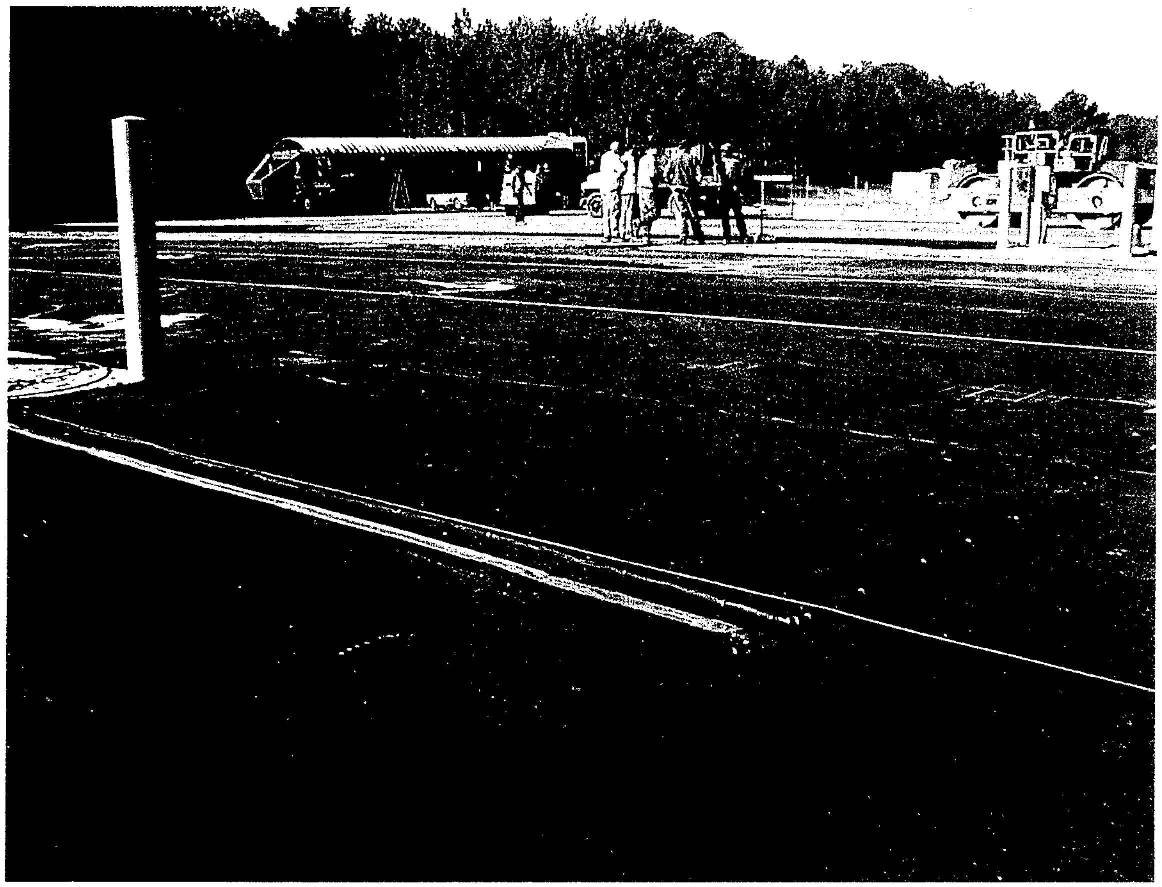


Figure 4.2 Photo of the thermocouples installed on the surface of the first lift of HMA

followed by three passes of the static roller, as determined from the results of the test strip. Figure 4.3 shows a picture of the 25,000-lb steel-wheel roller used. Additional passes of the static rollers were made to smoothen the surface of the pavement as needed. Figure 4.4 shows the finished test pavement.

4.4 Density of the Compacted Pavement

The two calibrated nuclear density gauges were used to check the density of the compacted mixtures after the completion of these six roller passes. After the nuclear density measurements were taken, core samples were taken from the same locations.

The coring and nuclear density testing plan for the test track is shown in Figure 4.5. A total of four cores and thirteen nuclear density measurements were taken per lift per lane after each lift was completed. Coring and nuclear density reading were performed by FDOT personnel. Core and nuclear density data taken at the same locations for lifts 1 and 2 are given in Tables 4.1 and 4.2, respectively. It can be seen that the density of each lift was within the target range. Thus, the test track has a fairly uniform density. Nuclear density at each location was the average of four readings. All of the nuclear density data are presented in Tables B1 through B14 in the Appendix B.

4.5 Volumetric Properties and Binder Contents

The Superpave and SBS-modified Superpave mixtures placed down on the test track were sampled at the hot-mix plant and tested for their volumetric properties and binder contents by FDOT personnel. One set of tests was run for every lift and every lane. Thus, a total of 14 sets of samples were collected and 14 sets of tests were run.

The asphalt mixture samples were compacted in a Superpave gyratory compactor using the same test parameters as used in the mix design procedure, and the volumetric

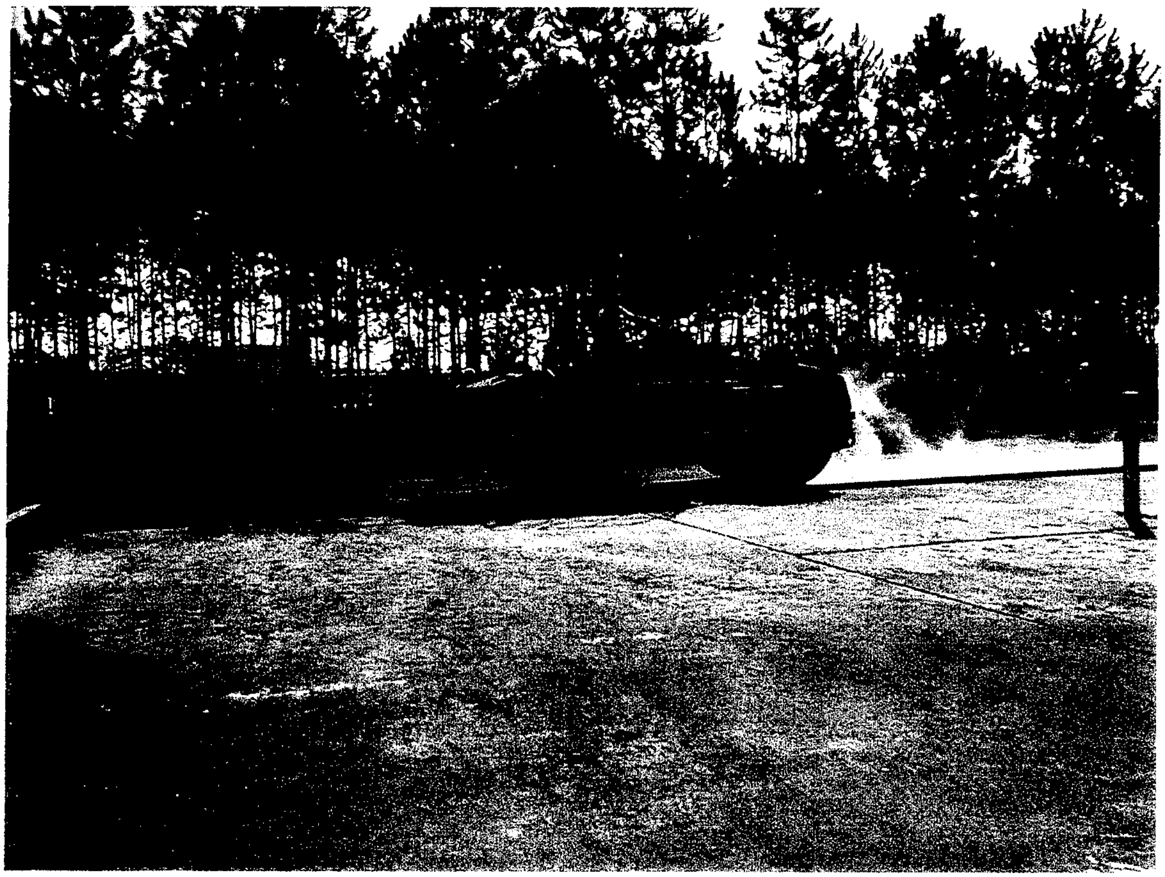


Figure 4.3 Photo of Steel-Wheel Roller used for compaction

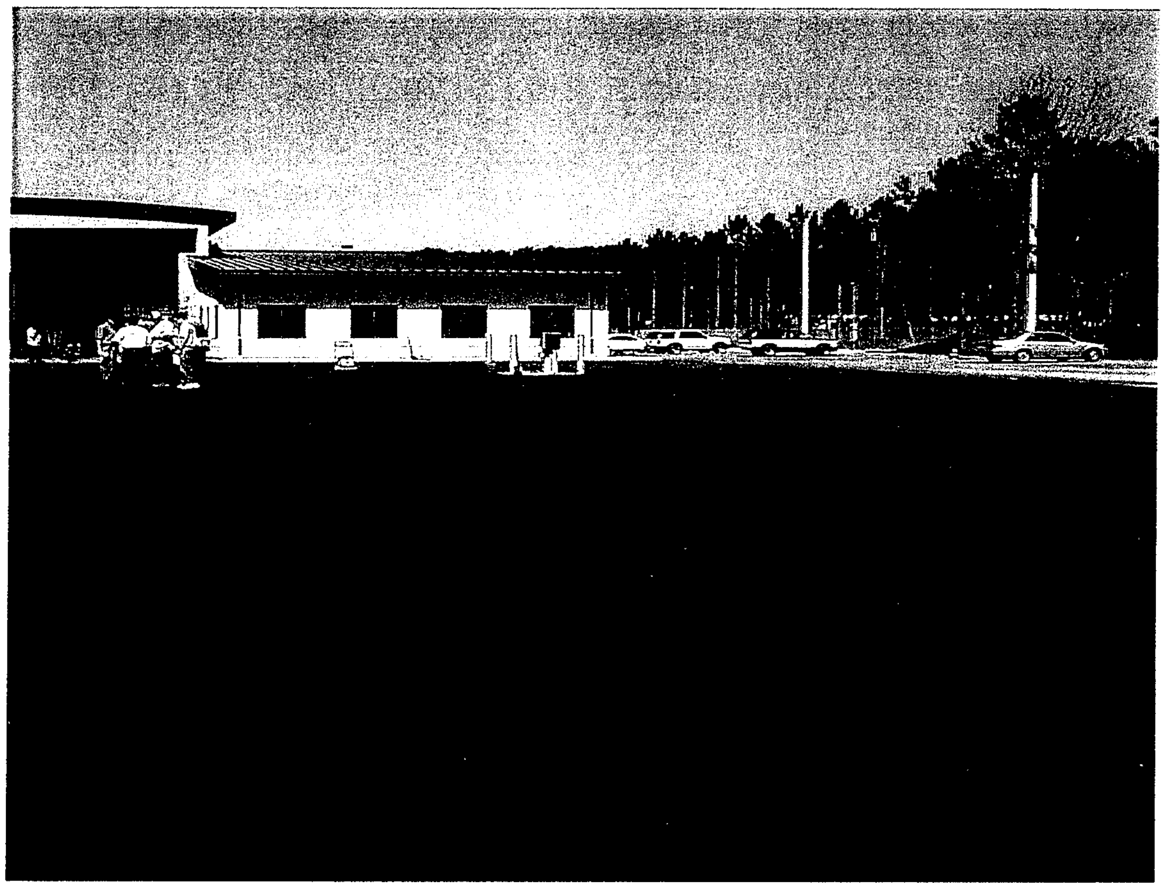
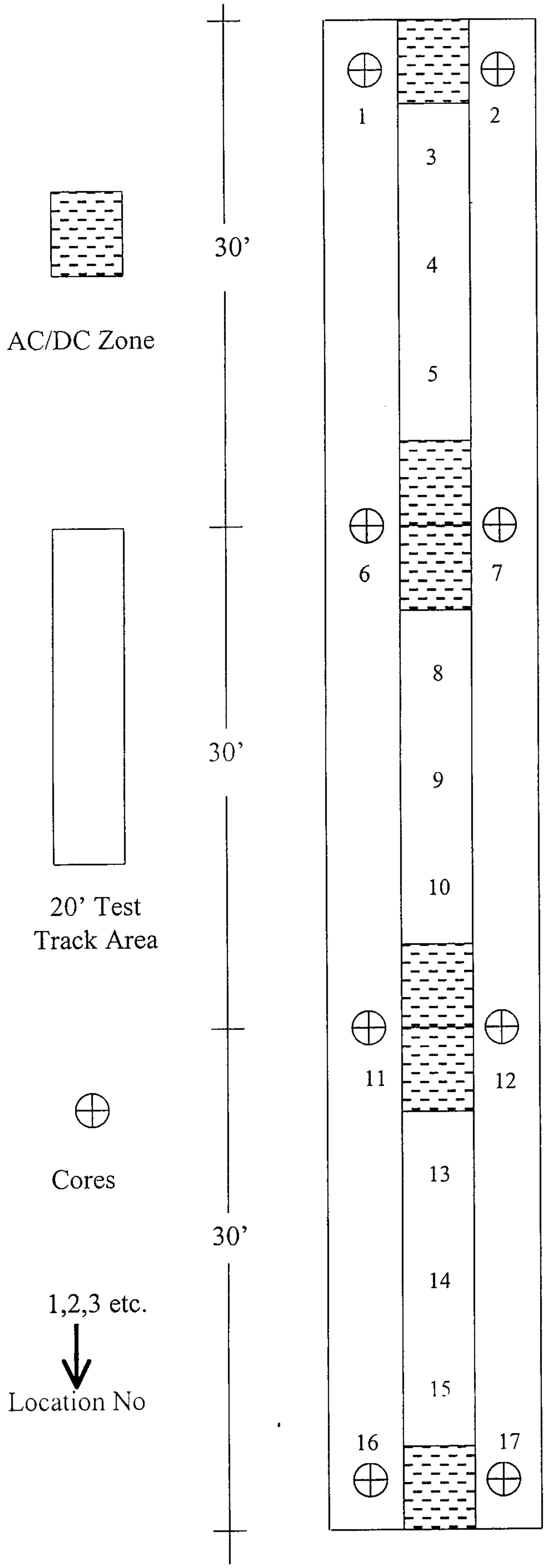


Figure 4.4 Photo of the Finished Test Track



Cores and Nuclear density measurements to be taken at the following locations per lane:

First Lift Coring
1, 7, 11 and 17

Second Lift Coring
2, 6, 12 and 16

Nuclear Density measurements

First Lift
1, 3, 4, 5, 7, 8, 9, 10, 11, 13, 14, 15 and 17

Second Lift
2, 3, 4, 5, 6, 8, 9, 10, 12, 13, 14, 15 and 16

Figure 4.5 Coring and Nuclear Density Testing Plan

Table 4.1 Core and Nuclear Density Data for Lift 1

Core Data							Nuclear Density Data
Lane	Location	Height (in)	G_{mb}	G_{mm}	$\%G_{mm}$	Measured Density (lb/cf)	Density Avg. (lb/cf)
1	1	1.92	2.137	2.268	94.2	133.4	130.6
1	7	1.96	2.138	2.268	94.3	133.4	131.9
1	11	2.04	2.149	2.268	94.7	134.1	133.4
1	17	1.88	2.102	2.268	92.7	131.2	130.6
1	**Average**	**1.95**	**2.132**		**94.0%**	**133.0**	**131.6**
2	1	1.83	2.128	2.263	94	132.8	130.7
2	7	2.04	2.072	2.263	91.6	129.3	127.2
2	11	1.75	2.123	2.263	93.8	132.5	130.7
2	17	1.83	2.077	2.263	91.8	129.6	127.5
2	**Average**	**1.86**	**2.100**		**92.8%**	**131.0**	**129.0**
3	1	1.35	2.115	2.271	93.1	132	128.1
3	7	1.71	2.080	2.271	91.6	129.8	127.3
3	11	1.27	2.120	2.271	93.4	132.3	132.4
3	17	1.38	2.081	2.271	91.7	129.9	128.5
3	**Average**	**1.43**	**2.099**		**92.4%**	**131.0**	**129.1**
4	1	1.71	2.132	2.280	93.5	133.1	133.3
4	7	1.46	2.089	2.280	91.6	130.4	127.7
4	11	1.67	2.141	2.280	93.9	133.6	130.3
4	17	1.63	2.086	2.280	91.5	130.2	127.3
4	**Average**	**1.62**	**2.112**		**92.6%**	**131.8**	**129.7**
5	1	1.60	2.134	2.276	93.7	133.1	131.2
5	7	1.71	2.125	2.276	93.4	132.6	132.6
5	11	1.60	2.141	2.276	94.1	133.6	134.3
5	17	1.92	2.108	2.276	92.6	131.5	130.7
5	**Average**	**1.71**	**2.127**		**93.4%**	**132.7**	**132.2**
6	1	1.81	2.108	2.261	93.2	131.5	130.2
6	7	1.77	2.138	2.261	94.6	133.4	134.7
6	11	1.90	2.141	2.261	94.7	133.6	132.5
6	17	1.54	2.127	2.261	94.1	132.7	138.8
6	**Average**	**1.75**	**2.129**		**94.1%**	**132.8**	**134.0**
7	1	1.92	2.145	2.264	94.7	133.9	134.6
7	7	1.75	2.168	2.264	95.8	135.3	135.5
7	11	1.88	2.176	2.264	96.1	135.8	137.0
7	17	1.67	2.134	2.264	94.3	133.2	133.6
7	**Average**	**1.80**	**2.156**		**95.2%**	**134.5**	**135.2**

Table 4.2 Core and Nuclear Density Data for Lift 2

Core Data							Nuclear Density Data
Lane	Location	Height (in)	G_{mb}	G_{mm}	$\%G_{mm}$	Measured Density (lb/cf)	Density Avg. (lb/cf)
1	2	2.13	2.088	2.272	91.9	130.3	129.1
1	6	1.92	2.129	2.272	93.7	132.9	134.3
1	12	2.21	2.112	2.272	92.9	131.8	134.0
1	16	1.75	2.113	2.272	93.0	131.8	130.7
1	**Average**	**2.00**	**2.110**		**92.9**	**131.7**	**132.0**
2	2	1.75	2.081	2.272	91.6	129.9	128.8
2	6	1.42	2.120	2.272	93.3	132.3	131.1
2	12	1.25	2.102	2.272	92.5	131.2	130.4
2	16	1.83	2.122	2.272	93.4	132.4	130.2
2	**Average**	**1.56**	**2.106**		**92.7**	**131.4**	**130.1**
3	2	2.13	2.096	2.278	92.0	130.8	130.1
3	6	1.92	2.124	2.278	93.3	132.6	132.3
3	12	2.21	2.074	2.278	91.0	129.4	128.4
3	16	1.75	2.120	2.278	93.0	132.3	130.6
3	**Average**	**2.00**	**2.104**		**92.3**	**131.3**	**130.4**
4	2	2.04	2.125	2.276	93.3	132.6	131.1
4	6	1.88	2.139	2.276	94.0	133.5	131.3
4	12	2.00	2.132	2.276	93.7	133.0	131.4
4	16	1.58	2.133	2.276	93.7	133.1	132.4
4	**Average**	**1.87**	**2.132**		**93.7**	**133.0**	**131.5**
5	2	2.04	2.099	2.278	92.2	131.0	130.2
5	6	1.88	2.117	2.278	92.9	132.1	131.1
5	12	1.88	2.102	2.278	92.3	131.2	129.8
5	16	1.92	2.116	2.278	92.9	132.0	131.2
5	**Average**	**1.93**	**2.108**		**92.6**	**131.6**	**130.6**
6	2	2.13	2.103	2.267	92.8	131.2	128.6
6	6	2.38	2.133	2.267	94.1	133.1	131.9
6	12	2.25	2.131	2.267	94.0	133.0	132.0
6	16	2.00	2.123	2.267	93.6	132.4	132.0
6	**Average**	**2.19**	**2.122**		**93.6**	**132.4**	**131.1**
7	2	1.79	2.089	2.275	91.8	130.4	131.0
7	6	1.50	2.129	2.275	93.6	132.8	130.4
7	12	1.96	2.098	2.275	92.2	130.9	130.2
7	16	1.63	2.121	2.275	93.2	132.3	133.1
7	**Average**	**1.72**	**2.109**		**92.7**	**131.6**	**131.2**

properties of the compacted mixtures were determined. Binder contents were determined by means of the Ignition Oven test. Sieve analyses were performed on the recovered aggregate after the ignition oven test.

Tables 4.3 and 4.4 show the comparison of the aggregate gradations, volumetric properties and binder contents of these sampled mixes with those of the job mix design for lifts 1 and 2, respectively. It can be seen that the recovered aggregates from the ignition oven tests were finer than the job mix formula. This difference might be caused by the loss of aggregate materials due to the ignition process.

The binder contents for the mixtures in Lanes 1, 3, 4, and 5 of Lift 1 were very close to the design binder content. However, the mixtures in Lanes 2, 6 and 7 of Lift 1 had higher binder contents than that of the design. Binder contents for all lanes of Lift 2 were close to the design value.

The air voids of all the compacted samples were lower than the design value of 4%. Particularly low air voids were observed for samples from Lanes 2, 6 and 7 of Lift 1. The low air voids for these mixtures can be explained by the high binder contents of these mixtures.

4.6 Additional Asphalt Mixture Samples

Additional samples of asphalt mixtures were collected at the hot-mix plant by the University of Florida investigators for additional laboratory testing. Four sets of samples were obtained. One set of samples was obtained for each lift of the unmodified Superpave mixture and each lift of the SBS-modified mixture.

A laboratory testing program will be performed to characterize these mixtures to evaluate the potential performance of these mixes based on the laboratory results, and to

Table 4.3 Comparison of Volumetric Properties of Asphalt Mixtures for Lift 1

LIFT 1										
	DESIGN	Binder : PG 76-22			DESIGN	Binder : PG 67-22				
	JOB MIX	Truck 1	Truck 3		JOB MIX	Truck 7	Truck 6	Truck 4	Truck 3	Truck 1
Property	FORMULA	Lane 1	Lane 2	Property	FORMULA	Lane 3	Lane 4	lane 5	Lane 6	Lane 7
1"		100.0	100.0	1"		100.0	100.0	100.0	100.0	100.0
3/4"	**100**	100.0	100.0	3/4"	**100**	100.0	100.0	100.0	100.0	100.0
1/2"	**93**	97.8	97.4	1/2"	**93**	97.6	98.8	96.9	97.8	97.5
3/8"	**89**	95.8	95.7	3/8"	**89**	95.1	96.7	93.4	96.0	94.9
#4	**71**	77.8	75.4	#4	**71**	74.9	76.8	74.3	76.0	74.1
#8	**53**	54.6	51.9	#8	**53**	54.3	54.0	53.9	55.9	53.8
#16	**42**	44.6	42.4	#16	**42**	44.6	44.1	45.2	46.0	43.7
#30	**35**	39.2	36.4	#30	**35**	38.1	37.8	39.4	39.3	36.7
#50	**22**	24.5	23.6	#50	**22**	24.2	23.4	24.3	24.5	23.9
#100	**9**	8.8	9.4	#100	**9**	9.4	8.3	8.5	9.1	10.2
#200	**4.5**	4.0	4.3	#200	**4.5**	4.2	3.6	3.7	4.2	5.0
AC content	**7.9**	8.0	8.3	AC content	**8.2**	8.0	8.2	8.0	8.4	8.7
G_{mm}	**2.273**	2.268	2.263	G_{mm}	**2.276**	2.271	2.280	2.276	2.261	2.264
G_{mb} @ N_{des}	**2.186**	2.196	2.215	G_{mb} @ N_{des}	**2.185**	2.200	2.196	2.197	2.204	2.220
Air Voids	**3.8**	3.2	2.1	Air Voids	**4**	3.1	3.7	3.5	2.5	1.9
VMA	**14.2**	13.9	13.4	VMA	**14.5**	13.7	14.0	13.9	14.0	13.6
VFA	**73**	77.2	84.2	VFA	**72**	77.2	73.6	74.9	81.8	85.7
P_{be}	**4.9**	5.1	5.3	P_{be}	**4.97**	5.0	4.9	4.9	5.4	5.4
Dust Ratio	**0.9**	0.8	0.8	Dust Ratio	**0.9**	0.8	0.7	0.7	0.8	0.9
% G_{mm} @ N_{ini}	**89.1**	90.6%	90.8%	% G_{mm} @ N_{ini}	**88.8**	90.2%	89.8%	90.5%	91.0%	90.8%

Table 4.4 Comparison of Volumetric Properties of Asphalt Mixtures for Lift 2

LIFT 2										
	DESIGN	Binder : PG 76-22				**DESIGN**	Binder : PG 67-22			
	JOB MIX	Truck 3	Truck 2	Truck 1		**JOB MIX**	Truck 1	Truck 3	Truck 4	Truck 6
Property	**FORMULA**	Lane 1	Lane 2	Lane 3	Property	**FORMULA**	Lane 4	lane 5	Lane 6	Lane 7
1"		100.0	100.0	100.0	1"		100.0	100.0	100.0	100.0
3/4"	**100**	100.0	100.0	100.0	3/4"	**100**	100.0	100.0	100.0	100.0
1/2"	**93**	97.5	97.1	98.9	1/2"	**93**	98.0	97.9	97.4	97.2
3/8"	**89**	95.4	94.6	96.9	3/8"	**89**	96.3	96.1	95.7	95.7
#4	**71**	76.1	76.5	76.0	#4	**71**	76.7	76.0	76.3	76.6
#8	**53**	54.4	55.2	54.0	#8	**53**	54.6	53.9	54.2	54.7
#16	**42**	45.1	45.3	44.4	#16	**42**	44.4	44.2	44.1	44.4
#30	**35**	38.5	39.2	38.1	#30	**35**	37.5	37.9	37.8	37.7
#50	**22**	23.9	24.0	24.3	#50	**22**	24.0	23.6	23.7	24.3
#100	**9**	8.8	8.8	9.3	#100	**9**	9.7	8.8	8.9	10.2
#200	**4.5**	3.9	3.9	4.1	#200	**4.5**	4.6	3.9	4.2	4.9
AC content	**7.9**	8.0	7.9	7.8	AC content	**8.2**	7.9	8.0	7.9	7.9
G_{mm}	**2.273**	2.272	2.272	2.278	G_{mm}	**2.276**	2.276	2.278	2.267	2.275
G_{mb} @ N_{des}	**2.186**	2.201	2.202	2.200	G_{mb} @ N_{des}	**2.185**	2.199	2.196	2.202	2.214
Air Voids	**3.8**	3.1	3.1	3.4	Air Voids	**4**	3.4	3.6	2.9	2.7
VMA	**14.2**	13.7	13.6	13.5	VMA	**14.5**	13.7	13.9	13.6	13.1
VFA	**73**	77.0	77.3	74.7	VFA	**72**	75.1	73.9	78.9	79.3
P_{be}	**4.9**	5.0	4.9	4.8	P_{be}	**4.97**	4.8	4.8	5.0	4.8
Dust Ratio	**0.9**	0.8	0.8	0.9	Dust Ratio	**0.9**	1.0	0.8	0.8	1.0
% G_{mm} @ N_{ini}	**89.1**	90.4%	90.5%	90.2%	% G_{mm} @ N_{ini}	**88.8**	89.7%	89.7%	90.4%	90.5%

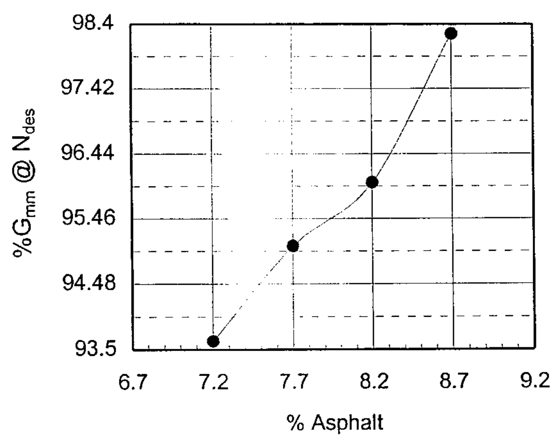
evaluate the correlation between the laboratory test results with the performance of the test sections.

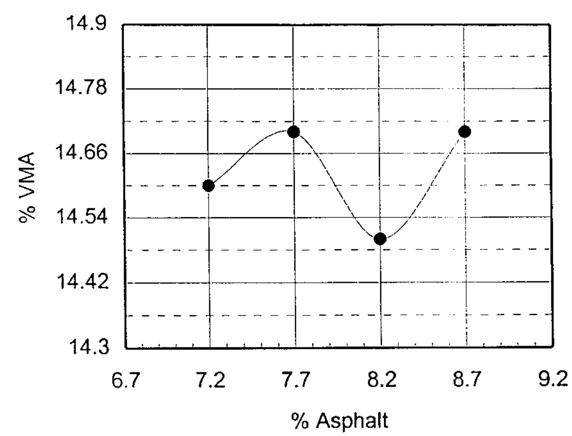
APPENDIX

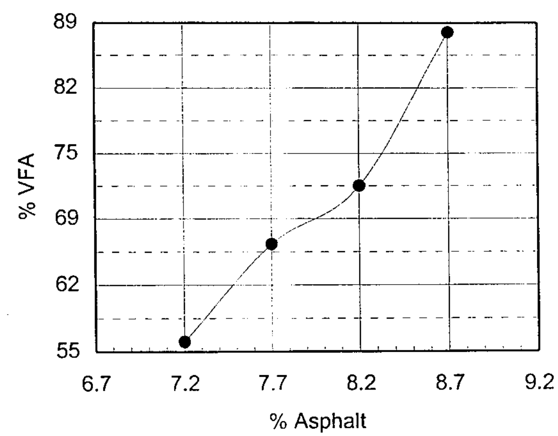
A

Table A1 Mix design data for the Superpave mix

P_b	G_{mb} @ N_{des}	G_{mm}	V_a	VMA	VFA	P_{be}	$P_{0.075}$ / P_{be}	%G_{mm} @ N_{ini}	%G_{mm} @ N_{max}
7.2	2.159	2.306	6.4	96.1	93	3.94	0.6	86.7	94.7
7.7	2.168	2.281	5.0	14.7	66	4.66	0.5	88.1	96.3
8.2	2.185	2.276	4.0	14.5	72	4.97	0.4	88.8	97.0
8.7	2.193	2.232	1.7	14.7	88	6.09	0.4	91.0	99.5





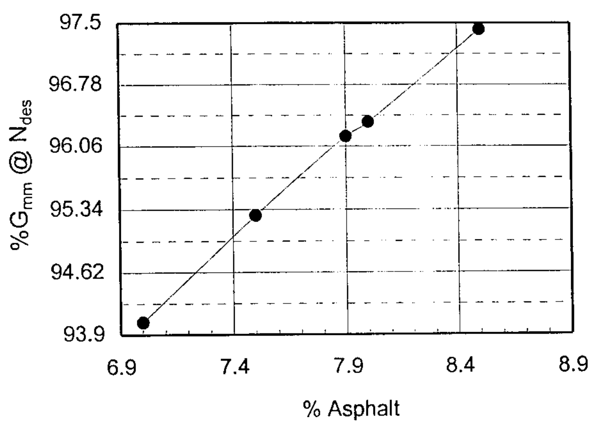


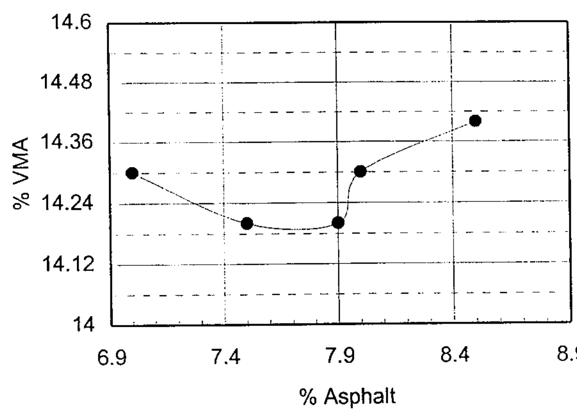
Optimum Asphalt Content	8.20%
Lab Density	136.3 lbs/ft
	=2185 kg/m3
VMA	14.50%

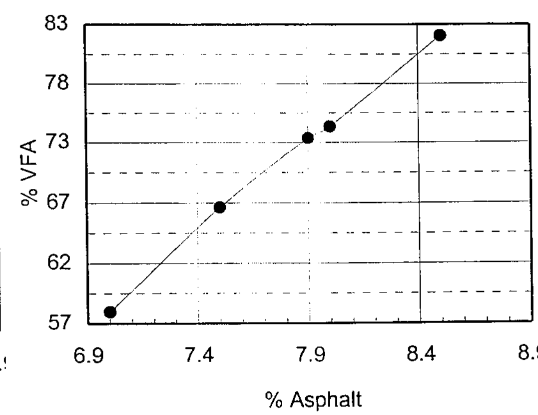
FAA	47%
%G_{mm} @ N_{des}	96
NCAT Oven Calibration Factor	-0.07%
Mixing Temperature	300°F=149°C

Table A2 Mix design data for SBS-modified Superpave mix

P_b	G_{mb} @ N_{des}	G_{mm}	V_a	VMA	VFA	P_{be}	$P_{0.075} / P_{be}$	$\%G_{mm}$ @ N_{ini}	$\%G_{mm}$ @ N_{max}
7.0	2.163	2.300	6.0	14.3	58	3.97	1.1	87.1	94.7
7.5	2.177	2.285	4.7	14.2	67	4.48	1.0	88.1	95.8
7.9	2.186	2.273	3.8	14.2	73	4.90	0.9	89.1	96.7
8.0	2.185	2.268	3.7	14.3	74	5.04	0.9	89.3	96.8
8.5	2.195	2.253	2.6	14.4	82	5.56	0.8	90.4	98.2







Optimum Asphalt Content		7.90%
Lab Density		136.4 lbs/ft
		(=2186 kg/m3)
VMA		14.20%

FAA	47%
$\%G_{mm}$ @ N_{des}	96.2
NCAT Oven Calibration Factor	-6.00%
Mixing Temperature	340°F=171°C
Compaction Temperature	325°F=163°C

APPENDIX

B

Table B1. Nuclear Density Data for Lane 1-Lift 1

	Density (lb/cf)				
Location	1	2	3	4	Average
1	131.7	129.3	131.3	130.2	130.6
2					
3	128.8	129.1	129.4	131.1	129.6
4	129.7	133.4	131.7	131.1	131.5
5	130.2	132.1	130.2	130.3	130.7
6					
7	130.9	131.2	132.8	132.8	131.9
8	131.0	131.4	132.7	132.2	131.8
9	136.8	135.0	134.8	136.3	135.7
10	132.5	132.3	131.6	132.0	132.1
11	134.2	133.0	133.2	133.3	133.4
12					
13	131.7	131.7	130.8	131.3	131.4
14	130.2	129.7	129.3	130.8	130.0
15	130.7	128.8	129.0	129.5	129.5
16					
17	130.6	131.0	130.1	130.7	130.6

Table B2. Nuclear Density Data for Lane 1-Lift 2

	Density (lb/cf)				
Location	1	2	3	4	Average
1					
2	129.1	128.9	129.6	128.6	129.1
3	129.3	130.1	129.6	130.6	129.9
4	129.6	129.7	131.1	130.9	130.3
5	131.3	130.2	128.8	130.5	130.2
6	135.5	133.5	132.9	135.1	134.3
7					
8	135.1	133.7	132.2	134.5	133.9
9	131.9	131.3	130.2	131.9	131.3
10	132.7	131.8	130.7	131.7	131.7
11					
12	134.3	135.0	134.8	132.0	134.0
13	129.6	130.5	130.3	131.4	130.5
14	131.9	129.4	129.8	130.4	130.4
15	131.6	131.7	127.7	131.9	130.7
16	128.2	131.3	132.6	130.6	130.7
17					

Table B3. Nuclear Density Data for Lane 2-Lift 1

	Density (lb/cf)				
Location	1	2	3	4	Average
1	130.1	128.8	131.2	132.8	130.7
2					
3	130.2	131.2	132.4	132.2	131.5
4	129.2	128.5	130.8	131.4	130.0
5	132.5	129.7	132.6	133.2	132.0
6					
7	126.7	126.7	126.4	129.0	127.2
8	132.9	134.5	132.2	129.5	132.3
9	129.8	129.8	130.4	127.9	129.5
10	132.3	132.4	133.0	130.9	132.2
11	129.9	129.8	131.4	131.5	130.7
12					
13	135.3	132.2	134.4	133.2	133.8
14	133.8	134.2	135.2	133.7	134.2
15	132.6	131.5	132.2	132.9	132.3
16					
17	125.8	126.8	129.4	127.9	127.5

Table B4. Nuclear Density Data for Lane 2-Lift 2

	Density (lb/cf)				
Location	1	2	3	4	Average
1					
2	128.6	128.2	128.4	130.0	128.8
3	132.1	131.9	132.9	131.2	132.0
4	131.1	132.0	133.2	132.4	132.2
5	132.3	132.1	133.4	132.4	132.6
6	131.8	130.5	130.5	131.5	131.1
7					
8	130.1	130.8	130.7	131.0	130.7
9	130.7	132.6	130.8	130.2	131.1
10	133.8	132.9	132.6	133.1	133.1
11					
12	130.0	129.7	130.4	131.4	130.4
13	132.0	130.7	132.1	130.6	131.4
14	132.6	131.0	132.0	130.3	131.5
15	132.1	130.8	133.1	131.5	131.9
16	130.2	130.7	130.0	129.8	130.2
17					

Table B5. Nuclear Density Data for Lane 3-Lift 1

	Density (lb/cf)				
Location	1	2	3	4	Average
1	127.6	127.6	129.5	127.7	128.1
2					
3	129.8	130.0	128.8	131.4	130.0
4	130.5	131.5	130.0	131.3	130.8
5	129.8	130.7	128.5	129.9	129.7
6					
7	126.2	126.7	128.1	128.1	127.3
8	133.9	133.9	132.4	136.1	134.1
9	130.8	132.0	131.3	132.7	131.7
10	130.8	132.2	132.0	133.8	132.2
11	133.2	132.7	132.4	131.3	132.4
12					
13	130.3	130.9	132.6	132.1	131.5
14	129.5	130.7	130.4	131.6	130.6
15	130.5	129.8	130.8	131.8	130.7
16					
17	129.0	129.6	127.6	127.8	128.5

Table B6. Nuclear Density Data for Lane 3-Lift 2

	Density (lb/cf)				
Location	1	2	3	4	Average
1					
2	129.2	129.6	131.0	130.7	130.1
3	129.5	130.8	130.4	131.2	130.5
4	132.0	130.1	130.2	131.5	131.0
5	132.4	131.3	129.9	130.0	130.9
6	132.5	132.4	132.0	132.3	132.3
7					
8	133.6	133.1	131.2	132.2	132.5
9	131.3	131.1	131.3	132.2	131.5
10	133.1	132.2	129.5	134.4	132.3
11					
12	128.5	128.6	127.7	128.7	128.4
13	131.9	129.4	128.9	129.6	130.0
14	131.6	131.1	129.9	130.7	130.8
15	136.7	136.2	135.7	136.6	136.3
16	130.1	130.3	131.5	130.5	130.6
17					

Table B7. Nuclear Density Data for Lane 4-Lift 1

	Density (lb/cf)				
Location	1	2	3	4	Average
1	133.7	129.7	138.6	131.3	133.3
2					
3	130.0	129.0	128.6	130.6	129.6
4	131.3	132.5	131.8	130.9	131.6
5	129.0	129.3	130.0	128.3	129.2
6					
7	127.9	127.2	128.1	127.6	127.7
8	132.5	132.4	133.7	132.3	132.7
9	131.2	130.8	131.7	133.4	131.8
10	132.6	130.7	130.0	132.8	131.5
11	129.9	130.8	130.3	130.2	130.3
12					
13	132.3	133.3	132.2	131.8	132.4
14	129.1	129.1	129.0	130.8	129.5
15	130.0	130.7	131.3	131.3	130.8
16					
17	127.0	125.9	127.2	129.1	127.3

Table B8. Nuclear Density Data for Lane 4-Lift 2

	Density (lb/cf)				
Location	1	2	3	4	Average
1					
2	131.5	130.6	131.3	130.9	131.1
3	132.1	133.3	130.9	132.3	132.2
4	131.4	133.3	132.7	131.9	132.3
5	130.4	131.5	131.4	132.0	131.3
6	131.5	131.2	131.0	131.5	131.3
7					
8	131.2	130.4	132.1	131.9	131.4
9	131.8	131.7	133.1	132.6	132.3
10	130.8	132.0	132.9	132.8	132.1
11					
12	130.7	132.0	130.8	132.0	131.4
13	131.1	132.9	132.3	131.3	131.9
14	131.5	130.6	131.8	132.3	131.6
15	132.0	131.0	131.0	131.8	131.5
16	133.4	132.2	131.8	132.3	132.4
17					

Table B9. Nuclear Density Data for Lane 5-Lift 1

	Density (lb/cf)				
Location	1	2	3	4	Average
1	130.3	130.3	132.5	131.6	131.2
2					
3	128.6	129.6	129.3	129.5	129.3
4	129.2	130.4	130.3	129.7	129.9
5	130.8	130.7	130.5	129.2	130.3
6					
7	132.5	132.4	132.1	133.2	132.6
8	131.0	132.8	132.8	133.0	132.4
9	131.4	131.5	131.6	130.9	131.4
10	132.3	131.8	130.6	132.4	131.8
11	134.2	134.2	133.8	135.0	134.3
12					
13	132.0	130.7	131.8	131.5	131.5
14	134.7	134.5	133.3	135.1	134.4
15	132.4	132.0	132.3	132.0	132.2
16					
17	131.0	131.0	130.1	130.6	130.7

Table B10. Nuclear Density Data for Lane 5-Lift 2

	Density (lb/cf)				
Location	1	2	3	4	Average
1					
2	130.3	130.0	130.4	130.0	130.2
3	131.6	132.0	132.4	132.1	132.0
4	132.5	132.6	131.8	132.7	132.4
5	131.0	130.5	133.3	132.0	131.7
6	131.0	130.9	131.5	130.9	131.1
7					
8	129.3	131.5	131.9	131.4	131.0
9	132.2	131.8	131.5	130.9	131.6
10	132.6	132.4	131.0	132.0	132.0
11					
12	130.5	129.2	130.0	129.5	129.8
13	129.8	130.0	130.5	128.9	129.8
14	130.9	131.5	131.5	131.4	131.3
15	131.3	130.5	130.1	132.4	131.1
16	129.0	131.1	132.3	132.4	131.2
17					

Table B11. Nuclear Density Data for Lane 6-Lift 1

	Density (lb/cf)				
Location	1	2	3	4	Average
1	128.9	131.4	130.2	130.4	130.2
2					
3	133.7	132.4	131.7	132.9	132.7
4	132.8	132.7	134.6	134.2	133.6
5	129.6	133.4	133.5	133.5	132.5
6					
7	132.0	141.8	133.1	131.8	134.7
8	133.2	133.6	134.1	132.1	133.3
9	135.1	132.7	134.1	135.0	134.2
10	133.0	132.6	132.1	133.0	132.7
11	133.2	131.6	132.6	132.5	132.5
12					
13	132.7	134.8	134.8	132.6	133.7
14	134.0	134.6	136.8	134.0	134.9
15	133.6	133.9	133.5	132.9	133.5
16					
17	135.3	137.0	141.9	141.0	138.8

Table B12. Nuclear Density Data for Lane 6-Lift 2

	Density (lb/cf)				
Location	1	2	3	4	Average
1					
2	128.6	127.9	128.9	129.1	128.6
3	131.3	128.7	128.8	130.1	129.7
4	132.0	132.8	131.7	131.3	132.0
5	132.8	132.2	133.6	133.9	133.1
6	132.0	132.0	131.6	132.1	131.9
7					
8	132.8	132.6	132.2	131.7	132.3
9	129.7	130.0	130.2	129.3	129.8
10	131.7	130.8	132.6	132.2	131.8
11					
12	131.2	133.4	130.8	132.4	132.0
13	131.9	131.7	130.9	132.8	131.8
14	130.9	132.2	131.9	131.7	131.7
15	129.8	131.0	129.5	131.7	130.5
16	131.1	132.6	132.5	131.6	132.0
17					

Table B13. Nuclear Density Data for Lane 7-Lift 1

	Density (lb/cf)				
Location	1	2	3	4	Average
1	135.4	134.1	133.9	134.8	134.6
2					
3	131.9	133.6	132.9	131.9	132.6
4	133.5	134.3	132.7	132.4	133.2
5	134.6	133.7	134.3	134.6	134.3
6					
7	136.5	134.7	135.5	135.3	135.5
8	134.9	134.5	135.0	135.5	135.0
9	136.2	135.9	135.5	135.6	135.8
10	134.2	134.3	134.3	133.9	134.2
11	137.0	136.3	136.5	138.0	137.0
12					
13	135.6	136.5	134.5	136.1	135.7
14	136.6	134.3	133.0	135.3	134.8
15	132.3	134.7	133.6	133.3	133.5
16					
17	134.7	133.8	131.9	134.0	133.6

Table B14. Nuclear Density Data for Lane 7-Lift 2

	Density (lb/cf)				
Location	1	2	3	4	Average
1					
2	131.7	130.8	131.1	130.3	131.0
3	128.3	128.6	128.6	128.7	128.6
4	130.2	128.1	128.2	129.2	128.9
5	131.0	130.0	131.3	129.9	130.6
6	130.0	129.6	131.2	130.8	130.4
7					
8	131.5	131.7	131.8	131.5	131.6
9	129.4	129.4	131.4	131.0	130.3
10	130.8	130.6	130.5	130.7	130.7
11					
12	131.5	130.2	129.1	130.1	130.2
13	127.8	128.5	130.7	130.3	129.3
14	131.3	129.7	128.4	131.4	130.2
15	131.5	130.8	130.9	130.5	130.9
16	133.9	132.7	133.8	131.9	133.1
17					