POST CONSTRUCTION EVALUATION

OF

SULPHUR-ASPHALT PAVEMENT TEST SECTIONS

Interim Report No. 3

FCIP Study No. 1-10-75-512

by

D. Saylak

B. Gallaway

Prepared For

State Department of Highways and Public Transportation

May 1977

Purpose:

To conduct post-construction testing and evaluation of a sulfur-asphalt binder concrete pavement test section located on US 69, 15 miles north of Lufkin, Texas.

Sampling Period:

Six (6) months after opening to traffic.

Background:

During September 1975, a 3,650 foot section of roadway being constructed on US 69 in Angelina County, Texas under Project RF 353(18), Contract No. 199-4 was set aside for a demonstration test of hot-mixed sulfur-asphalt pavement sections. These sections were constructed with a sulfur-asphalt emulsion (SAE) binder in accordance with a process developed by Societe Nationale des Petroles d' Aquitaine (SNPA).

At the completion of the pavement placement, cores were obtained from District 11, State Department of Highways and Public Transportation (SDHPT) and testing was completed in accordance with the test Matrix shown in Figure 1. A second set of cores was received from District 11 in August 1976. The results of tests performed on these cores appear in Interim Reports Nos. 1 and 2 published in January 1976 and October 1976, respectively.

In April 1977, a third shipment of cores was obtained from District 11. These cores were taken from the road six months after the facility was opened to traffic (12 months after the completion of construction). The latest test series was designed I + 6. Table 1 shows the current test results along with those taken for the preliminary (P), Initial (I) and I+6 data series, associated mix designs and location along the roadway. The engineering properties with respect to the various mixture designs for the

I + 6 test series are shown in Table 2. A comparison of the properties of each mix type at the initial testing phase (I) and the I + 6 phase is shown in Table 3.

Tables 1 through 3 indicate that the densification process continued during the first six months that the pavement was open to traffic. Accordingly, the air void content of nearly every pavement type at each location was significantly decreased. The Hveem stability values increased at most stations, but slightly decreased at others. The Marshall stability values show a substantial increase at nearly every benchmark; while Marshall flow values remain approximately the same or displayed slight decreases. The splitting tensile strength test results displayed erratic behavior with values for some stations increasing, some decreasing and some remaining relatively stable. Most of these increases and decreases did not exceed 25 to 30 percent with the majority being around 5 percent. These variations are usually attributed to a combination of differences in the pavement material as placed and to random experimental error. The resilient modulus values remained essentially unchanged for many sections but decreased at other stations. There appeared to be a marked decrease in the M_R values for all Type D mixes containing either pure asphalt or a sulfur-asphalt binder.

During this reporting period thermal expansion tests were conducted and these data are shown in Table 4. These data indicated that no significant difference in the thermal expansion characteristics of these pavement mixes are created due to the presence of sulfur. All values range between 29 and 35 x 10^{-6}/°C. Thus, no differential expansion problems should be encountered at the interface between a sulfur-asphalt pavement and a conventional asphaltic concrete.

Visual Survey

On site visual surveys were recently made of the sulfur-asphalt test sections, the controls at the site and the conventional paving north of the test site by B. M. Gallaway of Texas Transportation Institute and Morgan Prince of State Department of Highways and Public Transportation. This survey revealed no distress of any significance in the test sections wherein sulfur-asphalt emulsion was used; however, considerable rutting has occurred in the conventional section north of the sulfur-asphalt test sections.

Scattered measurements of rutting were made in both the conventional section north of the test section and in the sulfur-asphalt sections. These measurements indicated 0.6 to 0.8 inches (15 to 20 mm) ruts in the conventional section while ruts in the sulfur-asphalt section measured 0.1 in. (2.5mm) or less.

Cores taken from the conventional paving north of the test site indicated stripping in the rutted areas. No stripping was evident in the sulfur-asphalt cores.

Tentatively, at least, it appears that the addition of sulfur to the asphalt has precluded stripping. Stripping is the apparent cause of rutting in the conventional paving north of the test site.

Conclusion:

Test results indicate the test section is experiencing normal densification from traffic loads. Visual inspection revealed no unusual performance problems associated with the experimental test material after six (6) months service.

Figure 1 - Testing Matrix

Test Description	Preliminary P	Initial I	I+6	I+12	I+18	I+24
1. Traffic Analysis						
a. Average Daily Traffic Count		←	continuous			→
b. Truck and Axle Weight Distribution		○				○
2. Visual Evaluation	△	△	△	△	△	△
3. Mays Meter (PSI)	△	△	△	△	△	△
4. Benkelman Beam Deflections	△	△	△	△	△	△
5. Dynaflect Deflections	△	△	△	△	△	△
6. Cored Samples						
a. Density; b. Stability, Marshall; c. Stability, Hveem; d. Resilient Modulus; e. Indirect Tension — set of 6 cores (min) at each test section per sampling period	△	△	△	△	△	△
f. Rice Specific Gravity	⊥					
g. Thermal Expansion	⊥					
7. Skid Resistance	△	△	△	△	△	△

○ Loadometer survey, 1-week duration

△ Evaluations on both sulfur-asphalt binder and asphalt binder pavement sections

⊥ Initial evaluation of paving materials

NOTES: 1. Preliminary testing will be performed at completion of pavement placement.
2. Initial testing will be performed one week after pavement is open to traffic.
3. Skid tests will be made on surface with s/a binder on the project but not at site of test section.

TABLE 1. TEST RESULTS FOR PRELIMINARY INITIAL AND INITIAL + 6 MONTHS SAMPLINGS

Mixture Type	Binder Content percent	Station			Density (pcf)			Rice Spec. Gravity	Air Voids, percent			Hveem Stab., percent			Marshall Stab., (lbs)			Marshall Flow (0.01 in)			Splitting Tensile Strength (psi)			Resilient Modulus x 10^6, (psi)		
		P	I	I+6	P	I	I+6	Gravity	P	I	I+6	P	I	I+6	P	I	I+6	P	I	I+6	P	I	I+6	P	I	I+6
HMAC	4.8	202+58	202+26	202+23	138	139	143	2.43	8	9	5	21	28	31	390	550	1010	16	14	12		170	120	0.24	0.84	0.59
(AC)	4.8		201+26	201+23		140	144	2.44		8	4		26	38		620	1140		13	12		150	125		0.67	0.59
	4.8	169+59	169+56	169+53		141	142	2.41		5	5		27	28		500	1280		15	13	50	160	130		0.78	0.52
	4.8		168+56	158+53		141	142	2.42		6	5		26	28		760	1370		14	13		135	110		0.78	0.48
HMAC	4.8	172+59	172+56	172+53	138	140	142	2.44	8	11	7	22	27	25	430	490	1100	15	15	13	35	90	135	0.29	1.22	0.52
(SAE)	4.8		175+56	175+53		140	142	2.46		10	5		25	29		600	1350		16	13		95	95		1.00	0.50
	5.65	175+60	175+56	175+53	134	142	144	2.44	11	8	4	19	22	26	220	630	1550	14	14	13	35	135	120	0.21	0.67	0.57
	5.65		172+56	172+53		143	144	2.44		7	4		28	30		710	1270		12	12		140	120		0.89	0.57
	5.65	197+10	198+26	198+23	137	140	142	2.44	8	11	5	18	31	32	200	720	1190	14	12	14		115	90	0.26	0.45	0.60
	5.65		195+26	195+23		143	143	2.46		7	6		31	33		710	1040		12	15		140	90		0.66	0.61
HOT SAND	5.4	202+59	202+26	202+23	119	119	119	2.44	21	22	22	15	21	19	350	650	620	14	14	15	30	90	100	0.16	0.31	0.24
(AC)	5.4		201+26	201+23		119	122	2.43		21	19		21	22		720	860		14	14		90	90		0.24	0.30
	5.4	179+60	179+56	179+53	113	124	121	2.44	22	20	19		19	21	70	1480	1480	15	16	13		90	90	0.11	0.35	0.28
	5.4		178+56	178+53		117	125	2.39		20	17		16	24		1020	1480		23	14		95	105		0.15	0.36
HOT SAND	6.0	183+59	183+42	183+39	113	121	121	2.42	23	21	20	21	24	22	170	340	960	13	12	12		80	65	0.13	0.28	0.24
(SAE)	6.0		182+56	182+53		118	121	2.46		25	17		24	19		1400	850		13	13		80	75		0.32	0.22
	6.0	195+60	195+26	195+23		118	119	2.44		22	22		32	20		560	960		14	13	30	70	60		0.31	0.29
	6.0		198+26	198+23		118	119	2.46		24	21		22	21		630	860		16	14		70	75		0.35	0.28
	6.35	186+59	186+26	186+23	115	121	121	2.40	21	20	22	20	23	20	20	610	730	15	14	13		95	85	0.14	0.36	0.18
	6.35		185+26	185+23		122	123	2.44		19	21		24	20		1350	950		12	13		90	85		0.25	0.28
	7.1	189+59	189+26	189+23	117	122	125	2.40	20	20	16	24	22	23	140	510	850	18	13	13	30	135	70	0.20	0.37	0.26
	7.1		191+26	191+23		121	125	2.43		22	17		22	27		520	850		15	12		100	80		0.21	0.26

TABLE 2. TEST RESULTS FOR EACH MIX DESIGN FOR THE INITIAL + 6 MONTHS TESTING PHASE

SAMPLE TYPE	BINDER CONTENT percent	DENSITY (pcf)	RICE SPEC. GRAVITY	AIR VOIDS percent	HVEEM STAB. percent	MARSHALL		SPLIT TENSILE (psi)	RESILIENT MODULUS ($x10^{-6}$ psi)
						STAB. (lbs.)	FLOW (0.01in)		
HMAC (AC)	4.8	143	2.42	5	31	1200	13	120	0.55
HMAC (SAE)	4.8	142	2.45	6	27	1230	13	115	0.51
	5.65	144	2.45	5	30	1260	14	105	0.59
HOT SAND (AC)	5.4	122	2.43	19	22	1110	14	95	0.29
HOT SAND (SAE)	6.0	120	2.45	20	21	910	13	70	0.26
	6.35	122	2.45	22	20	840	13	85	0.23
	7.1	125	2.43	17	25	850	13	75	0.26

TABLE 3. INITIAL AND INITIAL + 6 MONTHS TEST RESULTS FOR EACH DESIGN

Sample Type	Binder Content percent	Density (pcf)		Rice Specific Gravity	Air Voids percent		Hveem Stability percent		Marshall Stability (lb)		Marshall Flow (0.01 in)		Splitting Tensile Strength (psi)		Resilient Modulus x 10^6 (psi)	
		I	I+6		I	I+6	I	I+6	I	I+6	I	I+6	I	I+6	I	I+6
HMAC (AC)	4.8	140	143	2.43	7	5	27	31	610	1200	14	13	155	120	0.07	0.55
HMAC	4.8	140	142	2.47	11	6	26	27	50	1230	16	13	95	115	1.11	0.51
(SAE)	5.65	142	144	2.45	8	5	28	30	690	1260	13	14	135	105	0.66	0.59
HOT SAND (AC)	5.4	120	122	2.45	21	19	19	22	970	1110	17	14	90	95	0.26	0.29
HOT SAND	6.0	119	120	2.46	23	20	26	21	730	910	14	13	75	70	0.31	0.26
(SAE)	6.35	122	122	2.46	20	22	24	20	980	840	13	13	95	85	0.30	0.23
	7.1	122	125	2.45	21	17	22	25	510	850	14	13	20	75	0.29	0.26

TABLE 4. THERMAL EXPANSION RESULTS FOR MIXES FROM LUFKIN FIELD TRIALS

MIX TYPE	BINDER %	BINDER TYPE	COEFFICIENT OF THERMAL EXPANSION /°C	COEFFICIENT OF THERMAL EXPANSION /°C
Type D	4.8	AC	30.3×10^{-6}	31.2×10^{-6}
	4.8	AC	32.0×10^{-6}	
	4.8	SAE	30.9×10^{-6}	31.0×10^{-6}
	4.8	SAE	31.2×10^{-6}	
	5.65	SAE	29.7×10^{-6}	30.8×10^{-6}
	5.65	SAE	31.9×10^{-6}	
Hot Sand	5.4	AC	32.4×10^{-6}	32.4×10^{-6}
	6.0	SAE	32.8×10^{-6}	33.2×10^{-6}
	6.0	SAE	33.6×10^{-6}	
	7.1	SAE	35.3×10^{-6}	35.2×10^{-6}
	7.1	SAE	35.1×10^{-6}	

Figure 1. Maintenance Rating Form for Flexible Pavements

DISTRICT NO. 11
RATERS GALLAWAY
DATE MONTH 5 DAY 13 YEAR 1977

LOCATION

FOREMAN NO.	
HIGHWAY CLASS	US
COUNTY NO.	3-ANGELINA
HIGHWAY NO.	US69
CONTROL	199
SECTION	4
FROM	
TO	
LANE	Both-South Bound
MAYS METER	74.0

PAVEMENT

RUTTING (%AREA)	① 1-15 ② 16-30 ③ >30	SLIGHT / MODERATE / SEVERE	< 0.1 in South Sec. > 0.5 in Control Sec
RAVELING (%AREA)	① 1-15 ② 16-30 ③ >30	SLIGHT / MODERATE / SEVERE	- NONE -
FLUSHING (%AREA)	① 1-15 ② 16-30 ③ >30	SLIGHT / MODERATE / SEVERE	- NONE -
CORRUGATIONS (%AREA)	① 1-15 ② 16-30 ③ >30	SLIGHT / MODERATE / SEVERE	- NONE -
ALLIGATOR CRACKING (%AREA)	① 1-5 ② 6-25 ③ >25	SLIGHT / MODERATE / SEVERE	- NONE -
LONGITUDINAL CRACKING (LIN. FT. PER. STA/LN)	① 0-99 ② 100-199 ③ >200	SLIGHT / MODERATE / SEVERE	- NONE -
TRANSVERSE CRACKING (NO. PER STA.)	① 1-4 ② 5-9 ③ >10	SLIGHT / MODERATE / SEVERE	- NONE -
CRACKS (1) SEALED (2) PARTIALLY SEALED (3) NOT SEALED			
PATCHING (%AREA)	① 1-5 ② 6-15 ③ >16	GOOD / FAIR / POOR	- NONE -
FAILURES / MILE	① 1-5 ② 6-10 ③ >10		

SHOULDER

PAVED	RIDE	Excellent
	CONTRAST	Good
	PAVEMENT EDGE	Smooth
	SHOULDER EDGE	Smooth
	CRACKS	None
	RAVELING OR FLUSHING	None
	VEGETATION	Modest
UNPAVED	PAVEMENT EDGE	
	RUTTING, CORRUGATIONS, LOOSE ROCK	

ROADSIDE AND DRAINAGE

LITTER	Slight
MOWING	Scheduled
VEGETATION	—
SLOPE EROSION	Minimal
CULVERTS	OK
DITCHES, OUTFALL, CHANNELS	Slight Prob.
ROADSIDE DRAINAGE	Acceptable

TRAFFIC SERVICE

GUARDRAILS	
SIGNS	
DELINEATORS	Not Appl.
STRIPING	
AUXILIARY MARKINGS	

OTHER	