LTRC 211

LATEX MODIFIED ASPHALT AND EXPERIMENTAL JOINT TREATMENTS ON ASPHALTIC CONCRETE OVERLAYS

EXPERIMENTAL PROJECT NO. 3

ASPHALT ADDITIVES

By

STEVEN L. CUMBAA, P.E.

SPECIAL STUDIES RESEARCH ADMINISTRATOR

And

HAROLD R. PAUL, P.E.

ASPHALT TECHNOLOGY RESEARCH ADMINISTRATOR

Research Report No. 211

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

The content of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the state or the Federal Highway Administration. This report does not constitute a standard, specification or regulation. The Louisiana Department of Transportation and Development and the Louisiana Transportation Research Center do not endorse products, equipment or manufacturers.

JUNE 1988

This report documents the construction and initial evaluation of several experimental features incorporated as part of an overlay of an existing PCC pavement in order to determine the feasibility of extending overlay service life. The experimental features utilized were several types of waterproofing membranes, sawing and sealing of joints in the asphaltic concrete overlay and the use of a latex-modified asphaltic concrete.

There were several problems noted during the construction of the overlay. When the roller passed over the transverse joints the hot mix mat appeared to shove,such that a noticeable, transversely oriented six-to-eight-inch-wide hump occurred along the joint. Generally, this condition was found in the membrane sections and only occasionally in the other sections. Reflective cracking immediately occurred at many of the transverse joints during the rolling operation, irrespective of section design.

Performance evaluations will be conducted over the next three years. Preliminary findings based on initial reflective crack measurements include: sawing and sealing over the existing joints appears to be the most effective treatment to control reflective cracking; latex-modified asphaltic concrete better controls reflective cracking than conventional hot mix; the Bituthene membrane is more effective than the other membranes used; and, there is little difference in performance of the conventional or latex-modified hot mix when the overlay is sawed and sealed over the existing joints.

ABSTRACT

This report documents the construction and initial evaluation of several experimental features which were incorporated as part of an overlay of an existing PCC pavement in order to determine the feasibility of extending overlay service life. The experimental features utilized were several types of waterproofing membranes, sawing and sealing of joints in the asphaltic concrete overlay and the use of a latex-modified asphaltic concrete.

There were several problems noted during the construction of the overlay. When the roller passed over the transverse joints the hot mix mat appeared to shove,such that a noticeable, transversely oriented six-to-eight-inch-wide hump occurred along the joint. Generally, this condition was found in the membrane sections and only occasionally in the other sections. Reflective cracking immediately occurred at many of the transverse joints during the rolling operation, irrespective of section design.

Performance evaluations will be conducted over the next three years and will include joint crack mapping, rutting, ravelling, cracking other than joint cracking, stripping, friction numbers, density and ride quality. Preliminary findings based on initial reflective crack measurements include: sawing and sealing over the existing joints appears to be the most effective treatment to control reflective cracking; latex-modified asphaltic concrete better controls reflective cracking than conventional hot mix; the Bituthene membrane is more effective than the other membranes used; and, there is little difference in performance of the conventional or latex-modified hot mix when the overlay is sawed and sealed over the existing joints.

TABLE OF CONTENTS

PAGE NO.

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The primary purpose of this experimental project was to evaluate the construction feasibility, performance and costs associated with the use of a particular asphalt modifier and two procedures for reducing reflective cracking. The experimental features utilized included the following:

1. Latex-modified asphalt,
2. Three types of waterproofing membranes, and
3. Sawing and sealing the overlay above the transverse contraction joint locations.

Reflective cracking of a new overlay due to the movements of the PCC slab below has historically been a detriment to the long-term serviceability of an overlay. The experimental features of utilizing a waterproofing membrane over the existing transverse joints prior to overlay and the sawing and sealing of transverse joints in the overlay are hoped to limit the severity and extent of this type of cracking. An added benefit of utilizing the membranes is that the amount of moisture penetrating the pavement structure through the joints should be reduced.

In addition to the experimental joint features examined on this project, DOTD officials decided to evaluate a modified asphalt cement in an effort to enhance asphalt properties and provide extended service life. The modifier chosen was a styrene - butadiene (SBR) latex. It is purported that the SBR latex will increase mix stiffness at high temperatures, thereby increasing stability while reducing mix stiffness at low temperatures in order to reduce cracking and provide greater flexibility.

The experimental portion of this project was conducted under the auspices of the Demonstration Projects Program of the Federal Highway Administration.

SCOPE

The scope of this study was limited to several test and control sections incorporated within a single overlay project. A complete factorial experiment was not attempted due to the uniqueness of the individual processes or treatments and their expected benefits. The project length was divided into eight areas, of approximately equal length, in which the experimental and control features were constructed. The experimental features included: waterproofing membranes, Bituthene, Petrotac and Tape Coat, sawing and sealing of joints in the overlay, and the use of a latex-modified asphalt concrete.

METHODOLOGY

PROJECT DESCRIPTION

The project into which the experimental features were incorporated is a four-lane urban section, 0.8 miles in length. The project is a section of route LA-US Business 61 and 190 in Baton Rouge. Baton Rouge, located in the south-central portion of Louisiana, can be considered near sea level and has a warm-to-moderate climate,with approximately sixty inches of rainfall yearly and generally has poor drainage characteristics. The PCC pavement was constructed in 1940 over an existing gravel road. The four-lane pavement structure with integral curb and gutter was originally divided by a raised grass median. The section consisted of slabs nine inches thick at the pavement edges, tapering to a six-inch thickness across the interior portion of the two lanes. Load transfer was provided by 3/4-inch smooth dowel bars, and slab lengths were typically 20 feet long. In 1965, turn lanes were added at a major intersection, located at one end of the project. Over the years the project has received generally light maintenance, consisting mostly of full-depth concrete patches. Skid resistance of the original roadway surface was low due to loss of surficial mortar surrounding the chert river gravel aggregate during 47 years of exposure to the traffic and environment. The current average daily traffic (ADT) on this four lane roadway is approximately 81,000.

The two-fold purpose of this construction project was to provide the roadway with a surface of acceptable frictional characteristics and to increase its capacity. Capacity was increased by removing the raised median and constructing in its place a continuous left-turn lane. Additionally, turn lanes were added at the major intersection previously mentioned. To improve the skid resistance, the section was overlaid with an 1.5 inches of LADOTD Type 3 (high stability) asphaltic concrete.

Table 1 provides a summary of sample measurements of joint faulting and width obtained prior to overlay. Fifteen consecutive transverse joints were randomly selected within each of the eight sections to serve as sample locations and facilitate the evaluation of the effectiveness of the various experimental features.

TABLE 1

JOINT FAULTING AND WIDTH DATA

	AVERAGE(in.)	RANGE(in.)	SAMPLE SIZE
FAULTING			
EASTBOUND	0.04	0.19	60
WESTBOUND	0.09	0.45	60
PROJECT	0.06	0.65	120
WIDTH			
EASTBOUND	0.89	1.59	60
WESTBOUND	0.97	1.57	60
PROJECT	0.93	2.40	120

CONSTRUCTION SEQUENCE

Construction of this project began in the Fall of 1987. Key Contractors, Inc. was the prime contractor, with Barber Brothers Construction Company subcontracting the overlay work. The construction items and general sequence of construction consisted of the following:

1. Full-depth patching of distressed slabs.
2. Removal of raised median.
3. Construction of turn lanes at the intersection.
4 Construction of continuous left-turn lane.
5. Cleaning of transverse joints.
6. Sealing of transverse joints with rubberized asphalt meeting ASTM D 3405.
7. Placing membrane over transverse joints on experimental sections of westbound lanes.
8. Overlaying with Type 3 HMAC.
9. Overlaying experimental section of eastbound lanes with Type 3 HMAC containing latex additive.
10. Sawing experimental section of overlay at transverse joint locations
11. Sealing of sawed joints in overlay with rubberized asphalt meeting ASTM D 3405.
12. Striping.

All construction activities were performed under full traffic, utilizing single-lane closures, and construction was completed in approximately six months. Figure 1, presented in Appendix A, is a diagram of the location of the experimental and control sections utilized on this project. A copy of pertinent project special provisions and plan details are included as Appendix B. Selected photographs of the various construction activities are presented as Figures 3 through 8 in Appendix C.

EXPERIMENTAL FEATURE CONSTRUCTION

WATERPROOFING MEMBRANE

Three types of waterproofing membranes were utilized and incorporated into three separate test sections (Nos. 1-3), as indicated in Figure 1. The control section for this evaluation is test section No.4. The installation of the membranes followed all patching and cleaning and resealing of the transverse joints.

The process of installation generally followed project specifications and was relatively problem-free. During overlay, problems associated with the transverse joints developed in the membrane test sections. When the roller passed over the transverse joints, the hot-mix mat appeared to shove and then a noticeable, transversely oriented six-to-eight-inch-wide hump occurred along the joint. The humping generally occurred in the membrane test sections and only occasionally occurred in other sections.

Another irregularity that occurred was that many of the joints were overfilled during sealing. The overfilled joints were not identified as a potential problem until the humping was noticed. At that time most of the membrane was placed and the overlay had commenced. The overfilled joints could not be corrected in most of the membrane test sections because much of the membrane had been placed and could not be removed prior to overlay. The excess joint sealant was removed along those joint locations where the membrane had not been placed in the westbound lanes and throughout the entire project in the eastbound direction. Removal was generally accomplished by heating the rubberized asphalt material with a torch and manually blade scraping off the excess, which extended above and outside the joint walls. This method of removal generally left a thin smear of sealant on the concrete surface near the transverse joints. Due to the fact that the humps occurred in the membrane sections and not in the
uncorrected control section (No. 4), it is believed that the excess joint sealant contributed little if any to the humping.

Other observed problems associated with the membranes were that traffic, power brooms and the paving machine caused excess damage to the membrane and occasional disbondment of the membrane from the PCC surface. Much of the damaged or disbonded membranes were not repaired due to the limited amount of these materials on hand and an unwillingness to stop construction of the overlay along this major urban thoroughfare.

In many instances, reflective cracking at the transverse joints occurred immediately during the rolling operation. This reflective cracking occurred throughout the project and is not restricted to particular test or control sections. The immediate occurrence of reflective cracking is attributed to excess joint deflection under the roller during compaction. Load transfer across the transverse joints has been rendered somewhat ineffectual over the years through the actions of pavement growth, concrete deterioration and dowel corrosion.

SAWING AND SEALING

Sawing and sealing the transverse joints in the new overlay took place in three of the four test sections of the eastbound lanes. The sawing and sealing test sections included portions of the project which contained both the conventional and modified mixes. For this experiment, test section No.4 serves as the control section for sawing and sealing of the standard mix and test area. No.5 serves as the control section for sawing and sealing in the latex-modified mix.

The previously indicated problem of overfilling the PCC joints was corrected in the entire eastbound direction. Prior to overlay, the locations of the transverse joints were marked in the median and along the curb. This process was complicated by the nonlinearity of the joints between lanes. Pavement growth, over the years had caused the lanes to shift longitudinally in relation to each other and the joints generally did not "line up" with each other. Location marks of various colors were used to facilitate relocation after overlay. Joint locations on the overlay were marked for sawing by utilizing a caulk line. Sawing, cleaning and sealing was accomplished according to plan details and specifications.

In many instances, reflective joint cracking occurred during rolling operations or soon thereafter, giving additional visual identification as to where to construct the joint. After sawing and sealing some cracking outside the constructed joint was noted.

LATEX-MODIFIED ASPHALT

Materials and Mix Design

The source of coarse aggregate, coarse sand and fine sand was a silicious river gravel from Acme Sand and Gravel. In addition to these materials, the contractor attempted to use reclaimed asphaltic concrete materials during the first day's production. However, problems in verifying job mix formula (JMF) criteria forced the contractor to abandon the use of this material in subsequent lots. Exxon supplied both the AC-30 used in the conventional wearing course and the AC-10 used in the latex-modified wearing course. Perma-Tac Plus antistrip agent supplied by Asphalt Products Co. was utilized at a rate of 0.5% by weight of the asphalt cement, according to specifications. The contractor used Ultrapave - 70 from the approved list of latex suppliers presented in the special provisions.

Job mix formulas for both the conventional and modified wearing course mix are provided in Table 2.

TABLE 2

RECOMMENDED JOB MIX FORMULA

U.S. SIEVE SIZE	PERCENT PASSING	JMF LIMITS
1 inch	100	100
3/4 inch	100	97-100
1/2 inch	91	85-100
No. 4	55	48-62
No. 10	41	35-47

No. 40	28	23-33
No. 80	16	12-20
No. 200	8	6-10
% A.C.	5.0	4.6-5.4
% Crushed	90	80 min.
Mix Temp, ^{0}F	355	330-380

Mix Time: Dry : 10 sec.

Wet : 50 sec.

MARSHALL TEST PROPERTIES

Specific Gravity	2.34	
Theoretical Gravity		2.44
Stability (lbs)	2040	
Flow (0.01 in)	12	
Air Voids (%)	4.1	
VFA (%)		74

Plant Production and Construction

All mix was produced at Barber Brothers plant No. 3, a 4-ton batch plant, located approximately 9 miles from the project site. As per the special provisions, the latex supplier was present to provide on-the-job technical assistance preceding and during the production of the modified hot mix. The manufacturer supplied equipment to meter the latex material directly into the pugmill. This equipment was capable of calibration in order to verify that output rate matched plant production. An indicator was located in the plant operator's control room to allow constant monitoring of the system. The latex was supplied in 55-gallon drums.

In the production sequence, the AC-10 asphalt cement was added to the heated-mixed aggregate, with the mixing continuing for at least 10 seconds, until the aggregate was completely coated with asphalt. Latex was then added and the mixing continued for at least 50 seconds in order to produce a homogeneous mixture. The latex hot mix was specified to be produced between 330-380°F.

Plant production of the asphaltic concrete began on November 11, 1987, and continued through November 24, 1987, under generally clear skies with daytime temperatures in the seventies and nighttime temperatures near forty degrees Fahrenheit. There were no modifications to normal plant production or roadway procedures other than those mentioned above.

Table 3 presents the plant production by lot, with all of the latex-modified mix being produced in lot 395. The tonnage of latex-modified mix produced corresponded to the amount that could be produced in order to completely utilize one tank truck of AC-10 asphalt cement. Lots 391, 392 and 394, utilizing the conventional mix, were placed in the westbound lanes and turnouts. All of the latex-modified hot mix was placed as lot 395 between stations 52+88 and 72+75 in the eastbound lanes. Conventional mix (lot 396) completed the overlay in the eastbound lanes.

TABLE 3

PLANT PRODUCTION

Lot No.	Date	Tonnage	Temperature,	Weather
		F	(High,Low)	

391	11/11/87	424.93	339	68, 37 Clear
392	ll/12-18/87	1008.54	338	78, 38 Clear
394	11/18-20/87	1005.54	331	74, 42 Clear
395	11/19/87	467.31	338	78, 45 Cloudy
396	11/23-24/87	328.45	315	75, 40 Clear

There were no noticeable problems associated with either the production or the laydown of the latex-modified mix. However, transverse cracking developed over some of the joints in the existing pavement immediately after rolling, similar to the cracking experienced with the rolling of the conventional mix. There were, however, no humps evidenced at the joints as occurred with the conventional mix in the membrane sections. Several days after construction, it appeared that some of the cracks had self-healed, as only those cracks over the widest joints were still visible.

Quality Control

Marshall stability (75-blow design) was used for acceptance testing, and other Marshall properties were used for mix control. In addition, aggregate gradations and binder content were used for control purposes. Plant Marshall data are provided in
Table 4, and extracted gradation and binder content are presented in Table 5.

The contractor started production of the conventional mix using JMF 31 in lot 391, which incorporated reclaimed asphaltic concrete materials. However, as allowed by specification, after the first two stabilities attained were below the limits for 100% payment, the contractor ceased production at 424.9 tons and submitted a new mix design. JMF 30, which did not incorporate reclaimed materials, was used for the remainder of the conventional mix. Since the tonnage of latex-modified mix was so low, there was not enough time to generate a completely new mix design. Therefore, the contractor was allowed to submit JMF 38, which incorporated the latex material and used the same optimum binder content design curves as JMF 30, such that total binder content and aggregate feeds were not changed. A similar methodology has been used successfully in prior experimental projects with latex additives.

Table 4 shows that the stabilities for the latex-modified mix were below the design minimum of 1700 lbs, and that the flow values were high. Also, the void levels were at the same level or less than those of the conventional mix. By the time these tests were completed, most of the experimental mix had been produced such that there was not time to attempt to adjust the mix design.

TABLE 4

PLANT MARSHALL PROPERTIES

Lot No.	JMF No.	Specimen No.	Stability (lbs)	Flow (0.01 in)	Specific Gravity	VFA (%)	Voids (%)
391	31	1	1526	10	2.34	76	3.7
		2	1578	11	2.34	76	3.7
392	30	1	1946	11	2.34	74	4.1
		2	1722	10	2.34	74	4.1
		3	1612	10	2.34	74	4.1
		4	1906	9	2.34	74	4.1
394	30	1	1770	9	2.34	74	4.1
		2	1722	10	2.35	75	3.7
		3	1640	11	2.35	75	3.7
		4	1906	10	2.35	75	3.7
395	38	1	1558	21	2.34	75	3.7
		2	1296	13	2.35	78	3.3
396	30	1	1794	13	2.33	72	4.5
		2	1738	11	2.34	74	4.1

However, it can not be established that the lower than anticipated stabilities were due to an improper mix design. It is also possible that the influence of the latex had not yet taken effect on the AC-10 asphalt cement viscosity such that the briquettes when tested may have had a lower viscosity than the conventional mix briquettes, thus negating a true comparison of stability.

The aggregate gradations presented in Table 5 demonstrate that gradations for the conventional and latex mix were similar. It is noted that the binder contents were generally either on the high side of the tolerance limits or above the mix design limits. This factor, with the latex mix binder content at 5.7%, combined with the possibility of lower binder viscosity, could have resulted in the very high flow values obtained on the Marshall specimen.

The lower than anticipated stability results did not seem to present a problem during laydown and compaction operations at the roadway. Roadway compaction data is provided in Table 6. It is observed that the latex-modified mix attained higher densification than the conventional mix.

TABLE 5

EXTRACTED GRADATION AND BINDER CONTENT

Lot No.	391	392		394		395	396
Gradation (% Passing)							
l inch	100	100	100	100	100	100	100
3/4 inch	100	100	100	100	100	100	100
1/2 inch	94	97	98	95	95	92	97
No. 4	56	52	59	57	56	55	56
No. 10	41	33	45	41	41	40	40
No. 40	26	22	29	28	28	26	27
No. 80	14	12	12	14	14	13	14
No. 200	9	8	7	8	9	7	9
% A.C.	5.4	5.0	5.8	5.3	5.4	5.7	5.9
% Crushed	78	81	86	87	84	81	87

TABLE 6

ROADWAY COMPACTION

Lot No.	391	392	394	395	396
Specific Gravity	2.25	2.28	2.17	2.2	2.24
	2.27	2.29	2.24	2.32	2.27
	2.30	2.28	2.22	2.28	2.21
	2.27	2.23	2.26	2.27	2.23
	2.26	2.30	2.28	2.27	2.31
Mean S.G.	2.27	2.28	2.23	2.29	2.25
% Plant Briquette	97.0	97.4	94.9	97.8	96.2
% Theoretical	93.4	93.4	91.4	94.2	92.2

In addition to the normal control and acceptance testing conducted at the plant, the plant technician compacted extra briquettes to be tested at the research laboratory. Also, samples of loose hot mix were collected. The results of this testing are presented in Table 7. Generally, these results verify those obtained at the plant. It should be noted, however, that the flow values were more in line with those found with the conventional mix. This finding should give credence to the possibility that the full reaction of latex and AC-10 had not taken place at the time of the plant testing.

TABLE 7

RESEARCH LAB MIX PROPERTIES

<u>Gradation</u> U.S. Sieve Size <u>Percent Passing</u>	Conventional Type 3 W.C.	Latex Mod. Type 3 W.C.
1 inch	100	100
3/4 inch	100	100
1/2 inch	93	95
No. 4	54	52
No. 10	41	38
No. 40	28	26
No. 80	14	13
No. 200	9	8
% Binder	5.54	5.36

<u>Marshall Properties</u>

Specific Gravity	2.355 2.353 2.351 2.354	2.343 2.346 2.344 2.343
Stability (lbs)	1690 1690	1345 1710
Flow (0.01 in)	6 6	5 7
Air Voids (%)	3.5 3.6 3.6 3.5	3.6 3.5 3.5 3.6
VFA (%)	77 76 76 77	76 77 77 76

PERFORMANCE EVALUATION

EVALUATION PLAN

Performance evaluations for the crack control measures will be conducted biannually for three years, or until extensive reflective cracking has occurred. This will include estimated point of initial cracking, rate-of-crack propagation and documentation of other problems which may develop. A survey will be made in each section to include 15 consecutive joints.

Performance evaluations of the asphaltic concrete will be conducted biannually for the first year and annually thereafter for a period of three years. These evaluations will include measurements or estimates of rutting, ravelling, cracking (other than joint cracking, stripping, friction numbers, density and ride quality.

Due to the variety of special features utilized on this project, it is anticipated that a number of assessments could be made with respect to their performance. Referring to Figure 1 (Appendix A) for section identification, the following treatments will be examined:

(1) control vs. all other sections (4 vs. 1,2,3,5,6,8);
(2) latex modified vs. latex mod w/saw & sealed joints (5 vs. 6);
(3) latex modified vs. waterproofing membranes (5 vs. 1,2,3);and,
(4) latex mod w/saw & sealed joints vs. membranes (6 vs. 1,2,3).

POST-CONSTRUCTION EVALUATION

Post-construction data was collected within several months after completion of the project. Table 8 presents a summary of the data collected.

TABLE 8

SUMMARY OF PERFORMANCE MEASUREMENTS

SECTION NO.	FEATURE	DIRECTION	SI*	SKID NO.	CRACKING LINEAR FEET
1	Petrotac Membrane	W.B.	3.4	39.9	83
2	Bituthene Membrane**	W.B.	3.6	46.6	30
3	Tape Coat Membrane	W.B.	3.4	46.6	96
4	Conventional	W.B.	4.0	46.8	123
5	Latex Asphalt	E.B.	3.1	41.7	81
6	Latex Asph/saw and seal	E.B.	3.5	45.2	25
7	Latex Asph/saw and seal	E.B.	3.2	45.8	18
8	Saw and Seal	E.B.	3.9	43.1	28

* Serviceability Index

** With Primer

PRELIMINARY FINDINGS

Based upon the initial measurements of length of reflective cracking the following is indicated:

1. Sawing and sealing over the existing transverse joints in a new overlay appears to be the most effective in controlling reflective cracking.

2. Latex-modified asphalts may indicate increased benefits over the conventional mix in controlling reflectiv

3. The Bituthene membrane may be the most effective of the three membranes used and may be as effective as sawing and sealing.

4. The Bituthene membrane was the only membrane installed utilizing a primer. The effectiveness of membranes cracking may be related to their bonding abilities.

5. Little difference is indicated in the effectiveness of sawing and sealing the conventional or latex-modified asphalts.

Figure 3

Excess joint seal material under membrane

Figure 4

Removing excess joint seal material

Figure 5

Joint seal material smeared on surface during removal

Figure 6

Sawing joint in overlay

Figure 7

Cracking outside of sawed joint

Figure 8

Mismatched joints due to pavement growth

APPENDIX A

DIAGRAM OF EXPERIMENTAL AND CONTROL SECTIONS

APPENDIX B

SPECIAL PROVISIONS

TYPICAL SECTIONS AND DETAILS

APPENDIX C

SELECTED PHOTOGRAPHS