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16. Abstract

Three test lanes were constructed at the Louisiana Pavement Research Facility (PRF) to study the performance of Asphalt Rubber Hot Mix Asphalt (AR-HMA) as compared to conventional Hot Mix Asphalt (HMA), to establish the structural capacity of AR-HMA materials, and to determine the best possible location of AR-HMA materials within the pavement structure. The first test lane consisted of an AR-HMA wearing course and conventional HMA for the binder course and base course. The second test lane consisted of conventional HMA for the wearing and binder courses and an AR-HMA base course. The third test lane (control section) consisted of conventional HMA for the wearing course, binder course, and base course.

This interim report documents the construction of the three test lanes. Properties of the HMA and the AR-HMA used for this construction are included along with a detailed instrumentation plan. The AR-HMA used in this experiment consisted of a wet process with ten percent pre-blended 80 mesh rubber and AC-30 asphalt cement. All sections were constructed utilizing current Louisiana Department of Transportation and Development (DOTD) standard specifications and special provisions.

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COMPARATIVE PERFORMANCE

OF

CONVENTIONAL AND RUBBERIZED

HOT MIX UNDER ACCELERATED LOADING,

CONSTRUCTION REPORT

Interim Report

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LTRC Report No. 331
Research Project No. 98-2P

LOUISIANA TRANSPORTATION RESEARCH CENTER,
LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
In Cooperation With
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

March 2000

ABSTRACT

Three test lanes were constructed at the Louisiana Pavement Research Facility (PRF) to study the performance of Asphalt Rubber Hot Mix Asphalt (AR-HMA) as compared to conventional Hot Mix Asphalt (HMA), to establish the structural capacity of AR-HMA materials, and to determine the best possible location of HR-HMA materials within the pavement structure. The first test lane consisted of an AR-HMA wearing course and conventional HMA for the binder course and base course. The second test lane consisted of conventional HMA for the wearing and binder courses and an AR-HMA base course. The third test lane (control section) consisted of conventional HMA for the wearing course, binder course, and base course.

This interim report documents the construction of the three test lanes. Properties of the HMA and the AR-HMA used for this construction are included along with a detailed instrumentation plan. The AR-HMA used in this experiment consisted of wet process with 10 percent pre-blended 80 mesh rubber and AC-30 asphalt cement. All sections were constructed utilizing current Louisiana Department of Transportation and Development (DOTD) standard specifications and special provisions.

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INTRODUCTION

In response to the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, Louisiana constructed five projects to evaluate several methods of using discarded tire rubber in highway pavements. There are various methods of incorporating rubber into asphalt mixtures utilizing either a wet process or a dry process. The wet process incorporates a ground rubber in the asphalt cement using time and temperature. The dry process uses ground rubber particles as an aggregate substitue in the mixture.

Eight variations of these two processes were constructed on the following projects:

US 61:	Patented wet process - Gap graded mixture (Arizona Process)
LA 15:	Generic wet process - Gap graded, 16 mesh mixture and Dense Graded 80 mesh mixture (Rouse)
LA 1040:	Patented dry process - Gap graded (Plus-Ride)
US 167:	Generic Dry Process - Gap graded, 16 mesh mixture and Dense Graded 80 mesh mixture (Rouse)
US 84:	Pre Blended Rubber - Presently allowed by the Specifications (Neste-Wright)

All of these pavements are still performing and are being evaluated under another research study. The generic "wet process" method with 80 mesh powdered Rouse rubber stood out among the various projects due to its adaptability to current construction practice. This type of process is used with conventional dense graded mixes and there are no patents associated with the process. Construction of this project incorporated the use of the 80 mesh powdered Rousse rubber in a wet process termed as Asphalt Rubber-Hot Mix Asphalt (AR-HMA). This source of material is readily available and located in Vicksburg, Mississippi.

This study was proposed to answer several concerns regarding asphalt-rubber practice. California had proposed a reduced overlay design procedure effectively reducing surface lift thickness when asphalt rubber was used. Their empirical field results along with laboratory fatigue test results indicate that such practice is warranted. However, strength parameters do not reflect the validity of this reduction in thickness design. A determination of structural strength appears to be needed for these mixes.

Original arguments that asphalt rubber mixes could not be recycled because of environmental concerns have since been rejected. Another way to overcome such a problem would be to place the asphalt rubber mix in a lower lift of the section design which might not be subject to recycling. Indeed, by placing the asphalt rubber in a thicker base lift(s), considerably more rubber would be used, thereby, also achieving the goal of using more discarded tires. In order to accomplish this, though, it would again be necessary to determine the structural contribution of such mixes.

This experiment is designed to to answer these questions by comparing conventional mixtures using the Louisiana standard AC-30 and PAC-40 asphalt mixtures to a AR-HMA modified mixture. Examining the laboratory tests of the mixtures and their performance under accelerated loading will provide invaluable information on the ability of AR-HMA asphalt materials to affect the fatigue resistance and overall performance of hot mix.

The performance of the AR-HMA will be compared with that of the conventional Hot Mix Asphalt (HMA) wearing course. Similarly, dense graded AR-HMA black base will be tested and compared to a conventional black base. Laboratory results from previous research indicate that the AR-HMA shows reduced thermal and reflective cracking, reduced rutting and slower aging than do conventional mixes. Field evaluation is needed to determine whether these benefits can be realized. Current results from ALF testing will provide the best basis for acquiring the necessary data to develop believable structural coefficients.

This interim report documents the construction of the three test lanes to be tested as experiment number two at the Pavement Research Facility (PRF).

OBJECTIVE

The first objective of this research is to evaluate the performance of conventional mix to AR-HMA mix under accelerated loading.

The second objective of this research is to determine the structural value of AR-HMA mix in section design and to determine the potential use in other than surface lifts, i.e., base course.

SCOPE

The scope of this project is to evaluate the pavement performance to failure under accelerated loading of the three test lanes constructed at the PRF. Additionally, materials characterization will be evaluated in a laboratory environment.

METHODOLOGY

The Louisiana Transportation Research Center's (LTRC) PRF is a permanent, outdoor, full scale testing laboratory purchased by and for the DOTD and is located on a six acre site in Port Allen, Louisiana. The purpose of this facility is to test and quantify full-scale pavement performance of various pavement types under accelerated loading using the Accelerated Loading Facility (ALF) device.

Site layout and experiment design

Figure 1 describes the layout and design of each of the three test lanes constructed for this study. Each lane was designed for an 8½ inch stone base. Lane 001 was designed to have the AR-HMA placed at the surface layer; lane 002 was designed to have the AR-HMA placed in the black base layer; and lane 003 was the control lane consisting of conventional mix throughout the layers.

The following is a description for each test lane constructed at the PRF:

Test Lane 2-1: 1½ inch AR-HMA wearing course, 2 inch HMA binder course, 3½ inch HMA black base, and 8½ inch stone.

Test Lane 2-2: 1½ inch HMA wearing course, 2 inch HMA binder course, 3½ inch AR-HMA black base, and 8½ inch stone.

Test Lane 2-3: 1½ inch HMA wearing course, 2 inch HMA binder course, 3½ inch HMA black base, and 8½ inch stone.

Each lane was constructed on an existing five foot embankment with the top 10 inches of the embankment being cement treated in order to stabilize the subgrade.

The conventional mix design consisted of Type 5A black base mix with AC-30 asphalt cement and 20 percent Recycled Asphalt Pavement (RAP); Type 8 binder course with PAC-40 asphalt cement and 20 percent Rap; and a Type 8 Wearing Course with PAC-40 asphalt cement. Louisiana type 8 mixtures are designed for high speed, high volume pavements which require the use of modified asphalt.

The contract was awarded to F.G. Sullivan, Jr. Contracting (Sullivan) of Baton Rouge, Louisiana, for $298,190. Construction of the three test lanes began on July 8, 1998 and was completed October 1, 1998.

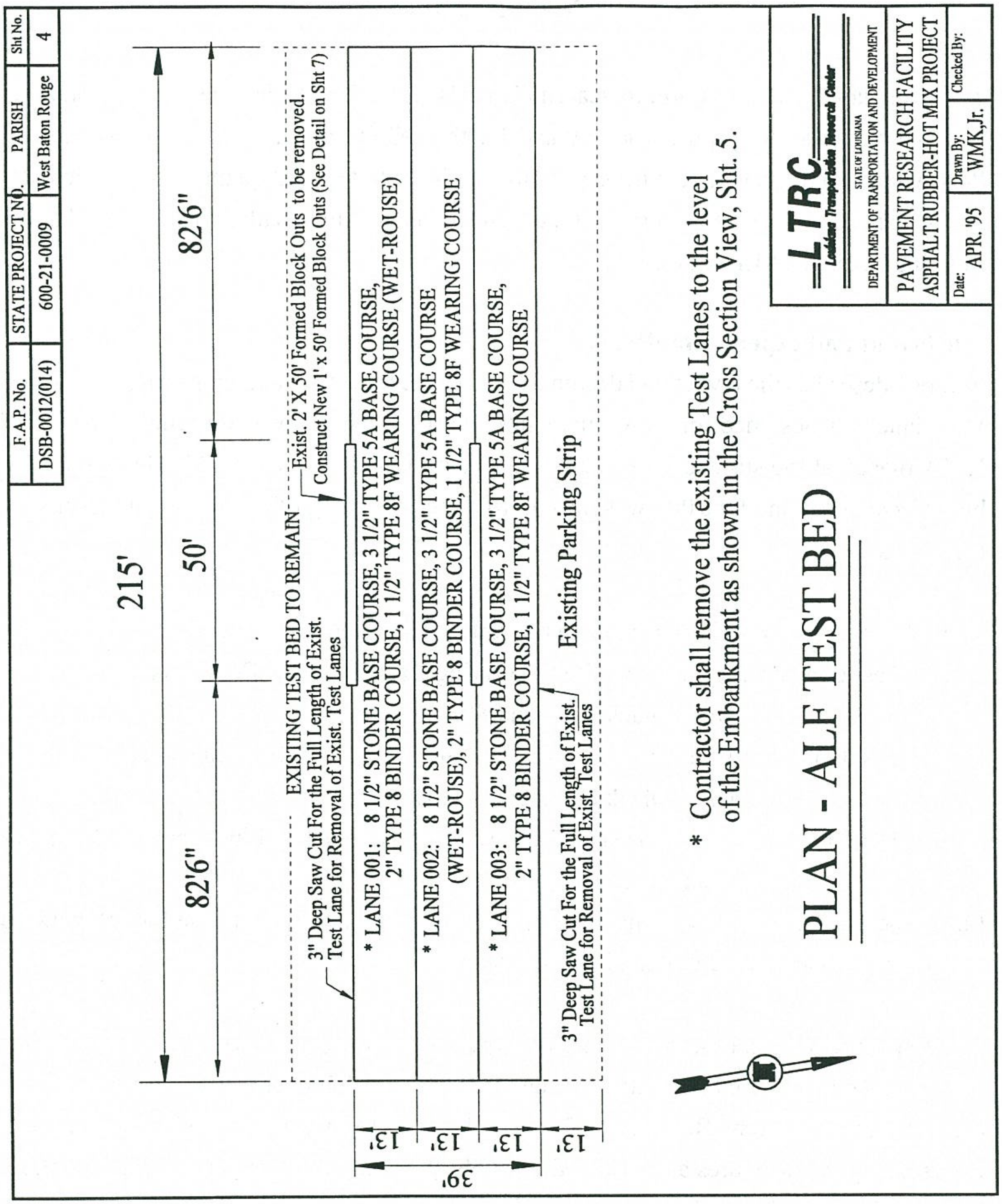


Figure 1

Test bed layout and section for second experiment test lanes.

Normal construction practices were followed so the project would be as representative as possible of actual highway practices, all in accordance with *Louisiana Standard Specifications for Roads and Bridges, 1992*. The contract specifications and special provisions are found in appendix A: Contract Specifications.

Materials and mix design

Asphalt cement. Louisiana DOTD specifies a PAC-40 asphalt cment which is typically modified with an elastomer for use on high volume roadways in the binder and wearing course mixtures. The PAC-40 used for this project was supplied by Eagle Asphalt. An AC-30 supplied by Eagle Asphalt was supplied for the conventional base course mix and was used as the blend asphalt cement for the rubber modified asphalt.

Based on the field projects previously constructed in Louisiana, a "wet process" asphalt-rubber binder using a No. 80 mesh powdered rubber was chosen for use. The rubber was supplied by Rouse Rubber Industries located in Vicksburg, Mississippi. The powdered rubber was blended at a rate of ten percent by weight of the AC-30 at 400° F for approximately one hour. This is similar to the processing of powdered rubber as specified in Florida DOT specifications. The selection of this rate was also influenced by a previous Louisiana study, "Characterization of Asphalt Cements Modified With Crumbed Rubber From Discarded Tires", LTRC Research Report Number 291, by Daly and Neglescu, which indicated incompatibilities of either powdered or crumb rubber used at higher rates when blended with asphalt cements supplied in Louisiana.

A liquid antistrip agent was added to all of the asphalt cements at a rate of 0.8 percent by weight as determined by Louisiana TR 322-92 which is a modified ASTM T-283 procedure.

Aggregates. The No. 5, No. 67 and No. 78 coarse aggregates and the No. 11 screenings were siliceous limestone supplied by Vulcan Materials Company, from Gilbertsville, Kentucky. The coarse siliceous sand was supplied by Quick Sand and Gravel from Watson, Louisiana. Aggregate properties are presented in Table 1.

Mix Designs. Typical Louisiana Marshall mix designs were required by the contract. Table 1 presents the proportioning of aggregate materials and composite gradations for the three mix types used. The mix designs for the one inch nominal size mix for the base and binder courses and the ¾ inch nominal size wearing course mix using the normally specified Louisiana asphalt

Table 1
Mix Design

HMAC Mix Designs							
Aggregate		Type 5 Base, %	Type 8 Binder, %	Type 8 Wearing, %	Apparent Gravity	Bulk Gravity	Absorption
Source	Type						
Vulcan Reed	No 5 LS	37	37	0	2.690	2.675	0.21
Vulcan Reed	No 67	0	0	45	2.696	2.681	0.21
Vulcan Reed	No 78	11	11	18	2.720	2.691	0.40
Vulcan Reed	No 11	21	21	22	2.701	2.650	0.71
Quick Sand	c sand	12	12	15	2.652	2.642	0.14
Mamonth dr	RAP	19	19	0	2.608	2.608	0.00
Gsb		2.655	2.655	2.654			
Max. Gravity		2.533	2.533	2.531			
Gmm		2.509	2.509	2.493			
Asphalt Liquid							
Binder	Type						
AntiStrip	Perm 99		0.8	0.8	0.8	1.03	
Eagle	AC30	2.6			1.03		
Eagle	PAC40	2.6		4.0*	1.03		
AC from RAP	AC30	0.9		0.9	1.03		
TOTAL % AC		3.5	3.5	4.0			

Gradation				
Sieve, mm	Sieve, in	Type 5 Base	Type 5 Binder	Type 8 Wearing
37.50	1.5	100	100	100
25.00	1	96	96	100
19.00	¾	84	84	98
12.50	½	69	69	84
9.50	⅜	61	61	64
4.75	No. 4	46	46	41
2.36	No. 8	36	36	28
1.18	No. 16	26	26	20
0.60	No. 30	21	21	15
0.43	No. 40	19	19	10
0.30	No. 50	16	16	8
0.18	No. 80	8	8	6
0.075	No. 200	5.3	5.3	4.4

Table 1 Cont'd
Mix Design

Consensus Aggregate Properties								
Aggregate		FAA Method A	Sand Eq. 4.75 mm	Flat & Elong % 5:1	CAA +two faces	Friction Rating	LA Abrasion	Soundness
Source	Type							
Vulcan Reed	No 5 LS			3	100	II	20.1 %	0.3
Vulcan Reed	No 67 LS			3	100	II	20.1%	0.3
Vulcan Reed	No 78			2	100	II	20.1%	0.3
Vulcan Reed	No 11	47	44					
Quick Sand	c sand	43	61					
Mamonth dr Rap					100.0			

* Lane 2 Base course and Lane 1 Wearing course contain Eagle AC30 with 10% Rouse Rubber

cements were submitted by the contractor in June 1998. A separate mix design was not required for the mixes using asphalt rubber modified asphalt cement. This material was substituted for the AC-30 and PAC-40 at the same rate as the conventional mixes. The contractor substituted a binder course for the base course mix as permitted by specification; the binder and base course mixes were, therefore, identical. These mixes contained twenty percent RAP material.

Construction

Embankment. Construction of the new test lanes began by removing three existing test lanes. An ALTEC RW18 vemeer type joint cutter was used to cut a joint along the edges of the test lanes to be removed. A John Deere 690 ELC track hoe was then used to excavate the existing test lanes. The material was loaded in dump trucks and placed in the back of the DOTD property which was latter spread smooth by the contractor.

Construction of the new test lanes continued with the placing and compacting of the stone base, when it was determined that the base was not stable enough for the construction of the Hot Mix Asphaltic Concrete (HMAC) layers, as determined by Dynaflect results. Through a plan change the contractor removed the base material to the top of the embankment and cement stabilized the embankment to a depth of 10 inches with 8 percent cement content based on design curves prepared by LTRC.

A John Deere dozer and Caterpillar grader was used to level and shape the existing underlying embankment. A-4 soil material stockpiled at the PRF site was placed in the low areas. After compacting the embankment with a steel roller, the contractor delivered 26.27 tons of cement to the site in covered dump trucks which was evenly spread over each test lane using a calibrated mechanical spreader. A Caterpillar SS 250 stabilizer was used to process the soil cement into the top 10 inches of the embankment material. Initial compaction was accomplished by a sheeps-foot roller followed by a John Deere steel roller. Final grade was accomplished using a motor grader followed by the steel roller. An MC-30 cutback asphalt prime coat was sprayed to seal the treated embankment at a rate of 0.10 gallons per square yard. Table 2 shows the nuclear density and moisture content results for the stabilized embankment using a Troxler Nuclear Density gauge.

Construction continued with the placement of the 1 x 50 foot formed block-outs. The block-outs were constructed of wood to provide an access area for instrumentation wiring which was installed by the PRF personnel. The PRF personnel began placing the pressure cell instrumentation on top of the embankment. The instrumentation plan is discussed in detail in the Instrumentation section of this report.

Table 2

Nuclear density results of stabilized embankment

Lane No.	Dry Weight Density #/Ft^3	STD, n=5	Moisture Content %	STD, n=5	Compaction %	STD, n=5
2-1	107.7	1.54	18.9	1.15	98.8	1.42
2-2	108.3	3.45	16.7	0.82	101.1	1.40
2-3	108.5	2.14	17.5	1.44	99.6	1.98

Base. The crushed stone was back dumped and spread with a John Deere dozer. Grading was accomplished using a Caterpillar grader and compaction was achieved using a vibratory steel roller. Water was used to aid in the compaction effort and to achieve proper moisture content.

The nuclear density and moisture content results of the completed stone layer are shown in table 3. The optimum density for the stone was 142.9#/ft^3 at 5.6 percent moisture content as measured by the DOTD district laboratory. Once the subbase was accepted, the contractor sprayed an asphaltic cement prime coat. An MC-250 cutback asphalt was used to prime the stone base with a measured 0.25 gallons per square yard. The total material used was approximately 250 gallons covering 1000 square yards.

Table 3
Nuclear density results of stone

Lane No.	Dry Weight Density #/Ft^3	STD, n=5	Moisture Content %	STD, n=5	Compaction %	STD, n=5
2-1	135.0	1.59	5.88	0.83	94.5	1.16
2-2	137.4	1.79	5.86	0.48	96.1	1.23
2-3	137.0	2.09	7.96	1.11	95.9	1.50

HMAC plant production

Production of asphalt cement. The AR-HMA was pre-blended by Blackledge Emulsion in Gulfport, MS. An 80 mesh Rouse rubber was blended at 10 percent by weight per contract specifications. A total 3,175 gallons of Eagle AC-30 was blended with 2,727 lbs. of 80 mesh rubber delivered on pallets in 80 lb sacks. The AR-HMA liquid was delivered in a typical transport and loaded at the contractors plant into a heated distributor with dual vertical mixers. The liquid was shipped the same day that the base mix was laid, and kept heated in the distributor until the wearing course was placed three days later. No problems in asphalt cement supply were reported, with the plant able to switch from normal supply to the Asphalt Rubber (AR) material without noticeable change in flow. The test results indicate typical values for the material used. Table 4, Asphalt Cement Test Summary, shows the AC-30 met a PG67-22 specification, the AR/AC 30 blend met a PG70-22 specification as did the PAC-40. The original stiffness of the AR/AC-30 and PAC-40 exceeded 1.0 Kpa a 76C. The AR/AC-30 blend did not meet the force ductility ratio required by the PAC-40 specifications for wearing courses in

Louisiana. The PAC-40 met all requirements of the current specification.

Plant mix summary. A summary of the plant Marshall results are shown in table 5, Marshall Properties. All plant volumetrics were within specifications, but the AR-HMA modified mixtures maintained about 4.5 percent voids whereas the conventional binders maintained 4 percent voids. The AR-HMA exhibited about 250 lbs less stability in the base and 400 lbs less stability in the wearing course which was similar to previous experience with AR-HMA mixtures. The AR-HMA wearing course exhibited the lowest stability at 1940 lbs. The AR-HMA mixtures were 0.5 percent higher in VMA at 12.8 on the base and 13.8 on the wearing course as compared to the conventional mixes. These VMA's were calculated using apparent specific gravities customary in Louisiana. The MS-2 method of comparing Gmm to the bulk specific gravity are included for information in the bottom of Table 5.

Table 4
Asphalt Cement Test Summary

Description	AC-30	AC-30 w/ AR-HMA	PAC-40	Specs.	AASHTO Method
Original Binder					
Rotational Viscosity; Brookfield, P.a.s., 135° C	0.463	3.10	1.05	3.0	TP48
Force Ductility, ratio of final/max load	Fail	Fail	Pass	0.3	
Dynamic Shear Rheometer, DSR,G*sin(delta),kpa,@10 rad/s					
64° C	1.7274	3.0659		1.0 min	TP5
67° C	1.2146		2.7328	1.0 min	TP5
70° C	0.8405	2.3991	1.8974	1.0 min	TP5
76° C		0.8914	1.0156	1.0 min	TP5
RTFO (TFO for AR-HMA)					TP240
% Loss		0.1	0.187	1.0 max	TP240
DSR, (64° C)		6.6001		2.2 min	TP5
DSR, (67° C)	3.488	4.2759		2.2	TP5
DSR, (70° C)	2.2942	3.218	3.2058	2.2 min	TP5
DSR, (76° C)		1.7412	1.8564	2.2 min	TP5
PAV					TP5
DSR, G*xsin(delta), kpa@10 rads/s, (25° C)	3628.3	2122.6	3175.1	5000 max	TP5

Table 5
Marshall Properties

TEST DESCRIPTION	ASPHALT MIX DESCRIPTION				
	Type 5 Base AC30	Type 5 Base CRM	Type 8 Binder P40	Type 8 Wearing P40	Type 8 Wearing CRM
Theoretical	2.533	2.531	2.533	2.531	2.531
Gmm	2.507	2.509	2.509	2.493	2.509
% AC By Weight	3.5	3.5	3.5	4.0	4.0
% AC By Volume	8.3	8.2	8.3	9.4	9.4
% Voids Total Mix	4.0	4.6	4.1	3.9	4.4
%VFA	67.5	64.0	66.6	70.8	68.2
%VMA	12.3	12.8	12.4	13.3	13.8
Unit Wt. Total Mix	151.8	150.6	151.5	151.8	151.0
Stability - Per C	2711	2455	2810	2430	1904
Flow	10	7	10	9	10
MS-2 METHOD					
Gmm	2.507	2.509	2.509	2.493	2.509
Gmb	2.410	2.392	2.406	2.410	2.398
% Voids	3.9	4.7	4.1	3.3	4.4
%VMA	12.7	14.1	13.1	12.3	13.7
%VFA	69.6	66.9	68.7	72.8	67.5
GTM RESULTS					
Theoretical	2.501	2.493	2.492	2.492	2.492
% Voids	4.40	4.26	4.00	5.11	4.11
Unit Wt.	149.21	148.93	149.24	147.56	149.08
GSI	0.97	0.96	0.96	0.96	0.97

HMAC Lay down

Tack coat. An asphalt emulsion was specified to allow a 50 percent dilution rate. The emulsion material was used between the HMAC layers and the amount placed between the binder course and base course was measured to be 0.02 gallons per square yard. The amount placed between the wearing course and binder course was measured to be 0.06 gallons per square yard. The following are results of the laboratory samples:

Tack Coat Type (% residual specified)

The sample was diluted with 51.6 % water.

Percent residue* 48.4%

Viscosity (Brookfield) .... 100 mPa

Test on Residue:

Dynamic Shear Rheometer	49C	52C
G*/Sin delta, Pascals =	1.2	0.81

* The percentage of emulsion residue was determined by AASHTO T 59-93, Residue by evaporation, method c.

Equipment. Sullivan Contractor's double barrel counter flow Astec plant utilized four of the five cold feed bins along with the recycling feed into outer shell of the drum. The mixture was stored in the silo while volumetric tests and gradations were evaluated. The laboratory at the plant site was fully equipped with a Troxler gyratory compactor, Marshall hammer and stabilometer , Troxler asphalt content oven, and all necessary scales and ovens to perform required tests, including gradation analysis, AC content, bulk specific gravity of the mixture and maximum specific gravity of the mixture. This plant, located on the north side of Highway 190 at the foot of the "Old" Mississippi River Bridge in Baton Rouge, is less than ten miles from the ALF site. At the site, a Barber Green track paver was used to place the HMAC. The paver accepted trucks directly into its receiving hopper as insufficient distance was available in incorporate a Material Transfer Vehicle (MTV) as is required on all paving projects in Louisiana.

Compaction, setting the rolling pattern. This section describes the rolling pattern set for the base course. The rolling pattern for the remaining lifts were performed in a similar manner. After placement of the HMAC, an Ingersoll-Rand DD90 vibratory steel roller followed by a Bomag BW-12 rubber wheeled roller was used for compaction. The vibratory steel roller made two passes and nuclear density measurements revealed an average nuclear density of 85.7 percent. The vibratory steel roller made two additional passes with an average density result of 89.9 percent. The roller made one additional pass without vibration which resulted in an average density of 92.0 percent. The center of the lane appeared to be compacting more than the outside, and a more concentrated effort was placed on the outside of the test lane. The rubber wheeled roller made two passes, concentrating more to the outside of the lane resulting in an average measured density of 90.8 percent. The rubber roller made one additional static steel pass which resulted in an average density of 92.4 percent. The steel roller made one last pass which resulted in an average measured density of 94.5 percent. Therefore, the following rolling pattern was set: four vibratory passes, one static steel pass, three rubber roller passes and one final static steel pass.

Post construction testing. The in-place densities as a percentage of maximum theoretical, Gmm are described in table 6. Figure 2 depicts the test lane compaction results obtained from the roadway cores. Table 7, presents a comparison of the average thickness of each HMAC layer between the measured elevation and the cores obtained. The elevations were taken at the centerline of each lane, every 10 feet.

Table 6

Summary of Average In-Place Density

Lane No.	WC PAC- 40 Density, %	WC AR-HMA Density, %	BC PAC-40 Density, %	Base AC-30 Density, %	Base AR-HMA Density, %
3	94.6				
2	93.3				
1		93.5			
3				94.5	
3			95.1		
2					94.6
2			95.0		
1				96.3	
1			95.5		
no. of cores	6	3	8	5	3
avg	94.0	93.5	95.2	95.1	94.6
std	1.0	0.5	0.3	1.0	0.7
% of Plant	97.89	97.53	99.10	99.1	99.30
% Pay	100	100	100	100	100

Evaluation plan

A series of cores and beams were taken to further evaluate the in-place asphalt pavement at various locations outside the actual area to be loaded. Dynaflect and Falling Weight Deflectometer (FWD) data were collected after placement of each lift. The evaluation of this data will be reported in the final report.

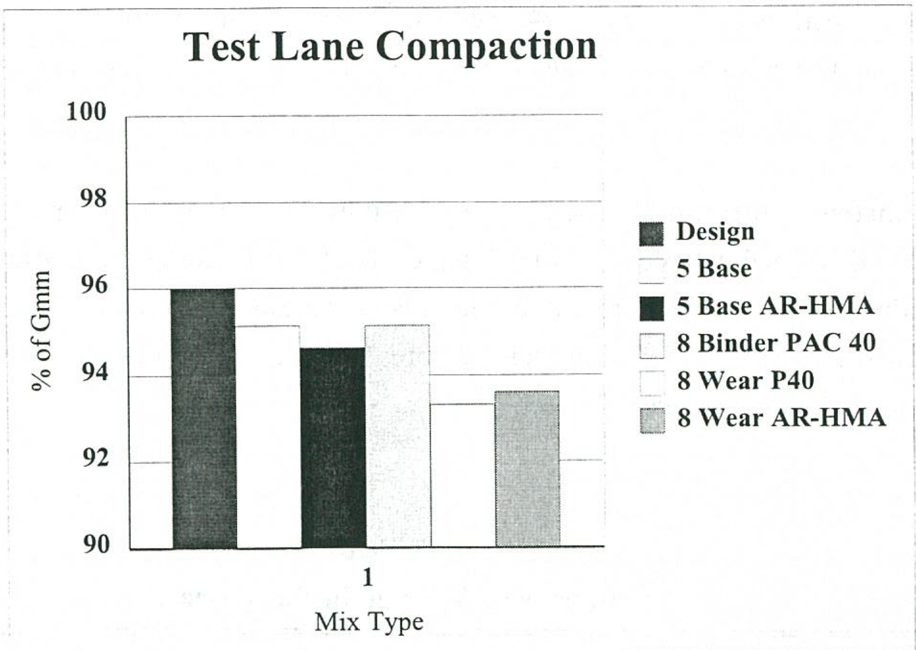


Figure 2.
Test lane compaction

Table 7
Average thickness by elevation vs HMAC cores

Type	Lane 2-1 (AR-HMA Wearing)					Lane 2-2 (AR-HMA Base)					Lane 2-3 (Control)				
	Elevations, in.		Core Thickness, in.			Elevations, in.		Core Thickness, in.			Elevations, in.		Core Thickness, in.		
	*Ave	*Std	Ave	Std	# of Cores	*Ave	*Std	Ave	Std	# of Cores	*Ave	*Std	Ave	Std	# of Cores
Wearing Course	1.58	.22	1.73	.13	3	1.80	.19	1.68	.19	3	1.36	.20	1.56	.16	3
Binder Course	2.60	.13	2.20	.57	3	2.76	.12	2.92	.12	3	2.68	.15	2.67	.31	3
Base Course	2.62	.27	3.37	.61	3	3.34	.37	2.73	.37	3	3.20	.27	3.40	.14	3
Total	6.8		7.30			7.90		7.33			7.24		7.63		

* Each average elevation was based on six measurements evenly spaced along the test section.

Instrumentation and data acquisition system

The purpose of the instrumentation and data acquisition system is to provide for a clear understanding of the pavement distress process and to aid in the characterization and evaluation of the relative pavement/base response to load.

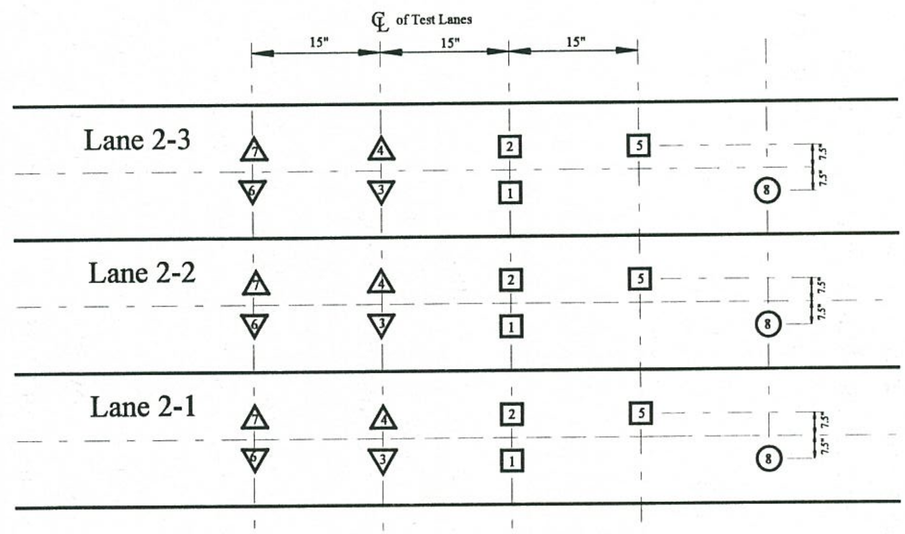
Each test lane was instrumented with strain measuring devices, pressure gauge devices and vertical deflection devices, which were placed at various layer interfaces. A new data acquisition system described below was also purchased to collect the data from the various instruments. Also, a permanent weather station is located at the PRF which is used to monitor daily weather patterns.

Figure 3 shows the instrumentation plan layout with a description of each type of gage used to collect the various types of data. Figures 4, 5, and 6 show the cross section locations of the gages used in each test lane respectively.

Strain gauges. The TML model KM-100-HAS is an H-bar type strain gauge as shown in figure 7 and is used to measure horizontal strains at the various interfaces in the HMAC. This model is a full bridge 350 ohm strain gage with a capacity of $\pm 5{,}000 \times 10^{-6}$. This gage can also be wired for quarter bridge operation for relative temperature measurement.

Pressure cells. The Geokon model 3500 earth pressure cell is designed to measure total pressure in earth fills and embankments as well as other structures. The pressure cell has a range up to 100 psi. It has a 350 ohm resistance strain gauge type with a 10 volt D/C maximum excitation. The pressure cell consists of two circular 9 inch diameter stainless steel plates welded contiguously around their periphery and space apart by a narrow cavity filled with an anti-freeze or mercury solution. A high pressure stainless steel tube connects to the plates with a pressure transducer placed in the cavity. External pressures acting on the cell are balanced by an equal pressure induced in the internal fluid. This pressure is converted by the pressure transducer into an electrical signal which is transmitted by a four conductor shielded cable to a readout location. The entire device weighs approximately five pounds. Figure 8 is a photograph of the gauge.

Vertical deflection devices. The Lucas Schaevitz Model GCA-121-1000 LVDT is an electro-mechanical transducer that produces an electrical output proportional to the displacement of a separate movable core. Since there is no physical contact between the movable core and coil structure, the LVDT is a frictionless device.



INSTRUMENTATION PLAN

Lane 2-1

1 - Embankment Pressure Cell - Rt
2 - Subbase Pressure Cell - Lt
3 - Subbase Strain Gage - Rt
4 - Subbase Strain Gage - Lt
5 - Base Pressure Cell - Lt
6 - Base Strain Gage - Rt
7 - Base Strain Gage - Lt
8 - Surface LVDT - Rt

Lane 2-2

1 - Embankment Pressure Cell - Rt
2 - Subbase Pressure Cell - Lt
3 - Subbase Strain Gage - Rt
4 - Subbase Strain Gage - Lt
5 - Base Pressure Cell - Lt
6 - Base Strain Gage - Rt
7 - Base Strain Gage - Lt
8 - Surface LVDT - Rt

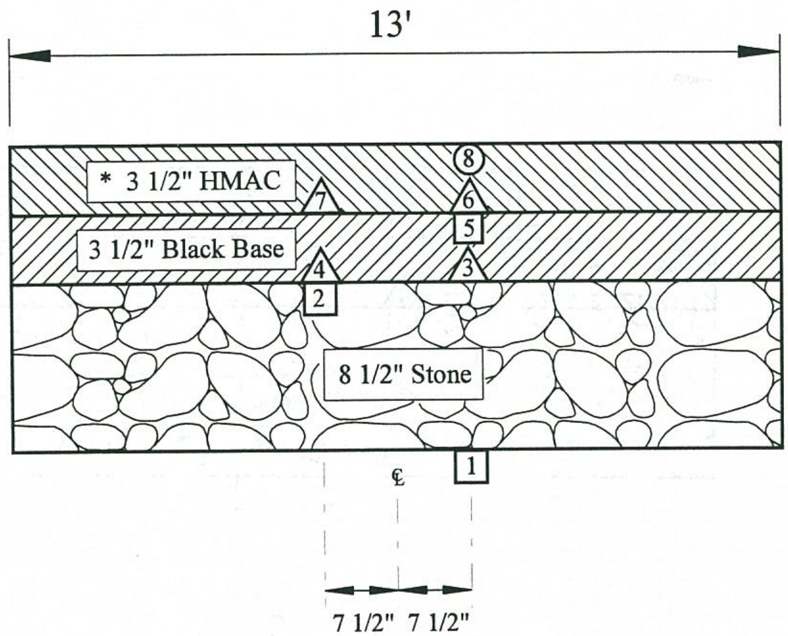
Lane 2-3

1 - Embankment Pressure Cell - Rt
2 - Subbase Pressure Cell - Lt
3 - Subbase Strain Gage - Rt
4 - Subbase Strain Gage - Lt
5 - Base Pressure Cell - Lt
6 - Base Strain Gage - Rt
7 - Base Strain Gage - Lt
8 - Surface LVDT - Rt

Figure 3.

Instrumentation plan.

Test Lane 2-1



Cross Section Looking West

* 2" Binder Course & 1/1/2" AR-HMA Wearing Course

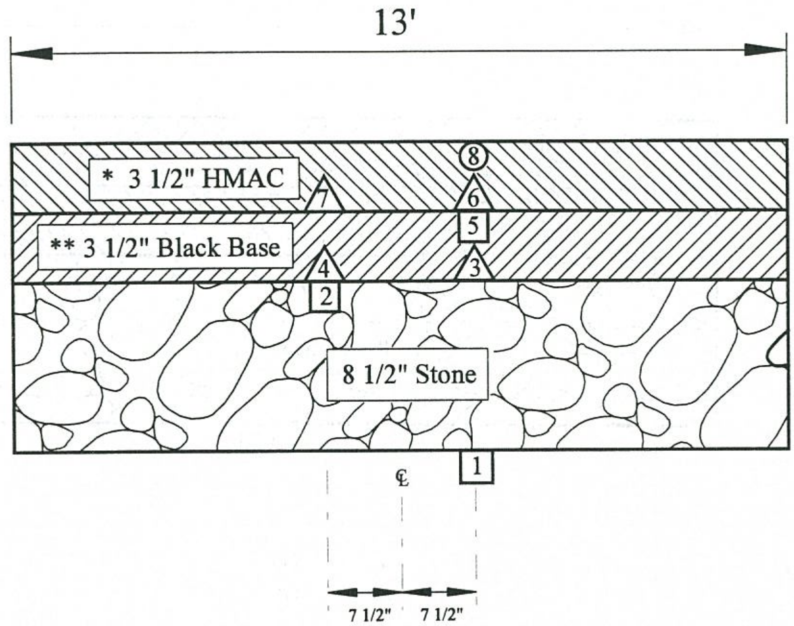
Lane 2-1 Legend

1 - Embankment Pressure Cell - Rt
2 - Subbase Pressure Cell - Lt
3 - Subbase Strain Gage - Rt
4 - Subbase Strain Gage - Lt
5 - Base Pressure Cell - Lt
6 - Base Strain Gage - Rt
7 - Base Strain Gage - Lt
8 - Surface LVDT - Rt

Figure 4.

Instrumentation cross section, lane 2-1.

Test Lane 2-2



Cross Section Looking West

* 2" Binder Course & 1/1/2" Conv. HMAC Wearing Course

** 3 1/2" AR-HMA Black Base

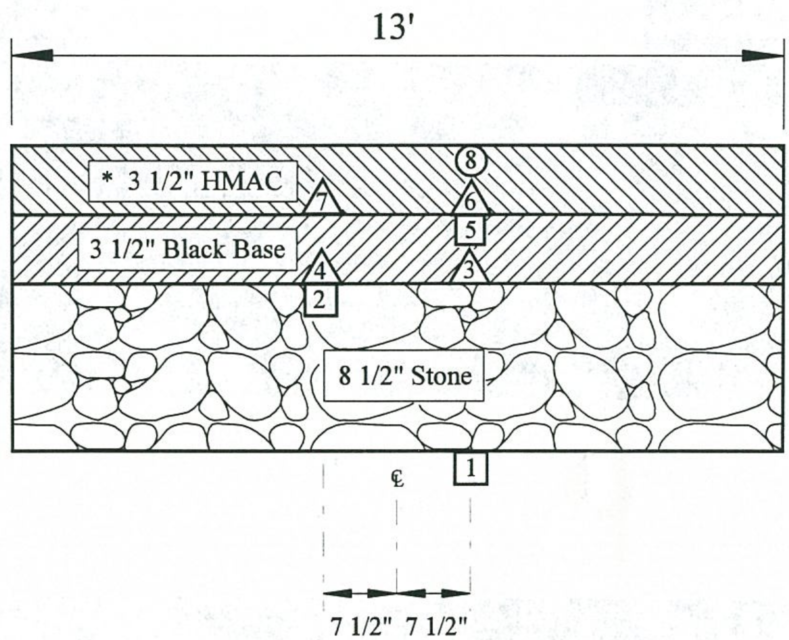
Lane 2-2 Legend

1 - Embankment Pressure Cell - Rt
2 - Subbase Pressure Cell - Lt
3 - Subbase Strain Gage - Rt
4 - Subbase Strain Gage - Lt
5 - Base Pressure Cell - Lt
6 - Base Strain Gage - Rt
7 - Base Strain Gage - Lt
8 - Surface LVDT - Rt

Figure 5.

Instrumentation cross section, lane 2-2.

Test Lane 2-3



Cross Section Looking West

* 2" Binder Course & 1/1/2" Conv. HMAC Wearing Course

Lane 2-3 Legend

1 - Embankment Pressure Cell - Rt
2 - Subbase Pressure Cell - Lt
3 - Subbase Strain Gage - Rt
4 - Subbase Strain Gage - Lt
5 - Base Pressure Cell - Lt
6 - Base Strain Gage - Rt
7 - Base Strain Gage - Lt
8 - Surface LVDT - Rt

Figure 6.
Instrumentation cross section, lane 2-3.

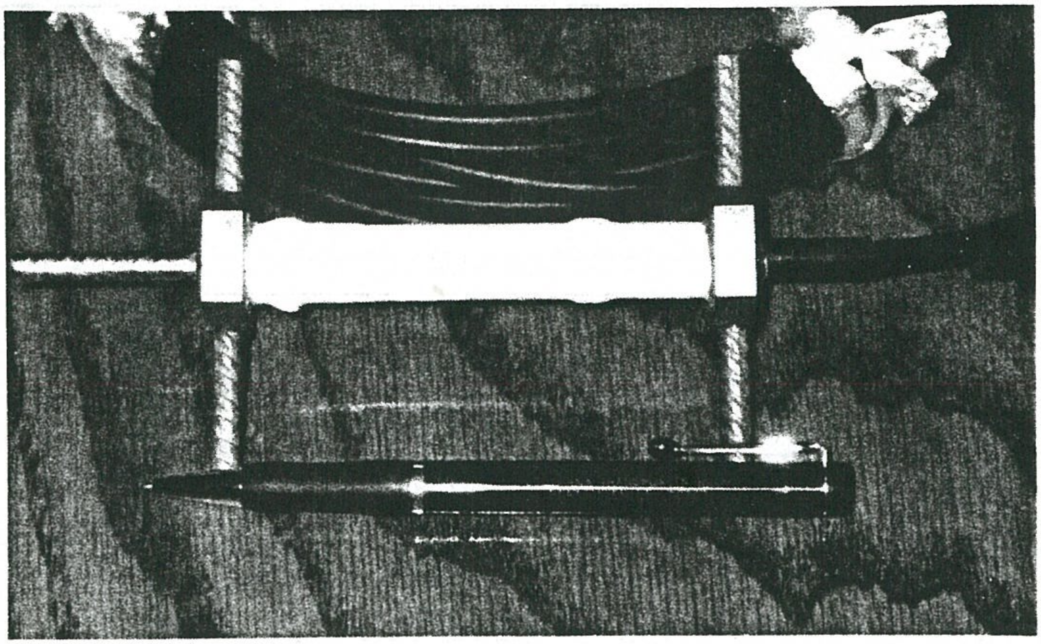


Figure 7.
TML H-Bar (KM-100-HAS) gage.

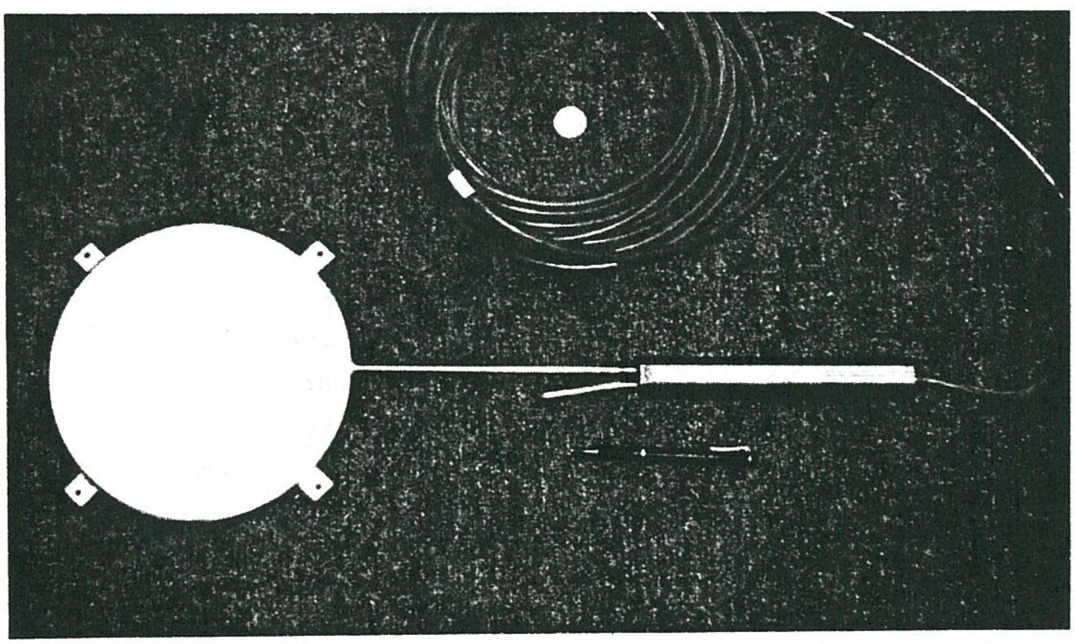


Figure 8.
Geokon pressure cell.

It is constructed of stainless steel with all electronic components hermetically sealed for added protection against hostile conditions. Internal construction prevents the core and shaft from rotating as they move longitudinally. The GCA-121-1000 is an AC excited LVDT with a range of ±1.000" and a sensitivity (mV/V/0.001") of .084. Its overall length is 13.01" and weighs 7.5 oz. Figure 9 is a photograph of the device.

Data acquisition system. The instrumentation and software chosen for this experiment is being provided by Optim Electronics. The data acquisition system being used is the Megadac 3415A which is capable of measuring 25,000 samples per second. It has up to 512 channels and 64 megabytes of internal non-volatile onboard memory. The signal conditioning provides for quarter, half and full bridge operation, programmable gain up to 4000, eight pole Butterworth filtering, auto balance, auto zero and voltage calibration. All of this functionality is computer controlled.

The software which controls the Megadac is Optim's TCS95. TCS is used like a workbook, where all information about the test's definition is stored in a unique TCS test file. Within the test's definition are worksheets, describing the requirements such as recording rates, sensor definitions and channel assignments to perform your data acquisition application.

Weather data acquisition. A Campbell Scientific Weather Station was installed at the northeast corner of the test bed to acquire weather data. The weather station is equipped with a CR10 data logger measurement and control module and utilizes PC208 operating software to collect the data. The weather station updates itself every 10 seconds, records the data every hour, and has the following capabilities to record: (1) temperature measurements from CS model HMP35C probes, (2) relative humidity measurements (maximum and minimums) from CS model HMP35C probes, (3) wind direction and speeds using Young's model 5103-5/5305-5, (4) solar watts per meter squared, (5) barometric pressure measurements (maximum, minimum, and average) using a model PTA427 probe, and (6) rain fall every hour and it's intensity using a CS model TE525 tipping bucket rain gauge.

The system is currently using eight temperature thermocouples to measure temperature at various levels in the pavement, however, it has the capability of using 30 temperature thermocouples.

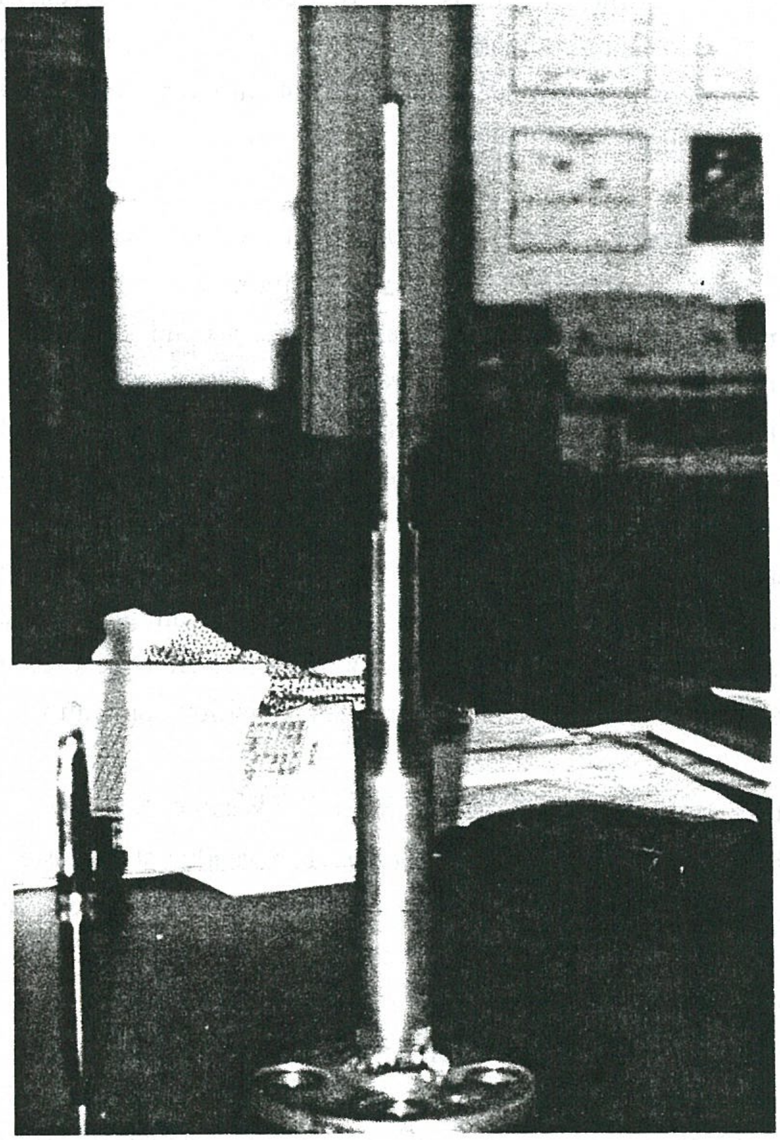


Figure 9.
Linear variable differential transformer (LVDT).

LIST OF ACRONYMS

ALF - Accelerated Loading Facility
DOT - Department of Transportation
Gb - Specific Gravity of Asphalt
Gmm - Maximum Specific Gravity, asphalt mixture
Gmb - Bulk Specific Gravity, asphalt mixture
Gsb agg - Bulk Specific Gravity, aggregates
Gse - Effective specific gravity, aggregate
GSI - Gyratory Shear Index
GTM - Gyratory Testing Machine
HMAC - Hot Mix Asphaltic Concrete
LDOTD - Louisiana Department of Transportation and Development
LTRC - Louisiana Transportation Research Facility
LVDT - Linear Variab' Differential Transformers
MTV - Materials Trans : Vehicle
Pabsorb - Asphlat absorpbed
Pbe - Effective asphalt content
PRF - Pavement Research Facility
STD - Standard Deviation
VFA - Voids filled with Asphalt
VMA - Voids in Mineral Aggregate

Appendix "A"

Construction Specifications

STATE PROJECT NO. 600-21-0009
SPECIAL PROVISIONS

GENERAL STATEMENT: The contractor must be aware of existing experimentation being performed at the Pavement Research Facility. The contractor will have restricted use of the facility as directed by the engineer. The Engineer may, at his discretion, waive any density requirements if, in his opinion, the contractor has exhausted all means possible to achieve that density.

CLASS II BASE COURSE: The base course shall be a Class II stone in accordance with Section 302 of the Standard Specifications. The base elevations shall be within ½" of the plan grade. A geotextile fabric, class "C" shall be placed prior to the base course as shown in the plans and according to the Standard Specifications.

ITEM S-001, ASPHALTIC CONCRETE - WEARING COURSE (TYPE 8F) (WET-ROUSE): ITEM S-002, ASPHALTIC CONCRETE - BASE COURSE (TYPE 5A) (WET-ROUSE):

DESCRIPTION: These items shall consist of the production, placement and compaction of a Type 8F Wearing Course and a Type 5A Base Course using a powdered ground tire rubber which has been reacted with the asphalt cement, meeting the requirements of Sections 501 and 503 of the 1992 Standard Specifications for Roads and Bridges or as modified herein.

MATERIALS:

Asphalt Cement: The asphalt cement shall be an AC-30 meeting the requirements of Section 1002.

Powdered Rubber Material: The crumb rubber material shall be a ground tire rubber produced by an ambient grinding method as supplied by Rouse Rubber Industries, Inc., P.O. Box 820369, Vicksburg, Ms 39182-0369. Contact: Mr. Michael Rouse, Phone: (601) 636-7141, FAX: (601) 636-1181. The product trade name is Ultrafine™ GF-80A.

The rubber shall be sufficiently dry so as to flow freely and to prevent foaming when blended with the asphalt cement. It shall be substantially free of contaminants including fabric, metal, mineral or other non-rubber materials. Up to four percent talc by weight of rubber may be added to prevent sticking or caking of the particles.

The crumb rubber material shall be supplied in moisture resistant packaging such as either disposable bags or other appropriate bulk containers. Each container or bag shall be labeled with the manufacturer's designation for the rubber and the specific type, maximum nominal size weight and batch or lot description. The crumb rubber material shall have a moisture content not to exceed 0.75 percent by weight. The specific gravity of the crumb rubber shall be 1.15 + or - 0.05 when tested in accordance with ASTM D-297, pycnometer method.

The gradation of the crumb rubber material based on a 100g sample size (up to 25 percent talc may be used) shall be:

US SIEVE SIZE	PERCENT PASSING
40	100
60	98-100
80	88-100
100	75-90

Production of Powdered Rubber Modified Asphalt Cement: The asphalt cement and the powdered rubber material shall be thoroughly mixed and reacted prior to mixing with aggregate materials. The powdered rubber material to be added shall be 10 percent by weight of the asphalt cement. A minimum reaction time of 30 minutes at a temperature of 310 - 350°F shall be required unless otherwise directed by the engineer. A minimum viscosity of 6 poises at 325°F shall be required.

The blending unit may be a batch type or continuous type and shall provide for sampling of the blended and reacted powdered rubber modified asphalt cement during normal plant production. Blending of the asphalt cement may be accomplished at a terminal facility or at the project site.

When blending at the project site, the powdered rubber content shall be monitored by the department on a daily basis using the weight of powdered rubber sued and the weight of asphalt cement or weight of crumb rubber modified asphalt cement.

When the powdered rubber modified asphalt cement is produced at a terminal facility, the supplier shall certify each load delivered to the project site with respect to: asphalt type and source, crumb rubber type and gradation, quantity of powdered rubber material, quantity of asphalt cement, reaction time and temperature and viscosity as specified above.

As a minimum, the powdered rubber modified asphalt cement shall be tested for viscosity by the department as follows:

(1) one per batch for batch blending at the project site
(2) twice per day for continuous blending at the project site
(3) each load when blended at a terminal facility
(4) beginning of each day when stored at a storage tank at the project site

The powdered rubber modified asphalt cement shall be rejected for use if it does not meet the minimum viscosity requirement.

JOB MIX FORMULA: The contractor shall provide a job mix formula at least 30 days prior to construction.

The mixture shall be the same as used for the Type 8F Wearing Course or the Type 5A Base Course. The powdered rubber modified asphalt cement shall be substituted for the conventional PAC-40 HG or AC-30 at the optimum asphalt content.

PLANT AND ROADWAY OPERATIONS: Other than production of the crumb rubber modified asphalt cement, no other plant modification are anticipated.

All normal plant quality control testing shall be conducted.

Pneumatic tire rollers shall not be used for compaction of the crumb rubber modified asphalt concrete.

The temperature of the mix going through the paver shall not be less than 280° F.

ACCEPTANCE TESTING: Stability requirements shall be waived for the crumb rubber modified asphalt concrete. However, Marshall stability tests shall be conducted at the normal frequency and shall be reported for informational purposes and for quality control of the mixture.

METHOD OF PAYMENT: The ASPHALTIC CONCRETE - WEARING COURSE (TYPE 8F) (WET-ROUSE) and the ASPHALTIC CONCRETE - BASE COURSE (TYPE 5A) (WET-ROUSE) shall be measured and paid for by the ton in-place. Such payment shall be for all materials, incidentals, production, hauling, Lay down and compaction.

Asphaltic Concrete - Wearing Course (Type 8F) (Wet-Rouse) and Asphaltic Concrete - Base Course (Type 5A) (Wet-Rouse) shall be measured by the ton and paid for at the contract unit price under:

Item S-001, Asphaltic Concrete - Wearing Course (Type 8F) (Wet-Rouse), per ton.

Item S-002, Asphaltic Concrete - Base Course (Type 5A) (Wet-Rouse), per ton.

ITEM S-003, REMOVAL OF EXISTING TEST LANES: This item consists of removing all of the material for the depth shown in the plans for the three test lanes including the stone surfacing adjacent to each end of those lanes. The contractor shall saw cut a 3" deep x ⅛" wide groove the full length of the test bed as shown in the plans before removal of any material. The contractor shall then roto-mill each test lane the full depth to the existing embankment grade as shown in the plans. The material removed from each test lane shall be disposed of at a location on the Pavement Research Facility site as directed by the engineer. This will also include, but not limited to, removing the formed block-outs and the stone material inside. The contractor will be allowed to place any removed stone surfacing material from the ends of the test lane, near to the construction area, to be reused after constructing the new test lanes.

After complete removal of all material, the contractor will be required to re-establish any deficiencies in the existing embankment to within ½" of plan grade at no direct pay. The contractor shall use the stockpiled A-4 soil material which is located at the Pavement Research Facility site as shown on the site plan to correct any of these deficiencies. The material shall be placed and compacted in accordance with section 203 of the standard specifications.

The removal of the existing three test lanes shall be measured per lump sum and paid for at the contract unit price under:

Item S-003, Removal of Existing Test Lanes, lump sum.

STATE PROJECT NO. 600-21-0009
SPECIAL PROVISIONS

ITEM S-004, 1' X 50' FORMED BLOCK-OUT: This item consists of constructing forms in accordance with the plans and these special provisions for the purpose of providing an access area for the instrumentation wiring which will be installed by the PRF personnel. The forms may be wooden or metal, 12 inches in height. Support stakes shall be placed a maximum spacing of 2 feet on center and driven into to the ground to provide adequate support. A 2" x 6" lateral brace shall be placed a maximum spacing of 4 feet on center, flush with the top of the forms. The forms shall be placed such that the smooth edge is adjacent to the test lanes (ie., the stakes and braces must not be in contact with the test lanes). The forms will remain in place and prior to the HMAC overlay, the blocked-out area shall be filled and compacted with stone in accordance with section 301 of the Standard Specifications. The stone shall be obtained from the stockpile specified under item S-005, Stone Stockpile and Surfacing.

The 1' x 50' formed block-out shall be measured per each unit and paid for at the contract unit price under:

Item S-004, 1' x 50' Formed Block-Out, Each.

ITEM S-005, STONE STOCKPILE AND SURFACING: This item consists of providing 100 tons of a stone stockpile, in accordance with section 1003, to be placed at the Pavement Research Facility site at the direction of the engineer. The stone shall be a Surface Course aggregate in accordance with section 1003.04. The stockpile will be used for stone surfacing in accordance with section 401 of the Standard Specifications, dressing, or for backfilling inside the formed blockout. This item also consists of constructing a crushed stone surfacing at each end of the newly constructed test lane areas as shown on the plans. The work will consist of constructing a transition wedge of stone, tapering from the top edge of the new test lanes to the existing embankment. The surfacing shall match the existing surfacing along the width of the three new test lanes on each end. Contractor shall dress the area around the construction area as required by the engineer at no direct pay. The stone surfacing shall be obtained from the stockpile and placed and compacted according to section 401.07 of the Standard Specifications.

Stone stockpile and surfacing shall be measured per lump sum and paid for at the contract unit price under:

Item S-005, Stone Stockpile and Surfacing, Lump Sum.

ITEM S-006, CONSTRUCTION LAYOUT: Subsection 105.08 of the Standard Specifications is deleted and the following substituted: The work required shall include all the necessary staking to adequately control the layout and subsequent checking of the various elements of the project. Locations of individual items shall be as shown on the plans or otherwise ordered by the engineer. This work includes but is not limited to:

1. The contractor verifying grades shown on the plans before construction.
2. Establishing the cross section baseline and reference points.
3. Staking edge lines and references for each test lane along with establishing

elevation check points along each side of test lanes as shown in the plans for the purpose of constructing each base layer.

4. Providing reference points and establishing center lines and edge lines for each test lane on final surface for stripping.

All elevation data shall be submitted to the Pavement Research Facility engineer. The contractor shall employ sufficient qualified engineering personnel experienced in layout and construction of highways, bridges and other construction to correctly establish and keep complete and comprehensive notebook records of all lanes and grades necessary from initial layout to final acceptance. The contractor will be liable for the accuracy of the initial layout and all subsequent alignments and elevations. At his own expense, the contractor shall rebuild, repair, or make good any portion of the work found to be incorrectly positioned either horizontally or vertically at any time before final acceptance. The contractor shall notify the engineer immediately of any apparent errors in the plans.

Construction layout will be paid in accordance with the following schedule:

Percent of Total Contract Amount Completed	**Allowable Percent of Lump Sum Price for Construction Layout**
Staffed	25%
25%	50%
75%	95%
100%	100%

Construction layout shall be measured per lump sum and paid for at the contract unit price under:

Item S-006, Construction Layout, Lump Sum.

ITEM S-007, GEOTEXTILE FABRIC (CLASS D)(12/94): This item consists of furnishing and installing geotextile fabric under the base course in accordance with the plans and as directed.

Geotextile Fabric shall conform to Section 1019, Class D.

Geotextile Fabric shall be placed as a separator between the base course and the embankment. The geotextile fabric shall be placed parallel to the centerline of the roadway. All adjacent rolls of geotextile will be overlapped a minimum of 12 inches, including the ends of the rolls. The top layer of the geotextile fabric will be overlapped in the direction of construction (previous roll on top) to prevent separation from aggregate placement.

The geotextile fabric should be placed as smooth as possible with no wrinkles or folds, except in curved road sections. The fold or overlap of cut pieces shall be in the direction of construction, and pinned, stapled or weighted with cover material.

Damaged geotextile fabric shall be either removed and replaced with new geotextile fabric or covered with a second layer of geotextile fabric extending 3 feet in each direction from the damaged area.

Prior to placement, rolls of geotextile fabric shall be furnished with suitable wrapping for protection against moisture and extended ultra-violet exposure. Each roll shall be labeled or tagged to provide product identification sufficient for field inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. Exposure of the geotextile fabric to the elements between Lay down and cover shall be a maximum of 7 days to minimize damage potential.

Geotextile fabric will be measured by the square yard of covered area in place.

Payment will be made at the contract unit price under:

Item S-007, Geotextile Fabric (Class D), per square yard.

ITEM S-008, DOWN TIME FOR BASE COURSE CONSTRUCTION: This item is intended to offset any unnecessary down time the contractor may experience due to changes or modifications required by the LDOTD during base course construction. This item will cover that down-time the contractor experiences to which he is unable to continue his normal daily operations. The item shall cover expenses associated with the shut-down which include labor, loss of machinery usage, and overhead. This item will **not** cover the following items:

1. Breakdown of the Contractors machinery.
2. Mobilization of any equipment necessary to the construction of the Base Course.
3. Shut down due to weather, which causes the contractor to cease construction.

The engineer will be required to keep all documentation indicating the reason(s) for the shut down and will keep adequate record of the hourly amount of down time. Documentation of the contractors normal daily hourly schedule of operations will be required prior to beginning construction. The decision to allow the contractor down time will be the sole responsibility of the engineer.

Down Time for Base Course Construction shall be measured per hour and paid for at the contract unit price under:

Item S-008, Down Time for Base Course Construction, per Hour.

ITEM S-009, DOWN TIME FOR ASPHALTIC CONCRETE CONSTRUCTION: This item is intended to offset any unnecessary down time the contractor may experience due to changes or modifications required by the LDOTD during construction of the Asphaltic Concrete sections. This item will cover that down-time, as specified herein, the contractor experiences to which he is unable to continue his normal daily operations. The item shall cover expenses associated with the shut-down which include labor, loss of machinery usage, and overhead. This item will **not** cover the following items:

1. Breakdown of the Contractors machinery.
2. Mobilization of any equipment necessary to the construction of the Base Course.
3. Shut down due to weather, which causes the contractor to cease construction.

The engineer will be required to keep all documentation indicating the reason(s) for the shut down and will keep adequate record of the hourly amount of down time. Documentation of the contractors normal daily hourly schedule of operations will be required prior to beginning construction. The decision to allow the contractor down time will be the sole responsibility of the engineer.

Down Time for Base Course Construction shall be measured per hour and paid for at the contract unit price under:

Item S-009, Down Time for Asphaltic Concrete Construction, per Hour.

CONTRACT TIME: The entire contract shall be completed in all details and ready for final acceptance within 45 working days. An additional 5 days is included and shall be set aside for LTRC personnel to complete their instrumentation of the test lanes. These additional days may be used by LTRC personnel at any time at their discretion, however it may not limit the contractor from working on other phases of this contract.

Prior to start of the working day period, the Contractor will be allowed 30 calendar days from the date stipulated in the Notice To Proceed to assemble materials, plants and equipment necessary for the construction of this project.

If the Contractor begins regular construction operations prior to expiration of the 30-day assembly period, the assessment of working days will commence at the time construction operations are begun.

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