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16. Abstract

This report documents the construction, initial evaluation and final 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 the asphaltic concrete 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 were conducted over three years and included joint crack mapping, rutting (non detected), ravelling, cracking other than joint cracking, stripping, friction numbers, density and ride quality. The final evaluation revealed: sawing and sealing over the transverse joints in the asphalt concrete overlay appears to be the most effective treatment to control reflective cracking; a slight improvement was noticed in the sawed and sealed sections with latex-modified asphalt concrete versus the sawed and sealed sections with conventional asphalt concrete.

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LATEX MODIFIED ASPHALT AND EXPERIMENTAL JOINT TREATMENTS
ON
ASPHALTIC CONCRETE OVERLAYS

FINAL REPORT

EXPERIMENTAL PROJECT NO. 3
ASPHALT ADDITIVES

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Conducted By
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METRIC CONVERSION CHART

SI UNIT CONVERSION FACTORS*

To Convert from	To	Multiply by
Length		
foot	meter (m)	0.3048
inch	meter (m)	0.0254
yard	meter (m)	0.9144
mile (statute)	kilometer (km)	1.609
Area		
square foot	square meter (m^2)	0.0929
square inch	square meter (m^2)	0.000645
square yard	square meter (m^2)	0.8361
Volume (Capacity)		
cubic foot	cubic meter (m^3)	0.02832
gallon (U.S. liquid)**	cubic meter (m^3)	0.003785
gallon (Can. liquid)**	cubic meter (m^3)	0.004546
ounce (U.S. liquid)	cubic meter (m^3)	0.03382
Mass		
ounce-mass (avdp)	kilogram (kg)	0.0284
pound-mass (avdp)	kilogram (kg)	0.4536
ton (metric)	kilogram (kg)	1000
ton (short, 2000 lbs)	kilogram (kg)	907.2
Mass per Volume		
pound-mass/cubic foot	kilogram/cubic meter (kg/m^3)	16.02
pound-mass/cubic yard	kilogram/cubic meter (kg/m^3)	0.5933
pound-mass/gallon (U.S.)**	kilogram/cubic meter (kg/m^3)	119.8
pound-mass/gallon (Can.)**	kilogram/cubic meter (kg/m^3)	99.78
Temperature		
deg Celsius (C)	Kelvin (K)	$t_k=(t_c+273.15)$
deg Fahrenheit (F)	Kelvin (K)	$t_k=(t_F+459.67)/1.8$
deg Fahrenheit (F)	Kelvin (K)	$t_c=((t_F-32)/1.8)$

*The reference source for information on SI units and more exact conversion factors is "Metric Practice Guide" ASTM E 380.

**One U.S. gallon equals 0.8327 Canadian gallon.

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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 in both conventional and latex-modified asphalt concrete.

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 waterproofing membranes over 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 determine if the modifiers 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 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, Bituthane, 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 was a four-lane urban section 0.8 miles in length of route LA-US Business 61 and 190 in Baton Rouge, located in the south-central portion of Louisiana. The location 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 surfacial 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 31,000.

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 friction properties, 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. Observing the table reveals that the average joint faulting was not excessive, however, the average joint widths were approaching 1".

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 and Figure 1A (presented in Appendix A) are diagrams 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 in Appendix C.

Westbound Roadway

Test Area 1	Test Area 2	Test Area 3	Test Area 4

Test Area 5	Test Area 6	Test Area 7	Test Area 8

Eastbound Roadway

Test Area	Asph. Impreg. Joint Membrn.	Saw/Seal Joints	Latex-Mod. Asphalt	Convent. Asphalt	Convent. Jnt Tmt.
1	X			X	
2	X			X	
3	X			X	
4				X	X
5			X		X
6		X	X		
7		X	X	X	
8		X		X	

Figure 1. Test areas of Florida Boulevard

EXPERIMENTAL FEATURE CONSTRUCTION

Waterproofing Membrane

Three types of waterproofing membranes were utilized and incorporated into three separate test sections (1-3), as indicated in Figure 1. The control section for this evaluation is test section 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. These distresses were associated with poor drainage and rocking slabs. Figure 2 shows a joint membrane being shoved to the surface of the overlay after three years of service.

Many of the transverse joints where the humping occurred during construction have extensive failures and have been patched several times with asphalt patch material. However, not all of the membrane treated joints have failed. Generally, the unfailed joints were less than 1/2" wide prior to overlay.

Another irregularity that occurred during construction 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

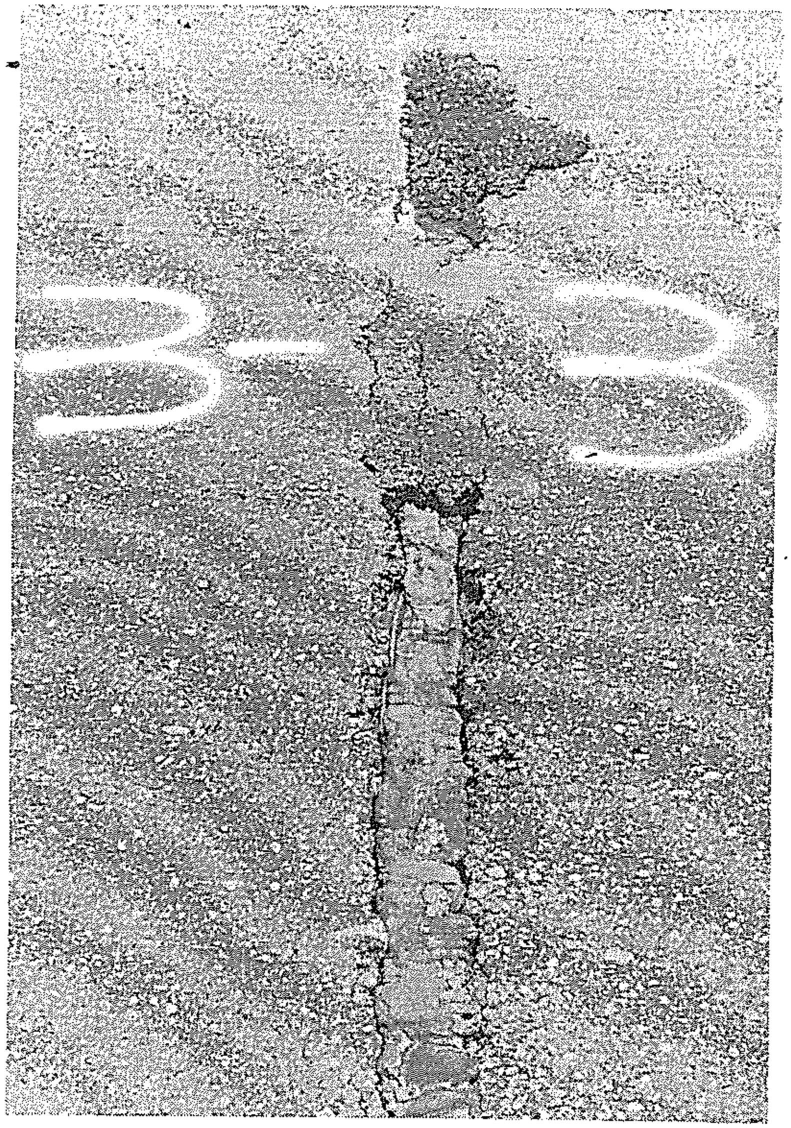


Figure 2. Exposed joint membrane.

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 scraping off the excess with a blade. 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 (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 damage to the membranes and occasional disbondment of the membrane from the PCC surface. Many 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 ineffectual over the years through the actions of pavement growth, concrete deterioration and dowel corrosion.

<u>Sawing and Sealing</u>

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 4 serves as the control section for sawing and sealing of the standard mix and test section 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 were not aligned 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.

As indicated previously, 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.

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. The job mix formula used for both the conventional and modified wearing course mix is 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, °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 Number 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+8[illegible] 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 °F	Weather (High, Low)
391	11/11/87	424.93	339	68, 37 Clear
392	11/12-18/87	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)							
1 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

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. 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. The results of these tests are provided in Table 8.

TABLE 7

RESEARCH LAB MIX PROPERTIES

Gradation U.S. Sieve Size Percent Passing	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

TABLE 8

MARSHALL PROPERTIES

	CONVENTIONAL ASPHALT				LATEX ASPHALT			
Spfc Grav	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
M_R (E6 psi)	-	0.34	-	0.13	-	0.14	-	0.16
S_T (psi)	-	178	-	190	-	167	-	183

PERFORMANCE EVALUATION

The various joint treatments and two asphalt mix designs were examined to evaluate performance characteristics for serviceability. Measurements of roughness, friction characteristics, transverse and longitudinal cracking, rutting, ravelling and patching were also obtained.

Table 9 identifies each evaluation site. There were eight sites chosen, each encompassing 2000 lane-feet. The combinations of modified and conventional asphalts and the various joint treatments used in each section are also detailed in the Table. An initial evaluation was conducted in January 1988 shortly after construction and subsequent evaluations were completed approximately three years later.

TABLE 9
TEST AREAS OF FLORIDA BOULEVARD

Test Area	Asph. Impreg. Joint Membrn.	Saw/Seal Joints	Latex-Mod. Asphalt	Convent. Asphalt	Convent. Jnt Tmt.
1	X			X	
2	X			X	
3	X			X	
4				X	X
5			X		X
6		X	X		
7		X	X	X	
8		X		X	

Serviceability and Friction Characteristics

The distresses in each test section were concentrated in the vicinity of preexisting cracks and transverse joints in the underlying PCC. Table 10 presents a summary of the data collected for the Serviceability Index (as estimated by LTRC) of each test section using the K.J. Law, model 8300 Roughness Surveyor. Little decline in serviceability was noted during the evaluation, although roughness is evident to vehicles as they pass over the transverse joints in Sections 1, 2, and 3 because of their spalling and ravelling. Section 4 also showed signs of crack upheavals and Section 8 ended near an intersection, exhibiting an increase in rutting and shoving.

TABLE 10

SERVICEABILITY INDEX

SECTION NO.	FEATURE	DIRECTION	*SI, Mo./Yr. 6/88	1/89	10/89	12/9
1	Petrotac Membrane	W.B.	3.4	3.4	3.3	3.2
2	Bituthene Membrane**	W.B.	3.4	3.3	3.4	3.1
3	Tape Coat Membrane	W.B.	3.4	3.4	3.2	3.1
4	Conventional	W.B.	3.8	3.8	3.7	3.5
5	Latex Mod. Asphalt	E.B.	3.2	3.4	3.3	3.2
6	Latex Mod. Asphalt w/ saw and seal	E.B.	3.3	3.4	3.3	3.2
7	Latex and Conv. w/ saw and seal	E.B.	3.1	3.3	3.3	3.2
8	Conv. w/ saw and seal	E.B.	3.7	3.8	3.5	3.4

* Serviceability Index
* With Primer

Friction testing of the latex-modified and conventional asphalt sections showed similar friction numbers among all test sections. Statistical observations of the second and third evaluations however, revealed that the taped conventional asphalt cement section had the highest friction number. The conventional jointed latex-modified asphalt cement section had the worst. All eight sections are currently maintaining adequate friction levels. See Figure 3.

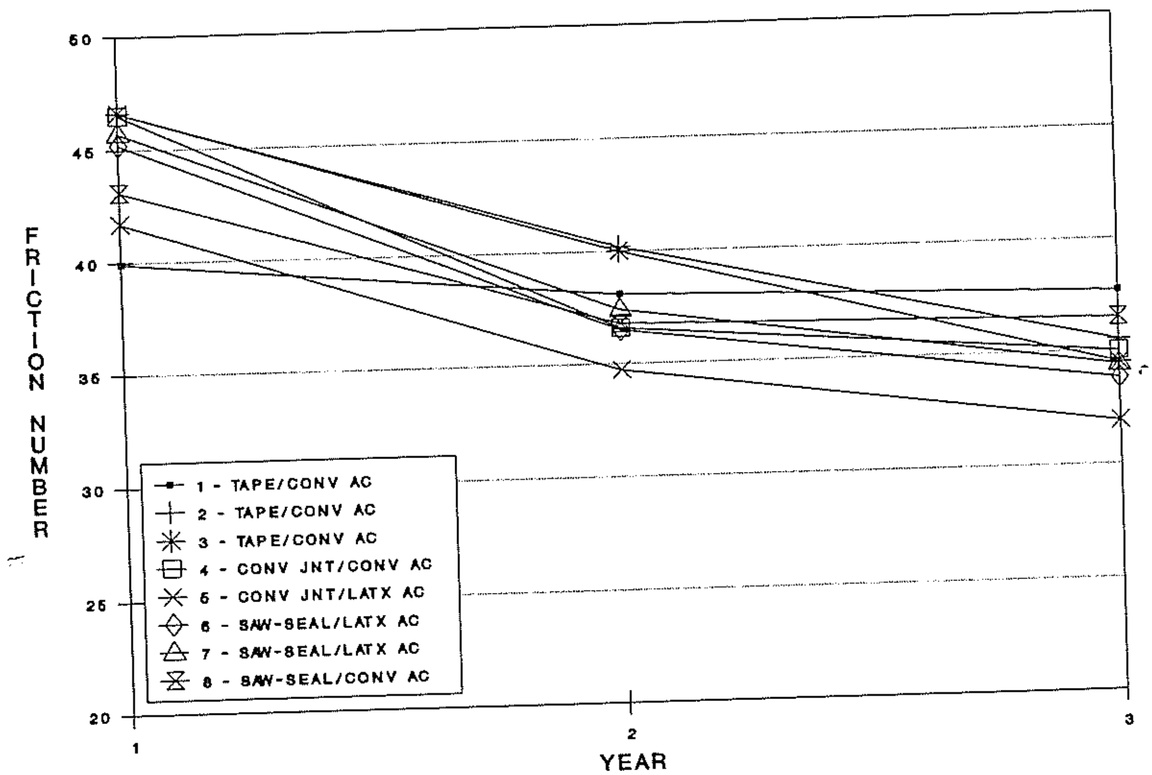


Figure 3. Friction numbers.

Field Samples

Samples in the form of roadway cores were taken from each section during the second and third evaluation years. Six inch diameter cores were used in order to obtain a sufficient quantity of binder for additional testing. This material was then subjected to extraction and asphalt cement recovery by the Abson process. Binder content and gradations were determined. The recovered asphalt cement was tested for viscosity (140°F), penetration (77°F) and ductility (77°F). Table 11 presents the results of the gradation analysis and Table 12, the binder properties.

TABLE 11

ROADWAY GRADATION ANALYSIS

TEST SECT	3/4"	1/2"	3/8"	No 4	No10	No40	No80	No200	% AC
1-1	100	96	85	55	37	17	9	6	6.2
1-2	100	95	81	55	36	22	10	6	6.1
2-1	100	98	89	58	38	25	14	10	5.9
2-2	100	94	81	52	36	23	13	8	6.1
3-1	100	95	80	54	37	23	12	8	5.9
3-2	100	94	80	54	39	26	14	9	6.4
4-1	100	97	85	58	42	28	15	10	6.2
4-2	100	95	83	57	41	26	13	8	7.5
*5-1	-	-	-	-	-	-	-	-	4.9
*5-2	-	-	-	-	-	-	-	-	5.3
*6-1	-	-	-	-	-	-	-	-	5.3
*6-2	-	-	-	-	-	-	-	-	5.4
7	100	94	82	59	41	27	13	8	6.0
8	100	96	87	61	45	30	15	9	6.2

* Gradation not available.

The extracted cores had gradations and asphalt contents which we generally the same as those obtained during production testing. T binder properties in all eight sections remained unchanged during t three year evaluation. After the first year on the roadway, t viscosities and penetrations of the latex-modified asphalt sections (6 and 7) were typical of a virgin AC-30 asphaltic cement. After 3 ye of service, the latex-modified binder properties were similar to that an AC-30 grade asphalt after plant production whereas the binder in t conventional AC-30 section had consistencies typical of 3-years of ag in the Louisiana environment. This suggests that as long as there is initial pavement distress in the form of permanent deformation, t latex modification of an AC-10 asphalt cement permits the use of a m durable binder. Additional service life should, therefore, anticipated.

TABLE 12

ROADWAY BINDER PROPERTIES

TEST SECT	DATE	Sp.Gr.	% AC	VISC 140F-P	PEN 77F	DUCT 77F
1-1	2/89 5/91	2.283 2.303	6.2 5.0*/ 5.2	11652 9623	37 31	150+ 130
1-2	2/89 5/91	2.301 2.294	6.1 5.3*/ 5.5	6558 9996	51 27	150+ 150+
2-1	2/89 5/91	2.299 2.296	5.9 4.9*/ 5.2	11916 46638	35 18	150+ 22
2-2	2/89 5/91	2.289 2.274	6.1 5.5*/ 6.0	11463 7485	32 32	150+ 150+
3-1 (Rap)	2/89 5/91	2.320 2.286	5.9 5.6*/ 6.2	10559 9509	42 33	-- 150+
3-2 (Rap)	2/89 5/91	2.279 2.301	6.4 5.8*/ 6.6	10559 8984	40 33	-- 150+
4-1 (Rap)	2/89 5/91	2.327 2.339	6.2 5.6*/ 6.0	9263 10540	45 29	-- 150+
4-2 (Rap)	2/89 5/91	2.320 2.310	7.5 5.8*/ 6.3	10714 8465	38 31	-- 150+
5-1	2/89 5/91	2.314 2.346	4.9 5.6*/ 5.9	4940 5531	61 30	-- 150+
5-2	2/89 5/91	2.318 2.336	5.3 5.0*/ 5.2	3914 7196	63 33	-- 150+
6-1	2/89 5/91	2.322 2.330	5.3 5.2*/ 5.4	2856 6083	90 33	-- 150+
6-2	2/89 5/91	2.341 2.333	5.4 5.0*/ 5.2	2699 3771	85 50	-- 150+
7	2/89 5/91	2.336 2.326	6.0 5.5*/ 5.9	5227 13967	58 23	-- 104
8	2/89 5/91	2.299 2.320	6.2 5.5*/ 6.1	10571 11240	61 27	-- 112

* Ash corrected value.

Final Performance Assessment

To date, the latex-modified and conventional asphalt sections are performing the same (with the exception of the areas around the joints). The majority of the distresses were concentrated around the reflected joints of each section. The long term growth of PCC pavement has resulted in large spaces of up to two inches wide at some transverse joints. These changes appear to have inhibited the ability of the membranes to prevent reflective cracking and act as water barriers. In many locations, cracking of the overlay was evident as early as the day of construction. The distresses worsened with spalling and ravelling at these joints over the three year evaluation.

A comparison of the latex-modified and conventional asphal concretes in conjunction with the conventional joint treatmen underscored the ability of the latex-modified asphalt to reduc cracking. Sawed and sealed joint sections exhibited littl preference for conventional or latex-modified asphalt cement an performed similarly. The joints in these sections demonstrate superior performance over the taped and conventional joints. Th cracking that did occur around the sawed and sealed joints (thoug rare) was largely associated with either the misalignment of th sawing and sealing feature or excessively wide PCC joints. (It i believed that the poor placement occurred because of gradu pavement growth and subsequent changes in joint alignment betwe lanes.) Further inspection of the crack map data revealed th lower distress with respect to cracking as well as spalling a ravelling was observed in the sawed and sealed joint sections aft the first three years of performance.

The final evaluation data were collected and photographs (s Appendix C) were taken of each test section after three years performance. Table 13 illustrates the percent of joints remain crack-free and the cost per lane-mile of latex-modified conventional asphalt concrete overlay and joint treatments. Joint treatment costs and joint-associated cracking length of each test section are examined in Figure 4. The Figure can be divided into three regions that correspond to each type of joint treatment. Region I (sections 1, 2 and 3) reflects high cost and a high level of joint-associated cracks that corresponds to taped joints and conventional asphaltic cement. Region II (sections 6, 7 and 8) has a cost similar to that of Region I but offers a significantly better performance level. These sections incorporated sawed and sealed joints and exhibited better performance when constructed with latex-modified asphaltic cement. Region III (sections 4 and 5) on the other hand, indicates that the use of the conventional joint treatment in conjunction with conventional asphalt cement yielded the highest level of joint-associated cracking. However, a substantial improvement in performance was realized with the use of latex-modified asphalt cement.

TABLE 13

SUMMARY OF JOINT CRACKING AND CONSTRUCTION COSTS

SEC	UNCRACKED JOINTS (%)	JOINT*1* COSTS ($/LANE MILE)	ASPHALT*2* COSTS ($/LANE MILE)	DESCRIPTION
4	26.1	5,702.40	18,585.60	CONV JNT & CONV AC
1	43.9	12,830.40	18,585.60	TAPE & CONV AC
3	50.8	12,830.40	18,585.60	TAPE & CONV AC
2	51.1	12,830.40	18,585.60	TAPE & CONV AC
5	61.1	5,702.40	22,070.40	CONV JNT & LATEX AC
8	73.6	11,404.80	18,585.60	SAW-SEAL & CONV AC
7	87.2	11,404.80	22,070.40	SAW-SEAL & LATEX AC
6	89.2	11,404.80	22,070.40	SAW-SEAL & LATEX AC

1 ASSUMES 264 JOINTS/12'LANE MILE
2 1.5", $32-CONV & $38-LATEX

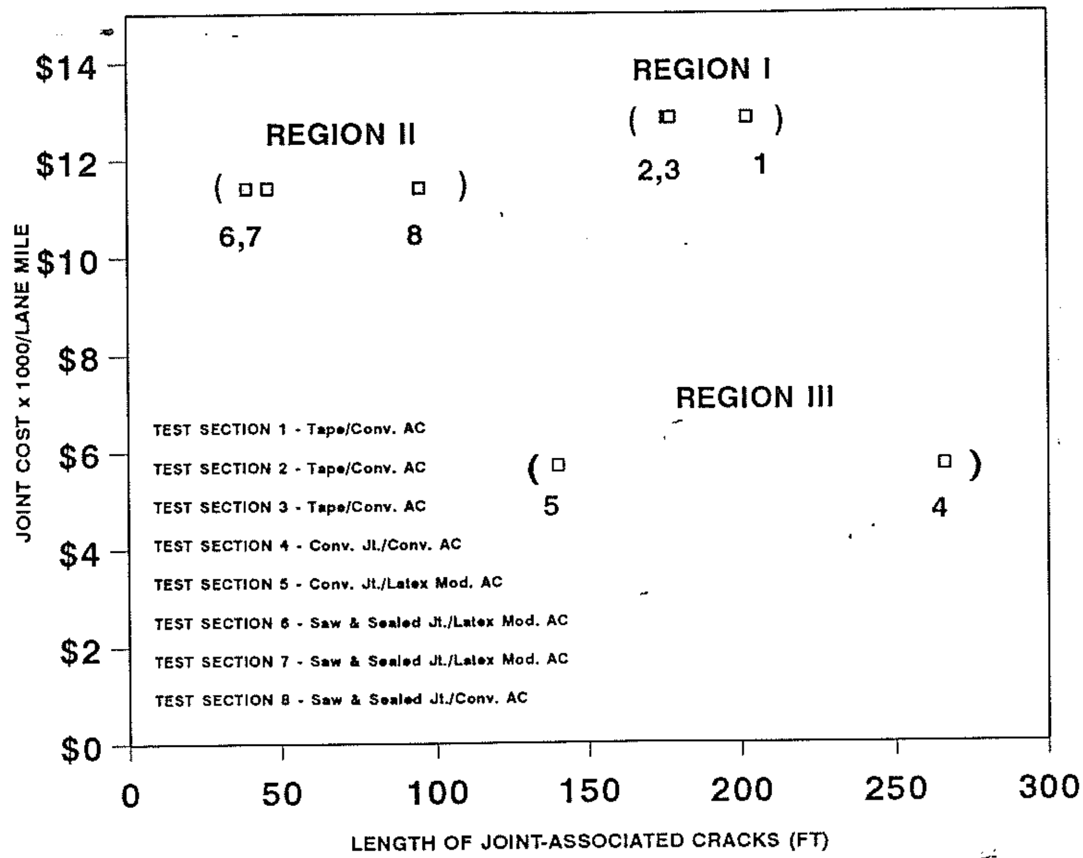


Figure 4. Joint cost and performance assessment.

Because cost and distress (cracking) are advantageous in the same direction (i.e. lower cost, lower cracking), the combined effect is evaluated as the product of the total crack length (at the joints and in the panels) and the total cost of each test section (cost-distress factor). A quantitative assessment of all eight test sections is provided in Figure 5. The bar chart shows that the sawed and sealed joint sections possess the lowest cost-distress factors and offered the least distress with respect to cost regardless of the type of asphalt cement used. Additionally, the figure supports the use of the conventional joint treatment when latex-modified asphalt cement is used.

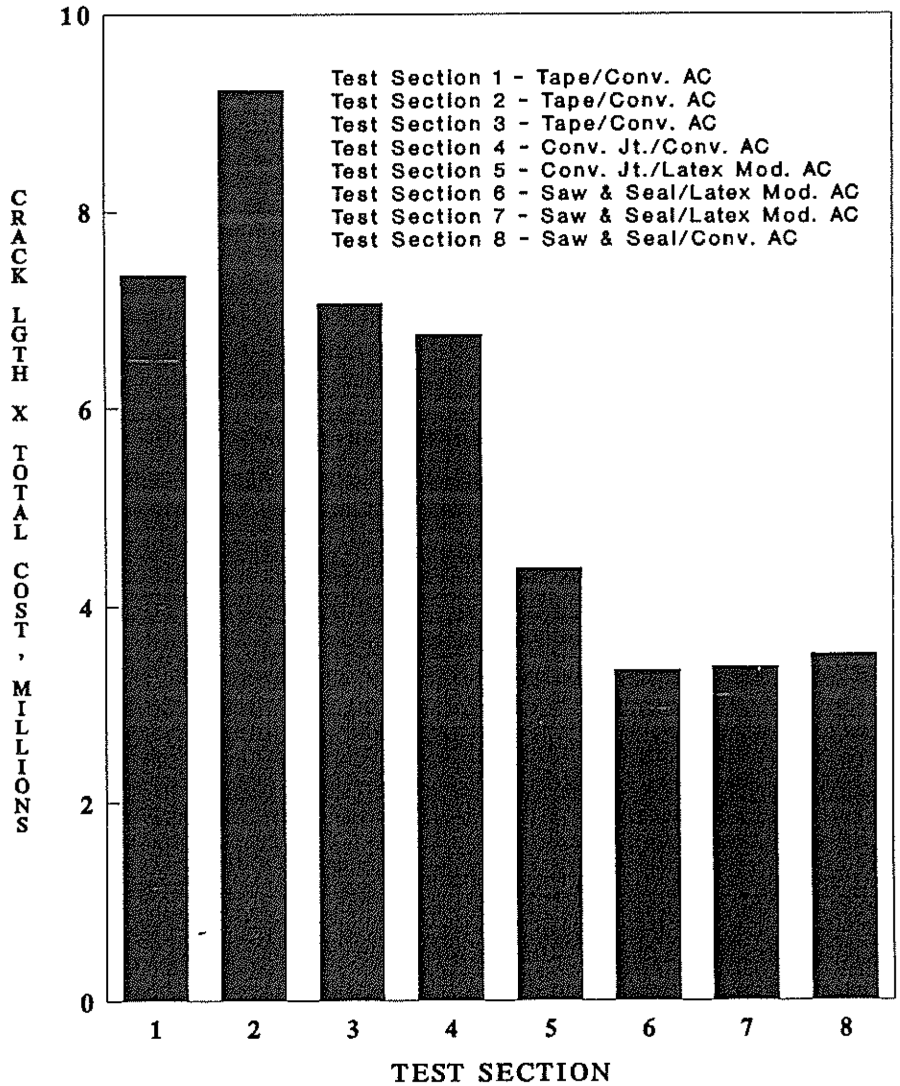


Figure 5. Cost-distress assessment.

CONCLUSIONS

The conclusions are constrained to the scope of this project. Replicate sections were not designed into the project because of the total project length.

1. Sawing and sealing over the existing transverse joints, in conjunction with either conventional or latex-modified asphalt cement, appears to be the most effective in controlling reflective cracking.

2. Latex-modified asphalts indicate increased benefits over the conventional mix in controlling reflective cracking when the conventional joint treatment is utilized.

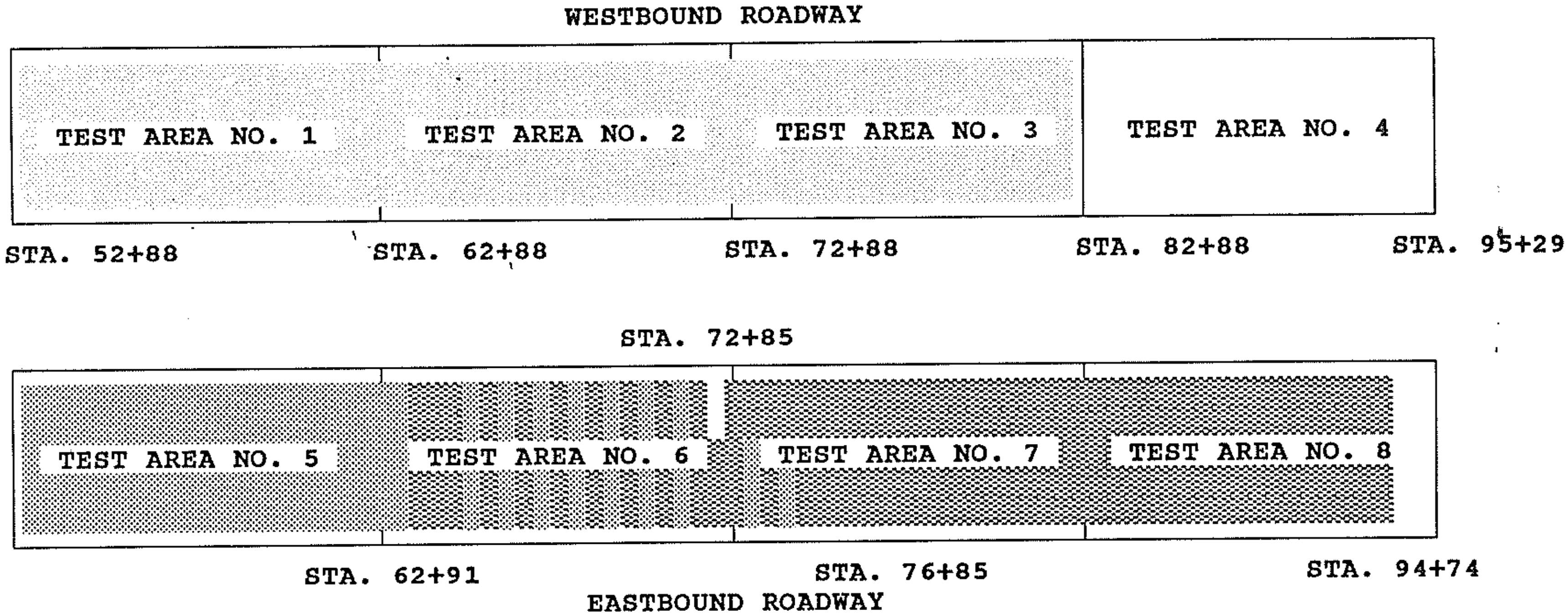
3. The membranes were not effective in controlling reflective cracking on this project. Their effectiveness may be related to poor subgrade support, rocking slabs and excessive joint width. This suggests that the use of membranes should be constrained to pavements with good subgrade support.

APPENDIX A

DIAGRAM OF EXPERIMENTAL AND CONTROL SECTIONS

STATE PROJECT NO. 013-04-32 F.A.P. NO. HES-13-01-(017)

PEACHTREE BLVD. - NORTH FOSTER DRIVE



TEST AREA	ITEM S-2 ASPHALT IMPREGNATED MEMBRANE	ITEM S-3 RUBBERIZED ASPHALTIC CONCRETE (1 1/2" THICK)	ITEM S-4 SAWING AND SEALING JOINTS IN ASPHALTIC CONCRETE OVERLAY
NO. 1 NO. 2 NO. 3 NO. 4 NO. 5 NO. 6 NO. 7 NO. 8	PETROTAC BITUTHENE TAPE COAT	TOTAL 467.312 TONS	TOTAL 4626.92 LIN. FT.

Diagram of Experimental and Control Sections

APPENDIX B

CONSTRUCTION SPECIFICATIONS

TYPICAL SECTIONS

AND DETAILS

ITEM S-001, SAWING AND RESEALING TRANSVERSE JOINTS: This item consists of removing joint sealants and incompressibles in transverse joints of existing concrete pavement and resealing the joints in accordance with the following requirements.

Existing joints shall be cleaned of existing sealant and incompressibles by routing, sawing or other approved methods. After cleaning, joints must be water blasted and if necessary, air blasted with compressed air. Joint faces shall be completely dry before installing the rubberized asphalt sealant.

Resealing materials shall be a rubberized asphalt sealant conforming to Subsection 1005.02(d)(2), installed in accordance with plan details and the manufacturer's recommendations.

At the contractor's option and prior to sealing the joint with rubberized asphalt, an approved heat resistant backer rod may be used. Seating depth shall be a minimum of one inch (1").

The resealed joint shall remain closed to traffic until, in the engineer's option, the sealant has satisfactorily cured.

Measurement will be made by the linear foot of joint cleaned and resealed, and payment will be made at the contract unit price under:

Item S-001, Sawing and Resealing Transverse Joints, per linear foot.

ITEM S-002, ASPHALT IMPREGNATED MEMBRANE: This work consists of cleaning the existing surface and placing a membrane over the transverse contraction joints as shown on the plans.

<u>General</u>: The waterproofing membrane shall incorporate a high strength heat resistant mesh embedded in a layer of self-adhesive rubberized asphalt. Primer shall be supplied by the manufacturer of the membrane or other approved equal which is compatible with the membrane.

SPECIAL PROVISIONS

<u>Materials</u>: Three waterproofing and stress absorbing membrane products will be used on an experimental basis in the test areas as shown in the plans. The three products are:

1) Petrotac by the Phillips Petroleum Company.
2) Tapecoat by the Tapecoat Company.
3) Bituthene by the W. R. Grace Company.

The product should have a minimum thickness of 60 mils and a width of between 11.5 and 12.5 inches.

<u>Construction</u>: The membrane shall be placed on transverse contraction joints only. Placement of the membrane will be done only when the temperature is above 40 °F and the pavement surfaces are dry and free of any dirt or debris.

When required by the manufacturer of the membrane, the surface shall be primed in accordance with the manufacturer's recommendations prior to placement of the membrane. The primer will be placed on the surface at the rate specified by the manufacturer of the primer, will extend 1" wider than the membrane, and will be allowed to dry until tack-free before applying the membrane. Sections which are primed shall be covered with membrane within the same day or repriming will be required.

All joints will be cleaned and sealed with a rubberized asphalt prior to placement of the membrane.

The membrane will be installed straight and wrinkle-free with no curled or uplifted edges. Any wrinkles over 3/8" in width shall be slit and folded down. After the membrane has been placed, it shall be pressed against the concrete or asphalt surface by means of a hand roller or other suitable equipment to insure proper bonding. Special attention should be given to insure that the edges and corners of the strips are bonded securely to the surface. Any strips with loose edges or corners should be rebonded or replaced prior to placement of the overlay at the expense of the contractor. All membranes shall be surface dry before placement of the asphaltic concrete overlay.

Traffic will be allowed to use the section after placement of the membrane and prior to placing the paving for a maximum period of four calendar days. Any damaged or disbonded membrane must be replaced prior to paving at no cost to the department.

Measurements: The quantity of membrane, complete in-place and accepted, will be measured in linear feet. The length for transverse joints treated will be measured on the typical cross section in the plans. Field measurements will be made as required to determine the exact length treated. No allowance will be made for laps.

Payment: Payment will be made at the contract unit price per linear foot of joint treated, which will include cleaning the surface and furnishing and placing the primer and membrane, and all other incidentals necessary to compte this item.

Payment will be made under:

Item S-002, Asphalt Impregnated Membrane, per linear foot.

ITEM S-003, RUBBERIZED ASPHALTIC CONCRETE: This item consists of furnishing and placing latex-modified Type 3 asphaltic concrete wearing course in accordance with plan details and Section 501 of the Standard Specifications as modified by the following.

Materials:

(a) Asphalt Cement: Grade AC-10 conforming to Section 1002.

(b) Latex: Latex shall be one of the following products or approved equal.

Polysar Latex 275

Polysar, Inc.
3805 Annicola Highway
Chattanooga, TN 37406
(605) 698-9200

Downright HM-100L Latex
Dow Chemical Company
Larkin Laboratory
Midland, MI 48674
(517) 636-9124

Ultrapave 70 Latex
Textile Rubber and Chemical Co., Inc.
1400 Tiarco Drive, S.W.
Dalton, GA 30720
(404) 277-1400

Mixture Composition and Production: Latex shall be added to the mix at a substitution rate of 3% latex solids by weight of the asphalt cement.

In a batch plant, the asphalt cement shall be added to the heated mixed aggregate and the mixing continued for at least 10 seconds and until the aggregate is completely coated with asphalt. Latex shall then be added and mixing continued for at least 50 seconds. In either a batch or dryer drum plant, mixing shall be sufficient to produce a homogeneous asphaltic concrete mixture. The discharge temperature from the mixer shall be 330 °F to 380 °F as required.

The supplier of the latex modifier shall provide on-the-job technical assistance preceding and during the production of the rubberized asphaltic concrete to assist and advise in handling, usage, testing and other aspects of the latex.

No special equipment will be necessary for mixing, hauling or placing the latex-modified mixtures except for equipment to introduce the latex into the mixer. Such equipment, available through the latex supplier, shall be capable of metering and uniformly distributing the latex into the mixture. The latex insertion system shall be capable of being calibrated to verify that output rate is matched with plant production. An indicator shall be located in the plant operator's control room to allow constant monitoring of the system.

During storage, the latex shall be protected from freezing and shall not be subjected to direct sun or heat. Bulk material shall be kept in an insulated tank and barrels must be warehoused until used.

Measurement and Payment: Measurement will be made by the ton of rubberized asphalt concrete in accordance with Subsection 501.13, and payment will be made in accordance with Subsection 501.14 except the payment will be made under:

Item S-003, Rubberized Asphaltic Concrete, per ton.

ITEM S-004, SAWING AND SEALING JOINTS IN ASPHALTIC CONCRETE OVERLAY: This item consists of sawing and sealing joints in asphaltic concrete overlay in accordance with plan details and the following requirements.

New joints shall be cut in the overlay at the location of the existing joints in the existing concrete pavement.

Sealing materials shall be rubberized asphaltic sealant conforming to Subsection 1005.02(d)(2), installed in accordance with plan details and the manufacturer's recommendations.

Joint shall be filled with sealant to within 1/4" of pavement surface.

The sealed joint shall remain closed to traffic until, in the engineer's opinion, the sealant has satisfactorily cured.

Measurement will be made by the linear foot of joint cut and sealed and payment will be made at the contract unit price per linear foot which includes all materials, labor and incidentals necessary to complete this item.

Payment will be made under:

Item S-004, Sawing and Sealing Joints in Asphalt Concrete Overlay, per linear foot.

COOPERATION WITH UTILITIES: Subsection 105.06 of the Standard Specifications is amended to include the following.

Utility facilities will be removed, relocated, adjusted or abandoned in accordance with agreements between the Department and utility owners listed below. Such work may be underway concurrently with the contractor's work and within construction limits covered by this contract. The furnishing of the following estimated completion times for utility work, determined by utility owners, is for information purposes only and will not relieve the contractor of any requirements of this Subsection nor will it preclude the granting of contract time credits in accordance with the provisions of this subsection.

ESTIMATED WORKING DAYS

UTILITY OWNER	AFTER RIGHT-OF-WAY IS CLEAR
Gulf States Utilities Co. (Elec.) P. O. Box 2431 Baton Rouge, Louisiana 70821 Attn: Mr. D. I. Lytle	60

CONTRACT TIME: The entire contact shall be completed in all details and ready for final acceptance within sixty-five (65) working days.

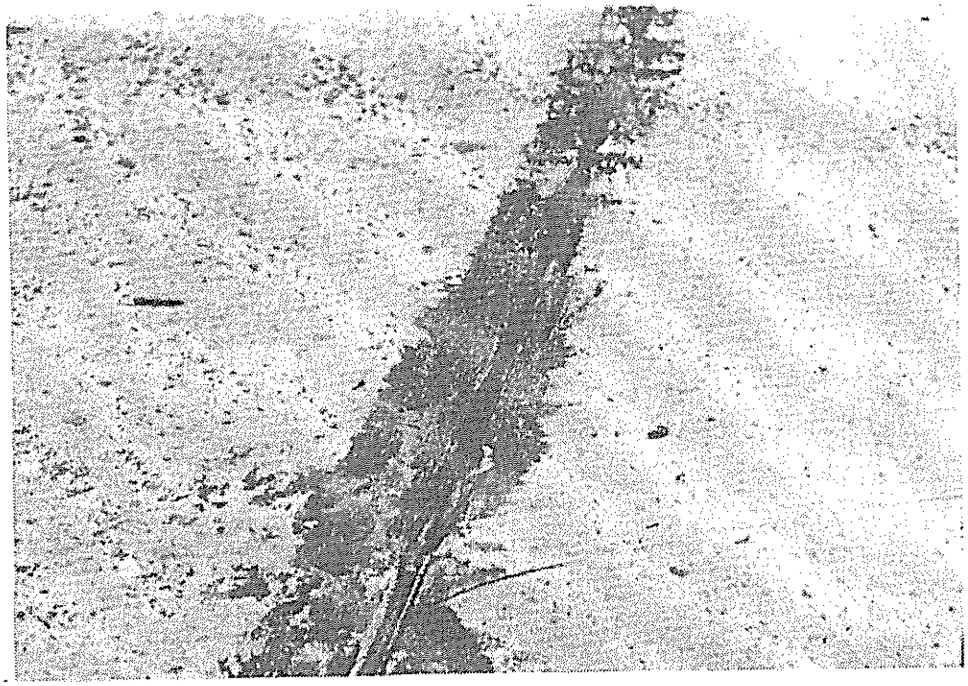
APPENDIX C

SELECTED PHOTOGRAPHS

CONSTRUCTION PHOTOGRAPHS

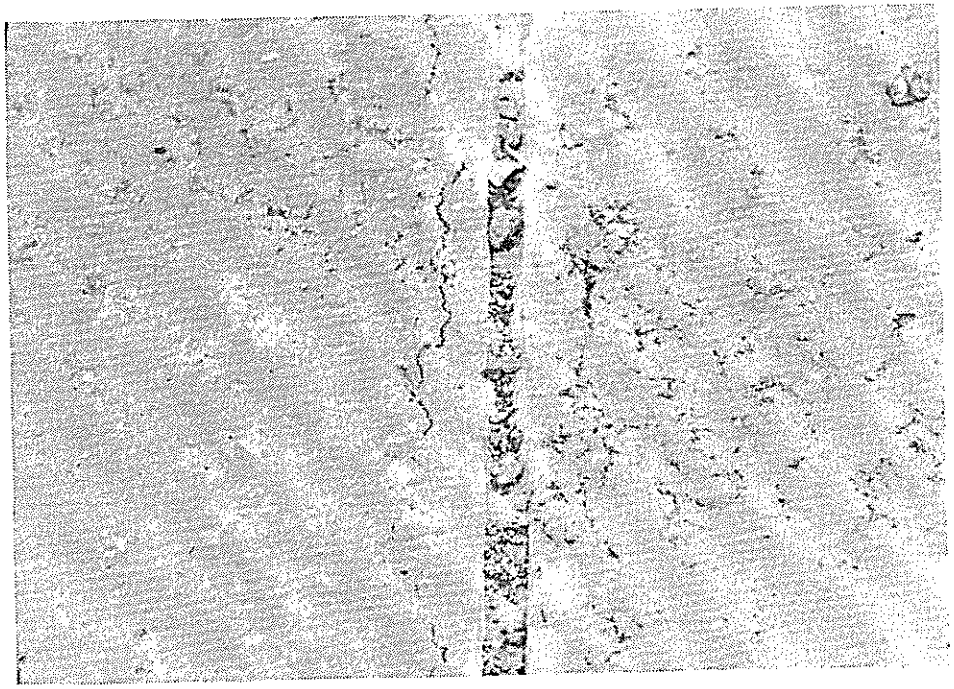
Excess joint seal material under membrane.

Removing excess joint seal material.

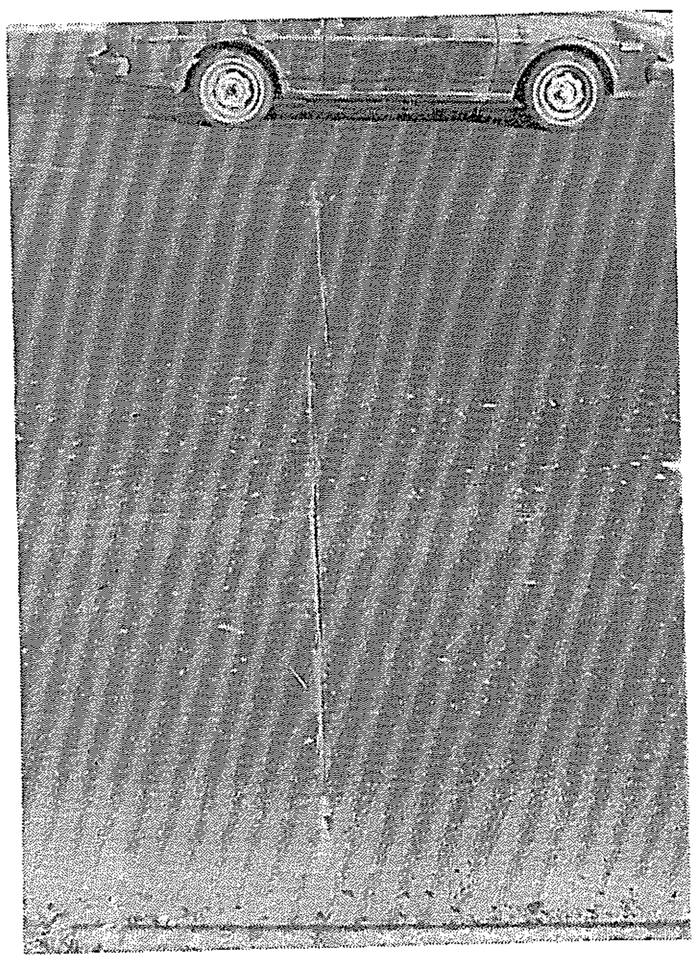


Joint seal material smeared on surface during removal.

Sawing joint in overlay.

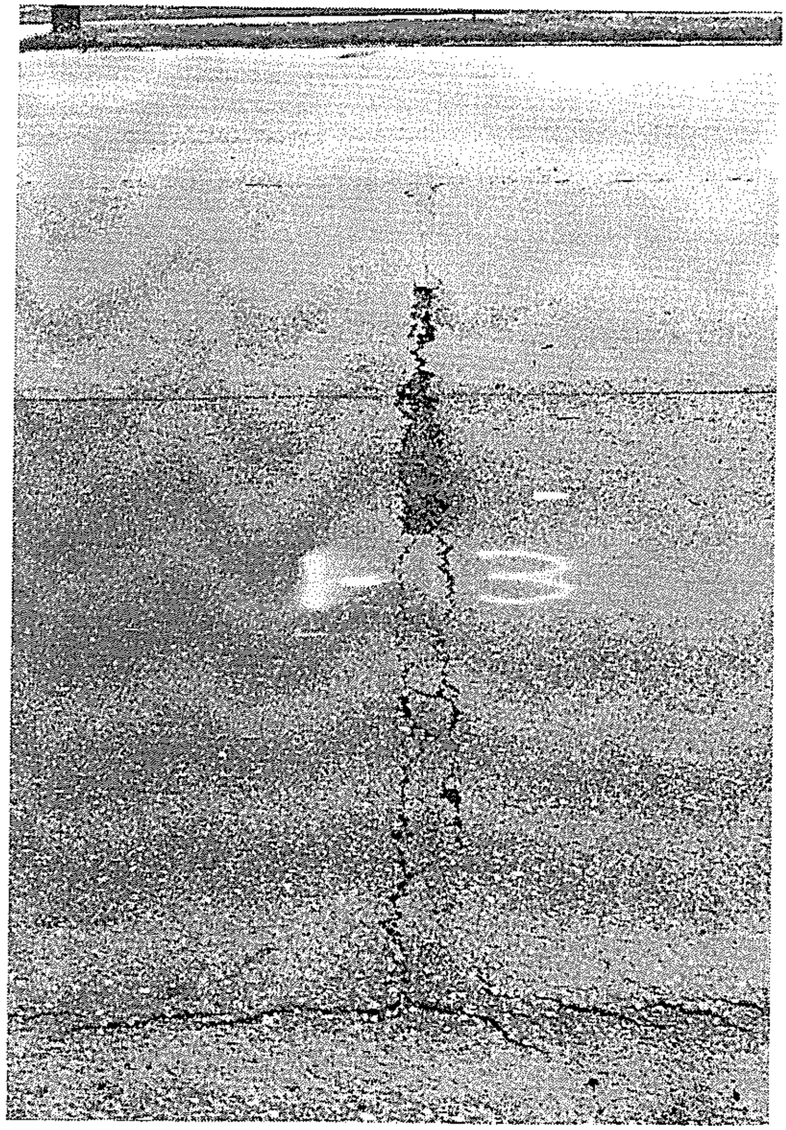


Cracking outside of sawed joint.

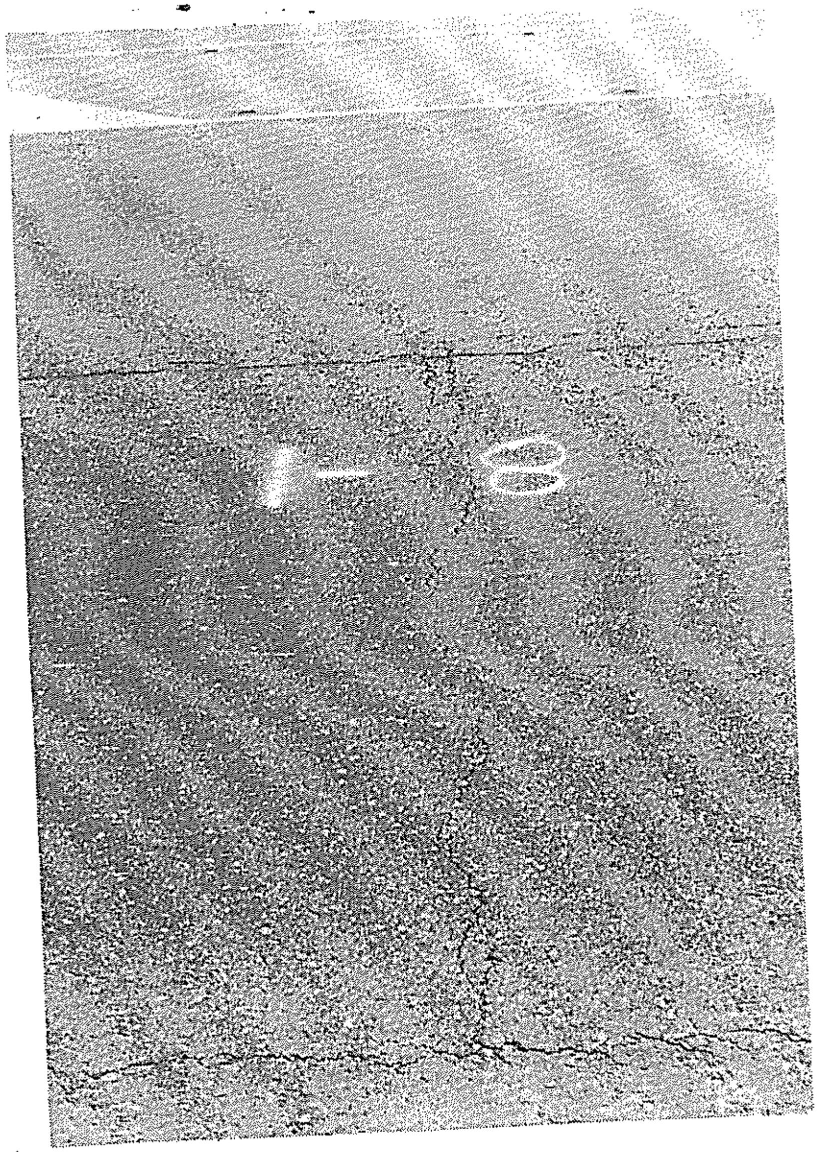


Mismatched joints due to pavement growth.

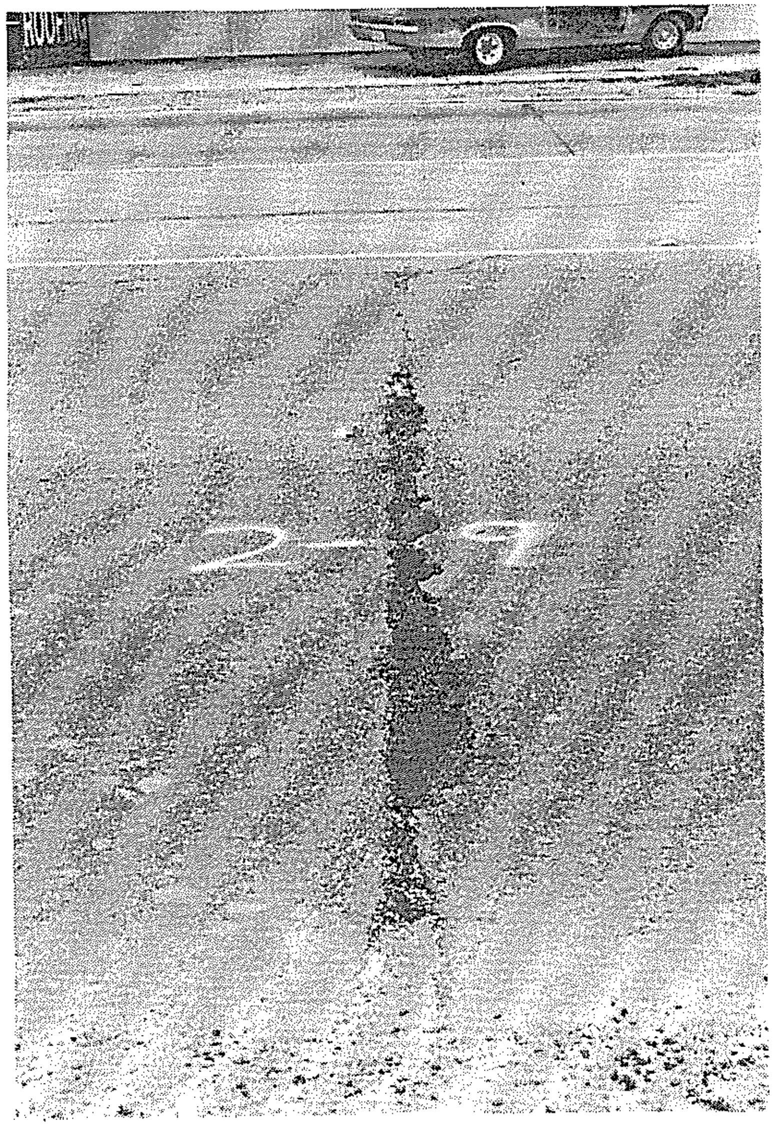
FINAL EVALUATION PHOTOGRAPHS



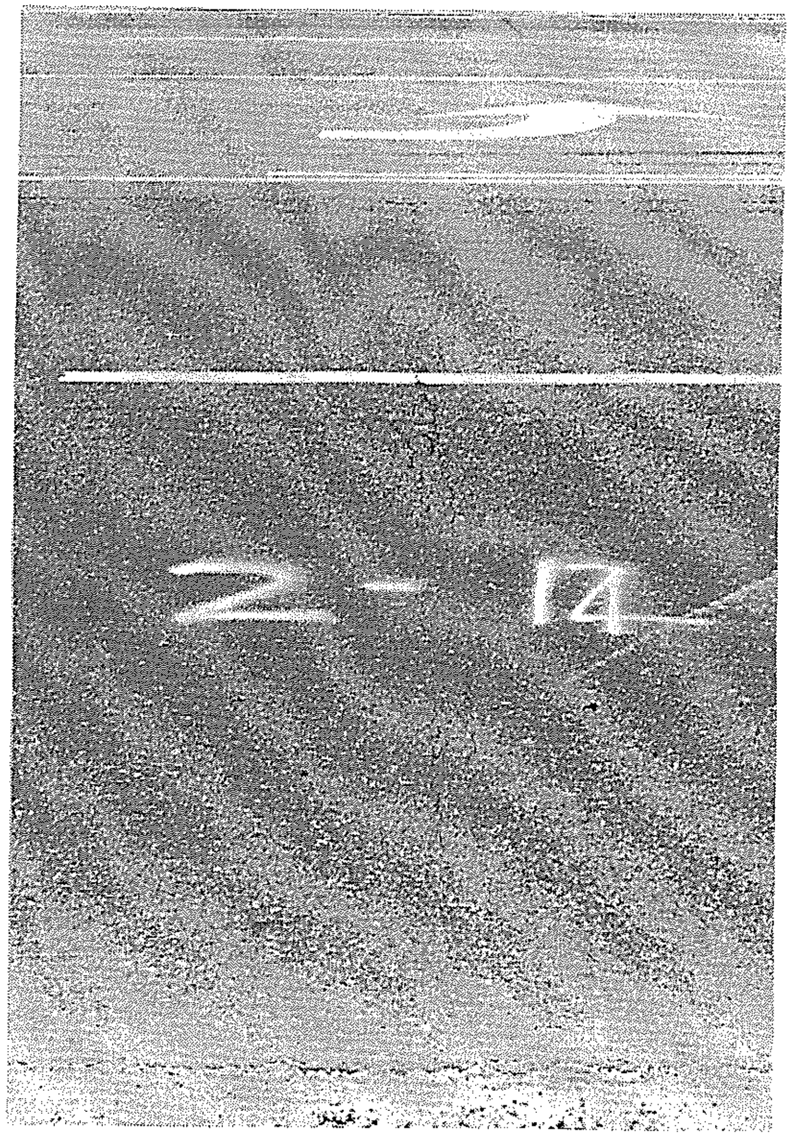
Test section 1. Taped-joint failure with maintenance patches (and conventional asphalt cement).



Test section 1. Less distressed taped-joint (with conventional asphalt cement).



Test section 2. Taped-joint failure with maintenance patches (and conventional asphalt cement).

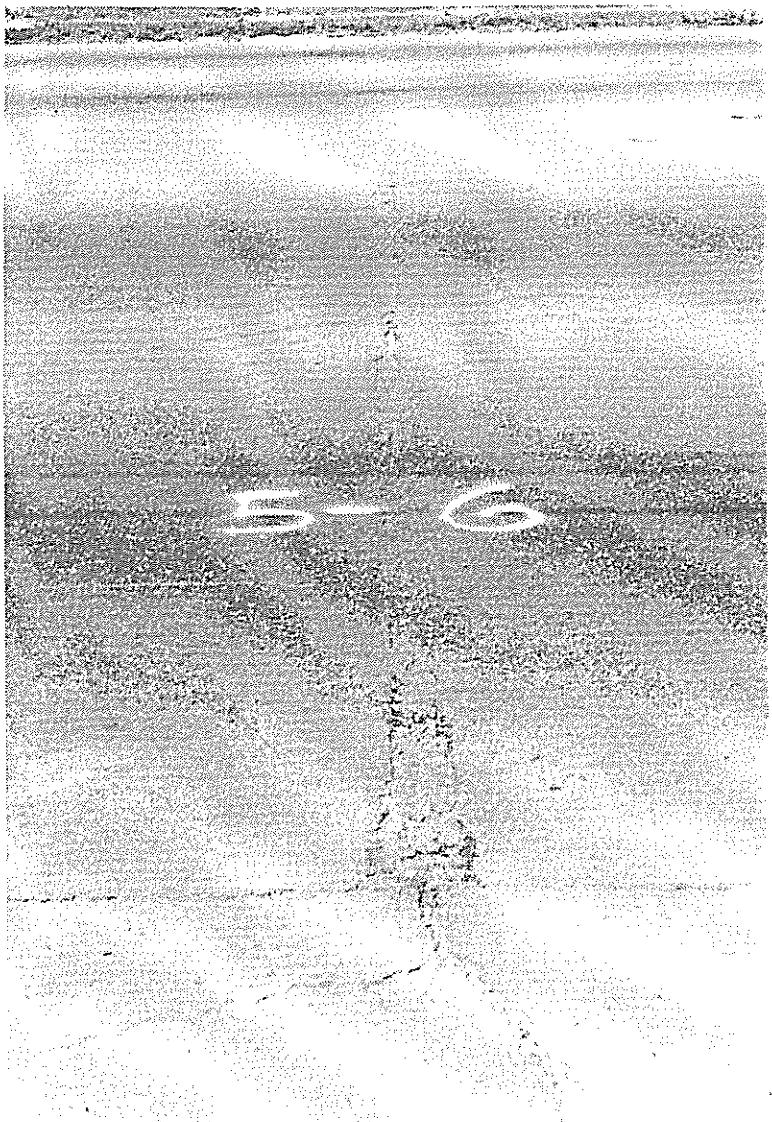


Test section 2. Less distressed taped-joint (with conventional asphalt cement).

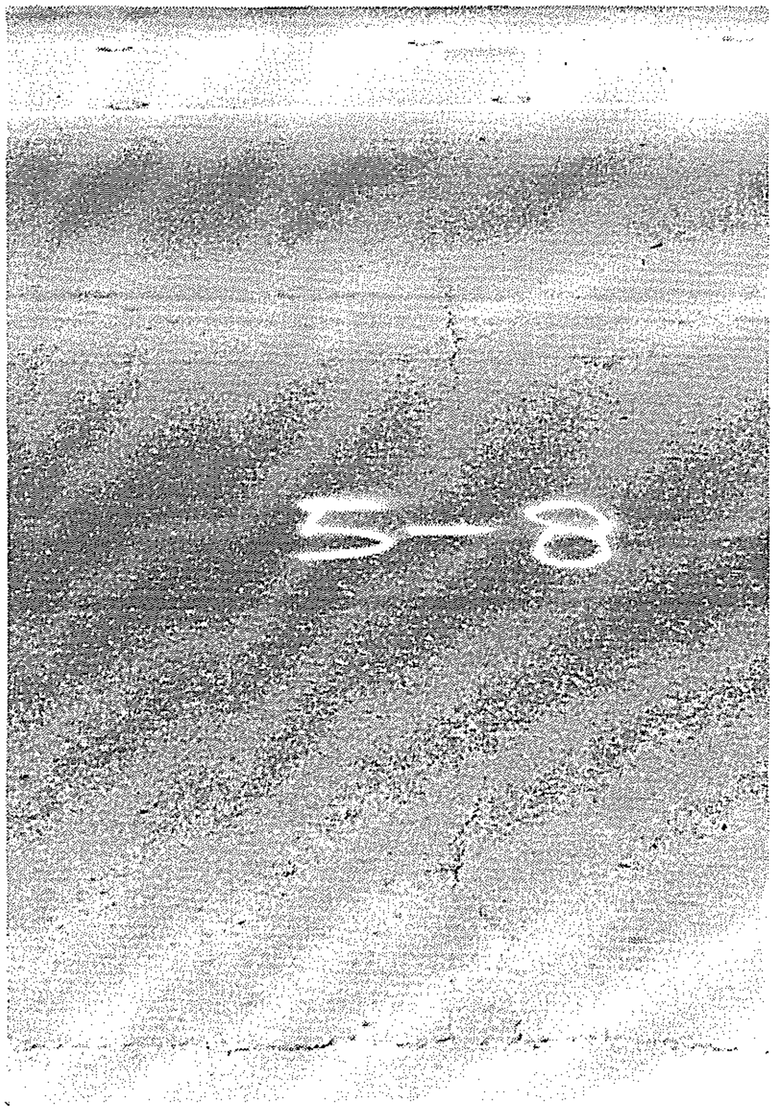
Test section 3. Taped-joint failure with maintenance patches (and conventional asphalt cement).

Test section 4. Conventional joint failure (with conventional asphalt cement).

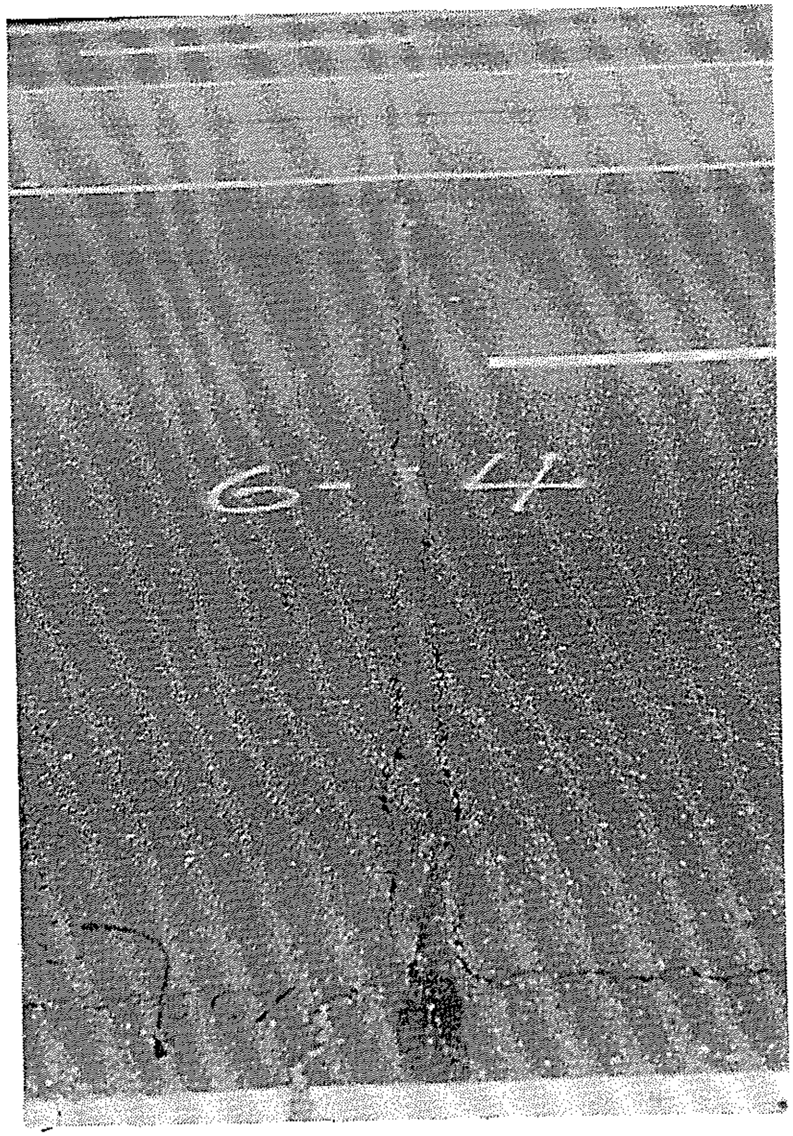
Test section 4. Less distressed conventional joint (with conventional asphalt cement).



Test section 5. Conventional joint failure (with latex-modified asphalt cement).

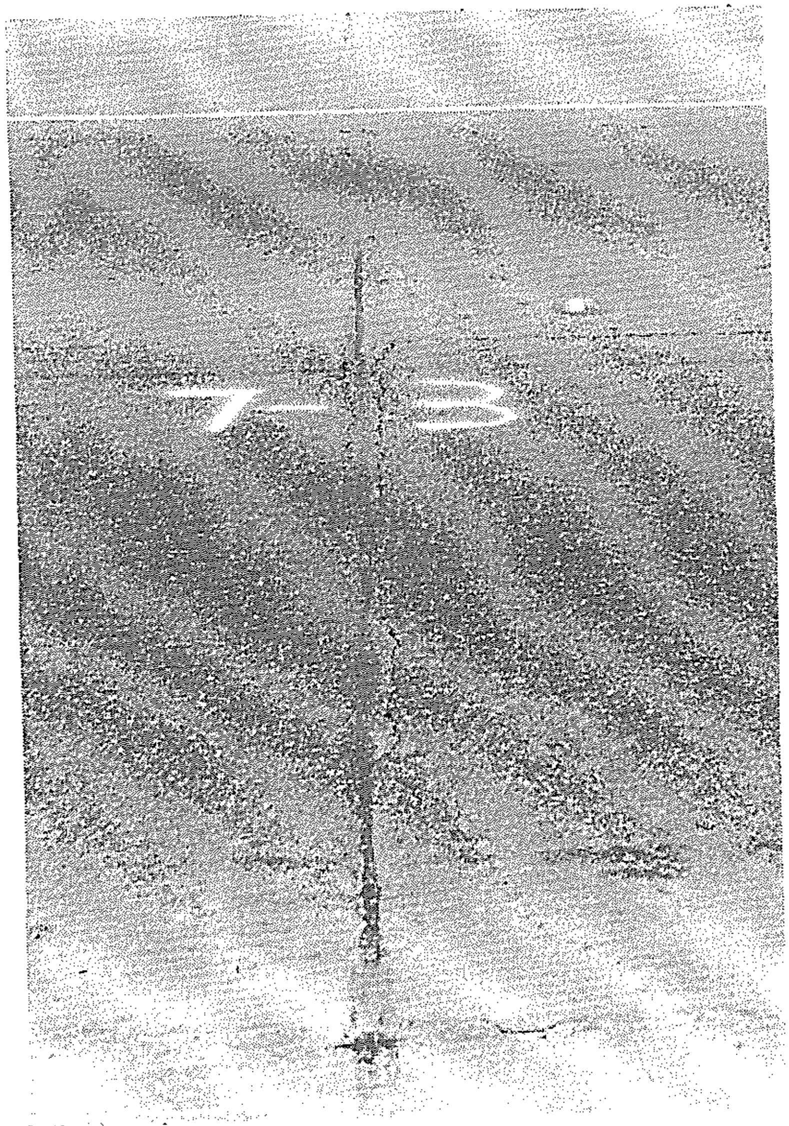


Test section 5. Less distressed conventional joint (with latex-modified asphalt).

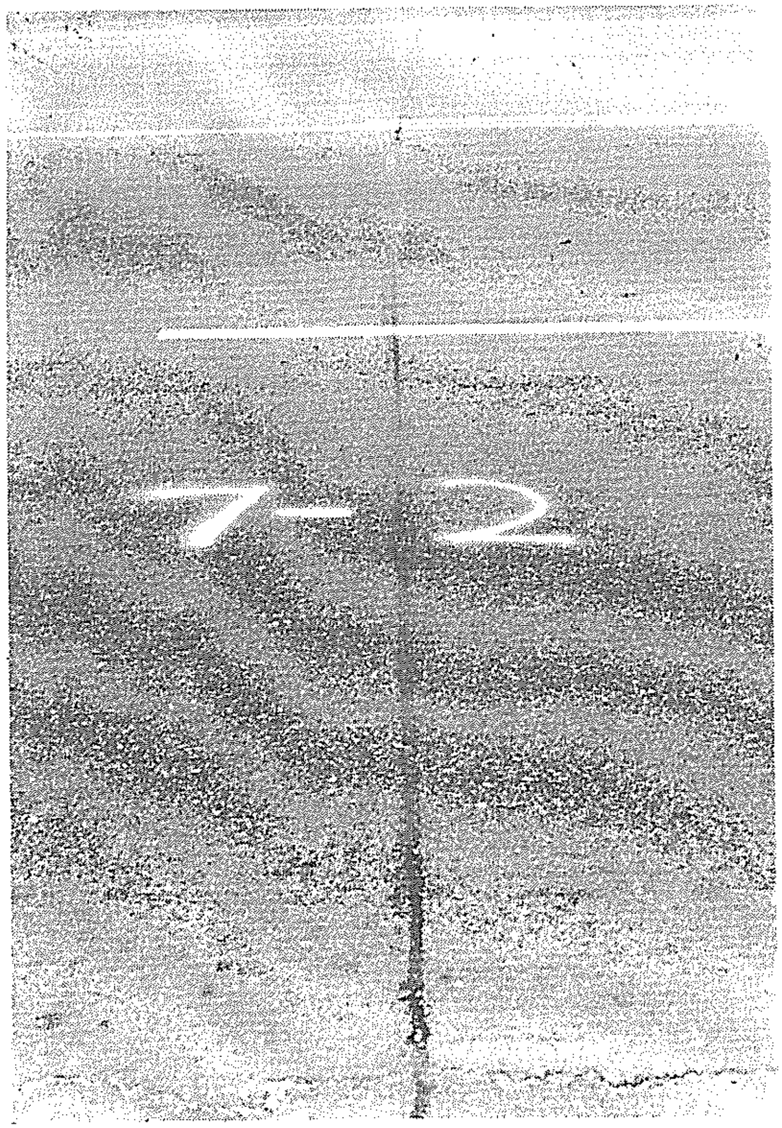


Test section 6. Slightly distressed sawed and sealed joint (with latex-modified asphalt cement).

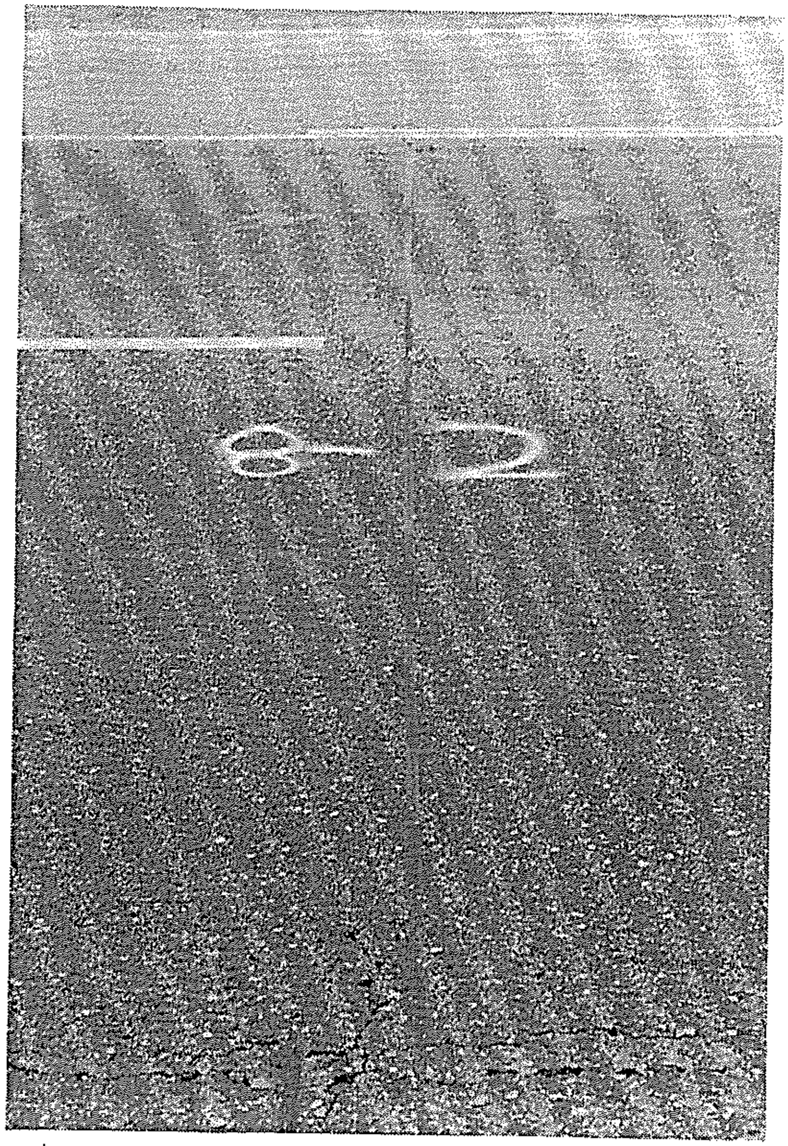
Test section 6. No-distress sawed and sealed joint (with latex-modified asphalt).



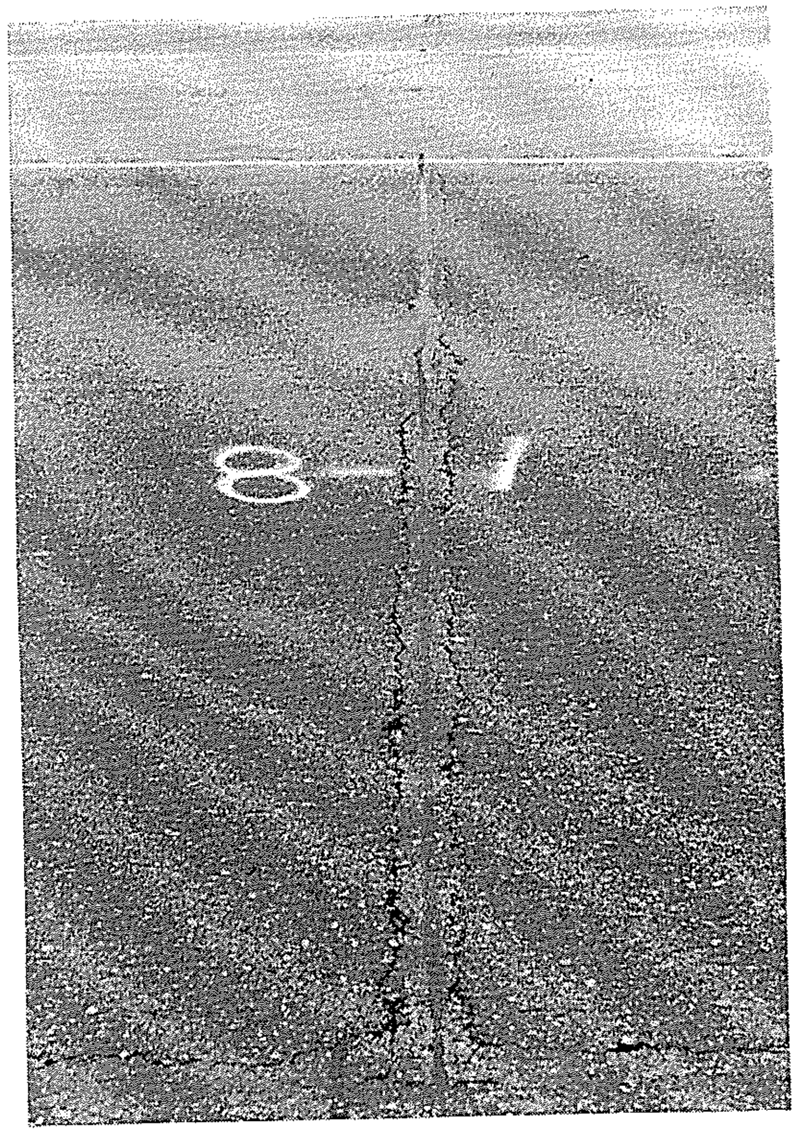
Test section 7. No-distress sawed and sealed joint.



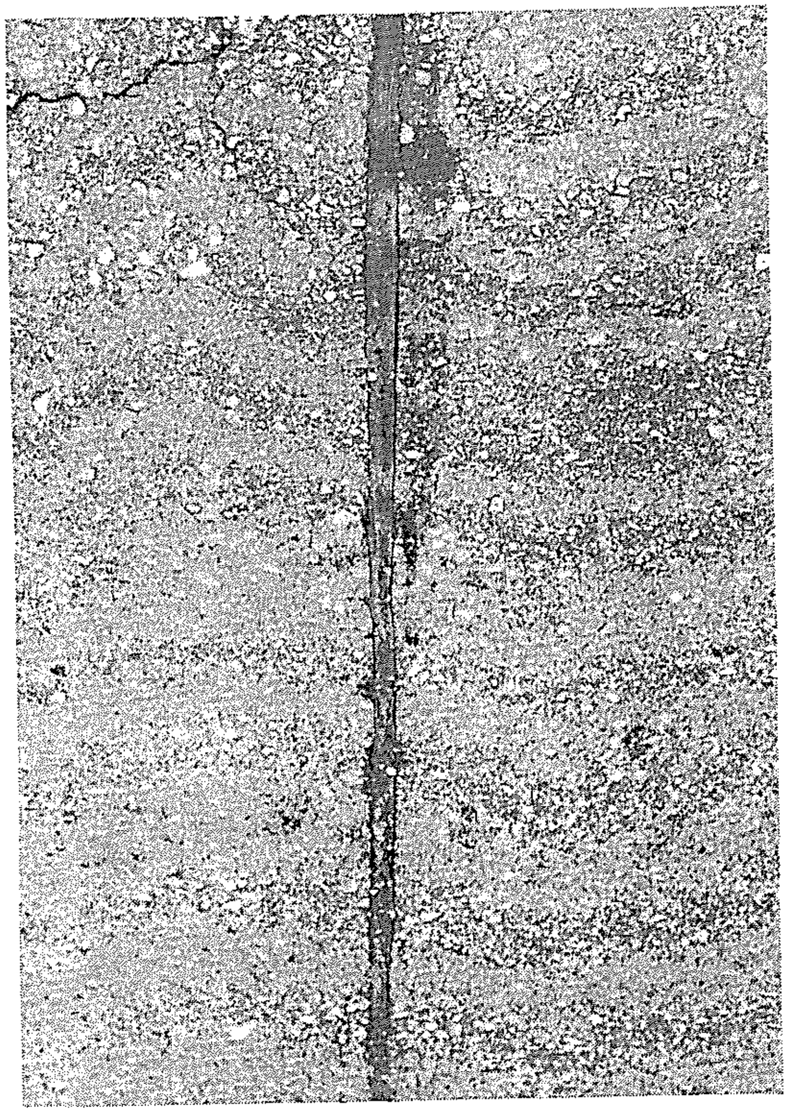
Test section 7. Slightly distressed sawed and sealed joint.



Test section 8. Distressed sawed and sealed joint (with conventional asphalt cement).



Test section 8. Sawed and sealed joint with
no transverse cracking (with conventional asphalt).



Close-up of sawed and sealed joint.