SDHPT 519-5

Post Construction Evaluation of Sand-Asphalt-Sulphur Test Section, Kenedy County, TX

Report No. 519-5

FCIP Study No. 1-9-76-519
DOT-FH-11-8608; Task Order No. 6
FHWA Expermental Project No. 06487600S

March, 1979

Technical Report Documentation Page

1. Report No. FHWA-TX-79-519-5	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Post Construction Evaluation of Sand-Asphalt-Sulphur Test Section, Kenedy County, Texas		5. Report Date March 1979
		6. Performing Organization Code
7. Author(s) Gallaway, B. M., Newcomb, D. E., Saylak, D.		8. Performing Organization Report No. 519-5 Interim Report No. 4
9. Performing Organization Name and Address Texas Transportation Institute Texas A&M University College Station, Texas 77843		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. FCIP DOT-FH-11-8608 T.O.#6
12. Sponsoring Agency Name and Address Federal Highway Administration, 400 7th St.,SW, Washington, DC 20591; The Sulphur Institute, 1725 K St., NW, Washington, DC 20006; U.S. Bureau of Mines, 500 Date St., Boulder City, Nevada 89005		13. Type of Report and Period Covered Interim Report
		14. Sponsoring Agency Code

15. Supplementary Notes

FHWA Exper. Proj 064876005

16. Abstract

This report is a part of the continuing post-construction evaluation of a sand-asphalt-sulphur field trial on US 77 in Kenedy County, Texas. This evaluation is now eighteen months old.

The report contains a brief description of background information, a statement of purpose, a summary of test results, and a brief analysis of the data.

Very little distress has been noted in the pavement. However, the test data seems to indicate that the job control asphaltic concrete is performing slightly better than the sand-asphalt-sulphur.

Previous reports which have been written on this post-construction evaluation include:

"Post Construction Evaluation of US 77, Kenedy County, Sulfur-Asphalt-Sand Pavement Test Sections," Interim Report No. 1, October, 1977.

"Beneficial Use of Sulphur in Sulphur-Asphalt Pavements," Quarterly Progress Report No. 1, February, 1978. (Interim Report No. 2)

"Beneficial Use of Sulphur in Sulphur-Asphalt Pavements," Interim Report No. 3, October, 1978.

17. Key Words field trial, sand, asphalt, sulphur, asphaltic concrete, post-construction evaluation.	18. Distribution Statement Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	15	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

POST CONSTRUCTION EVALUATION
OF
SAND-ASPHALT-SULPHUR
TEST SECTION, KENEDY COUNTY, TEXAS

Interim Report No. 4

FCIP Study No. 1-9-76-519

DOT-FH-11-8608 T. O. No. 6

Prepared by

B. M. Gallaway

D. E. Newcomb

D. Saylak

Prepared for

Federal Highway Administration

and

State Department of Highways and Public Transportation

Texas Transportation Institute

Texas A&M University

College Station, Texas

March, 1979

Post Construction Evaluation of Sand-Asphalt-Sulphur Test Section, Kenedy County, Texas

Introduction and Background:

During the month of April, 1977, a 3,000 ft. (915 m) section of U.S.77 in Kenedy County, Texas, five miles south of Sarita was set aside for a demonstration of sand-asphalt-sulphur paving mixtures. The experimental sections were placed in the two north-bound lanes between stations 1985+00 and 2015+00 in conjunction with Highway Project TQF 913(13) under the jurisdiction of District 21, Texas State Department of Highways and Public Transportation (SDHPT). The pavement was constructed under a concept which was developed and patented by Shell Canada Limited. This concept involves the utilization of sulphur as a structuring agent in paving mixtures which contain poorly graded sands. These sands are plentiful in many areas of the United States, particularly along the Gulf Coast States.

Through efforts initiated by the Sulphur Institute, and co-sponsored by the U. S. Bureau of Mines, the Texas Transportation Institute (TTI) has, during the past six years, conducted an extensive laboratory program to verify the sand-asphalt-sulphur (SAS) concept developed by Shell Canada. This effort is directed toward promoting the use of sulphur in asphaltic - aggregate mixtures in the United States. The construction of this test section represents the next stage of verification through field evaluation.

A construction report describing the details of design and placement of the test section is available upon request. The report includes details of materials, mix designs, equipment, materials handling, quality control, and evolved gas analyses (1).

Upon completion of the test sections, cores were obtained by District 21 personnel and a series of tests were run (2). Data were processed and a report was prepared. This testing period was designated as initial (I). At six-month intervals following construction, TTI personnel took cores and performed a series of tests on these cores. During the same six-month intervals SDHPT personnel collected field data in the form of Dynaflect deflections, Mays Ride Meter roughness measurements, and visual distress evaluations. Both in-situ testing and core testing have been performed in accordance with the Test Matrix presented in Figure 1. A detailed layout of the test sections is presented in Figure 2.

Purpose:

To conduct post-construction testing and evaluation of an SAS experimental test section located on U.S.77 in Kenedy County, Texas, in District 21 of the SDHPT.

Test Results and Discussion:

The results of the I+18 core testing are presented in Table 1. Table 2 compares all results of core testing through February, 1979. Specific methods of testing are listed below:

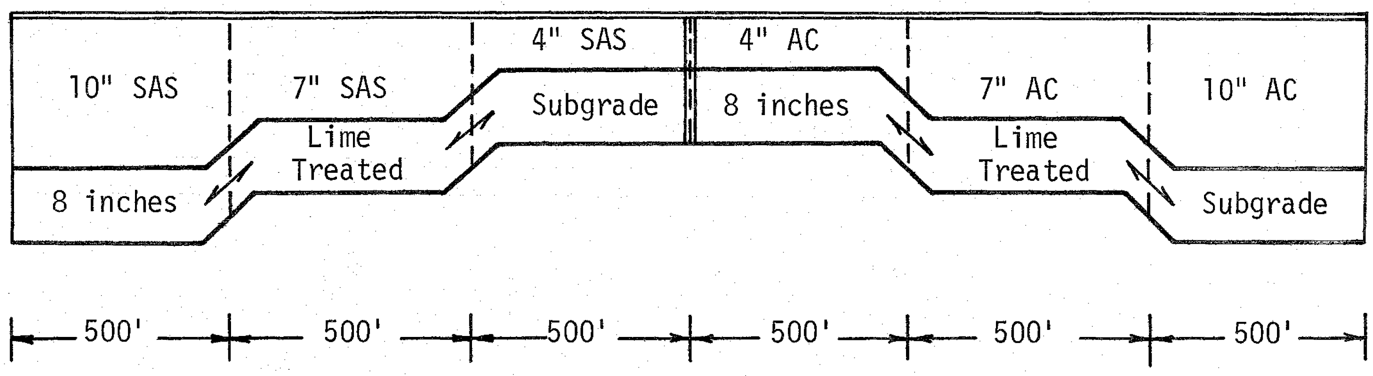
ASTM D-2041-71	Density
ASTM D-1559-73	Marshall Stability and Flow
ASTM D-1560-65	Hveem Stability
as per Schmidt (3)	Resilient Modulus, 68°F
ASTM C-0496-71	Indirect (Splitting) Tension
ASTM D-2041-71	Rice Maximum Specific Gravity

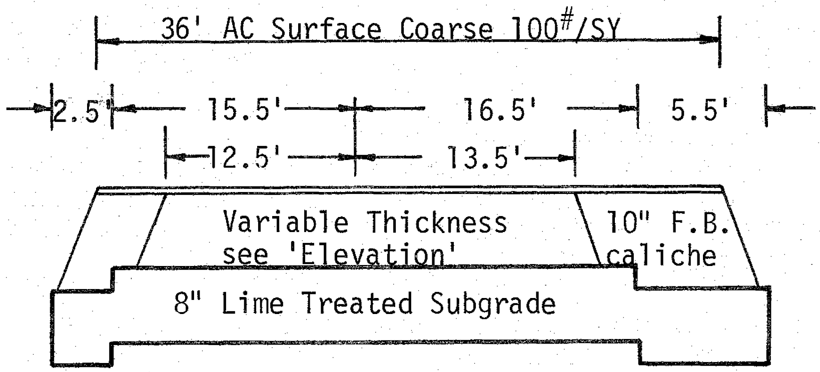
Table 2 shows that SAS has a consistently higher Marshall stability than the job control asphaltic concrete (AC). The Marshall flow is somewhat lower for the SAS sections. Also, the Hveem stability is slightly higher for the SAS sections. The resilient modulus and splitting tensile strength of the AC sections are significantly greater than those of the SAS sections.

Test Description	Initial* I	6 mo.	12 mo.	18 mo.	36 mo.
			Time Intervals		
1. Traffic Analysis					
a. Average Daily Traffic Count	←		continuous		→
b. Truck and Axle Weight Distribution	○				○
2. Visual Evaluation	△	△	△	△	△
3. Mays Meter (PSI)	△	△	△	△	△
4. Dynaflect Deflections	△	△	△	△	△
5. Core Samples**					
a. Field Density and Rice Specific Gravity	△	△	△	△	△
b. Stability, Marshall	△	△	△	△	△
c. Stability, Hveem	△	△	△	△	△
d. Resilient Modulus	△	△	△	△	△
e. Indirect Tension	△	△	△	△	△
6. Interim Reports	△	△	△	△	△

○ Loadometer Survey, 1-Week Duration
△ Evaluations on Both Sand-Asphalt-Sulphur Mixes and Conventional Asphaltic Concrete Sections
* Initial Testing Performed One Week After Pavement Opened To Traffic
** Set of 3 Cores (minimum) at Each Test Section Per Sampling Period (Each Lane)

Figure 1 Testing matrix for SAS Trials, US 77, Kenedy County, Texas





Cross-Section
N-S Right Lanes

SAS Sand-Asphalt-Sulphur Pavement Material

AC Asphaltic Concrete Pavement, Type D

Schematic Does Not Scale

1 in = 25.4 mm
1 ft = 0.305 m
1 lbm = 0.454 kg
1 yd^2 = 0.836 m^2

Figure 2 Layout of field test section in Kenedy County on U.S. 77

Table 1 Field core test results for December 1978

Type	Binder Content Percent	Specific Gravity	Marshall Stability (lbf)	Marshall Flow (0.01 in)	Hveem Stability Percent	Resilient Modulus at 68^{o}F	Splitting Tensile (psi)
11" SAS	$6.2/_{13}$*	2.02	1725	9	30	0.73	178
8" SAS	$6.2/_{13}$*	2.04	1977	9	36	0.77	168
5" SAS	$6.2/_{13}$*	2.05	1785	10	30	0.91	183
5" AC	6.2	2.29	660	13	25	1.52	291
8" AC	6.2	2.29	518	11	28	1.41	279
11" AC	6.2	2.29	644	11	29	1.54	262

* The mix design established for these systems was 6.2 weight percent asphalt and 13 weight percent sulphur.

1 lbf = 4.45 N
1 in = 25.4 mm
1 psi = 6.89 kPa

Table 2 Field core test results for all testing periods

Type	Binder Content Percent	Specific Gravity	Marshall Stability (lbf)	Marshall Flow (0.01 in)	Hveem Stability Percent	Resilient Modulus at 68°F (psi x 10^6)	Splitting Tensile (psi)	Date	Rice Max. Specific Gravity
11" SAS	6.2/13 *	2.02	1350	17	25	0.46	155	4/77(0)**	2.29
		2.20	1445	8	31	0.70	160	12/77(6)	
		2.04	2070	10	42	0.48	200	6/78(12)	
		2.02	1725	9	30	0.73	178	12/78(18)	
8" SAS	6.2/13 *	2.01	1885	15	34	0.44	145	4/77(0)	2.24
		2.04	1740	9	30	0.64	150	12/77(6)	
		1.99	1210	10	28	0.48	205	6/78(12)	
		2.04	1977	9	36	0.77	168	12/78(18)	
5" SAS	6.2/13 *	2.01	1890	14	32	0.45	155	4/77(0)	2.31
		2.05	1875	10	38	0.77	185	12/77(6)	
		2.05	1450	9	30	0.55	235	6/78(12)	
		2.05	1785	10	30	0.91	183	12/78(18)	
5" AC	6.2	2.13	340	11	36	0.73	215	4/77(0)	2.38
		2.25	580	13	26	1.28	290	12/77(6)	
		2.25	930	14	27	1.16	325	6/78(12)	
		2.29	660	13	25	1.52	291	12/78(18)	
8" AC	6.2	2.26	675	18	*	0.81	240	4/77(0)	2.38
		2.26	665	11	27	1.23	255	12/77(6)	
		2.25	685	14	26	0.99	273	6/78(12)	
		2.29	518	11	28	1.41	279	12/78(18)	
11" AC	6.2	*	*	*	*	*	*	4/77(0)**	2.40
		2.24	705	12	29	1.12	255	12/77(6)	
		2.27	420	12	24	1.02	310	6/78(12)	
		2.29	644	11	29	1.54	262	12/78(18)	

* The mix design established for these systems was 6.2 weight percent asphalt and 13 weight percent sulphur.

** Pavement age in months.

1 lbf = 4.45N
1 in = 25.4 mm
1 psi = 6.89 kPa

Table 3 Dynaflect results as computed by STIF 2

Percent Binder and Mix Type	Station	Pavement Thickness,* in	Maximum Dynaflect Deflection 10^{-3} in	Surface Curvature Index	Stiffness Coefficient of Pavement	Stiffness Coefficient of Subgrade	Date
$6.2/_{13}$ SAS**	1985+00		0.422	0.040	0.85	0.23	12/13/77(6)***
	to	11	0.492	0.057	1.14	0.24	6/6/78(12)
	1990+00		0.384	0.030	1.41	0.24	12/4/78(18)
$6.2/_{13}$ SAS	1990+00		0.534	0.077	0.76	0.24	12/13/77(6)
	to	8	0.628	0.134	1.07	0.27	6/6/78(12)
	1995+00		0.507	0.091	1.18	0.27	12/4/78(18)
$6.2/_{13}$ SAS	1995+00		0.849	0.160	0.76	0.24	12/13/77(6)
	to	5	0.930	0.189	1.75	0.24	4/6/78(12)
	2000+00		0.816	0.155	1.81	0.25	12/4/78(18)
6.2 AC	2000+00		0.796	0.121	0.83	0.23	12/13/77(6)
	to	5	0.921	0.165	1.85	0.24	6/6/78(12)
	2005+00		0.790	0.130	1.95	0.24	12/4/78(18)
6.2 AC	2005+00		0.759	0.080	0.85	0.21	12/13/77(6)
	to	8	0.990	0.165	1.22	0.23	6/6/78(12)
	2010+00		0.790	0.130	1.45	0.24	12/4/78(18)
6.2 AC	2010+00		0.486	0.031	0.97	0.21	12/13/77(6)
	to	11	0.762	0.072	1.26	0.21	6/6/78(12)
	2015+00		0.801	0.087	1.58	0.22	12/4/78(18)

* All sections have 1 inch asphaltic concrete wear course and 8 inch lime treated subgrade.

** $6.2/_{13}$ = weight percent of asphalt and sulphur in the paving mixture.

*** Pavement age in months.

1 in = 25.4mm

Table 4 Mays Ride Meter test results for road serviceability index

Station No. 1985+00 to 2015+00 (SAS, then AC). Mays Ride Meter readings taken at 264 ft (80.5 m) intervals.

	1985+00 (SAS)						(AC)				2015+00
* Wheel Path No. 1											
6/15/77 (0)***	3.1	3.8	2.8	3.2	2.8	2.9	3.1	3.3	3.2	3.7	3.7
11/15/77 (6)	3.6	3.8	3.8	3.8	3.3	3.2	3.6	3.9	3.8	4.2	3.9
6/16/78 (12)	3.6	3.9	3.8	3.9	3.6	3.8	4.0	4.1	4.1	4.4	4.4
12/28/78 (18)	3.4	3.9	3.8	3.6	2.9	3.3	3.5	4.1	4.0	4.2	4.1
** 12/28/78 (18)	3.4	4.0	3.8	3.9	3.6	3.5	3.9	4.4	4.3	4.4	4.3
* Wheel Path No. 2											
6/15/77 (0)	3.1	4.1	2.6	3.2	3.7	2.9	3.9	4.2	3.3	4.1	3.7
11/15/77 (6)	3.3	4.1	3.6	4.2	4.1	3.8	4.5	4.4	4.1	4.5	4.5
6/16/78 (12)	3.4	3.9	3.8	4.1	4.1	3.4	4.3	4.4	4.2	4.6	4.4
12/28/78 (18)	2.8	3.6	3.9	4.0	3.9	3.6	4.1	3.9	3.4	4.0	3.9
* Wheel Path No. 3											
6/15/77 (0)	2.5	3.2	2.7	2.9	3.1	2.3	3.9	3.4	2.8	3.3	3.7
11/15/77 (6)	3.0	3.9	3.5	4.1	3.8	3.0	4.5	4.0	4.0	4.2	4.5
6/16/78 (12)	3.0	3.2	3.5	3.6	3.3	2.7	4.4	4.1	4.2	4.1	3.9
12/28/78 (18)	2.6	3.7	3.4	3.3	3.4	3.0	3.8	3.7	4.0	3.9	3.8
** 12/28/78 (18)	3.0	3.4	3.8	3.0	3.1	2.8	4.5	4.2	4.1	4.3	4.1
* Wheel Path No. 4											
6/15/77 (0)	2.5	2.9	2.9	2.5	2.9	2.1	3.6	3.9	3.7	3.1	-
11/15/77 (6)	3.8	3.7	3.9	2.9	3.0	2.9	4.1	3.9	4.2	3.1	3.9
6/16/78 (12)	3.6	3.6	3.6	2.8	2.9	2.7	3.9	3.9	4.1	4.1	3.9
12/28/78 (18)	3.5	3.0	3.8	3.1	3.3	2.9	4.1	3.9	4.3	3.9	3.8

* Mays Ride Meter readings taken with vehicle straddling wheel paths.

** Mays Ride Meter readings taken with wheels in wheel paths.

*** Pavement age in months.

Personnel of the SDHPT took Dynaflect measurements in accordance with the procedure set forth by Scrivner and Moore (4). A summary of the results of the STIF 2 computer treatment of the Dynaflect data is presented in Table 3. In general, the differences in the data with respect to time may be attributed to seasonal (temperature) variation. However, the 11 inch (279 mm) AC section may be showing distress since its maximum Dynaflect deflections and surface curvature indexes are increasing.

Table 4 presents a summary of the Serviceability Index for each wheel path as computed from the Mays Ride Meter test performed by District 21 personnel. The Mays Ride Meter and its operations are described in Reference 5. There are no significant trends with time that have developed as of yet. It should be noted that one set of readings taken in December of 1978 were the first in which the wheels of the Mays Ride Meter car were in the wheel paths as opposed to straddling them. Table 4 also reveals that the serviceability index for the SAS sections is lower than that of the AC sections. The probable cause of this was discussed in the last progress report.

The pavement rating score (PRS) presented in Table 5 was arrived at from a visual distress survey conducted by the SDHPT. The procedure for pavement rating was established by Epps, et. al. (6). In this rating the serviceability index was not included in order to give a more nearly accurate representation of any visual distress. Slight amounts of rutting and minor surface raveling were reported by the SDHPT. The rutting was probably consolidation of the material by the action of traffic rather than actual distress. Raveling occurred in the surface course which is not under evaluation in this study. Therefore, the only points deducted in the pavement rating were for longitudinal and transverse cracking.

Table 5 Pavement rating scores exclusive of serviceability index and raveling

Station No.	Pavement Thickness and Type	Pavement Rating Score Percent
1985+00 - 1990+00	11 in (279 mm) SAS	100
1990+00 - 1995+00	8 in (203 mm) SAS	97
1995+00 - 2000+00	5 in (127 mm) SAS	97
2000+00 - 2005+00	5 in (127 mm) AC	100
2005+00 - 2010+00	8 in (203 mm) AC	97
2010+00 - 2015+00	11 in (279 mm) AC	100

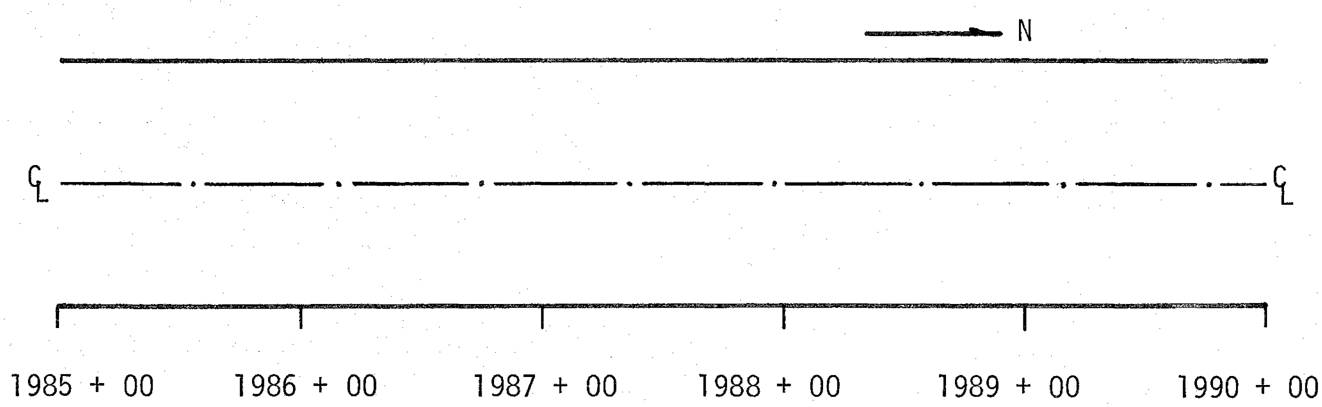


Figure 3a Results of Visual Distress Survey for 11 in. (279 mm) SAS Section

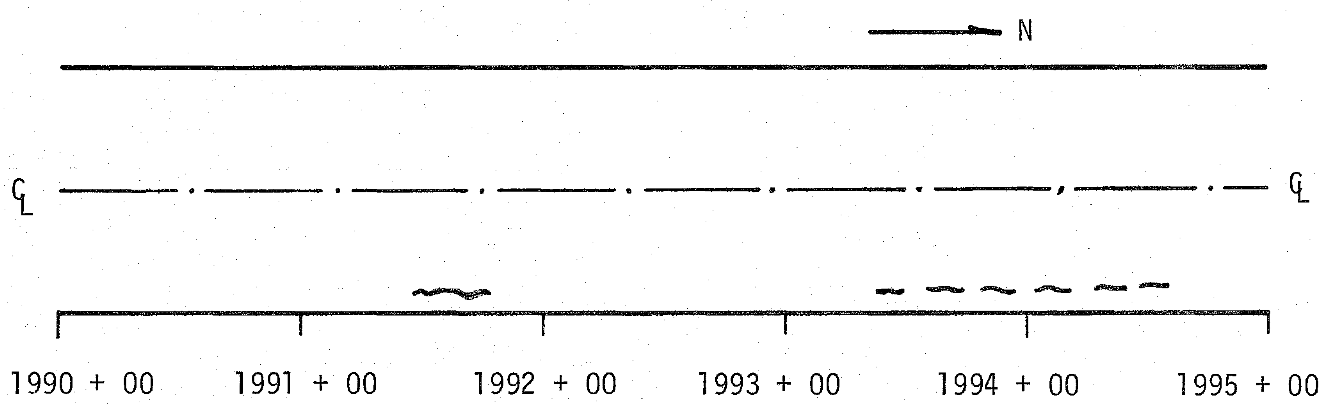


Figure 3b Results of Visual Distress Survey for 8 in. (203 mm) SAS Section

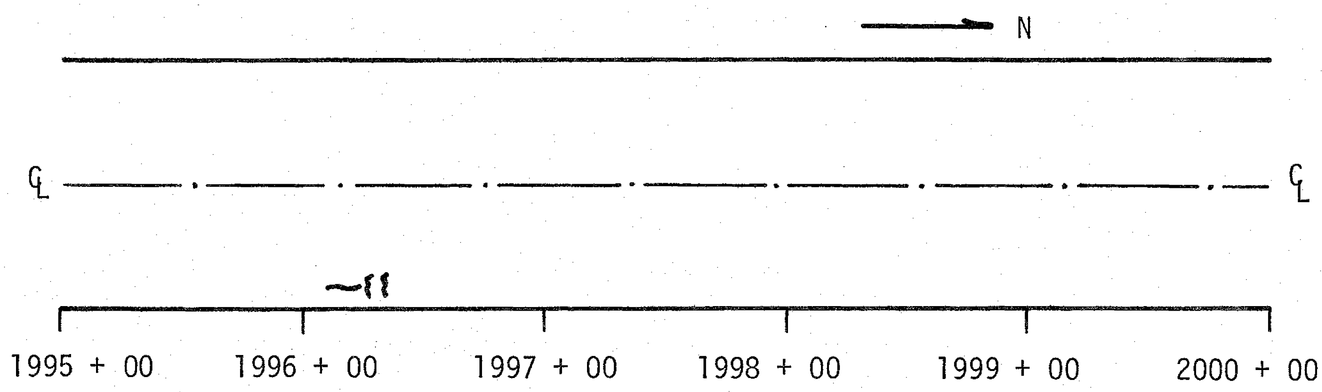


Figure 3c Results of Visual Distress for 5 in. (127 mm) SAS Section

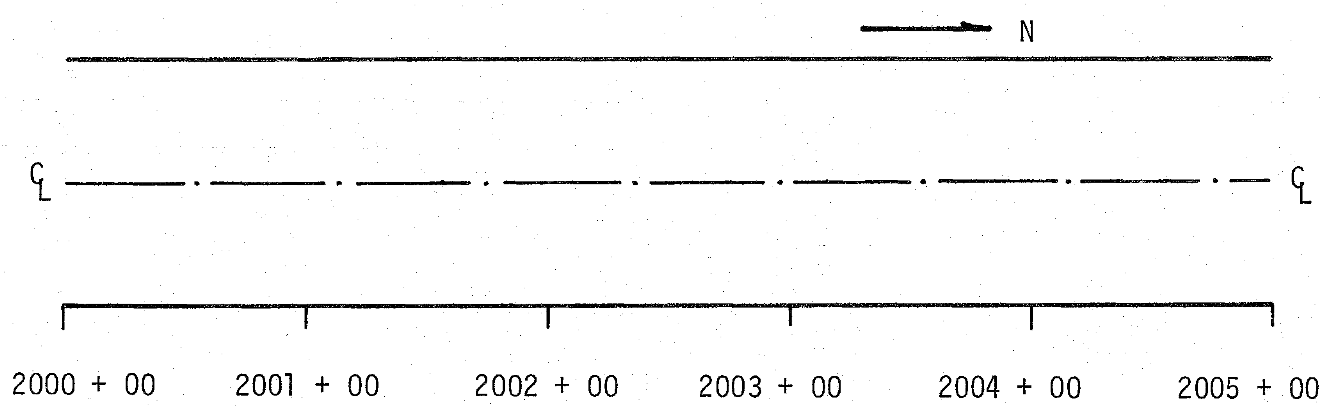


Figure 3d Results of Visual Distress for 5 in. (127 mm) Ac Section

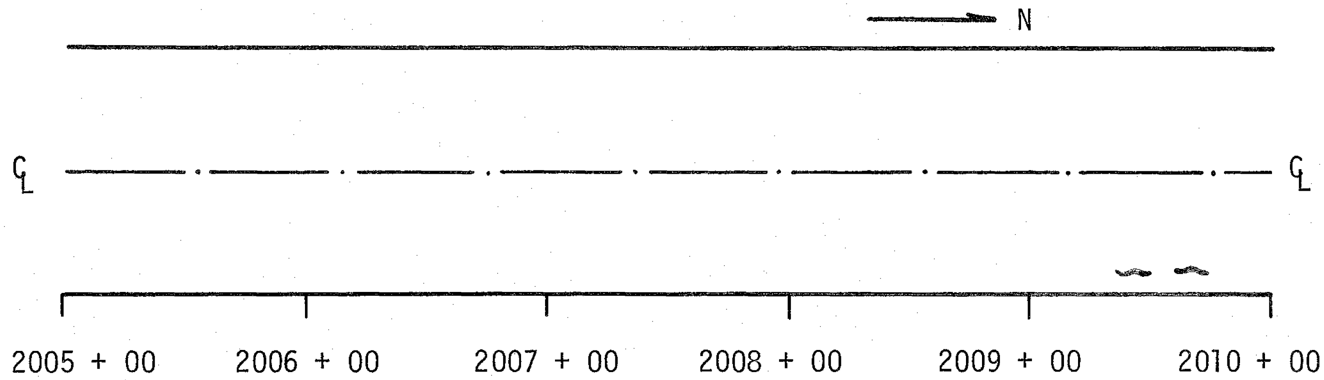


Figure 3e Results of Visual Distress Survey for 8 in. (203 mm) AC Section

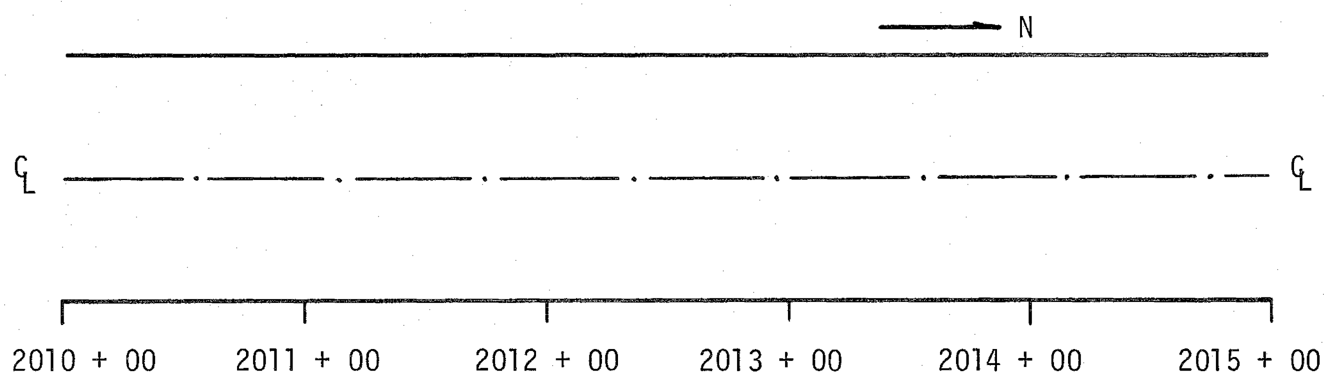


Figure 3f Results of Visual Distress Survey for 11 in. (279 mm) AC Section

Figures 3a through 3f depict the cracks in the pavement for each section. Most of the longitudinal cracks appear in the 8-inch (203 mm) SAS section (1990+00 to 1995+00) in the right wheel path of the outside lane. Overall, the SAS sections are showing more cracks than the AC sections.

Conclusion:

Generally, it appears as though the AC sections are performing slightly better than the SAS sections. However, the SAS sections are showing some superior qualities of their own, particularly with respect to stability.

REFERENCES

1. Izatt, J. O., Gallaway, B. M., Saylak, D., Sand-Asphalt Pavement Experimental Project Highway U S 77, Kenedy County, Texas, "A Construction Report," April, 1977.

2. Saylak, D., Gallaway, B. M., "Post Construction Evaluation of U S 77 Kenedy County Sulphur-Asphalt-Sand Pavement Test Sections," Interim Report No. 1, October, 1977.

3. Schmidt, R. M., "A Practical Method for Determining the Resilient Modulus of Asphalt Treated Mixes," Chevron Research Company, Richmond, California, Highway Research Board Meeting, January 18, 1972.

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. 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.

6. 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.

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
21	KENEDY	327	02		US - 77	12-13-77	29

DYNAFLECT DATA

STATION	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
2011+15	0.480	0.450	0.410	0.350	0.320	0.030	0.21	0.97	
2011+45	0.460	0.430	0.400	0.340	0.310	0.030	0.21	0.96	
2011+75	0.450	0.430	0.390	0.330	0.300	0.020	0.20	1.10	
2012+05	0.470	0.440	0.400	0.330	0.300	0.030	0.21	0.96	
2012+35	0.480	0.440	0.400	0.330	0.300	0.040	0.22	0.87	
2012+65	0.460	0.430	0.390	0.330	0.300	0.030	0.21	0.96	
2012+95	0.480	0.450	0.410	0.340	0.310	0.030	0.21	0.97	
2013+25	0.520	0.490	0.440	0.370	0.330	0.030	0.20	1.00	
2013+55	0.530	0.490	0.440	0.370	0.340	0.040	0.21	0.89	
2013+85	0.530	0.500	0.440	0.380	0.340	0.030	0.20	1.00	
AVERAGES	0.486	0.455	0.412	0.347	0.315	0.031	0.21	0.97	
STANDARD DEVIATION						0.006	0.01	0.06	

NUMBER OF POINTS IN AVERAGE = 10

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,&5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENT OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENT OF THE PAVEMENT