Field Trials of Sulphur-Extended-Asphalt in Open Graded Friction Course

Loop 495, Nacogdoches, Texas

Progress Report No. 2

TTI Project 2547

FCIP Study No. 1-11D-80-547

by

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and

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Purposes

The purposes of FCIP Study No. 1-11D-80-547 are to conduct and report on post-construction testing and evaluations that have been carried out for the sulphur-extended-asphalt (SEA) open graded friction course (OGFC) experimental test section on Loop 495 located in Nacogdoches, Texas and District 11 of the Texas State Department of Highways and Public Transportation (SDHPT).

Background

On August 7 and 8, 1980, a 9600-foot (2928-m) length of the two northbound lanes of Loop 495 was paved with approximately 1 inch (25.4 mm) of 35/65 composition SEA binder OGFC as a demonstration for SEA paving mixtures. A schematic of this test section appears in Figure 1.

The construction of this SEA binder OGFC experimental section was made possible by a "Field Change" in the contract between Moore Brothers Construction Company of Lufkin, Texas and the SDHPT on Project CSB 138-2-26, etc. for Loop 495 in Nacogdoches. A separate agreement was made between Moore Brothers and the Sulphur Institute whereby the Institute would reimburse Moore Brothers for additional costs incurred for placing the SEA binder OGFC, above those costs for placing the conventional asphalt cement binder OGFC.

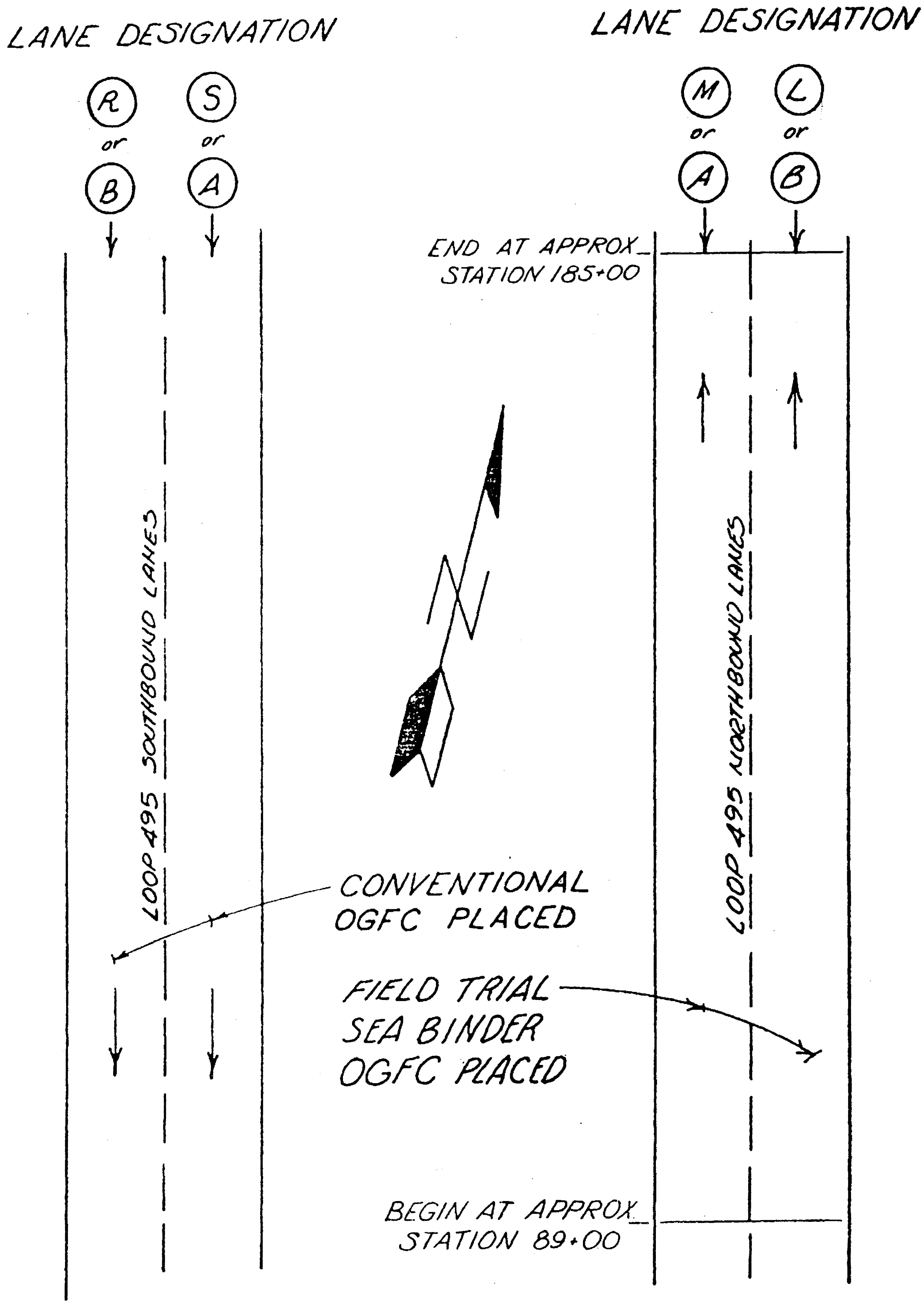

Figure 1. Schematic plan layout of Loop 495 travel lanes for field trials

There were four original objectives for the SEA binder OGFC field trials on Loop 495 which were as follows: (1) to employ SEA binder for the first time in a Texas OGFC pavement; (2) to evaluate the introduction of sulphur and asphalt cement into a dryer-drum using separate streams (All previous of uses of SEA binders had been in weigh-batch plants.); (3) to determine differences in properties of OGFC designs using SEA binder and conventional asphalt cement as related to production, laydown, compaction and performance under traffic and (4) to continue to evaluate construction associated emissions from SEA binders.

Research Report 547-1 dated January, 1981 describing the construction details for the SEA binder OGFC experimental section has been prepared and submitted to the SDHPT (1). Available upon request, this report provides details concerning materials, mix designs, equipment, plant operations, materials handling, quality control and evolved sulphur gas emissions data (1).

Since construction of the field trials on Loop 495, SDHPT and Texas Transportation Institute (TTI) personnel have collected pavement cores and conducted pavement evaluation tests on both the SEA binder OGFC and the two adjacent asphalt cement binder OGFC control lanes on Loop 495. This history of testing to date is shown in the testing matrix in Figure 2. A discussion of the pavement evaluation tests and results through 1982 is given in the sections of this progress report which follow.

Test Description	SEA OGFC Project Is Open To Traffic August 9, 1980 To*	Sept. 1980 To+1mo.	Jan. 1981 To+6mo.	May 1981 To+10mo.	Aug 1981 To+12mo.	Aug 1982 To+24mo.	Aug 1983 To+36mo	Aug 1984 To+48mo
1. Traffic Analysis								
a. ADT, % Trucks								
b. 18 kip ESAL	X	. Continuous . .	. . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . .X
2. Visual Evaluation for PRS		X			X	X	X	X
3. Mays Meter for SI		X			X	X	X	X
4. Dynaflect Deflections		X			---	---	---	X
5. Skid Resistance Measurements		X			X	X	X	X
6. Texture Measurements		X			X	X	X	X
7. Field Permeability, Measurements		X		X	---	X	X	X
8. Cored Samples					X	X	X	X
a. Resilient Moduli					X	X	X	X
b. Air Voids					X	X	X	X
c. Specific Gravities					X	X	X	X
9. Progress Reports					X	X	X	
10. Interim (Construction) Report			X					
11. Final Report								X

*Note: Conventional asphalt cement binder OGFC control section was opened to traffic June 17, 1980, or seven weeks earlier than SEA binder OGFC.

Figure 2. Testing and reporting schedule for Loop 495, Nacogdoches, Texas.

Test Results

Tables 1 and 2 summarize the results of field testing on the travelled and passing lanes, respectively, of Loop 495 through August, 1982, or through two post-construction evaluation periods. References (2), (3), (4) and (5) contain the procedures for the pavement rating score, PRS; serviceability index, SI; Dynaflect deflection and field permeability test. Skid numbers, SN's, were determined with a SDHPT Standard ASTM E-274 skid trailer (6), and surface texture measurements were taken using the SDHPT Sand-Patch Method (7).

Table 3 contains the results of laboratory testing on field cores taken to date. The specific methods of testing utilized are listed below:

Resilient modulus, M_R, at 77°F	as per Schmidt (8)
Bulk specific gravity	ASTM D-2726-73 (6)
Rice specific gravity	ASTM D-2041-78 (6)
Percent air voids	as per Benson et al. (1)

Table 4 contains the traffic estimates for Loop 495 from 1980 through 1983. The anticipated annual growth rate for Loop 495 is 1.1 percent for 1983. As indicated in this table, the traffic in the northbound SEA OGFC lanes has been running about 45 percent of the total traffic. However, correspondence from SDHPT Division 10 to Fred C. Benson on December 21, 1982 indicated that the latest traffic count showed a 50-50 directional split. Other traffic counts at East Texas State University (to the south) in 1975 and 1981 re-

Table 1. Results of field testing on travelled lanes of Loop 495 OGFC.

Pavement Section	Pavement Rating Score (PRS) Percent	Average Serviceability Index (SI)	Maximum Dynaflect Deflections, 10^{-3} Inches	Average Skid Numbers $SN_{40}(SN_{20})$	Average Texture Measurements Inches	Average Field Permeability K_v, cm/sec	Date of Test
35/65 SEA	98	4.2	0.828	40(47)	0.093	0.525	9-9-80
Binder	--	---	---	---	---	0.279	5-28-81
OGFC	98	4.2	---	36(44)	0.085	---	8-11-81
Lane L or B (Northbound)	95	3.6	---	42(--)	0.073	0.203	8-12-82
Conventional	96	3.9	0.893	39(46)	0.095	0.467	9-9-80
Asphalt Cement	--	---	---	---	---	0.283	5-28-81
Binder OGFC	95	3.9	---	32(40)	0.077	---	8-11-81
Lane R or B (Southbound)	87	3.6	---	32(--)	0.066	0.151	8-12-82

Note: --- Test not taken this date.

Table 2. Results of field testing on passing lanes of Loop 495 OGFC.

Pavement Section	Pavement Rating Score (PRS) Percent	Average Serviceability Index (SI)	Maximum Dynaflect Deflections, 10^{-3} Inches	Average Skid Numbers $SN_{40}(SN_{20})$	Average Texture Measurements Inches	Average Field Permeability K_v, cm/sec	Date of Test
35/65 SEA Binder OGFC Lane M or A (Northbound)	99	4.4	0.763	41(48)	0.103	0.533	9-9-80
	--	---	---	---	---	0.374	5-28-81
	95	4.1	---	42(47)	0.090	---	8-11-81
	93	3.9	---	44(--)	0.081	0.184	8-12-82
Conventional Asphalt cement Binder OGFC Lane S or A (Southbound)	97	4.1	0.831	43(51)	0.091	0.432	9-9-80
	--	---	---	---	---	0.338	5-28-81
	97	4.0	---	40(47)	0.086	---	8-11-81
	92	3.9	---	43(--)	0.076	0.189	8-12-82

Table 3. Results of field core testing on Loop 495.

	Pavement Section				Date of Coring
	35/65 SEA Binder OGFC		Conventional Asphalt Cement Binder OGFC		
	Lane L	Lane M	Lane R	Lane S	
Average Air Voids Percent	34 (13*) 21 (3*) 17 (3*) 20 (5*)	30 (15*)	19 (14*) 31***(3*) 16 (3*) 16 (5*)	24 (7*)	9-9-80 8-10-81 8-10-81** 9-3-82
Average Bulk Specific Gravity	2.194 (13*) 2.138 (3*) 2.255 (3*) 2.232 (5*)	2.299 (15*)	2.129 (14*) 2.069 (3*) 2.153 (3*) 2.204 (5*)	2.142 (7*)	9-9-80 8-10-81 8-10-81** 9-3-82
Average Rice Specific Gravity	2.359 (3*) 2.352 (3*) 2.378 (3*) 2.400 (5*)	2.333 (2*)	2.263 (3*) 2.232 (3*) 2.320 (3*) 2.324 (5*)	2.240 (3*)	9-9-80 8-10-81 8-10-81** 9-3-82
Resilient Modulus M_R, 10^6 psi	0.062 (2*) 0.073 (3*) 0.087 (3*) 0.155 (5*)	0.054 (4*)	0.055 (1*) 0.053 (3*) 0.097 (3*) 0.084 (5*)		9-9-80 8-10-81 8-10-81** 9-3-82

*Number in parenthesis indicates number of samples tested.

**These were laboratory remolded specimens made from cores.

***These cores were damaged in shipping.

Table 4. Traffic estimates for Loop 495.

	1980	1981	1982	1983
1. Average Daily Traffic (ADT) (Northbound SEA Lanes)	9,620	9,800 (4,450)	10,000 (4,500)	10,100 (4,550)
2. Directional Distribution Factor, Present	60-40	60-40	60-40	60-40
3. Design Hour Volume (DHV) Percent	10.9	10.9	10.9	10.9
4. Percent Truck				
a. ADT	5.0	5.0	5.0	5.0
b. DHV	3.0	3.0	3.0	3.0
5. Anticipated Annual Growth Rate, Percent	2.0	2.0	2.0	1.1
6. Average of Ten Heaviest Wheel Load Daily (ATHWLD), Pounds	11,300	11,300	11,300	11,400
7. Tandem Axles in ATHWLD, Percent	70	70	70	70

vealed the northbound traffic to be from 51.2 to 48.7 percent of the total traffic.

Discussion of Results

As shown in Tables 1 and 2, for both travelled lanes L and R and passing lanes M and S of Loop 495, some declines have occurred in values for Pavement Rating Scores, PRS; average Serviceability Index, SI; average texture and field permeability, K_v. The greatest declines have occurred in field permeability for all lanes, PRS for Lane R and SI for Lane L.

SI values are approximately equal for all lanes, with those in the travelled lanes being somewhat lower but still very acceptable at 3.6 for both lanes. Average texture depths are approximately equal for all four lanes and still very high as of August, 1982. Textures are slightly higher for the SEA OGFC lanes.

Average field permeability is somewhat higher for SEA Lane L than for conventional binder Lane R of the travelled lanes. Field permeabilities for the two passing lanes are approximately equal.

As shown in Tables 1 and 2, average skid numbers, SN_{40}'s, have not declined for any lane since 1981. These 1982 values average in the forties for all lanes except Lane R, with an SN_{40} average of 32, which is the travelled lane of the southbound conventional asphalt cement binder OGFC lanes. Indeed, skid numbers are higher for Lanes L, M and S for 1982 versus 1981.

It is notable that the skid numbers are holding much better for SEA OGFC Lane L than for Lane R. As discussed earlier, the traffic volumes for the northbound lanes of Loop 495 are at least 45 percent of the total volume and may be closer to 50 percent. The probable reason for the lower skid numbers in Lane R is the much greater area of incipient flushing present than in Lane L, although some near flushed areas occur in all four lanes of Loop 495.

Table 3 gives results for averages of bulk specific gravity, Rice specific gravity, percent air voids and resilient modulus, M_R, values obtained from cores taken from the SEA and conventional binder OGFC paving on Loop 495 from 1980 through 1982. From inspection of this table the general trend for the SEA OGFC cores to have somewhat higher average values for each test is seen to continue for 1982 also.

According to 1982 results, the SEA binder OGFC travelled Lane L has a somewhat higher air voids content at 20 percent than the conventional binder OGFC travelled Lane R. Also, these results indicate that neither lane has closed up appreciably since 1981, with 1982 air void contents being approximately equal to the 1981 values.

Resilient modulus, M_R, results in Table 3 indicate the 1982 SEA binder OGFC cores to be undergoing stiffening relative to 1981 core test results. The 1982 M_R results for Lane L are about twice of those for Lane R, which are slightly less than for 1981 Lane R results.

Conclusions

Both SEA binder OGFC and conventional binder OGFC pavements on Loop 495 are performing well as of August 1982. Most test results show the SEA binder OGFC pavement to be performing somewhat better than the control asphalt cement binder OGFC pavement.

The notable features are (1) how well the skid numbers on all four lanes of Loop 495 have held from 1981 to 1982 and (2) the large difference between the average skid numbers for SEA OGFC Lane L and conventional OGFC binder Lane R, both being travelled lanes.

Concerning flushing which is the main distress on Loop 495, all four lanes contain spots, some of which are probably caused by underlying patches. Some significant flushing is present in the passing lane, Lane M, of the Loop 495 northbound SEA OGFC lanes, especially near intersections and median turn openings. The two southbound conventional OGFC lanes are the most affected by flushing or near flushing, especially Lane R.

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