Field Trials of Sulphur-Extended-Asphalt in Open Graded Friction Course
Loop 495, Nacogdoches, Texas

Progress Report No. 1

TTI Project 2547

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

Report No. 547-2

by

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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 evaluation 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 in 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) section of the two northbound lanes of Loop 495 was paved with approximately 1 inch (25.4 mm) of 35/65 SEA binder OGFC as a demonstration for SEA paving mixtures. A schematic illustration 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 State Department of Highways and Public Transportation on SDHPT 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.

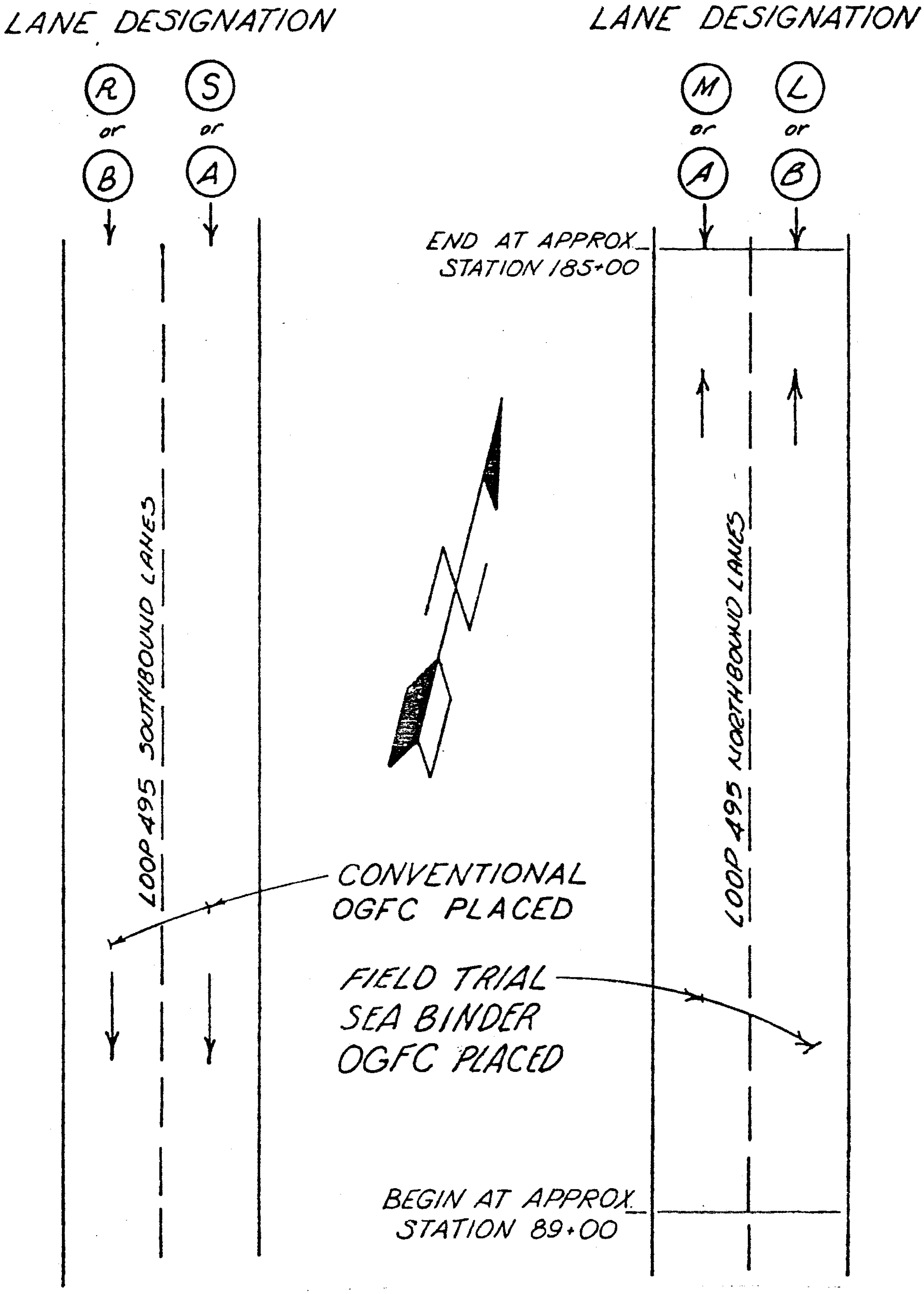

Figure 1. Schematic plan layout of Loop 495 travel lanes for field trials

There were four original principal objectives for the SEA binder OGFC field trials on Loop 495, and these 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 of these materials. (All previous uses of SEA binders have been in weight 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 sulphur gas 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 and is available upon request. The report describes details of materials, mix designs, equipment, plant operation, materials handling, quality control and evolved sulphur gas emissions data (1).

Since construction of the SEA binder OGFC experimental section in August, 1980, SDHPT and TTI personnel have collected pavement cores and conducted other 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 the results are given in the sections that 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	---	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 the passing lanes, respectively, of Loop 495 through August of 1981. 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 were determined with a SDHPT standard ASTM E-274 skid trailer (6) and texture measurements were taken using the SDHPT Sand-Patch Method (7).

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

Resilient Modulus, 77°F	as per Schmidt (8)
Bulk Specific Gravity	ASTM D-2726-73 (6)
Rice Specific Gravity	ASTM D-2041-78 (6)

Table 4 contains the traffic estimates for Loop 495 from 1980 through 1982. The anticipated annual growth rate for Loop 495 is two percent.

Discussion of Results

As shown in Tables 1 and 2 for both the travelled lanes L and R and the passing lanes M and S, average values of Serviceability Index, SI; average skid number, SN_{40} (SN_{20}); surface texture; and field permeability, K_v, for the SEA OGFC have remained either somewhat higher or about equal to those for the conventional asphalt cement binder OGFC. These differences do not appear to be significant at this time. Concerning field permeabilities, the trend for both the travelled and passing lanes is for the permeabilities to become approximately equal at an age of 10 months service for the SEA binder OGFC and 11 months service for the conventional binder OGFC.

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)	.093	0.525	9-9-80
Binder	--	---	---	---	---	0.279	5-28-81
OGFC	98	4.2	---	36(44)	.085	---	8-11-81
Lane L or B							
(Northbound)							
Conventional	96	3.9	0.893	39(46)	.095	0.467	9-9-80
Asphalt Cement	--	---	---	---	---	0.283	5-28-81
Binder OGFC	95	3.9	---	32(40)	.077	---	8-11-81
Lane R or B							
(Southbound)							

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
Conventional Asphalt cement Binder OGFC Lane S or A (Southbound)	97	4.1	0.831	43(51)	.091	0.432	9-9-80
	--	---	---	---	---	0.338	5-28-81
	97	4.0	---	40(47)	.086	---	8-11-81

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

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

*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
1. Average Daily Traffic (ADT)	9,620	9,800	10,000
2. Directional Distribution Factor, Percent	60-40	60-40	60-40
3. Design Hour Volume (DHV) Percent	10.9	10.9	10.9
4. Percent Trucks			
a. ADT	5.0	5.0	5.0
b. DHV	3.0	3.0	3.0
5. Anticipated Annual Growth Rate, Percent	2.0	2.0	2.0
6. Average of Ten Heaviest Wheel Load Daily (ATHWLD), Pounds	11,300	11,300	11,300
7. Tandem Axles in ATHWLD, Percent	70	70	70

The original overall permeabilities for the SEA binder OGFC were an average of 18 percent higher in September, 1980. This was due, most likely, to a difference in accumulated traffic applications.

Tables 1 and 2 show the average skid numbers at both 40 mph (64.4 km/h) and 20 mph (32.2 km/h) to have declined slightly since September 1980 for both pavements. The greatest decline is in the conventional binder OGFC pavement surface of the travelled lanes.

The Pavement Rating Scores for all the pavement surfaces are high, with the largest decline in PRS coming in the SEA binder OGFC passing lane M due to a slight decline in Serviceability Index and the incidence of a small amount of flushing at the beginning of the placement and at one intersection. Some flushing has also occurred in the conventional binder OGFC travelled lane at a plant entrance at the south end of the project.

Table 3 shows the results of laboratory tests conducted on cores taken from the OGFC pavements. Generally, average values for bulk specific gravities, Rice specific gravities and resilient moduli have changed little for either the SEA binder or conventional binder OGFC cores. Air voids in the SEA binder pavement OGFC cores show a decline from approximately 32 percent to 21 percent from 1980 to 1981. Remolded cores for 1981 give a 17 percent air voids. The August, 1981 value of 31 percent for air voids in the conventional binder OGFC cores appears too high and is probably due to damaged cores causing high measurements for core volume. Remolded cores for 1981 give a 16 percent air voids for the conventional binder OGFC which is similar to the SEA binder OGFC cores.

Conclusions

Both SEA binder OGFC and conventional binder OGFC pavements on Loop 495 are performing well. Most test results show the SEA binder OGFC pavement to be performing slightly better than the control.

REFERENCES

1. Benson, F. C. and Gallaway, B. M., "Field Trials of Sulphur-Extended-Asphalt Binder in Open Graded Friction Course Loop 495, Nacogdoches, Texas", Research Report 547-1, prepared under Demonstration Study 1-11D-80-547 for the Federal Highway Administration, January 1981.

2. Epps, J. A., Meyer, A. H., Larrimore, I. E. Jr., and Jones, H. L., "Roadway Maintenance Evaluation User's Manual", Research Report 151-2, Texas Transportation Institute, September 1974.

3. Goss, C. L., Hankins, K. D., and Hubbard, A. B., "Equipment for Collecting Pavement Roughness Information", Department Research Report No. 2-1, Texas State Department of Highways and Public Transportation, December 1976.

4. Scrivner, F. H. and Moore, W. M., "An Electro-Mechanical System for Measuring the Dynamic Deflection of a Road Surface Caused by an Oscillating Load", Research Report No. 32-4, Texas Transportation Institute, December 1964.

5. Britton, S. C., Gallaway, B. M. and Tomasini, R. L., "Performance of Open Graded Friction Courses", Texas Transportation Institute Research Report 234-1F, June 1979.

6. ___________, 1981 Annual ASTM Standards, Part 15, American Society for Testing and Materials, Philadelphia, Pennsylvania, 1980.

7. ___________, Manual of Testing Procedures, 400-A Series, Physical Section, State Department of Highways and Public Transportation, revision published by the Department, January 1978.

8. Schmidt, R. J., "A Practical Method for Measuring the Resilient Modulus of Asphalt Treated Mixes", Highway Research Record No. 404, Highway Research Board, Washington, D. C., 1972.