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16. Abstract

Fabric underseals were placed in asphalt concrete overlay systems in four different regions of Texas in 1979 and 1980. The overlaid pavements included asphalt concrete, portland cement concrete and a freshly cold-milled asphalt concrete. Relative reflection cracking has been evaluated annually on these test sections for up to three years. Laboratory tests on the construction materials have been performed. At this time, there is no substantial evidence from which one could conclude that one fabric offers an advantage over another fabric or that fabric, in general, is better than none at all.

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EVALUATION OF FABRIC INTERLAYERS

by

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Research Report 261-2

Research Study No. 2-9-79-261

Sponsored by

Texas State Department of Highways and

Public Transportation

U. S. Department of Transportation

Federal Highway Administration

TEXAS TRANSPORTATION INSTITUTE

Texas A&M University

College Station, Texas 77843

November, 1982

PREFACE

This is the second report issued under Research Study 2-9-79-261, "Evaluation of Fabric Underseals". The first report (261-1) entitled "Laboratory Evaluation of Selected Fabric for Reinforcement of Asphaltic Concrete Overlays" by D. Pickett and R. L. Lytton was issued in May 1981 and dealt primarily with the development of a technique to analyze laboratory data using fracture mechanics and finite element theory. These methods were applied to test results using the "overlay tester", a device for quantifying a pavement system's relative resistance to reflective cracking. Significant findings are presented regarding optimum location of a fabric within a pavement system and optimum tack coat associated with a fabric.

DISCLAIMER

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to Texas SDHPT personnel for their interest and willingness to participate in this research program. The efforts of A. L. Ledbetter (District 4), Joe W. Lane and William P. Harrington (District 7), Charles H. Reasonover and Lawrence W. Leake (District 10) and G. J. Camargo (District 21) are gratefully acknowledged.

Technical guidance for the investigation was provided by Bill Elmore of D-9.

Professor B. M. Gallaway served as project manager and editor.

Laboratory testing was conducted by Chris Cook.

Typing of the manuscript was completed by Emily Arizola, Melony McCoy and Bea Cullen.

Without the help of these individuals this work would have been much more difficult.

IMPLEMENTATION STATEMENT

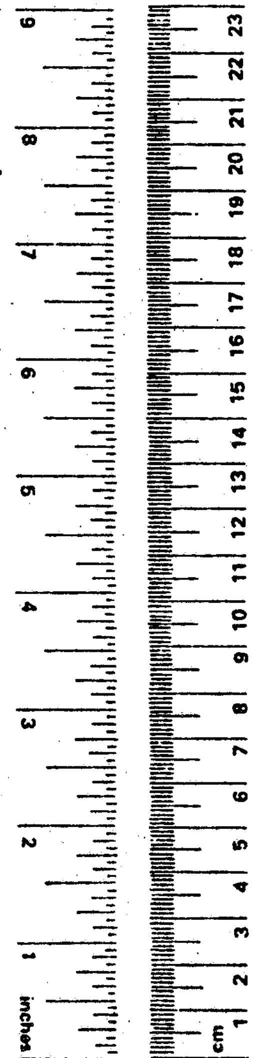
In general, the field tests of fabrics installed to reduce reflective cracking in asphalt concrete overlays is presently inconclusive. That is, based on the test sections described herein, no positive statements can be made regarding the ability of fabrics to reduce reflective cracking beyond three years in service. However, during the course of this study, certain design and construction procedures and fabric properties seemed to be more suitable. Recommendations pertaining to these procedures and properties have been made and should be implemented.

The test sections described in this report have been documented in considerable detail. A great deal of research effort has been invested in these highway research projects. It is, therefore, recommended that research study 2-9-79-261 be continued for an unspecified period to evaluate the long-term effects of fabrics installed to reduce or delay reflection cracking.

METRIC CONVERSION FACTORS

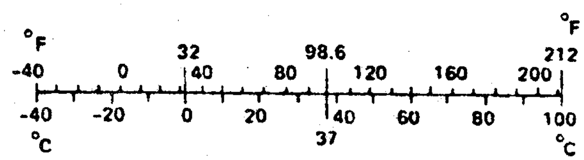
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



* 1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

TABLE OF CONTENTS

INTRODUCTION

What can be done to reduce reflection cracking in asphalt concrete overlays? A number of methods have been tried with varying degrees of success. These methods will usually fall under one or more of three categories. The three categories and their associated methods are listed below:

1. Reinforce the overlay.
    a. Thicker overlays of dense graded asphalt concrete
    b. Fabric interlayer
    c. Fibers in asphalt concrete overlay
    d. Reinforcing steel or wire mesh
    e. Low rubber content mixtures or plant mix seals
2. Insulate overlay from high stress areas (cracks).
    a. Fabric-asphalt interlayer
    b. Fiber-asphalt cement interlayer
    c. Asphalt rubber chipseal
    d. Unstabilized aggregate interlayers
    e. Stone dust bond breakers
    f. Thick overlays of large maximum size open-graded asphalt stabilized interlayers
3. Restrengthen cracked pavement prior to overlaying
    a. Heater-scarification
    b. Spray applications of asphalt cement softening agents

Some of these methods offer the additional advantage of retarding the flow of surface water through an overlay even after moderate cracking of the overlay.

Fabrics have been utilized in Civil Engineering applications for site stabilization, filter systems, reinforcing interlayers in asphalt concrete, as an integral layer in overlay systems to reduce the occurrence of reflection cracks and to seal against the ingress of moisture into pavement bases, subbases and subgrades. Fabrics have proven benfits in applications for site stabilization. However, the benefits derived from fabrics utilized as reinforcing interlayers to reduce reflection cracking and to seal pavements is not well defined.

Fabrics have been placed in asphalt concrete overlay systems since the 1960's for the purpose of reducing and/or delaying the occurrence of reflection cracking. Results of field trials around the nation are available but generally inconclusive in many respects. An extensive bibliography is included in Appendix F. Prior to 1979 the Texas State Department of Highways and Public Transportation (Texas SDHPT) had utilized some fabrics. However, with the exception of one rather extensive project, insufficient information had been developed defining pavement conditions existing at the time of fabric installation and subsequent pavement performance. Therefore, it was desirable to place additional test sections in various Texas climates.

Specifications used for fabrics in Texas have often been proprietary in nature and, in effect, allowed only specific fabrics to be used in experimental sections. In 1976 the Materials and Test Division (D-9) of the Texas SDHPT recognized the need for a competitive specification and began to collect the existing information and to work with known fabric manufacturers. The review of information gathered from both Departmental projects and projects placed in other States indicated that there appeared to be some benefits obtained from the use of fabrics in some situations but no apparent benefits in others. Furthermore, no conclusions were reached as to what fabric physical properties were necessary to provide acceptable field performance. Consequently, an open specification was prepared and adopted by Texas SDHPT.

In order to resolve some of the problems identified above, a field and laboratory research program was initiated by the Texas Transportation Institute under sponsorship of the Texas SDHPT and FHWA. The primary objectives of this study are to develop the information necessary to evaluate the performance of fabrics in order 1) that realistic specification limits may be established, 2) to determine the types of distress, if any, that fabrics can economically be used to correct, 3) to ascertain fabric properties that will optimize field performance, 4) to define satisfactory field installation procedures for utilizing fabrics and 5) to establish an economic cost-benefit relationship for fabric overlay systems.

Field installations consisting of eight to thirteen one-quarter mile test sections in four different areas of the state were constructed. Two projects were constructed in 1979, one in 1980 and one in 1981. The test sections involved placement of a fabric followed by a hot-mix asphaltic concrete (HMAC) overlay. Ten different fabrics were tested. They were compared to a control section consisting of either a conventional HMAC overlay with no interlayer or one with a chipseal as an interlayer. One location included a test section containing a chipseal using asphalt rubber as an interlayer (underseal). All test sections were installed over cracked asphalt concrete or portland cement concrete pavements to evaluate the relative ability of the interlayer to reduce reflection cracking.

Field performance of these test pavements has been evaluated for periods up to three years. Laboratory tests have been conducted on all paving materials.

The purpose of this report is to describe the construction of the field installation, identify the properties of the construction materials, and evaluate the early performance of the test sections.

SUMMARY OF FIELD PROJECTS

Field test projects involved the application of engineering fabrics with an asphalt concrete overlay in an attempt to rehabilitate a cracked pavement and reduce reflection cracking. Four projects (Figure 1) were installed and are described in this report (Table 1). Project details are presented in chronological order of their construction. Specific information about each project is furnished in Table 1. Environmental and traffic data have been included in the table to indicate the types of environments to which these pavements are exposed. Additional temperature data (1) collected since construction of each project are presented in the appendices.

The following types of data were collected on most of these pavements: roughness (Maysmeter), deflection (dynaflect), surface texture (silicon putty), condition survey and sample crack maps (three 100 ft. maps per test section). Tabulated results of these observations are contained in the appendices.

Asphalt Cement

Asphalt cements used in the paving mixtures and that used as tack for the fabrics were obtained from five different manufacturers. They are identified in Table 1. Properties of these asphalts are listed in Table 2.

Aggregate

The types of aggregate blended to produce the project gradation are given in Table. Aggregate gradations obtained from cores from the four projects are graphically depicted in Figures 2 through 6.

Fabrics

Engineering fabrics installed at each of the four research projects are listed in Table 1 and described in Table A1, Appendix A. Properties of these fabrics were measured by SDHPT personnel and are presented in Table 3.

In order to select the most advantageous fabric from a materials properties and economics standpoint, the State and Contractors should be aware of materials now on the market. A partial list of these materials and manufacturers is given in Table A2, Appendix A.

Asphalt Concrete Mixtures

Cores were obtained from each of the four projects and tested in the laboratory to obtain relative values of stability, stiffness, strength and water susceptibility. Results from these tests are given in Table 4. Plots of resilient modulus as a function of temperature are given in Figures A1 through A5.

Other Materials

Asphalt rubber was used as an underseal on one test section in District 7. It was applied as a chipseal using Grade 3 precoated crushed stone.

Liquid Antistrip additives were used in the paving mixtures placed in District 10. In the first course (Type B), one percent of Antistrip A was added to the asphalt cement. In the second course (Type D), one percent of Antistrip B was added to the asphalt cement.

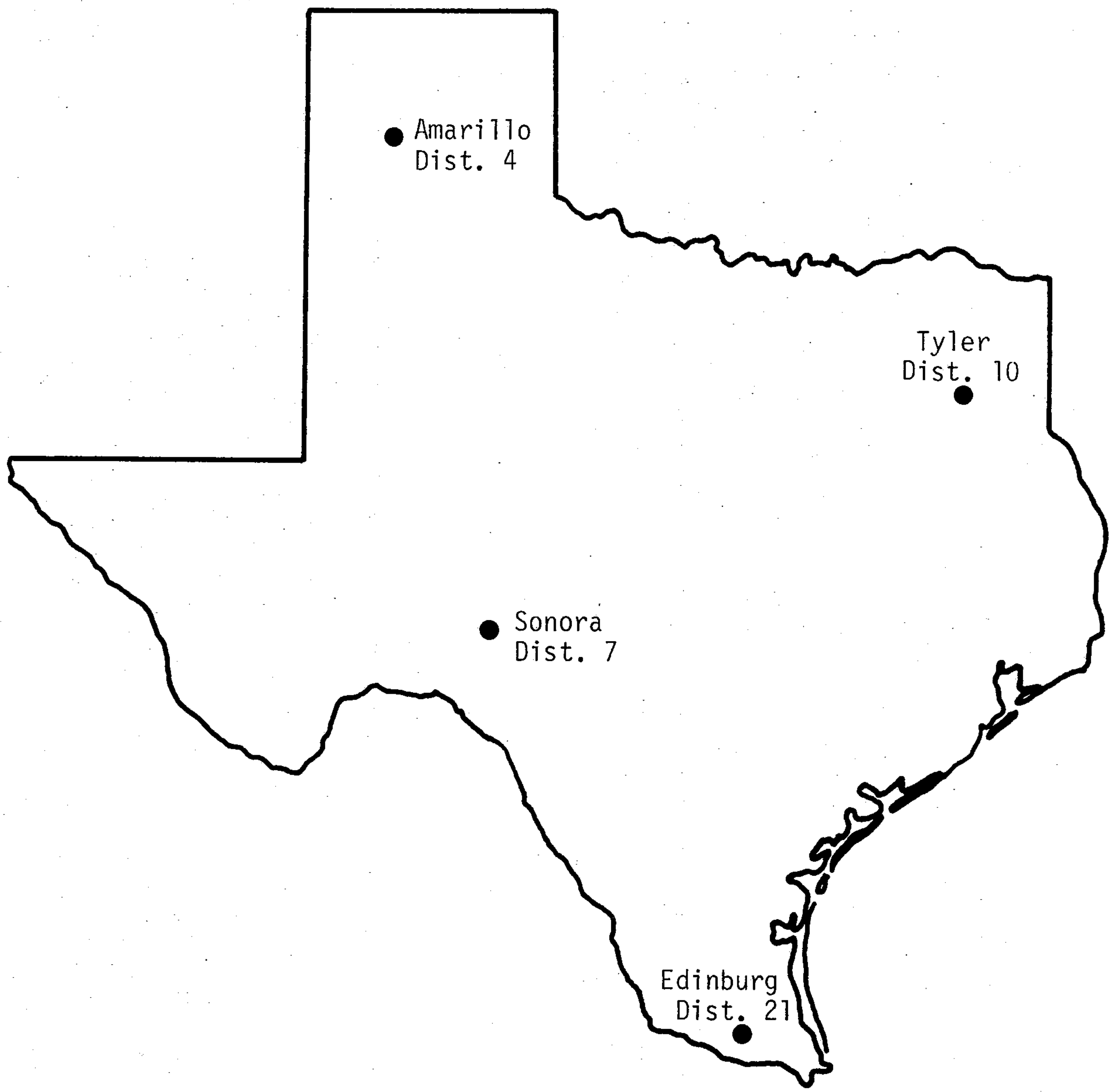


Figure 1. Location of Trial Field Sections

Table 1. Summary Field Projects where Fabrics were Installed

Item	Location					
	West of Sonora	West of Amarillo	Dowtown Edinburg		East of Tyler	
Highway Designation	IH-10	IH-40	US 281 and SH 107		IH 20	
District Number	7	4	21		10	
County and Number	Crockett (53)	Oldham (180)	Hidalgo (109)		Gregg (93)	
Control-Section No.	141-1	90-4	255-7 & 8 and 342-1		495-6 & 7	
No. of Lanes each Direction	2	2	2		2	
Existing Pavement						
Layer 1 (Top)	3" HMAC	1" HMAC (Type D)	1" HMAC*		8" CRCP	
Layer 2	15" Flex Base	3" HMAC (Type A)	12" Flex Base		RC-2 membrane	
Layer 3	Subbase	12" Flex Base	Subgrade		6" Soil Cement	
Layer 4	-	6" Lime Tr.Subgr.	-		Subgrade	
Date of Overlay Construction	Aug-Sept 1979	Sept 1979	Feb 1980		July 1981	
Fabrics Used						
1	Chipseal (Control)	Control	Control		Control	
2	Fabric 1	Fabric 1	Fabric 1		Fabric 3	
3	Fabric 2	Fabric 2	Fabric 2 (SH 107)		Fabric 4	
4	Fabric 3	Fabric 3	Fabric 3		Fabric 7	
5	Fabric 4	Fabric 4	Fabric 4		Fabric 8	
6	Fabric 5	Fabric 5	Fabric 5		Fabric 9	
7	Asp-Rub Chipseal				Fabric 10	
HMAC Overlay	Type D	Type D	Type D		Type B	Type D
Asphalt Type & Grade	AC-10	AC-10	AC-10		AC-20	AC-20
Asphalt Source	Refinery 4	Refinery 5	Refinery 15		Refinery 6	Refinery 24
Aggregate Type	Crsh Limestone + Field Sand	Crsh Limestone + Field Sand + Blow Sand	River Gravel + Sand		Crsh Limestone + Field Sand	Lt wt + conc. Sand + fld sand
Asphalt Additives	None	None	None		Antistrip A	Antistrip B
Asphalt Tack Coat for Fabrics						
Type and Grade	AC-20	AC-10	AC-10		AC-20	
Source	Refinery 4	Refinery 5	Refinery 15		Refinery 24	
Traffic Data**			(US 281)	(SH 107)		
ADT	3,400	7,900	19,500	13,000	14,000	
Percent trucks	24.1	23.8	3.4	18.2	22	
Equivalent 18K axle loads	5,983	15,468	19,043	1,476	-	
Percent Tandem Axles	90	20	90	40	40	
Weather Data (1)						
Temperature						
Normal Max, °F	95	91	97		94	
Normal Min, °F	33	22	49		35	
Typical Max Drop, °F/hr	-	5	-		-	
Typical Max 24 hr Drop, °F	-	60	-		-	
Frost Penetration, in.	1	12 (max)	0		1	
Freeze Index	0	0	0		0	
Precipitation						
Annual Ave. Precip, in.	19	20	18		43	
Annual Ave. Ice/Snow, in	1	15	Trace		2	

*Approximately 2 inches of ACP had been removed by cold milling prior to placement of fabric.

**Traffic data as of 1980.

Table 2. Properties of Asphalt

Condition	Property	Value for Given Location				
		Dist 4	Dist 7	Dist 10		Dist 21
Original	Grade	AC-10	AC-10	AC-20*	AC-20**	AC-10
	Penetration					
	77°F (25°C) 100 gm, 5 sec	106	79	64		90
	39°F (4°C) 100 gm, 5 sec	8	-	2		-
	39°F (4°C) 200 gm, 60 sec	24	-	13		-
	Viscosity					
	77°F (25°C), poises x 10^5	8.5	-	-		-
	140°F (60°C), poises	1124	1065	1760		822
	275°F (135°C), poises	5.33	2.60	3.21		2.37
	R & B Soft. Pt., °F	116				-
After TFOT	Penetration					
	77°F (25°C) 100 gm, 5 sec	73	47	37		45
	Viscosity					
	77°F (25°C), poises x 10^5	15				-
	140°F (60°C), poises	1823	2327	3888		2471
	275°F (135°C), poises	7.40	-			-
	R & B Soft. Pt., °F	124	-	130		-
Recovered from cores	Penetration					
	77°F (25°C) 100 gm, 5 sec	80	52	45	71	36
	39°F (4°C) 200 gm, 60 sec	24	10	10	21	18
	Viscosity					
	77°F (25°C), poises x 10^5	16	-			115
	140°F (60°C), poises	1568	1856	3138	2501	3893
	275°F (135°C), poises	5.67	2.97	4.27	4.51	4.0
	R & B Soft. Pt., °F	121	124	124	124	138

*Asphalt used in Type B limestone mixture.

**Asphalt used in Type D lightweight mixture.

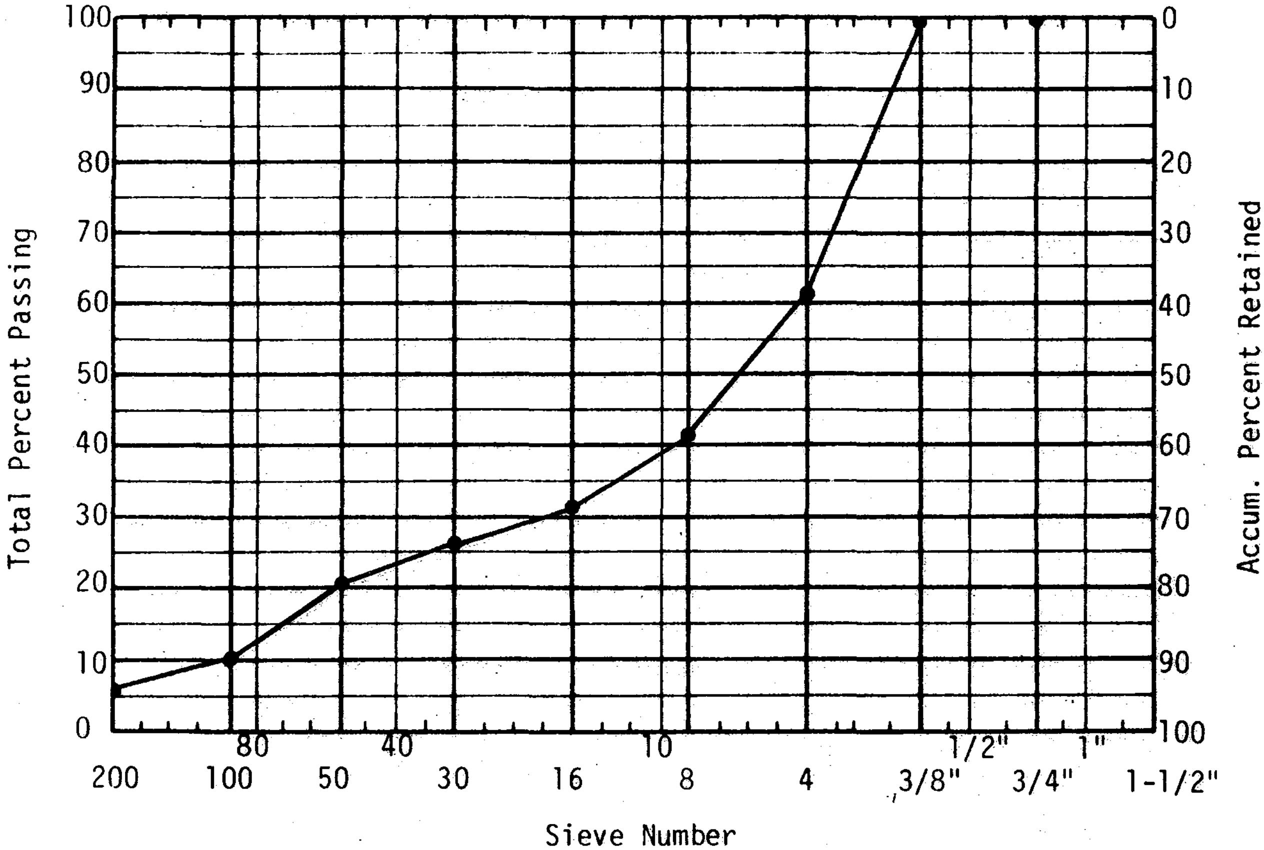


Figure 2. Aggregate Grading of District 7 Cores (Sonora).

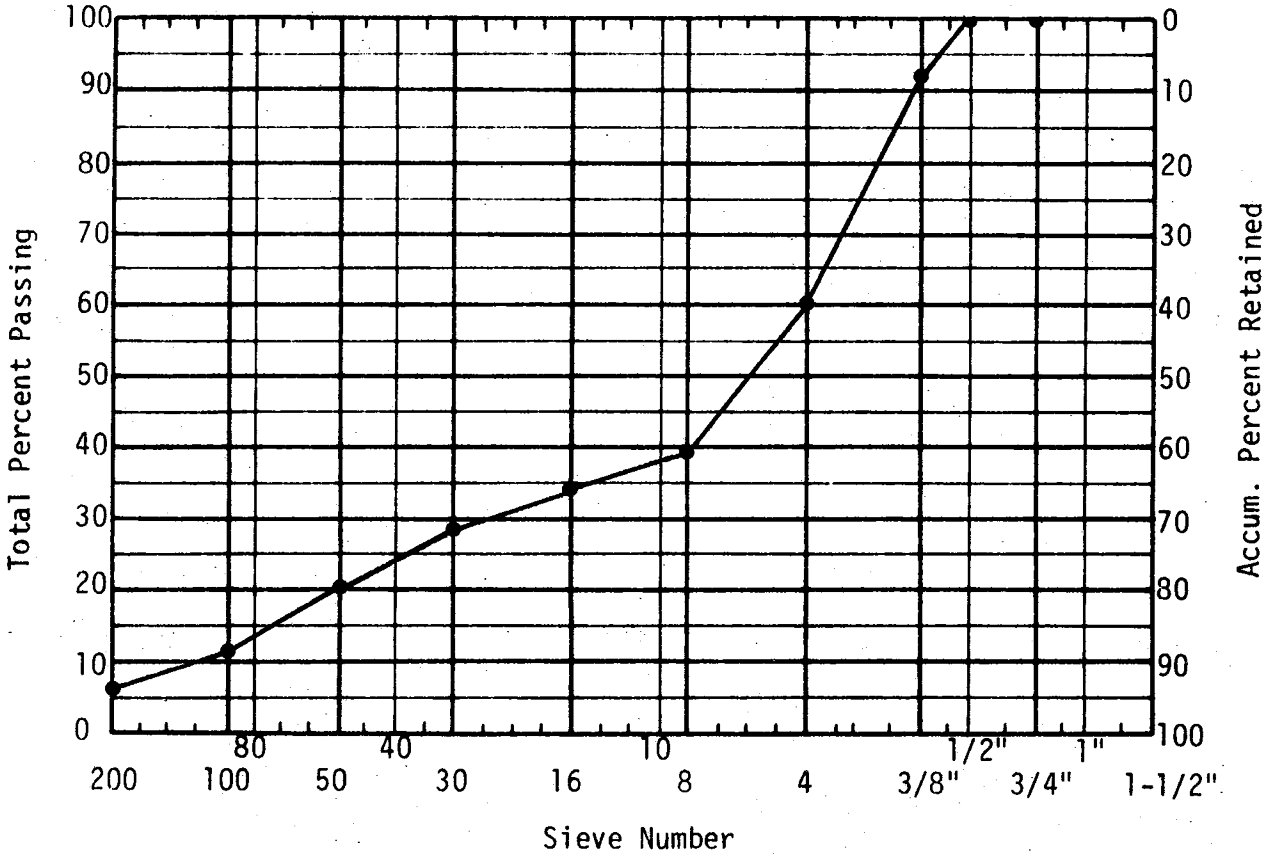


Figure 3. Aggregate Grading of District 4 Cores (Amarillo).

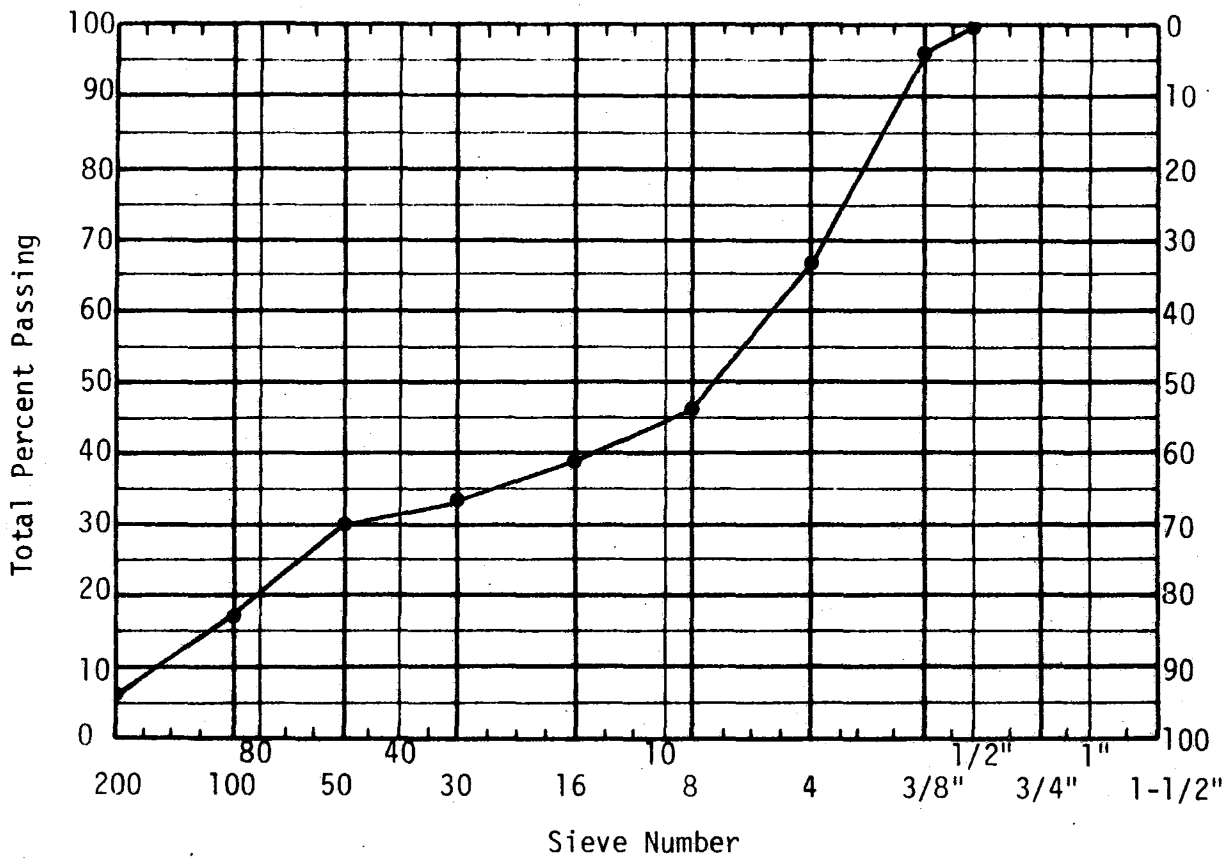


Figure 4. Aggregate Grading of District 21 Cores (Edinburg).

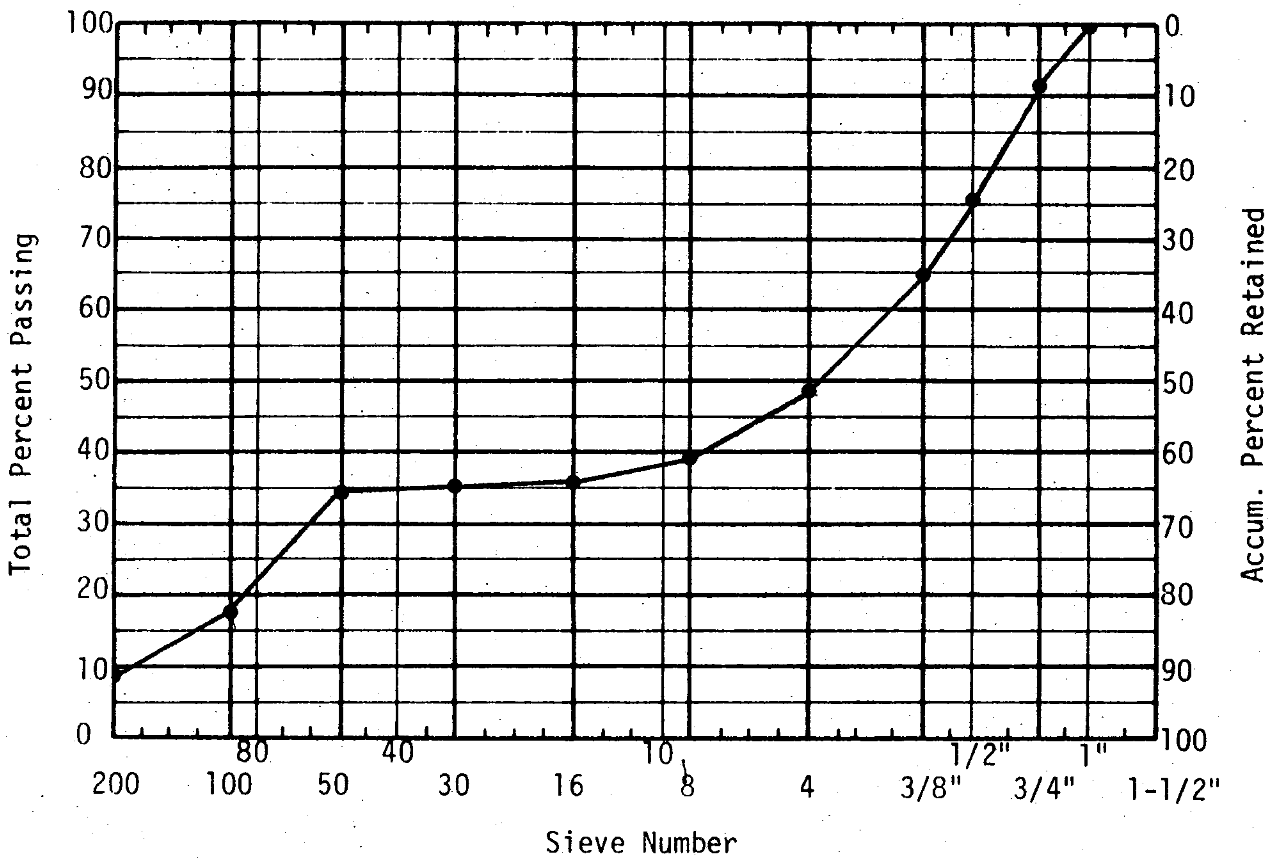


Figure 5. Aggregate Grading of Type B mix from District 10 Cores (Tyler).

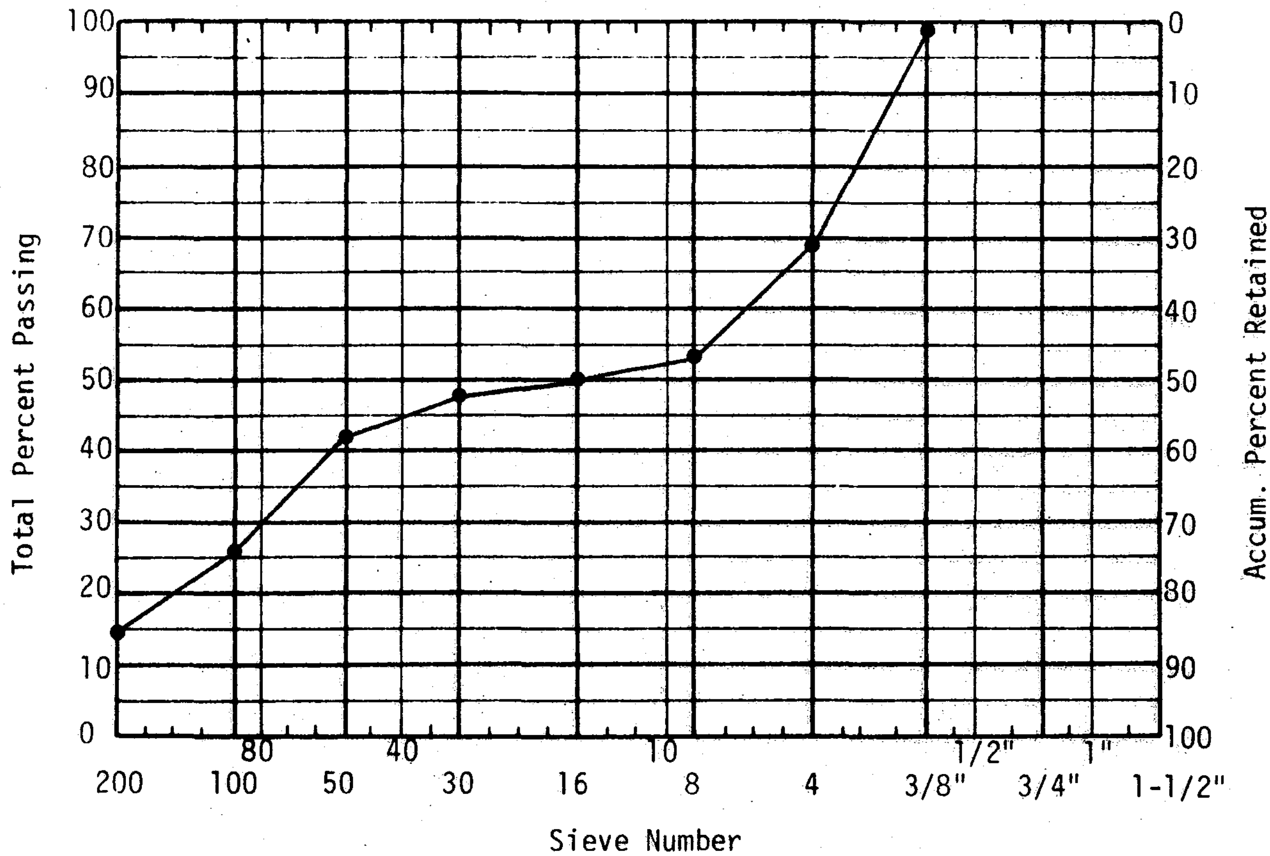


Figure 6. Aggregate Grading of Type D mix from District 10 Cores (Tyler).

Table 3. Properties of Fabrics as Measured by SDHPT (D-9) in Accordance with Specifications in Item 3099.

District No.	Fabric I.D.	Average Fabric Weight, oz/yd^2	Machine Direction (warp)		Cross-Machine (Fill)		Asphalt Rentention, oz/ft^2	Change in Area, percent
			Elongation, percent	Break, pounds	Elongation, percent	Break, pounds		
7	1*	4.4	85	148	84	128	4.2	0
	2*	7.1	91	215	108	211	5.2	0
	3*	4.2	103	75	65	92	2.2	-2
	4*	4.2	76	121	67	154	3.6	-5
	5*	8.6	78	300+	97	300+	4.9	0
4	1	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-
	3	4.3	84	91	71	112	2.2	-2.0
	4	4.3	69	115	82.9	133	3.6	-4.8
	5	8.4	71	300+	71	300+	4.2	0
21	1	4.9	95	113	99.8	116	3.6	-2.3
	2	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-
	4	4.6	104	124	91	186	4.0	-9.0
	5	-	-	-	-	-	-	-
	6	6.5	83	162	91	113	3.8	0
10	3	4.6	90	154	79	110	3.4*	0*
	4	4.5	94	81	76	118	2.3*	0*
	7	3.0	50	89	59	73	-	-
	8	4.1	52	116	57	96	1.6	0
	9	5.1	140	117	161	112	3.9*	0*
	10	4.9	58	102	47	76	-	-

*Only one sample tested.

Table 4. Properties of Core Specimens from Asphalt Overlays Before and After Moisture Treatments.

Dist. No.	Type Mix	Condition of Core	Asphalt content weight percent	Air Voids, weight percent	Resilient Modulus, psi x 10^6 -10°F (-25°C)	33°F (1°C)	68°F (20°C)	77°F (25°C)	104°F (60°C)	Splitting Tensile Test[1] at 77°F Stress, psi	Strain, in/in	Modulus psi	Hveem Stability	Marshall Test Stability lbs	Flow .01 in
7	D	Original	4.8	4.5	4.58	3.09	0.695	0.383	0.035	98	0.0058	17,200	31	730	13
		After 7 day[2]	-	-	-	-	-	0.122	-	-	-	-	28	1,250	21
		After Lott[3]	-	-	-	-	-	0.372	-	65	0.0012	55,900	13	-	-
4	D	Original	5.2	8.7	3.46	1.65	0.422	0.182	0.037	64	0.0046	15,000	48	590	10
		After 7 day	-	-	-	-	-	0.076	-	-	-	-	23	407	24
		After Lott	-	-	-	-	-	0.023	-	25	0.0012	21,400	22	-	-
21	D	Original	4.5	6.1	5.00	2.56	0.843	0.589	0.116	104	0.0054	20,700	37	1,450	8
		After 7 day	-	-	-	-	-	0.274	-	-	-	-	30	897	17
		After Lott	-	-	-	-	-	0.090*	-	25*	0.0090*	3,725**	-	-	-
10	D	Original	9.0	7.8	2.11	0.81	0.211	0.106	0.031	93	0.0078	12,000	19	925	10
		After 7 day	-	-	-	-		0.126	-	81	0.0076	10,900	26	-	-
		After Lott	-	-	-	-		0.128	-	92	0.0070	13,300	-	-	-
10	B	Original	4.6	4.3	1.82	1.61	0.642	0.500	0.072	215	0.0102	21,100	44	1,010(1)	11
		After 7 day	-	-	-	-	-	0.479	-	-	-	-	48	1,350	13
		After Lott	-	-	-	-	-	-	-				-	-	-

[1]Values for splitting tensile test were determined at point of failure.

[2]Values measured after saturation and 7-day soak procedure.

[3]Values measured after 18 cycle Lottman moisture treatment procedure.

*Results questionable as specimens were quite thin (less than one-inch).

FINDINGS

The four field trials are described in detail in the following paragraphs. They are presented in the chronological order of their installation.

DISTRICT 7

An 8.75 mile section of Interstate Hgihway 10 (Project IR 10-3(58) 372) in Crockett County from 6.6 miles east of Ozona to the Sutton county line was overlaid with hot mix asphalt concrete HMAC in the Fall of 1979. Thirteen one-quarter mile (1320 ft.) test sections were designed and installed to evaluate the comparative ability of fabric interlayers to reduce or delay reflection cracking. Three different types of interlayers were installed at different locations prior to application of the HMAC overlay. They include (1) fabrics, (2) an asphalt-rubber chipseal and (3) a conventional chipseal. Five different fabrics were evaluated in this trial.

Figure B1, Appendix B. shows the layout of the test sections and identifies the type of underseal in each. Table B3 contains weather data for Ozona from September 1979 to August 1982.

Preconstruction

The existing asphalt concrete pavement structure prior to overlaying is briefly described in Table 1. It consisted of 15-inches of flexible base and 3-inches of HMAC (170 lb/yd^2 Type C plus 150 lb/yd^2 Type D) originally constructed in 1969. Transverse, longitudinal and alligator cracking was prevalent in the travel lane for the entire length of this project. The most severe cracking was in the right wheelpath which was also rutted and exhibited evidence of pumping in certain areas. There was very little cracking in the passing lane. Typical cracking patterns are shown in Figures B2 in Appendix B.

The structural condition of the original roadway is described by measurements obtained using the dynaflect (Table B1). Pavement surface texture was measured using the silicon putty method (2) (Table B2).

It was determined that, a few years before, a thin "level-up" course of HMAC had been placed on all the test sections in the westbound lanes and on test section 7-IH10-AR in the eastbound lanes. This level-up course had not been placed on any other test sections in the eastbound lanes. Fewer cracks were visible at the pavement surface in those sections containing the level-up course. In order to accomodate this difference, the test sections will be treated on two distinct groups: (1) those with the level-up course and (2) those without the level-up course.

Although total traffic volume on this roadway is rather low, the percentage of trucks is quite high (Table 1).

Construction

Construction of the test sections was accomplished in August and September of 1979. After patching the existing pavement to repair localized failures, a predetermined quantity of asphalt tack (AC-20) was applied to the pavement surface. A small tractor with special attachments to handle the 13.6 foot rolls of fabric was used to apply the fabric to the tacked pavement. The fabrics were applied in the travel and passing lanes from two to twenty minutes after the asphalt tack was applied. No fabric was placed on the shoulder. A pneumatic roller was employed to strengthen the bond between the fabric and the old pavement surface. Transverse fabric joints were typically overlapped six inches and tacked with emulsified asphalt. Following a light application of sand, the test sections were opened to traffic for a period of one to three weeks. Different test sections carried traffic for different lengths of time (Table 5). A HMAC overlay was placed on each test section at a rate of approximately 180 pounds per square yard (about 1 3/4-inches compacted thickness). Compaction was achieved using two steel wheel rollers (a three wheel breakdown plus a tandem) and a train of four pneumatic rollers.

Two test sections, designated as control sections, received a single course chipseal using AC-5 and grade 3 precoated crushed stone (Class B Type PB GR 3) (3). One additional test section received a single course chipseal using asphalt-rubber and the same type grade 3 precoated crushed stone. The stone was applied on these three sections at a rate of one cubic yard per eighty square yards.

Table 5 gives information describing each of the test sections in District 7. Detailed descriptions of the construction materials are presented in Appendix A.

This field test project on IH-10 is located on a fairly straight section of rural interstate highway in gently rolling hills. The fabrics were installed with minimal wrinkles. It appeared, however, that the thicker (8 oz/yd^2) fabrics were installed with less wrinkles than the thinner (4 oz/yd^2) fabrics. Wrinkles in this straight section were

Table 5. Description of Test Sections on IH10 in Sutton County (District 7).

Test Section Identification	Underseal Material		Asphalt Tack			Chipseal	ACP Overlay		
	Type Used	Application Date	Type/ Grade	Ave. Rate gal/yd^2	Ave. Temp °F	Aggregate Type/Rate	Ave. Rate lb/yd^2	Ave. Temp °F	Application Date
Eastbound									
7-IH10-2E	Fabric 1 4 oz/yd^2	9/11/79	AC20	0.29	330	NA	185	310	9/18/79
7-IH10-3E	Fabric 2 8 oz/yd^2	9/11/79	AC20	0.35	330	NA	185	330	9/19/79
7-IH10-4E	Fabric 5 8 oz/yd^2	9/5/79	AC20	0.41	330	NA	185	330	9/18/79
7-IH10-5E	Fabric 3 4 oz/yd^2	9/5/79	AC20	0.30	315	NA	179	320	9/19/79
7-IH10-6E	Fabric 4 4 oz/yd^2	9/5/79	AC20	0.21R 0.29L	330	NA	179	320	9/20/79
7-IH10-CE	Chipseal	8/15-79	AC 5	0.29	340	Cl B Ty PB Gr 3 1 yd^3/80 yd^2	179	310	9/19/79
7-IH10-AR	Asphalt Rubber Chipseal	8/9/79	Rubber, Diluent, AC5 and AC10	0.60	325	Cl B Ty PB Gr 3 1 yd^3/80 yd^2	~180	-	9/ /79

Table 5. Continued.

Test Section Identification	Underseal Material		Asphalt Tack			Chipseal	ACP Overlay		
	Type Used	Application Date	Type/ Grade	Ave. Rate gal/yd^2	Ave. Temp °F	Aggregate Type/Rate	Ave. Rate lb/yd^2	Temp °F	Application Date
<u>Westbound</u>									
7-IH10-1W	Fabric 4 4 oz/yd^2	9/6,10/79	AC20	0.23	330	NA	167	320	10/2/79
7-IH10-2W	Fabric 1 4 oz/yd^2	9/11/79	AC20	0.27	335	NA	179	320	10/1/79
7-IH10-3W	Fabric 2 8 oz/yd^2	9/11/79	AC20	0.33	335	NA	179	320	10/1/79
7-IH10-4W	Fabric 5 8 oz/yd^2	9/7/79	AC20	0.38	330	NA	179	320	10/1/79
7-IH10-5W	Fabric 3 4 oz/yd^2	9/7/79	AC20	0.28	330	NA	178	325	9/28/82
7-IH10-CW	Chipseal	8/15/79	AC5*	0.30*	340*	Cl B Ty PB Gr 3 1 yd^3/80 yd^2	178	325	9/28/79

*For the chipseal, no additional tack was placed on top prior to overlay.

typically longitudinal.

Soon after application of Fabrics 1 and 2, they were observed to "fluff up" due to the action of traffic. It appeared that the tires became sticky due to tracking in asphalt sprayed outside the edge of the fabric or asphalt which bled through the fabric. The sticky tires subsequently pulled up the fibers near the fabric's surface thus giving the fluffed appearance. A notable quantity of fibers were completely removed from the mat and deposited in the weeds alongside the roadway. After a few hours and a light application of sand, the fabric was pressed flatly onto the pavement by traffic. Fabrics 1 and 2 were exposed to traffic from 7 to 20 days. This incident may have reduced the effectiveness of the fabric, particularly in the wheelpaths.

Although a very small quantity of fibers was observed alongside the sections containing Fabrics 3, 4 and 5, the fluffing phenomenon was not experienced with these fabrics. It is surmised that these fibers were abraided away by traffic prior to overlaying.

Visual inspection during construction showed that Fabric 4 did not slip as much under the wheels of the pneumatic roller as did the Fabric 3. This was particularly noticeable when rolling on a grade. Fabric 3 was manufactured with a "glaze" (thermally bonded) on both sides of the fabric; whereas, Fabric 4 has the "glaze" on one side and is fuzzy on the other side. The fuzzy side is designed to be placed next to the asphalt tack on the old pavement surface to provide reinforcement at the interface. The fuzzy side provides a greater effective surface area of the fabric which offers better adhesive and shear strength. This is in agreement with results observed in the laboratory by Button, et al.(1)

Blisters up to approximately 4 inches in diameter were observed in Fabric 4 in one isolated area (not in a test section). This segment of fabric was installed on a surface-dry pavement shortly after a shower. It is postulated that moisture in small crevices in the pavement was sealed in by the fabric-asphalt membrane; the trapped moisture was later vaporized due to heating by the sun on the dark surface thus forming the blisters.

Post Construction

By February of 1980, after a severe winter, a few transverse cracks had appeared in the shoulder in certain areas of the east-bound travel lane. The cracks did not continue into the travel lane. No fabric was installed in the shoulders. It is therefore, reasonable to assume that the fabrics were delaying reflection cracking. The second winter was unusually mild and no cracking was evident in any of the test sections nineteen months after construction.

A record of maximum and minimum temperatures and changes in temperature (1) are included in Table B3, Appendix B.

After the nineteen-month performance period, slight flushing was observed in the control and asphalt rubber test sections of the eastbound lanes. This could be a result of excessive asphalt material in the chipseals. This flushing is not serious at this point, but it will be monitored closely.

After thirty-three months in service, little change had taken place since the previous evaluation. Flushing was still noticeable in the control section and the asphalt rubber sections of the eastbound lanes and several transverse cracks were present in the shoulder. No cracks, however, had encroached the traveled area of the roadway.

The overlay appeared to be in excellent condition. There is no evidence to indicate that one fabric performs different from another or that a chipseal using asphalt or asphalt rubber performs different from a fabric.

DISTRICT 4

A 13.2 mile section of Interstate Highway 40 in Oldham County from 1.0 mile east of Vega to 0.3 mile west of Potter County line was overlaid with HMAC in the summer and fall of 1979. The Federal Aid Project designation was IR40-1(102)038. An area containing 8 one-quarter mile test sections was designated as a field trial to evaluate fabrics installed to reduce reflection cracking. The existing pavement was asphalt concrete. A level-up course of HMAC was applied in the summer of 1979. The fabrics and an HMAC overlay was placed in the fall of 1979. Five different types of fabric are included in the eight test sections (Table 1).

Figure C1, Appendix C, shows the locations of the test sections in District 4. Table C2 provides temperature data (1) from Amarillo since construction of the test sections.

Preconstruction

The existing pavement structure consisted of six-inches of lime-stabilized subgrade, twelve-inches of gravel base, six-inches of asphalt stabilized base, three-inches of Type A hot mix asphalt concrete and one-inch of Type D hot mix asphalt concrete. In the summer of 1978, a seal coat was applied using Grade 3 precoated stone, which resulted in a fairly rough textured pavement surface. There was concern about placing the fabrics directly on this rough surface, since the action of traffic in conjunction with the highly textured surface might damage the fabric. Therefore, a level-up course of HMAC was placed in May 1979. The fabric and HMAC overlay were placed in September 1979, about 4 months later.

This construction project was not designated as a field trial for this study until after the sealcoat was placed in 1978. Consequently, the research team was unable to visually observe the cracks in the existing pavement. It was, therefore, impossible to make sketches of the original crack patterns, which are considered an important portion of this study. However, verbal communication with the District Construction Engineer and an exhaustive series of photographs prepared by District 4 personnel revealed that, originally, there was considerable fatigue cracking in the travel lane with some thermal (transverse) cracking and moderate rutting throughout the project.

Deflection data (Table C1) were obtained on these sections during the time between the installation of the level-up course and the installation of the final overlay.

Traffic information for this section is given on Table 1.

Construction

The level-up course was applied in the spring of 1979 and consisted of 65 pounds of HMAC per square yard. Application of the new fabric and the additional overlay on the test sections four months later is described below.

After ambient temperature reached 65°F (19°C), a predetermined quantity of asphalt tack was applied. A small tractor with special attachments was used to apply the fabric to the tacked pavement. Only the traveled roadway was covered. No fabric was placed on the shoulder. The fabric was rolled using a pneumatic roller. Fabric construction joints were tacked using a slow setting anionic emulsion (EA-11M). After applying sand to the fabric surface, to aid in absorbing any excess asphalt tack, the roadway was opened to traffic. The fabrics were exposed to traffic for 2 to 7 days before overlaying. An HMAC overlay was placed on each section at a rate of approximately 125 pounds per square yard. Compaction was accomplished using a dual-tandem steel-wheel roller, two smaller tandem steel-wheel rollers (after 10 to 20 minutes), then finally a pneumatic roller.

A total of eight test sections was constructed. Six of them contained a fabric and two of them were control sections which contained only a light tack between the level-up and the final overlay. A summary of the construction materials and their rates of application and the timing sequence is given in Table 6.

These test sections on IH 40 are located on a straight, flat section of rural interstate highway which typifies optimum conditions for the placement of engineering fabrics. It was noted during construction that the thick fabrics (8 oz/yd^2) were installed with significantly less wrinkles than similar thinner fabrics (4 oz/yd^2).

Soon after the areas containing Fabrics 1 and 2 were opened to traffic, the fabrics were observed to "fluff up", as previously reported (District 7). It appeared that the tires became sticky due to tracking in asphalt cement which bled through the fabric. The tacky tires pulled up the fibers near the upper surface of the fabric thus giving the fluffed appearance. Some fibers were actually removed from the mat as evidenced by a considerable quantity that was observed alongside the roadway.

Table 6. Description of Test Sections on IH 40 in Oldham County (District 4).

Test Section Identification	Underseal Material		Asphalt Tack			ACP Overlay-Type D		
	Type Fabric	Application Date	Type/ Grade	Ave. Rate gal/yd^2	Ave. Temp °F	Ave. Rate**, lb/yd^2	Ave. Temp °F	Application Date
Eastbound								
4-IH40-A	None (Control)	-				124	1-270 2-300	9/20/79 9/15/79
4-IH40-B	Fabric 2 8 oz/yd^2	9/13/79	AC-10	1*-0.17 2-0.21	1-350 2-350	124	1-270 2-300	9/20/79 9/15/79
4-IH40-C	Fabric 1 4 oz/yd^2	9/13/79	AC-10	1-0.18 2-0.13	1-360 2-350	124	1-295 2-300	9/20/79 9/15/79
4-IH40-D	Fabric 4 4 oz/yd^2	9/11,12/79	AC-10	1-0.15 2-0.15	1-360 2-360	124	1-295 2-300	9/20/79 9/15/79
Westbound								
4-IH40-E	Fabric 4 4 oz/yd^2	9/27/79	AC-10	1-0.18 2-0.16	1-355 2-355	126	1-275 2-275	10/4/79 10/2/79
4-IH40-F	Fabric 5 8 oz/yd^2	9/26,27/79	AC-10	1-0.20 2-0.15	1-355 2-360	126	1-265 2-265	10/4/79 10/2/79
4-IH40-G	Fabric 3 4 oz/yd^2	9/26,27/79	AC-10	1-0.15 2-0.13	1-355 2-350	126	1-265 2-265	10/4/79 10/2/79
4-IH40-H	None (Control)	-				126	1-265 2-265	-

*1 = Passing Lane
2 = Travel Lane

**Level-up course of 65 lb/yd^2 was applied a few months prior to the ACP overlay over the fabric.

After a few hours, the pavement surface apparently became less sticky due to the blotting effects of the sand plus cooling of the pavement surface. Cleaner tires of subsequent traffic then pressed the fabric flatly onto the pavement surface. It may never be determined whether or how much this incident affected the ability of the fabric to reduce reflective cracking.

Post Construction

After seven months in service, following the severe winter of 1979-80, a visual evaluation (in April 1980) revealed a considerable quantity of cracks. Several transverse cracks had appeared at the pavement surface which spanned part or all of the roadway. An intermittant longitudinal crack just to the right of the center of the travel lane was visible along approximately 90 percent of each test section. Typical cracking patterns are presented in Figures C2a through C2d in Appendix C. Although it has not been verified, it is assumed that most, if not all, of these are reflection cracks. At the time of the evaluation, the majority of these cracks had been filled with an asphalt crack sealing material.

After nineteen months in service, visual evaluation (April 1981) revealed a very small number of new cracks. No other signs of distress were observed. The lack of additional deterioration is attributed in part to the mild winter of 1980-81.

After thirty-three months in service, no new cracks were observed in the mapped areas; however, several of the old cracks had grown a small amount (6 to 12-inches). Slight rutting (about 1/8-inch) was present in most of the travel (outside) lanes on both the eastbound and westbound sides. Very slight flushing was noted throughout all the test sections in the travel lanes. Scattered areas of slight to moderate raveling was observed in the passing lanes on both sides; a few areas were also noted in the travel lanes. It was determined that in March of 1982, a fog seal consisting of 0.10 gallon per square yard of EA-11M (85% water + 15% emulsion) had been applied to arrest this raveling. This may have contributed to the slight flushing mentioned earlier. There were no consistent differences between any of the test sections from which one could conclude that one fabric offers an advantage over another or that any fabric is better than none at all.

During construction the supply of Fabric 1 was depleted without completely covering test section 4-IH10-B. Therefore, Fabric 2 was placed in the easternmost 24 feet of the travel lane of this test section The thicker Fabric 2 was placed on an asphalt tack of approximately 0.13 gallons per square yard, which is significantly less than the desired quantity for the 8 ounce per square yard fabric. After 33 months of service, this segment of pavement has not exhibited any signs of distress which might be attributed to the insufficient tack coat.

DISTRICT 21

In February 1980, several thousand square yards of engineering fabric were placed with an HMAC overlay on US 281 and SH 107 in Edinburg in an attempt to reduce reflection cracking of the new overlay. The Project number was HES000S(26). Seven fabric test sections approximately 385 feet in length were installed. After milling off much of the old asphalt concrete pavement, six different types of fabrics were applied at different locations and overlaid with HMAC.

Figure D1, Appendix D, gives the location of each test section and identifies the type of fabric in each. Table D3 gives temperature data (1) from McAllen since February 1980.

Construction of the US 281 and SH 107 pavements are quite similar (see Table 1) and will, therefore, be treated together in this section of the report.

Preconstruction

Prior to construction, 1 3/4 to 3-inches of the existing asphalt concrete was removed by cold milling to preserve the curbline. Typically, the resulting surface texture was quite rough as shown by texture measurements (2) in Table D2, Appendix D. Generally, the remaining pavement system consisted of approximately 12 inches of flexible base and 1-inch of HMAC. There were, however, a few small areas where all of the HMAC was milled away and the flexible base was visible.

Cracking patterns visible at the pavement surface prior to milling were mostly of the fatigue variety with some trasnverse cracks in isolated areas (Figure D2, Appendix D). Cracking patterns were quite variable from one location to another and ranged in intensity from almost none in a 100 foot length to continuous, severe alligator cracking in one or both wheelpaths. There was evidence of rutting and pumping in isolated areas. Cracking patterns were no longer visible after the milling procedure.

The structural condition of the pavement after the milling operation and prior to overlaying is described by measurements obtained using the dynaflect (Table D1).

Construction

The fabric test sections in District 21 are located in the urban area of Edinburg. Although these test sections are fairly straight and level, there are a number of intersections several of which have traffic lights. The test sections are therefore exposed to a considerable quantity of shear forces produced by acceleration, deceleration and turning movements of traffic. Table 1 shows that a considerably greater quantity of traffic exists on US 281 than on SH 107.

Construction of the test sections in Edinburg was accomplished in January and February 1980. The fabrics were applied curb to curb directly on the highly textured milled surface after application of predetermined quantities of an asphalt tack coat. Table 7 lists the materials and their application rates and the timing sequence utilized in each test section. (Note the wide variation in tack rate as shown by the coefficient of variation for test sections 4, 5 and 6). A small tractor was used to place the fabrics in the conventional manner. Then the fabric was rolled using a pneumatic roller. At this point, the pavement was opened to traffic for a period ranging from one day to two weeks.

An HMAC overlay was placed on each test section at a rate of approximately 160 pounds per square yard (about 1 5/8 inches in thickness after compaction). The asphalt concrete mat was compacted using two passes of a vibratory steelwheel roller followed, at length, by a few passes of a pneumatic roller.

Seven 1500 foot test sections containing a fabric and one 384 foot control section containing no fabric were built. The lane configuration and fabric installation pattern for US 281 and SH 107 are shown in

Table 7. Description of Test Sections on SH107 and US 281 in Hidalgo County (District 21).

Test Section Identification	Underseal Material		Asphalt Tack				HMAC Overlay-Type D		
	Type Fabric	Application Date	Type/ Grade	Ave. Rate gal/yd^2	C_v** Rate Percent	Ave. Temp °F	Ave. Rate lb/yd^2	Ave. Temp °F	Application Date
21-SH107-1	Fabric 2 8 oz/yd^2	2/6,7/80	AC-10	0.36	4.9	340	148	287	2/11&20/80
21-US281-2	Fabric 6 6 oz/yd^2	1/28,29/80	AC-10	0.28	9.1	340	153	295	2/7/80
21-US281-3	Fabric 6 6 oz/yd^2	1/28,29/80	AC-10	0.28	9.5	340	151	292	2/7,8/80
21-US281-4	Fabric 5* 8 oz/yd^2	2/7,8,11,20/80	AC-10	0.48	13.1	342	157	283	2/20,21/80
21-US281-5	Fabric 4* 4 oz/yd^2	2/8,11,19/80	AC-10	0.32	16.3	340	160	285	2/20,21/80
21-US281-6	Fabric 3* 4 oz/yd^2	2/8,11,19/80	AC-10	0.32	20.8	340	159	284	2/20,21/80
21-US281-7N	Fabric 1 4 oz/yd^2	2/5,6/80	AC-10	0.26	5.7	337	160	294	2/7,20/80
21-US281-7S	Fabric 1 4 oz/yd^2	2/6,7/80	AC-10	0.32	8.3	340	165	293	2/7,20/80
21-US281-C	None	-			-		163	294	2/7,20/80

*During construction the fabric in a small portion of this test section was damaged by prolonged rainfall and was replaced using Fabric 1.

**C_v = Coefficient of variation of asphalt tack.

Figure D3, Appendix 3.

Due to heavy, prolonged rainfall immediately after application of Fabrics 3, 4 and 5 and before placement of the HMAC overlay, it became necessary to replace the fabric in certain areas of sections 21-US281-4, 5, and 6. The only available replacement fabric was Fabric 1. Repairs consisted of complete removal of the damaged fabric and replacement with the Fabric 1 in the western 6 feet of the northbound passing lane and the adjacent 6 feet in the eastern portion of the center left turn lane (see Table D3) at the following locations:

Section 21-US281-4 - STA 1026+60 to STA 1030+38

Section 21-US281-5 - STA 1030+38 to STA 1034+00

Section 21-US281-6 - STA 1045+38 to STA 1049+70

These areas will be observed to ascertain whether significant changes develop which may be attributed to this treatment.

Traffic was again observed to "fluff" fabrics 1, 2 and 6. Since these phenomena were similar to those observed in District 7 and 4 and have been previously discussed in some detail, further discussion will not be given here.

Post Construction

In May 1980, after 3 months in service, longitudinal cracking was observed in test section 21-US281-2. The crack was approximately 20 feet in length and was located just outside the inside wheelpath of the southbound travel lane. It is apparently associated with a longitudinal joint in Fabric 6. Slight alligator cracking was observed in one isolated area (approximately 4 square feet) at the above location. No cracking or other signs of distress were observed in any of the other test sections.

Twelve months after construction, visual observation indicated an increase in the number of cracks in the overlay. An area in section 21-US281-C (Control section) about 2 feet wide and 130 feet long exhibited substantial alligator cracking. These cracks were apparently reflected as this area originally contained severe alligator cracking. Sections 21-SH107-1, 21-US281-2, and 21-US281-3 contained longitudinal cracking located just outside the inside wheelpath of the travel lane. Most of these longitudinal cracks were attributed to longtudinal construction joints in the fabric. All three of these sections contained fabrics from a common manufacturer. Other than an occassional isolated crack, there were no other notable signs of pavement distress in any of the other test sections.

Twenty-eight months after construction, a few new isolated areas of alligator cracking were observed (approximately one per test section). Many of these were apparently not reflection cracks, since cracks were not originally recorded in these locations. (The reader should be reminded that most of the ACP was milled off prior to this fabric/overlay operation). Some looked like typical fatigue-type cracking; whereas, others looked more like small, round base failure (1 to 1 1/2-feet in diameter) which typically develop into a pothole. A few additional longitudinal cracks were observed which, by comparison with the original cracks maps, definitely appeared to be reflective cracks. No transverse cracks were observed. Slight rutting was present, particularly near intersections equipped with signal lights.

There are no indications of differences between fabrics or advantages to be gained by the application of a fabric to prevent reflection cracking.

Based on the performance of the field tests in District 21 at this time, it appears that fabrics can be successfully installed on a pavement surface shortly after cold milling. Prior to overlaying, the fabrics appeared to only "touch the high spots" of the highly textured surface. After 2 1/2 years in service no problems have developed that have been related to the milled surface. In fact, the highly textured surface at the fabric interface may serve to reduce the probability of overlay slippage. This may have been particularly beneficial in the District 21 test project since the overlay was quite thin (1 1/2-inch) and is subjected to comparatively large shear forces as it is located in an urban area. Rough textured surfaces will, however, require additional asphalt tack coat to satisfy the pavement surface "hunger".

DISTRICT 10

Federal Aid Project number EACIR20-6(49)572 was initiated in midsummer 1981. This project consisted of the repair of continuously reinforced portland cement concrete (CRCP) and placement of a fabric interlayer and two lifts of HMAC (Type D over Type B) on 13.17 miles of IH 20 near the Smith-Gregg County line. Approximately 8.34 miles of this project is in Smith County; whereas, the remaining 4.83 miles is in Gregg County. Seven one-quarter mile (1320 feet) test sections were installed in Gregg County to evaluate the effectiveness of six different commercially produced engineering fabrics employed to reduce reflective cracking. Two one-quarter mile test sections were installed in Smith County which contained only a three foot wide strip of fabric placed on the joint between the CRCP and the soil cement shoulder.

Figure E1, Appendix E, shows the limit of each test section in

District 10 and identifies the fabric utilized herein. Table E3 gives temperature data (1) for Tyler since July 1981.

Preconstruction

The original pavement system, composed of 6-inches of cement stabilized base and 8-inches of CRCP with soil cement shoulders, was constructed in 1965. Transverse cracks spaced, on the average, about 3.3 feet apart were prevalent throughout this project. Typical cracking patterns are depicted in Figure E2, Appendix E. In the most severely cracked areas, particularly those which were exhibiting substantial vertical movement upon loading, the concrete was completely removed and replaced with new reinforced concrete. These areas are shown as patches in Figure E2.

Dynaflect data obtained prior to overlaying with asphalt concrete is given in Table E1, Appendix E. A limited quantity of surface texture data (1) was obtained on the original concrete surface and is presented in Table E2.

Construction

Straight sections of CRCP afforded ideal conditions for installation of the fabrics with minimal wrinkles. Table 1 shows that this roadway carries a considerable quantity of heavy truck traffic and receives twice as much rainfall as any of the other fabric test projects.

Construction of the fabric test sections in District 10 was completed in July and August of 1981 in accordance with the following general procedures. After completion of the localized patching (mentioned earlier), a specified quantity of asphalt tack was applied to the pavement surface. Representatives from each fabric manufacturer supervised installation of their own fabric in the test sections to insure that installation procedures were optimized and hopefully to maximize fabric performance.

Fabrics were installed in the usual manner using a small tractor with special attachments to handle the fabric roll and apply the fabric smoothly to the pavement surface. Both the traveled roadway and the shoulders were covered. Fabric construction joints were tacked at the overlap using hot AC-20. The fabrics were typically overlapped about 6 to 8 inches. Two passes of a pneumatic roller insured good adhesion of the fabric to the pavement surface.

The HMAC was placed approximately 0.5 to 2.5 hours after the fabric; hence, the fabrics were not exposed to traffic. About 2-inches of Type B HMAC (Table 8) containing primarily crushed limestone and AC-20 were placed in one lift. Compaction was achieved using a vibratory steelwheel breakdown roller followed by pneumatic rollers and a tandem steelwheel finish roller. A second lift consisting of one-inch of Type D HMAC containing a gap graded mixture of lightweight synthetic aggregate with field sand and concrete sand and AC-20 was placed a few weeks later. The Type D paving mixture was compacted using a three-wheel steelwheel roller followed by a tandem steelwheel finish roller.

Eleven different test sections were constructed. Six contained a fabric completely covering both lanes. Two contained a three foot strip of Fabric 4 centered over the longitudinal joint between the shoulder and the CRCP. And three, containing no fabric, were reserved as

Table 8. Description of Test Sections on IH20 in Gregg Smith County (District 10)*.

Test Section I. D.	Underseal Material: Type Fabric	Underseal Material: Appl Date	Asphalt Tack: Type/Grade	Asphalt Tack: Ave. Rate gal/yd^2	Asphalt Tack: Ave. Temp °F	Hot Mix Asphalt Concrete Overlay, Type B: Ave. Rate lb/yd^2	Type B: Ave. Temp °F	Type B: Appl Date	Type D: Ave. Rate lb/yd^2	Type D: Ave. Temp °F	Type D: Appl Date
10-IH20-1E	Fabric 10	7-20-81 7-21-81	AC-20	0.18 0.25	280 325	192 205	300	7-20-81 7-21-81	113 116	300 285	8-24-81 8-25-81
10-IH20-2E	Fabric 7 3 oz/yd^2	7-20-81 7-21-81	AC-20	0.18 0.20	350 315	192 205	300	7-20-81 7-21-81	113 116	300	8-24-81 8-25-81
10-IH20-3E	Fabric 9	7-20-81 7-21-81	AC-20	0.19 0.24	375 300	192 205	270	7-20-81 7-21-81	113 134	300 320	8-24-81 8-27-81
10-IH20-4E	Fabric 3 4 oz/yd^2	7-20-81 7-21-81	AC-20	0.22 0.25	425 300	192 205	270	7-20-81 7-21-81	113 121	300 320	8-24-81 8-28-81
10-IH20-5E	Fabric 4 4 oz/yd^2	7-20-81 7-21-81	AC-20	0.22 0.24	410 300	182 205	270	7-20-81 7-21-81	113 121	300 320	8-24-81 8-28-81
10-IH20-6E	Fabric 8 4 oz/yd^2	7-20-81 7-21-81	AC-20	0.30 0.27	225 300	192 205	270	7-20-81 7-21-81	114 121	300 300	8-24-81 8-28-81
10-IH20-7E	Control (No Fabric)	-	-	-	-	197 201	295	7-22-81 7-23-81	114 121	310 300	8-26-81 8-28-81
10-IH20-8E	3' Strip Fabric 4	8-15-81 8-21-81	AC-20	0.24 0.28	315 325	188 187	290	7-14-81 7-16-81	109 118	295 275	8-15-81 8-21-81

Table 8. Continued.

	Underseal Material		Asphalt Tack			Hot Mix Asphalt Concrete Overlay					
						Type B			Type D		
Test Section I. D.	Type Fabric	Appl Date	Type/ Grade	Ave. Rate gal/yd^2	Ave. Temp °F	Ave. Rate lb/yd^2	Ave. Temp °F	Appl Date	Ave. Rate lb/yd^2	Ave. Temp °F	Appl Date
10-IH20-8W	3' Strip Fabric 4	6-23-81 6-22-81	AC-20	.242 .260	340 335	181 183	265 275	6-22-81 6-23-81	113 114	300 300	9-26-81 9-28-81
10-IH20-9E	No Fabric	-	-	-	-	188 187	290	7-14-81 7-16-81	109	295 275	8-15-81 8-21-81
10-IH20-9W	No Fabric		-	-	-	181 182	265 275	6-22-81 6-23-81	113 114	300 300	9-26-81 9-28-81

*Uppermost entries within each block represent inside (passing) lane;

Lower entries within each block represent outside (travel) lane.

control sections.

Post Construction

Three months after construction, visual observation revealed slight flushing in isolated areas in the wheelpaths of the travel lane in all test sections. No flushing was visible in the passing (inside) lane. There were no other visible signs of distress. What appeared to be segregated mix was observed in small isolated areas ususally no larger than 6 to 8 square feet. In some of these areas coarse aggregate was predominate as evidenced by the rougher texture and in other areas, fine aggregate was predominate as evidenced by the smoother texture.

After six months in service, very slight flushing was visible in the right wheelpath of the travel (outside) lane in all test sections. Section 10-IH20-2E exhibited continuous slight flushing in both wheelpaths of the travel lane. Flushing was not noticeable in the passing lane of any of the sections.

PROJECT COST DATA

Cost information supplied by district personnel and based on contractor bid prices is presented in Table 9. From these data, an overall average cost (in rounded figures) for furnishing and placing a fabric interlayer of average thickness is 1.10 dollars per square yard including asphalt tack. At the writing of this report the costs of fabric and asphalt cement are down from the 1980 values but the cost of labor is somewhat greater.

Currently, economic advantages gained from the application of these fabrics to reduce reflection cracking cannot be determined, since there are no significant differences in visible cracks between the test sections with and without fabrics. It can be stated, then, that based on results of the field experiments described herein, more than three years are required to determine whether fabrics are economically beneficial when applied to reduce reflection cracking.

Table 9. Approximate Costs Associated with Fabric Interlayers and Comparative Costs of Additional 1" Overlay and Conventional Chipseal (Based on 1980 contractor bid prices).

Item	Average Cost per square yard, dollars			
	Dist 7*	Dist 4	Dist 21	Dist 10
Fabric & Placement	0.84	1.10	1.09	0.50
Tack Coat @ 0.25 gal/yd^2	0.19	0.24	0.19	0.25
Fabric Placement Only (Labor)	-	-	0.39***	-
Total Fabric Installation**	1.03	1.34	1.28	0.75
Additional 1" of Overlay	1.69	2.00	1.20	1.73
Seal Coat	0.77	0.65	0.39	0.85

* Cost of asp-rubber w/agr 3 aggr = $1.24/yd^2

** Based on a hypothetical tack coat of 0.25 gal/yd^2

*** Part of the fabric used in District 21 was in stock prior to obtaining bids.

PROBLEMS EXPERIENCED AT SELECTED FIELD PROJECTS IN TEXAS

Numerous pavement rehabilitation projects in Texas have involved the use of fabric interlayers or underseals. Most of these have been successful; a few have been disastrous. Two things seem to be common to many of the "disasters" - thin overlays and high traffic volume.

Overlays less than 1 1/2-inches in thickness placed over a fabric interlayer on high traffic volume facilities have exhibited premature distress in several locations (Table 10). Similar problems have been reported in other states (4 and 5). Distress occurs, typically, during the first year after construction and appears as alligator cracking or slippage at the fabric interface. Alligator cracking is most likely to appear in the wheelpaths on straight sections; whereas, slippage is more probable in urban areas at intersections or in curves where shear forces (from braking or turning movements) are maximized.

Thin overlays are difficult to adequately compact which, of course, results in comparatively high air voids. Water can penetrate this permeable layer until it reaches the asphalt-impregnated fabric interlayer. The water may remain near the bottom of the new overlay for extended periods depending on the weather. This moisture in combination with traffic can weaken the overlay by freeze-thaw cycling or possibly by stripping near the bottom of the layer. Distress develops first in the wheelpaths due to repetitve loading of traffic on the weakened pavement layer.

One mechanism by which fabrics are purported to reduce reflective cracking is by relieving shear (horizontal) strains at the fabric-asphalt

Table 10. Summary of Selected Field Projects Containing Fabrics which have Experienced Problems

Location	Thickness of Overlay, in.	Date of Installation	Date of Distress	Type(s) of Distress	Comments
Dist 5 - Parmer Co. US 60	1 1/4	July-Sep 80	Spring 81	Extensive slippage and shoving with cracking.	Similar mix performing well on adjacent sections with no fabric.
Dist 5 - Lubbock Loop 289N	1 1/4	May 80	Winter 80/81	Extensive cracking.	Drum mix plant, low quality HMAC.
Dist 10 - Smith Co. IH-20	1 1/2	July 81	Jan 82	Alligator cracking wheelpath.	First occurred after snow, ice and severe cold weather.
Dist 21 - McAllen 10th St.	1	Aug 79	Sept 79	Rutting and shoving.	Most likely due to low stability of overlay mixture.
Dist 21 - Donna Silver St.	1	Spring 79	Summer 79	Slippage near intersections.	
Dist 24 - El Paso Alameda Ave.	1 1/2	Sept 78	Aug 80	Slippage at curves and intersections.	Occurred during period of abnormally high temperatures.
City of Wichita Falls Hempstead and 9th Streets	1 1/2	May 81	July 81	Slippage at intersections and curves with cracking.	No problems with similar construction and no fabric. Low tack likely contributed to problem.

interlayer. That is, the fabric interlayer offers a shear plane to absorb or dissipate a portion of the shear stresses before they reach the new overlay and cause reflective cracks. Shear forces of considerable magnitude are developed at the base of thin pavement sections simply by the passage of heavy wheel loads. According to laboratory tests (6), under normal conditions the shear strength at a fabric interface is more than adequate to sustain these stresses. However, if the overlay has been weakened, particularly in the vicinity of the fabric interface (say, by moisture), then excessive lateral movement at or just above the fabric interface is likely to occur with the passage of each heavy wheel load. This, of course, will result in premature fatigue failure of the new overlay.

In areas where high shear forces are developed, the distress may appear as slippage. Slippage cracks are typically crescent shaped with the arched end of the crack pattern pointed in the direction opposite that of vehicle travel. Shear strength at the fabric interface as well as compressive and tensile strength of the asphalt concrete (all of which must be exceeded for localized slippage to occur) are lowest at high ambient temperatures. Therefore, slippage problems are most likely to occur in urban areas during hot weather.

Slippage should not be confused with problems resulting from unstable overlay pavement mixtures. Distress due to low stability will appear as plastic deformation within the mixture such as rutting, shoving, corrugations, etc. Cracking is not normally associated with mixtures of low stability; and fabrics should not be blamed for these types of distresses.

Moisture can be trapped below an undersealed and overlaid pavement which can migrate upward through cracks and pores in the old pavement until it encounters the impermeable asphalt-fabric interlayer. Evidence indicates that moisture can accumulate at the underside of the fabric interlayer and after a period of time seriously reduce the bond strength between the fabric and the old pavement. Horizontal components of stresses imparted by repetitive vertical wheel loads and other shear forces can eventually result in fatigue-related pavement distress or slippage.

In all fairness to fabrics, personnel from several districts in Texas as well as other parts of the nation have reported notable reductions in reflective cracking when using fabrics as compared to identical sections containing no fabric. In many cases, extensive cracks have reflected through a conventional overlay during the first winter; whereas a similar overlay with a fabric underseal exhibited little or no cracking during the same period.

OTHER EXPERIENCE IN TEXAS

DISTRICT 6 (7)

Test sections containing various combinations of fabric, sealcoat and HMAC overlays were installed on IH 20 in Midland County in 1973 and 1974. Descriptions of the rehabilitative construction techniques employed and the quantity of reflection cracking observed in 1979 are given in Table 11.

It is seen that the fabric plus chipseal plus 1.25-inch overlay gave the best results after 7 years in service with only 15 percent reflective cracking. The 2.5-inch overlay yielded the next best results with only 20 percent reflective cracking and the fabric plus 1.25-inch overlay gave 32 percent reflective cracking after 7 years. Based on these data it appears that the fabric-asphalt interlayer did not perform as well as an additional 1 1/4-inch of HMAC between 3 and 7 years in service. Use of fabrics can, however, be of particular value in sections where an increase in pavement thickness is undesirable, such as in curb and gutter sections or below an overpass.

Chronological progression of reflection cracking for selected District 6 test sections is depicted in Figure 7. This plot illustrates the rapid progression of reflection cracks during the first year or two for the sealcoat plus fabric and the conventional thin (1 1/4-inch) overlay; whereas, the thicker overlay (2 1/2-inch) and those overlays reinforced and/or undersealed with a fabric and/or a sealcoat exhibited a delay of 2 to 3 years before significant reflection cracking was visible.

Table 11. Reflective Cracking Measurements on IH 20, Midland County, District 6.

Test Section Limits Beginning Milepost	Date of Construction	Type of Construction	Percent Reflective Cracking in 1979
124.5	April 1974	Control Section 1 1/4-inch HMAC	57
125.0	April 1974	Fabric + 1 1/4-inch HMAC	32
125.5	7/73 Sealcoat 4/74 Overlay	Sealcoat + 1 1/4-inch HMAC	47
126.0	April 1974	1 1/4-inch HMAC + Fabric + Seal-coat	15
126.5	July 1973	Sealcoat + 1 1/4-inch HMAC with 3% latex	59
127.0	July 1973	Fabric + Sealcoat	Failed
127.5	July 1973	Sealcoat + 1 1/4-inch HMAC with 6% latex	66
128.0	7/73 Sealcoat 4/74 Overlay	Fabric + Sealcoat + 1 1/4-inch HMAC	53
128.5	April 1974	2 1/2-inch HMAC	20
129.0	July 1973	Sealcoat + 1 1/4-inch HMAC with 10% latex	61
129.5	April 1974	1 1/4-inch HMAC + Emulsified rubber solution	63

(After Reference 7)

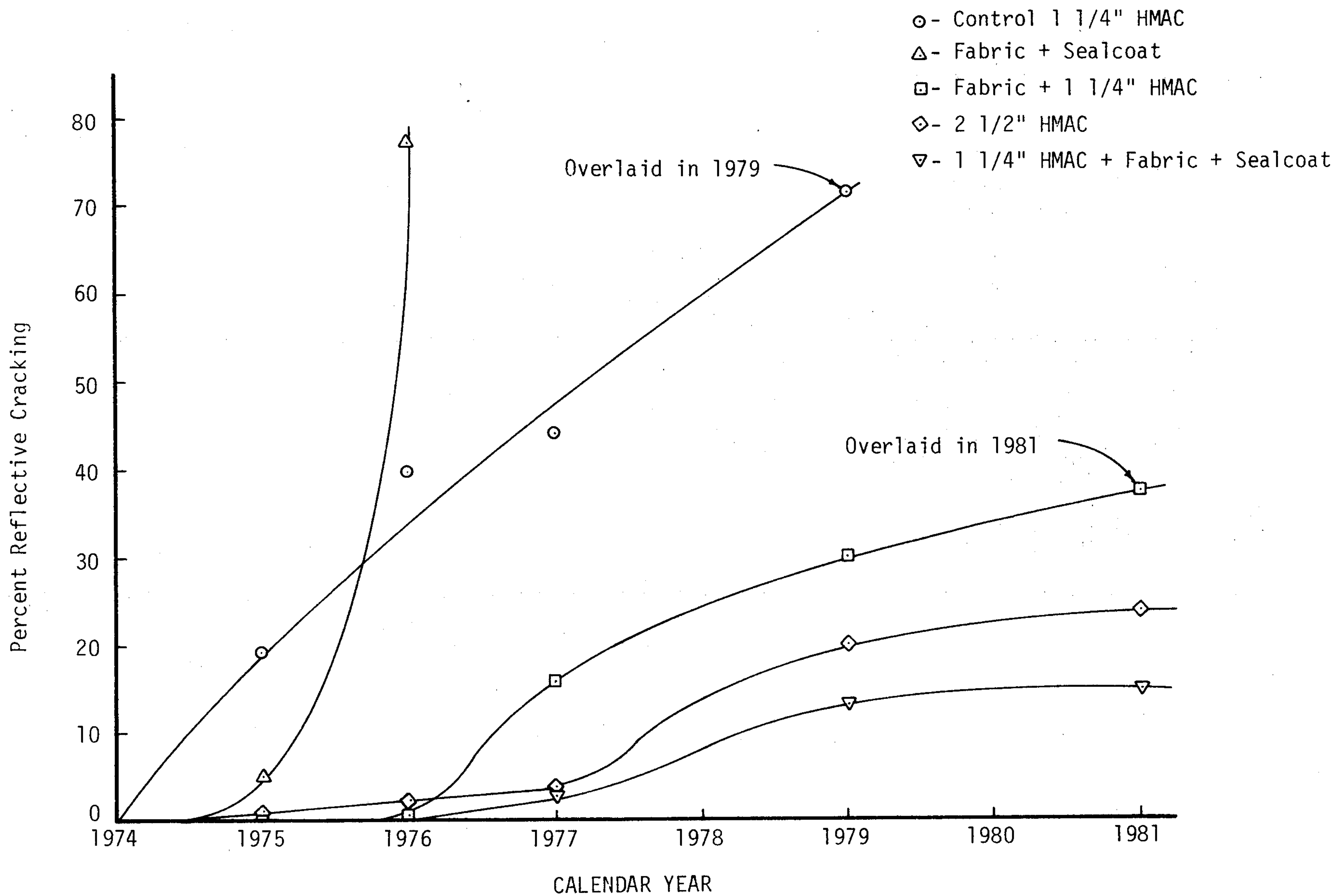


Figure 7. Reflection Cracking Progression for Selected Rehabilitative Treatments. (After Reference 7)

LABORATORY TESTING AT TEXAS A&M UNIVERSITY

Laboratory tests on fabric and paving mixtures containing fabrics have been conducted at the Texas Transportation Institute (6,8,9 and 10) for Mirafi Inc (formerly Celanese Fibers Marketing Company) to establish mechanisms responsible for the performance of fabrics as reflection crack arrestors and determine desirable fabric properties. The research program included testing to determine the following:

1. Asphalt content of fabric at saturation,
2. Temperature - shrinkage characteristics of fabrics,
3. Adhesive strength between pavement and fabric,
4. Shear strength of old pavement-fabric-new overlay interface,
5. Resistance to thermal reflection cracking (overlay tester) and
6. Tensile properties of fabric-mixture system.

Some of these methods used to describe the above parameters were developed in the course of this research.

Several properties of the fabrics were determined by Mirafi Inc and are included in the report. Fabric properties recorded were grab strength, grab elongation, toughness, Mullen burst, free shrinkage force and high hysteresis test. Fabric properties were compared to laboratory test results and some significant correlations were found.

Asphalt content of fabrics at saturation was determined by soaking the fabric in hot asphalt cement, placing it between two absorbent papers, then pressing out the excess asphalt using a hot iron. Asphalt contents at saturation ranged from 0.03 to 0.33 gallons per square yard (0.00013 to 0.00015 m^3/m^2). With this knowledge about the fabric and similar information about the pavement surface, Equation 1 may be used to obtain pavement tack coat quantities:

$$Q_d = 0.08 \pm Q_c + Q_s \qquad \text{Equation 1}$$

where

Q_d = design tack quantity, gal/yd^2

Q_s = fabric asphalt saturation content, gal/yd^2 and

Q_c = correction based on asphalt demand of old surface, gal/yd^2.

The 0.08 is an average value based on field experience for overlays with no fabric.

Linear shrinkage was determined by soaking the fabrics in hot asphalt then simply measuring the change in dimensions. The temperature of 250°F appears to be critical, above which some shrinkage is exhibited in most fabrics.

A construction cracking test was devised to determine if fabric shrinkage could cause early cracking in a new overlay. In the presence of wrinkles or cuts (or joints without sufficient overlap) in certain fabrics cracks due to fabric shrinkage may appear in thin overlays within less than one hour. Fabrics with free shrinkage in excess of about 7 percent or fabrics with shrinkage forces in excess of about 100 grams (8) may cause cracking during construction. Fabrics with linear shrinkage greater than 5 percent after soaking in 300°F asphalt for 30 minutes may cause construction cracking. Techniques to minimize these adverse effects are given in the report (8).

Peel strength, a measure of adhesive strength between a fabric and a tacked pavement surface, was quantified. Adequate adhesion between the fabric and the old pavement surface is important during construction to prevent the fabric from "rolling-up" of "wrinkling" under construction equipment. Surface charactersitics of a fabric as well as quantity and grade of asphalt cement tack can affect peel strength.

Interface shear strength was measured by using a test method developed to simulate the braking action of a wheel on a pavement. The apparatus exerted shear stresses within a test specimen at the fabric-pavement interface. Fabrics will significantly decrease interfacial shear strength of an asphalt overlay at lower service temperatures where shear strength is more than adequate; however, the effect of fabrics on interfacial shear strength is much less at higher temperatures where shear strength becomes critical. Shear strength is directly related to surface texture and frictional properties of fabrics and somewhat dependent on tack coat quantity. Laboratory test results indicate that properly installed fabrics will not compound overlay slippage problems.

Fatigue cracking of pavements is caused by repetitive wheel loads and will appear as alligator cracking in the wheel path. Flexural fatigue test results on asphalt concrete containing fabrics were compared with a similar mixture containing no fabric. Test results indicate that, when a fabric is placed within a specimen to withstand a portion of the tensile load, fatigue performance can be improved. Fabrics with fuzzy surfaces and capable of holding more asphalt appear to give best fatigue results. Thin fabrics are more sensitive to asphalt tack rate.

Resistance to thermal reflection cracking was determined using the "overlay tester". This machine was designed to simulate the cyclic displacements within a pavement due to periodic thermal variations. Laboratory test data indicates all the fabrics studied will significantly reduce thermal reflection cracking of asphalt concrete.

Tensile properties of the fabric-mixture system were determined from uniaxial tensile tests. Results of these tests can be used to define the material's stress-strain behavior and predict thermal cracking. Indications are that the use of fabrics will improve tensile properties of asphalt concrete, particularly at low strain levels, which is important from a pavement performance standpoint.

Increased tack coat quantity appears to enhance performance of most of these laboratory tests. However, this may be due to the migration of the excess asphalt into the voids of the asphalt concrete specimens during compaction thus improving its inherent performance under tensile stresses.

Existing field data was summarized and briefly discussed which includes systems other than fabrics used to retard reflection cracking. The basic conclusions include the following: (1) fabrics perform well in mild climates, (2) fabrics are most effective in arresting alligator-type cracking, (3) performance of fabrics is not good when placed over thermally cracked pavements and (4) for flexible pavements with alligator cracking a fabric with one inch of asphalt concrete will perform about equivalent to 2-inches of asphalt concrete overlay. However, field performance information will be required prior to stating these conclusions with confidence.

Finite element theory and fracture mechanics were applied to the overlay test and direct tension test results (8, 11). Fracture properties of asphalt concrete can be altered substantially by the inclusion of fabrics. For this analysis, it appears that best performance may be obtained by placing a level-up course on the old pavement prior to the placement of fabric and the overlay.

SUMMARY OF CONCLUSIONS

Conclusions 1 through 10 are based on results of field and laboratory tests conducted during this study. Conclusions 11 through 16 are based on analyses of other available information involving the application of fabrics to reduce reflection cracking in asphalt concrete overlays.

1. After up to three years in service, there are no consistent differences between any of the test sections from which one could conclude that one fabric offers an advantage over another or that fabric, in general, is better than none at all.

2. Pneumatic rolling of the fabric immediately after application will maximize adhesive strength and shear resistance and minimize its disruption by traffic, construction equipment or wind.

3. Traffic action can delaminate and/or remove fibers from fabrics. Some types of fabrics are more susceptible to this phenomena than others.

4. Fabrics can be successfully employed on very highly textured surfaces such as freshly milled pavement, in fact, a highly textured surface at the fabric interface may decrease the probability of overlay slippage.

5. Pneumatic rolling of fabric on a slope sometimes resulted in slippage (downhill) of the fabric at the hot asphalt tack interface. Fabrics with a somewhat "fuzzy" surface next to the asphalt tack offer more resistance to slippage (and thus wrinkling) under tires of construction equipment than the smoother surfaced fabrics.

6. Additional tack (emulsified asphalt or hot asphalt cement) applied between overlapped layers of fabric at construction joints will minimize disruption of fabric by wind or construction equipment.

7. Some wrinkling of fabrics during installation is unavoidable. On a straight section, wrinkles (if any) will be typically longitudinal sometimes amplified by action of the pneumatic roller if the fabric is not fairly taut in the transverse direction. On a curved section wrinkles will, of course, be transverse and largest toward the inside of the curve. Heavier or thicker fabrics (field tests involved 8 oz/yd^2 fabrics) resist wrinkling during installation better than the thinner fabrics (4 oz/yd^2). Certain fabrics are noticeably stiffer than others of equal weight; they also seem to offer resistance to wrinkling.

8. Bubbles two to six inches in diameter appeared in a fabric that was placed shortly after a summer shower and left exposed for several days (District 7). Even though the pavement surface appears dry, small voids in the pavement will contain water for fairly long periods. Moisture in the small openings will be effectively sealed in by the fabric-asphalt membrane and later vaporized by solar heating thus causing bubbles to form under the mat. This situation should be avoided whenever possible but if bubbles do form they should be eliminated by slitting and rolling with a pneumatic roller prior to overlaying.

9. Exposure of fabric to prolonged rainfall and traffic action immediately after installation can adversely affect the fabric-to-pavement bond. In severe cases, isolated areas of fabric may become completely separated from the pavement. A highly textured pavement surface, where there are significant voids between the fabric and the pavement surface, will most likely be detrimental to this situation. This may have been a contributing factor at the related incident in District 21 (described earlier).

10. Thin overlays (less than 1 1/2-inches) placed over fabric on high traffic-volume roadways can, under certain conditions, result in premature failure of the overlay.

11. Fabrics which exhibit free shrinkage in excess of 5 percent upon exposure to 300°F for 30 minutes can cause hairline cracks to appear during construction at wrinkles or improperly overlapped cuts in the fabric.

12. Laboratory tests have shown that a fabric interlayer will improve the tensile properties of asphalt concrete, particularly at low strain levels. This appears to be advantageous from a pavement performance viewpoint.

13. Presently it appears fabrics are most effective in arresting reflection of alligator-cracking and least effective against thermal-type cracking.

14. The asphalt impregnated fabrics usually remain intact even after moderate cracking and may, therefore, aid in reducing the flow of surface water to the base.

15. Insufficient asphalt tack applied for fabric adhesion can result in failures due to slippage at the fabric interface, especially in areas of high shear forces during periods of hot weather. Excessive tack can migrate to the pavement surface and appear as flushing in the wheelpaths. Low viscosity asphalts are more susceptible to "bleed through" than higher viscosity materials.

16. Fabrics can be of particular value in sections where an increase in pavement thickness is undesirable, such as in curb and gutter sections or below an overpass.

RECOMMENDATIONS

The field study reported herein should be considered only as a first stage program. Annual observations of the test sections should be continued until realistic estimates of the benefits of the different fabrics can be established.

Based on the results of the study at this stage, the following recommendations are given as guides to minimize problems during construction and early service-life and to maximize long-term performance of fabrics installed to arrest reflection cracking:

1. Patch potholes, fill cracks larger than one-eighth inch, and eliminate faulting prior to application of fabric.

2. Fabric installed to reduce reflection cracking should not be unnecessarily exposed to traffic and the elements. Exposure can only serve to damage the fabric and thus reduce its effectiveness even though the fabric may not appear to be damaged. Traffic will abrade away fibrous material to varying degrees depending upon the type of fabric; this was manifested during the field tests by the quantity of fibers observed alongside the roadway. Tires will pinch or wear holes in the fabric at the peaks of the larger aggregate in the old surface. Fabric will be damaged predominantly right where it is needed most which is in the wheelpaths. Furthermore, from a skid resistance standpoint, a dangerous situation could develop on exposed fabric, particularly during periods of wet weather.

"Cure time" for the asphalt cement tack coat prior to covering with the overlay is not necessary. Only an insignificant quantity of volatiles will evaporate from asphalt cement at normal pavement service temperatures even after several months.

3. Fabric should be overlapped at transverse joints with top layer pointed in direction of travel of traffic and/or construction equipment. Joints should be tacked with a reasonable quantity of emulsified asphalt or hot asphalt cement. Adequate overlap of fabrics at transverse joints should be at least one foot; whereas overlap of longitudinal joints can be as little as six-inches.

4. Cutback asphalts should never be used as tack or to secure fabric overlaps. The petroleum-based solvents in cutbacks are damaging to most synthetic fabrics.

5. It is recommended that large wrinkles be cut and overlapped to reduce the localized bulkiness of the fabric. Wrinkles can be a source of premature cracking in the overlay due to compaction without firm support or possibly due to fabric shrinkage (particularly if the fabric shrinks more than about 5 percent upon exposure to the hot overlay) (8).

6. Maximum allowable values of fabric linear shrinkage should be considered for a fabric specification. A critical value appears to be near 5 percent. Additional research would be necessary to establish this limit.

7. Avoid the use of thin, high void overlays with fabric, particularly on high traffic volume facilities. An overlay thickness of 1 1/2-inches should be considered a minimum for use with fabrics. Only dense graded mixtures with low permeability should be installed over a fabric.

8. Consider a specification to cover fabric surface texture. This appears to be important from the standpoint of shear strength at the fabric/asphalt concrete interface. Laboratory tests showed higher shear

strength at the fabric interface when using fabrics with fuzzy surfaces as compared to fabrics with smooth surfaces (6).

9. The appropriate viscosity grade of asphalt cement to utilize as fabric tack coat for a particular job should be based on the maximum temperature of the overlay at laydown, range of ambient temperatures, solar radiation, traffic volume and weight, and magnitude of expected shear forces. It should be as soft as possible to allow proper functioning of the strain-relieving interlayer while providing adequate adhesive and shear strength between layers. Grade AC-10 is recommended for moderate to low temperature environments and AC-20 is recommended for high temperature environments. Generally, use same grade as used in HMAC.

10. Asphalt saturation content of a fabric is dependent upon thickness and absorbency of the fabric and should be quantified prior to designing a pavement containing fabric. Two methods of estimating asphalt retention of a fabric are reported in the literature (8, 12). The proper quantity of asphalt tack is dependent not only on fabric properties but also on the condition of the old pavement surface.

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APPENDIX A

Engineering Properties of Materials

Table A1. Physical Description of Fabrics Installed in Test Sections

Fabric I. D.	Nominal Weight, oz/yd^2	Nominal Thickness, mils	Material	Type Construction	Type Filament	Fiber Bonding
1	4	60	Polyester	Nonwoven	Continuous	Needle-punched
2	8	90	Polyester	Nonwoven	Continuous	Needle-punched
3	4	–	Polypropylene	Nonwoven	Staple	Needle-punched and heat bonded on both sides
4	4	–	Polypropylene	Nonwoven	Staple	Needle-punched and heat bonded on one side
5	8	–	Polypropylene	Nonwoven	Staple	Needle-punched and heat bonded on one side
6	6	75	Polyester	Nonwoven	Continuous	Needle-punched
7	3	15	Polyester	Nonwoven	Continuous	Spunbonded and heat bonded
8	4	17	Polyester	Nonwoven	Continuous	Spunbonded and heat bonded
9	5	60	Polypropylene	Nonwoven	Continuous	Spunbonded and needle-punched
10	5	-	Polyester and Polypropylene	Nonwoven	Continuous	Woven

Table A2. Partial List of Manufacturers of Fabrics, Tapes, Etc., which are used as Interlayers.

Material	Manufacturer	Description
Amopav	Amoco	Non-woven polypropylene
Bidim Cerex	Monsanto Company	Non-woven polyester fabric, spunbonded nylon fabric
Bituthene	W. R. Grace	Polypropylene fabric with rubberized asphalt backing
Durglass	Johns-Mansville	Non-reinforced fiberglass mat
Extrudamat	Hercules	Short length polypropylene fibers applied as an asphalt slurry
Fibretex	Crown-Zellerbach	Spunbonded polypropylene (5 layers)
Glass Fiber	Burlington Glass Company	
Mirafi	Mirafi, Inc.	Non-woven polypropylene and polyethylene
Petromat	Phillips Fibers Corporation	Non-woven polypropylene
Polygard	Polygard Products	Rubberized asphalt with fabric backing
Protecto-wrap	Protecto-wrap Company	Bituminous resin modified with a synthetic resin and reinforced with a fabric
Reepav Typar	DuPont	
Trevira	Hoechst	Spunbonded continuous filament polyester
Trutex	True Temper	
Varistrate	3M Company	

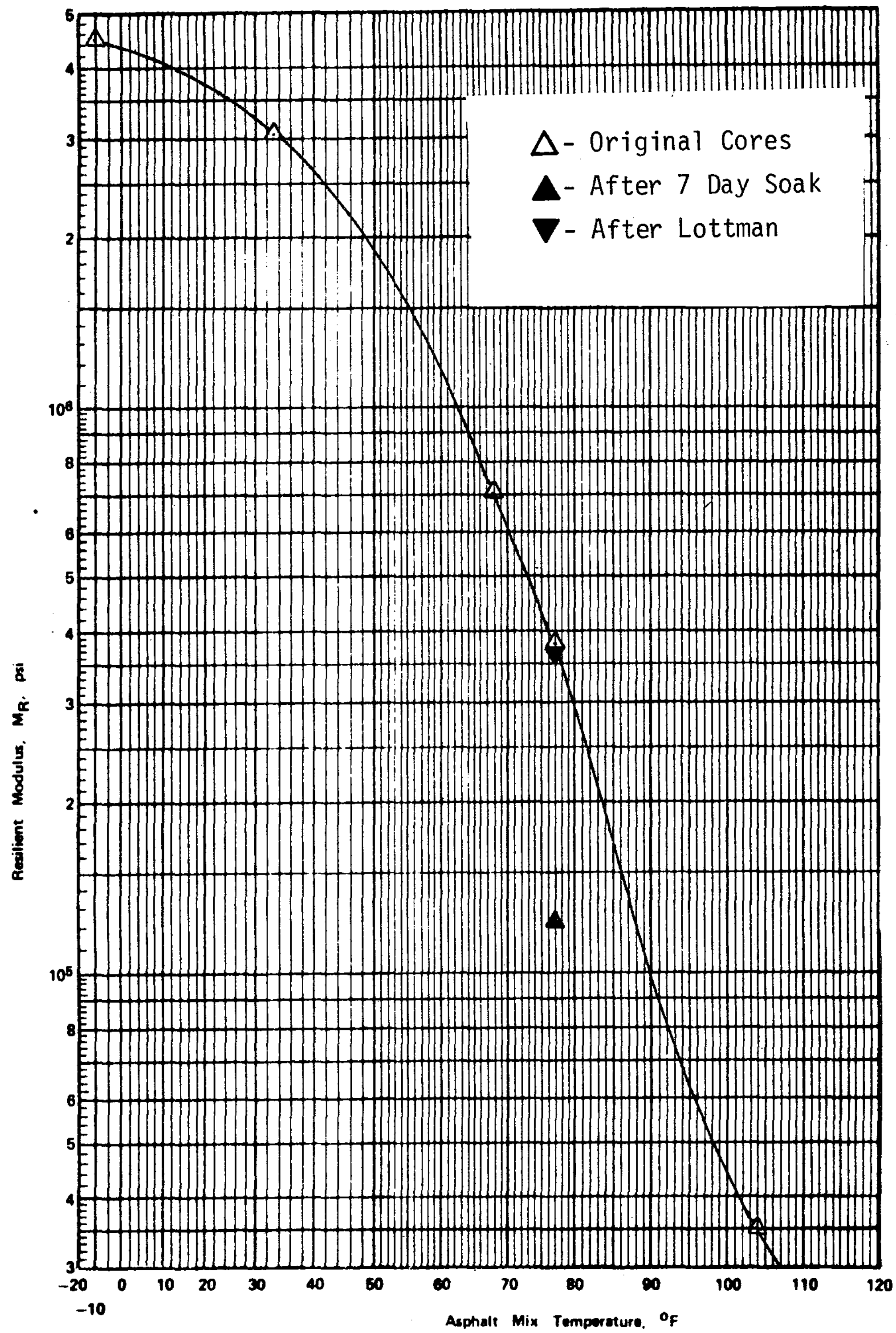


Figure A1. Resilient Modulus (M_R) as a function of Temperature for Cores from District 7 plus M_R after Moisture Treatment.

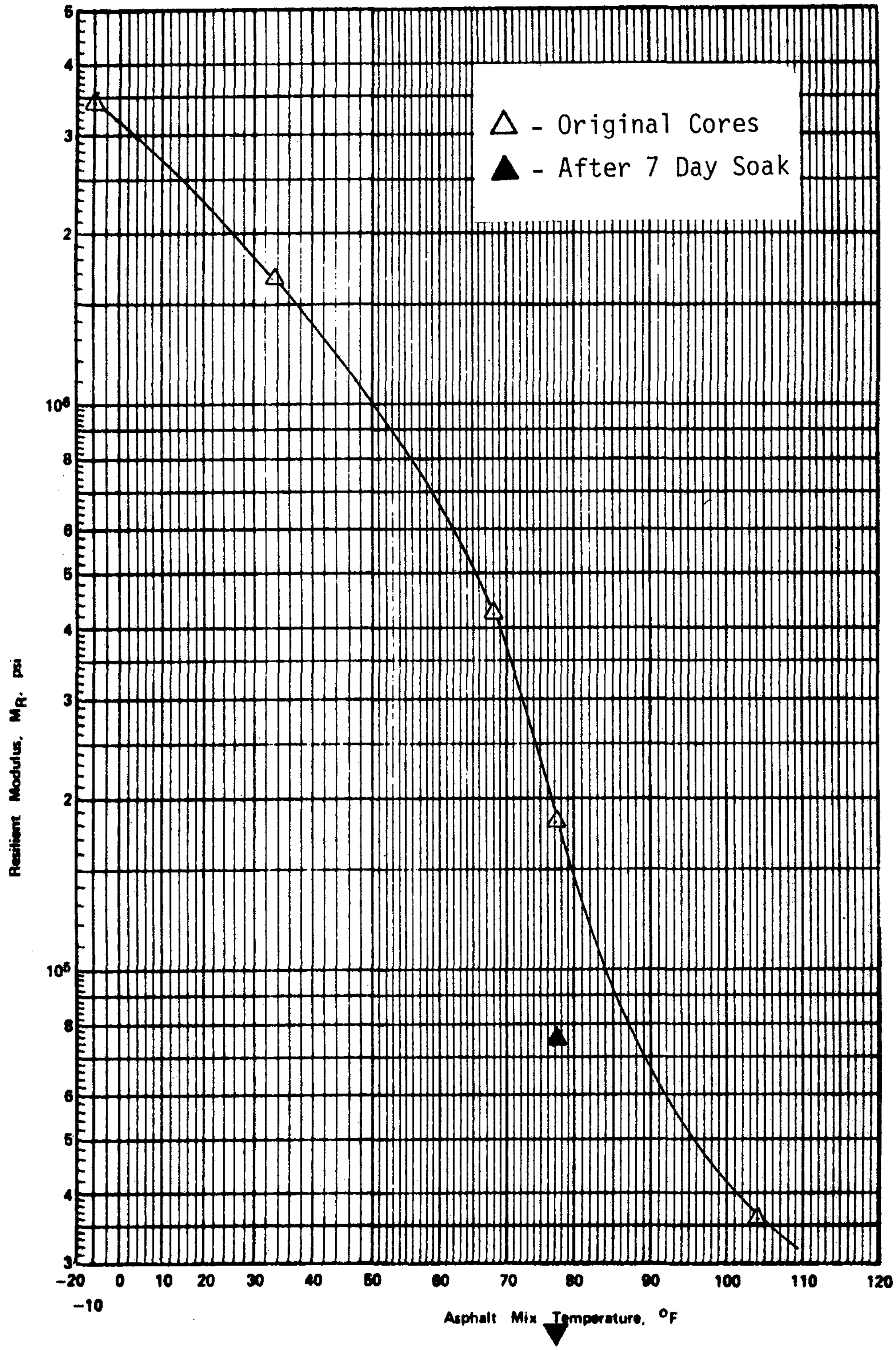


Figure A2. Resilient Modulus (M_R) as a function of Temperature for Cores from District 4 plus M_R after Moisture Treatment.

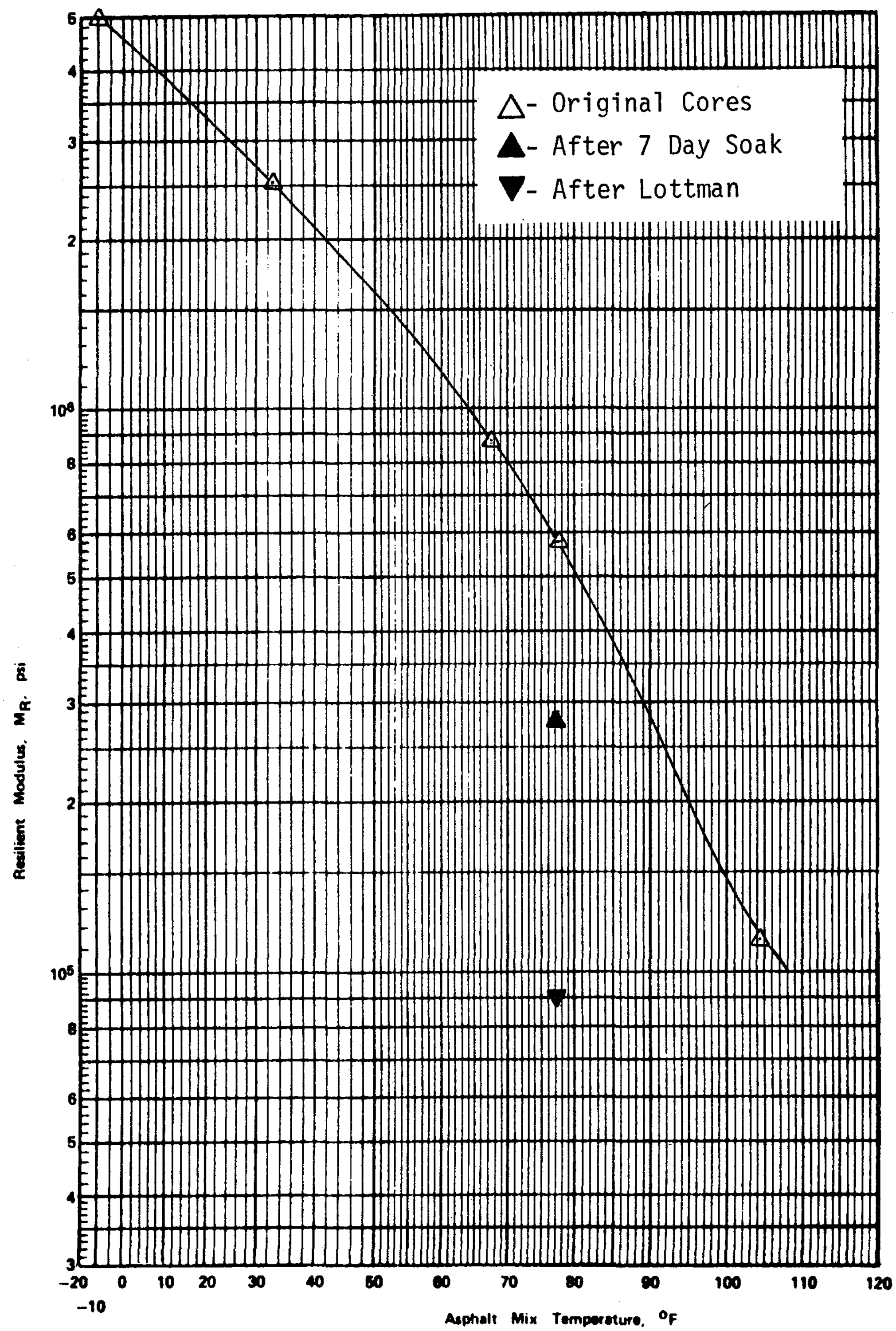


Figure A3. Resilient Modulus (M_R) as a function of Temperature for Cores from District 21 plus M_R after Moisture Treatment.

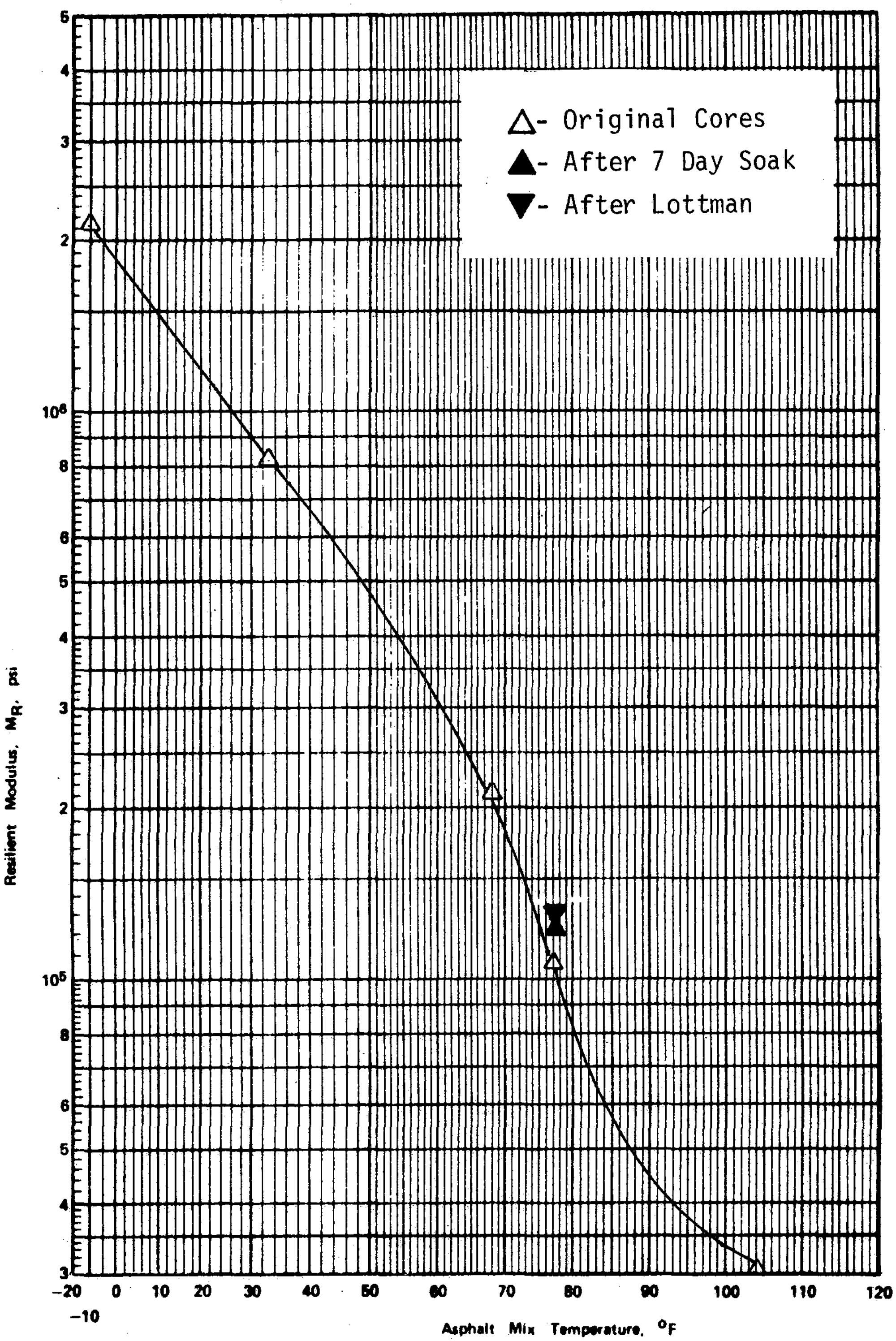


Figure A4. Resilient Modulus (M_R) as a function of Temperature for Type D Cores from District 10 plus M_R after Moisture Treatment.

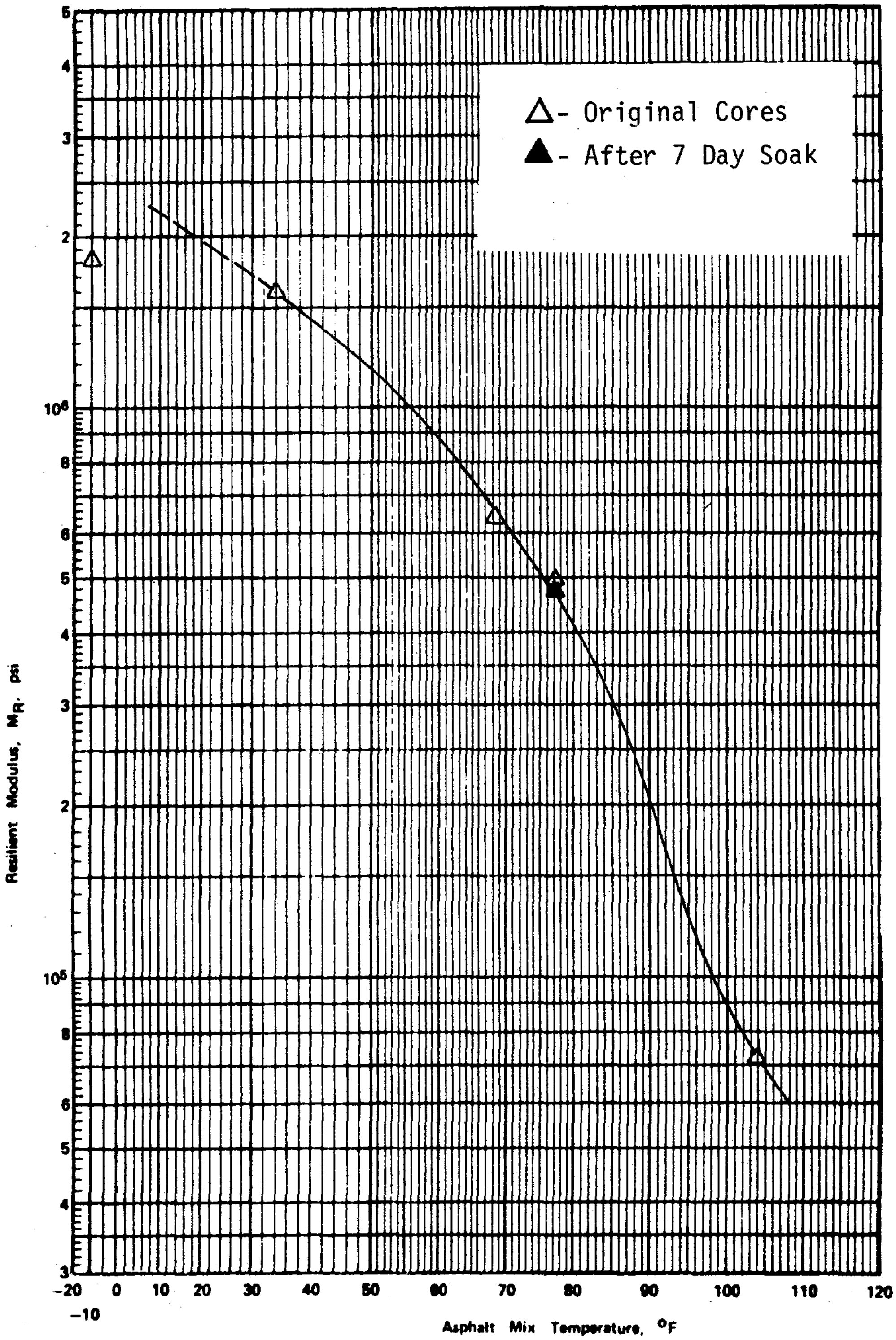


Figure A5. Resilient Modulus (M_R) as a function of Temperature for Type B Cores from District 10 plus M_R after Moisture Treatment.

APPENDIX B

Test Results in District 7 (IH 10)

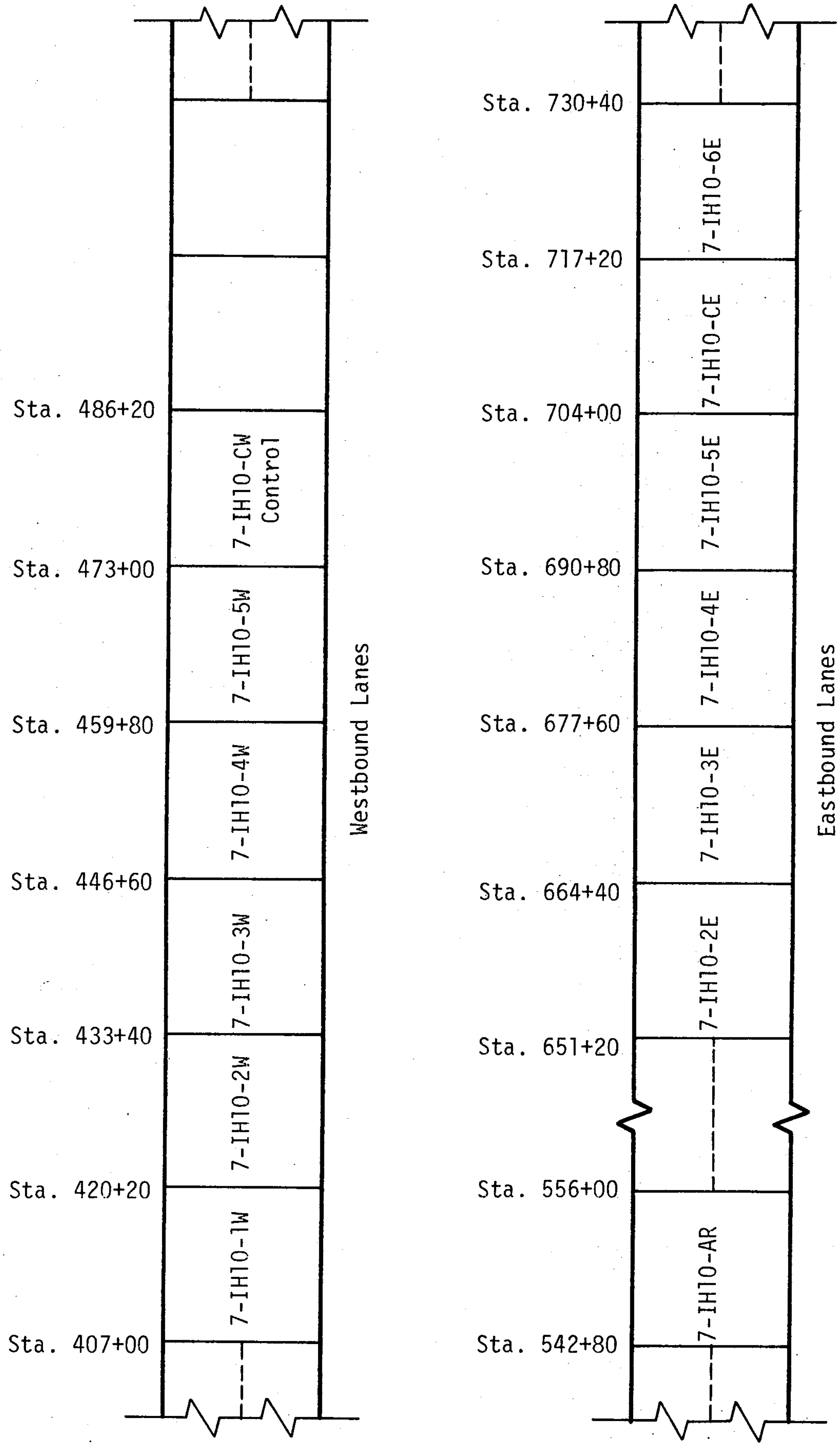


Figure B1 . Location of Test Sections on IH10 in District 7 West of Sonora

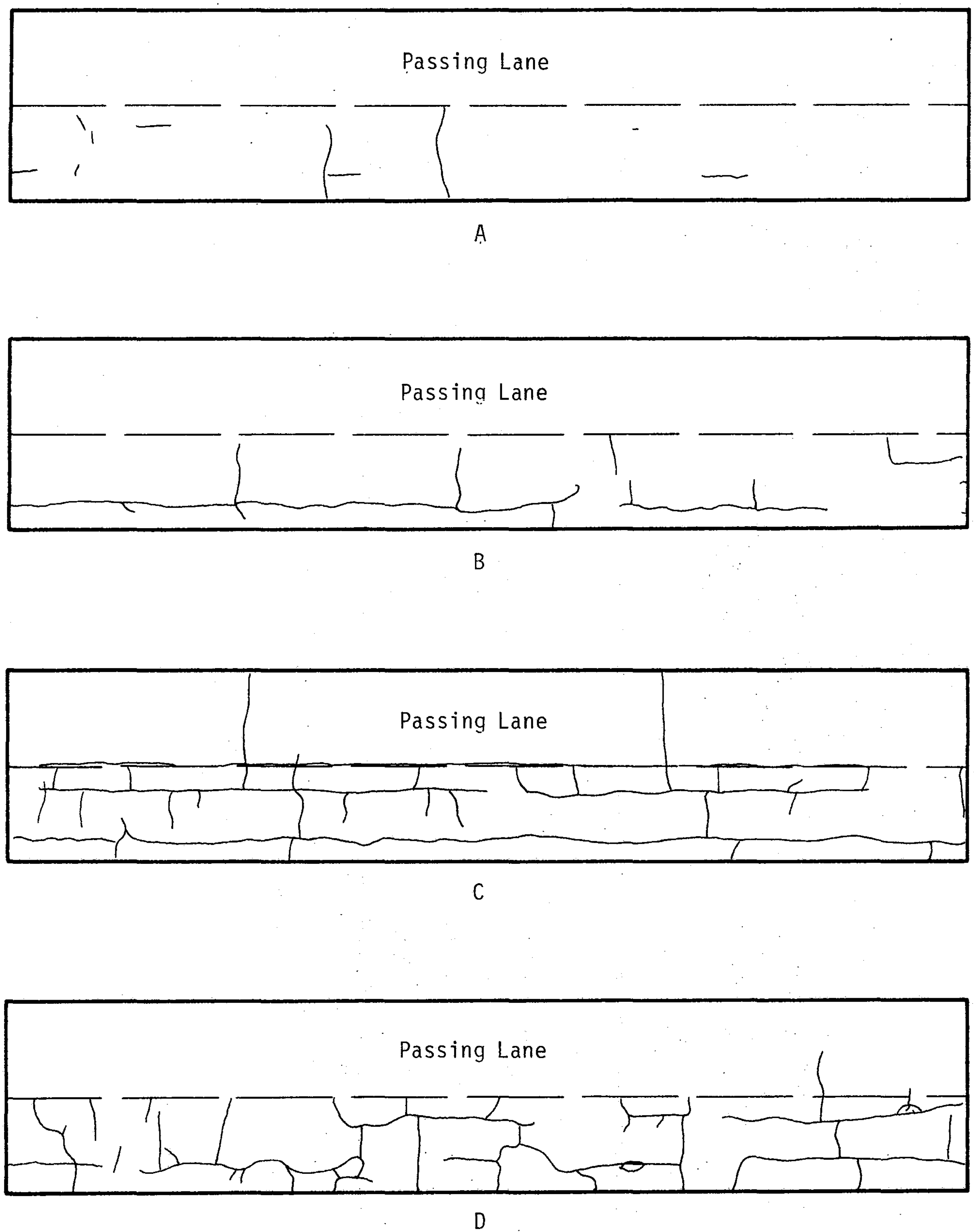


Figure B2. Typical Cracking Patterns on IH 10 West of Sonora (District 7) Prior to Overlaying (Maps are typically 100 ft. x 24 ft.).

Table B1. Dynaflect Data from District 7

Test Section ID	Maximum Deflection, mils			Surface Curvature Index, mils		
	Mean	Std Dev	Coef Var	Mean	Std Dev	Coef Var
Eastbound						
7-IH10-2E	0.312	0.071	23%	0.162	0.045	28%
7-IH10-3E	0.312	0.093	30%	0.134	0.056	42%
7-IH10-4E	0.216	0.067	31%	0.104	0.041	39%
7-IH10-5E	0.255	0.124	49%	0.124	0.071	57%
7-IH10-6E	-	-	-	-	-	-
7-IH10-CE	0.414	0.057	14%	0.182	0.044	24%
7-IH10-AR	-	-		-	-	-
Overall Avg	0.302	0.082	29%	0.141	0.051	36%
Westbound						
7-IH10-1W	0.845	0.149	18%	0.228	0.037	16%
7-IH10-2W	0.665	0.287	43%	0.176	0.052	29%
7-IH10-3W	0.763	0.362	47%	0.259	0.132	51%
7-IH10-4W	0.478	0.224	47%	0.189	0.086	45%
7-IH10-5W	0.715	0.387	54%	0.252	0.099	39%
7-IH10-CW	0.85	0.262	31%	0.27	0.063	23%
Overall Avg	0.592	0.279	47%	0.229	0.078	34%

Table B2. Surface Texture Measurements (1) Prior to Overlay from IH 10 (District 7).

Surface Texture Depth*, inches							
Section I. D.	Travel Lane				Passing Lane		
Eastbound	OWP	BWP	IWP	C_L	IWP	BWP	OWP
7-IH10-2E	0.069	0.100	0.077	0.115	0.119	0.152	0.111
7-IH10-3E	0.083	0.091	0.070	0.130	0.101	0.130	0.119
7-IH10-4E	0.082	0.104	0.098	0.150	0.107	0.104	0.116
7-IH10-5E	0.088	0.107	0.083	0.100	0.118	0.114	0.114
7-IH10-CE	0.068	0.114	0.077	0.072	0.112	0.116	0.100
7-IH10-AR	0.007	0.028	0.023	0.068	0.056	0.046	0.043
Westbound							
7-IH10-1W	0.004	0.002	0.006	0.038	0.051	0.051	0.020
7-IH10-2W	0.018	0.062	0.016	0.038	0.019	0.046	0.018
7-IH10-3W	0.015	0.024	0.006	0.044	0.033	0.055	0.035
7-IH10-4W	0.016	0.024	0.008	0.045	0.032	0.047	0.045
7-IH10-5W	0.009	0.0025	0.007	0.033	0.025	0.083	0.030
7-IH10-CW	0.018	0.028	0.007	0.026	0.020	0.051	0.054

OWP - Outer Wheelpath

BWP - Between Wheelpath

IWP - Inner Wheelpath

*Silicon Putty Method

Table B3. Temperature Data from Ozona (Sonora) District 7

Month	Average Monthly Temperatures Maximum	Minimum	Highest	Lowest	Maximum Drop in 24 hours
1979					
Sept	89	58	99	48	44
Oct	85	51	97	29	46
Nov	64	35	79	11	49
Dec	61	33	78	13	46
1980					
Jan	61	32	79	21	45
Feb	64	33	82	20	52
Mar	71	39	85	8	63
Apr	79	47	89	30	45
May	84	61	97	50	34
June	94	70	106	65	34
July	98	73	104	64	38
Aug	92	69	98	60	33
Sept	87	67	95	55	36
Oct	76	50	88	30	45
Nov	63	35	88	20	51
Dec	60	34	78	20	54
1981					
Jan	59	32	79	22	48
Feb	61	37	79	10	60
Mar	66	42	84	26	37
Apr	76	56	85	36	42
May	83	59	97	40	33
June	87	66	95	56	-
July	93	69	98	61	27
Aug	94	66	100	58	31
Sept	88	59	98	43	35
Oct	77	55	91	32	35
Nov	72	38	85	22	48
Dec	65	29	80	12	49

Table B3. Continued.

Month	Average Monthly Temperatures				Maximum Drop in 24 hours
	Maximum	Minimum	Highest	Lowest	
1982					
Jan	61	27	81	1	60
Feb	59	32	82	10	48
Mar	73	45	93	18	44
Apr	79	52	96	39	53
May					
June					
July					
Aug					

APPENDIX C

Test Results in District 4 (IH 40)

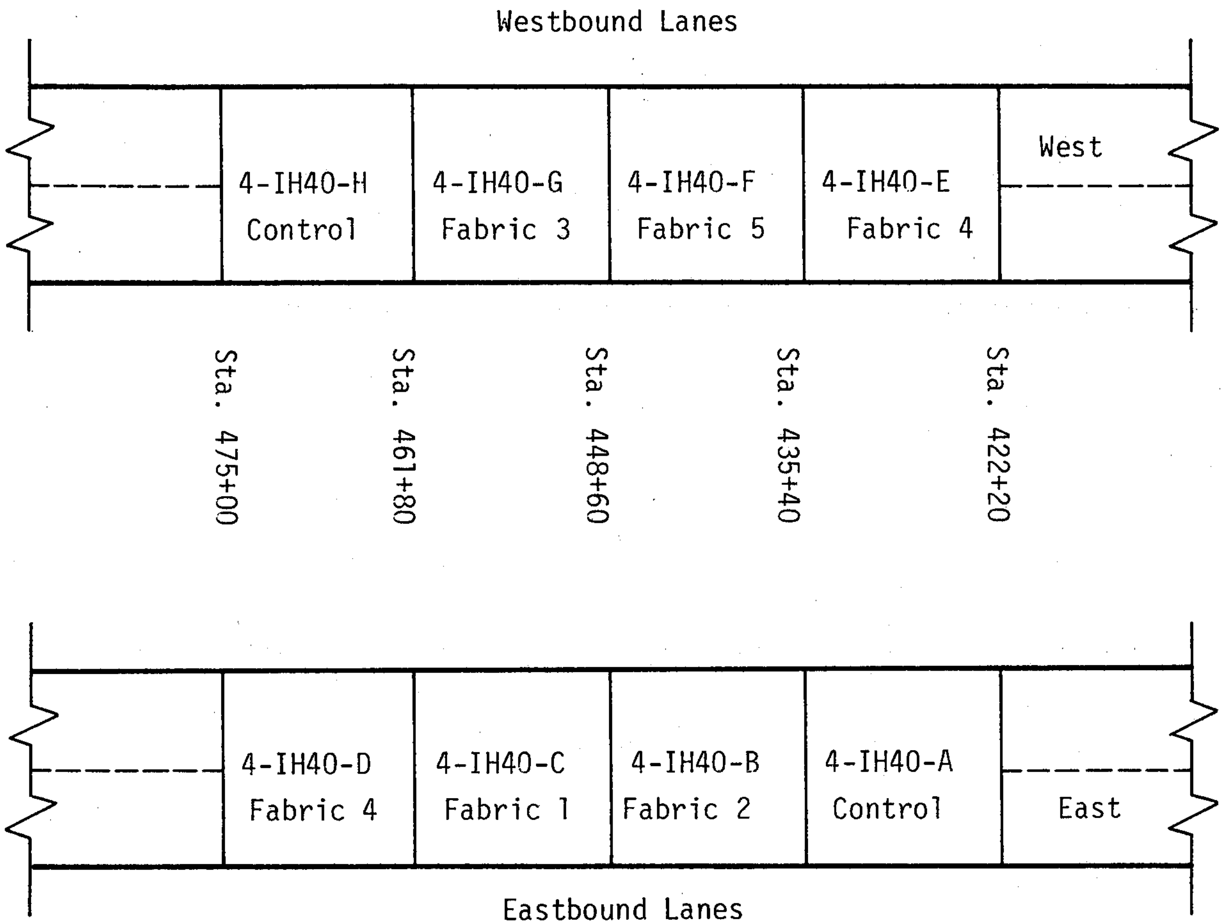


Figure C1. Location of Test Sections on IH40 in District 4 West of Amarillo
*Eastermost 24 feet of section 4-IH40-C received Fabric 2.

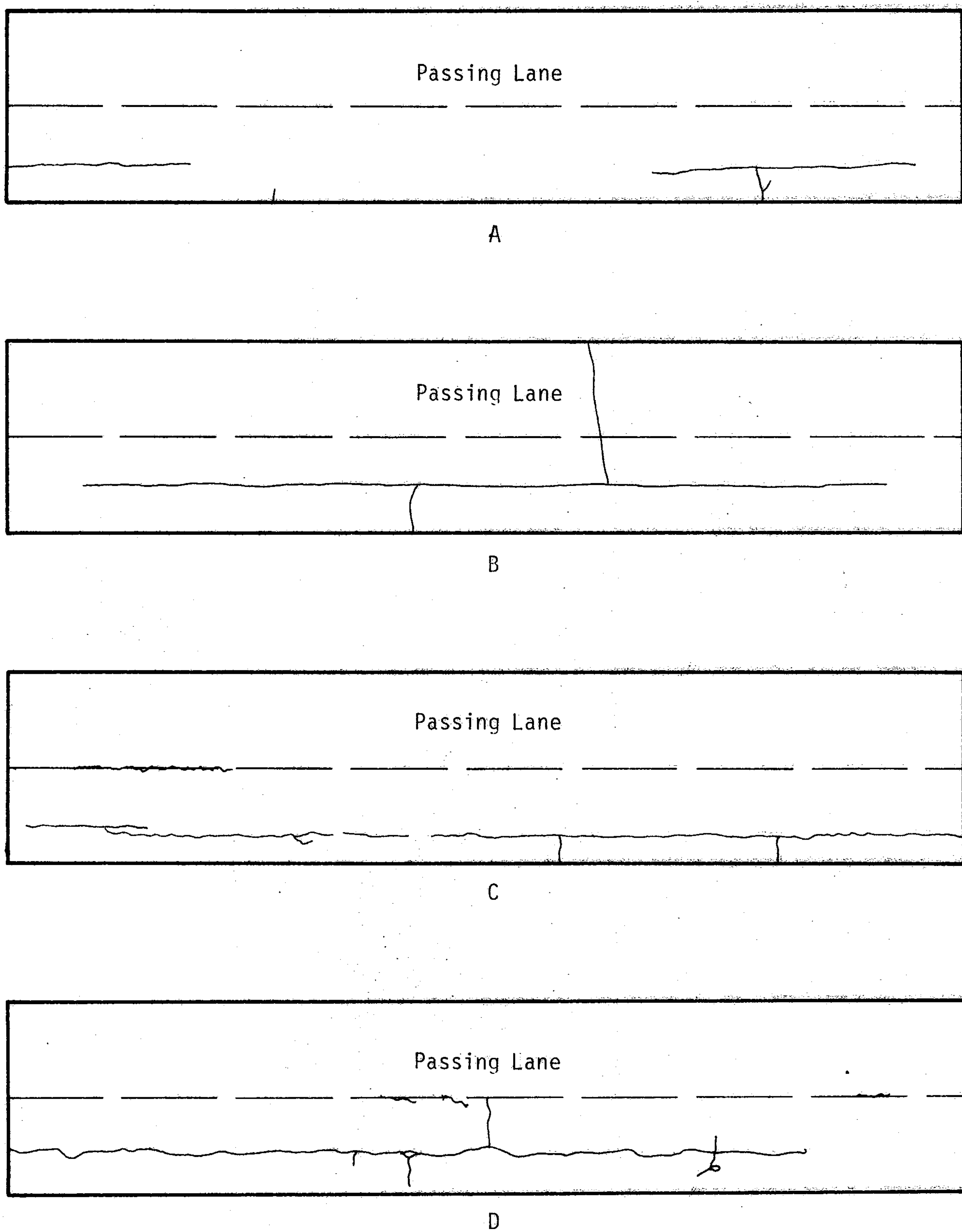


Figure C2. Typical Cracking Patterns on IH40 West of Amarillo (District 4) (These reflected through overlay during first winter). (Maps are typically 100 ft. x 24 ft.).

Table C1. Dynaflect Data from District 4

Test Section ID	Maximum Deflection, mils			Surface Curvature Index, mils		
	Mean	Std Dev	Coef Var	Mean	Std Dev	Coef Var
Eastbound						
7-IH40-A	1.13	0.136	12%	0.28	0.057	20%
7-IH40-B	1.32	0.151	11%	0.38	0.068	18%
7-IH40-C	1.38	0.157	11%	0.40	0.054	14%
7-IH40-D	1.44	0.176	12%	0.42	0.069	16%
Overall Avg	1.32	0.155	12%	0.36	0.062	17%
Westbound						
7-IH40-E	1.37	0.104	8%	0.45	0.058	13%
7-IH40-F	1.44	0.177	8%	0.50	0.055	11%
7-IH40-G	1.38	0.100	7%	0.45	0.044	10%
7-IH40-H	1.53	0.090	6%	0.56	0.092	16%
Overall Avg	1.43	0.118	7%	0.49	0.067	13%

Table C2. Temperature Data from Amarillo District 4.

Month	Average Monthly Temperatures Maximum	Minimum	Highest	Lowest	Maximum Drop in 24 hours
1979					
Sep	83	56	94	46	40
Oct	76	44	94	31	45
Nov	52	29	68	16	42
Dec	53	24	73	9	51
1980					
Jan	47	23	73	9	46
Feb	50	25	77	9	36
Mar	59	28	76	4	44
Apr	67	38	85	26	42
May	75	49	92	41	35
June	93	64	106	51	37
July	97	68	104	62	34
Aug	92	65	99	58	36
Sept	83	58	97	42	38
Oct	72	42	84	21	43
Nov	56	29	87	3	47
Dec	56	26	77	11	45
1981					
Jan	53	23	75	13	47
Feb	59	25	83	-7	51
Mar	62	36	83	22	44
Apr	79	52	89	37	49
May	80	52	93	37	42
June	93	64	107	48	-
July	95	68	105	58	35
Aug	86	63	95	56	28
Sept	81	57	91	47	35
Oct	69	44	85	28	42
Nov	63	35	80	23	44
Dec	55	25	76	13	40

Table C2. Continued

Month	Average Monthly Temperatures Maximum	Minimum	Highest	Lowest	Maximum Drop in 24 hours
1982					
Jan	54	21	73	2	63
Feb	50	22	82	-5	45
Mar	64	31	82	9	44
Apr	70	38	89	24	55
May					
June					
July					
Aug					

APPENDIX D

Test Results in District 21
(US 281 and SH 107)

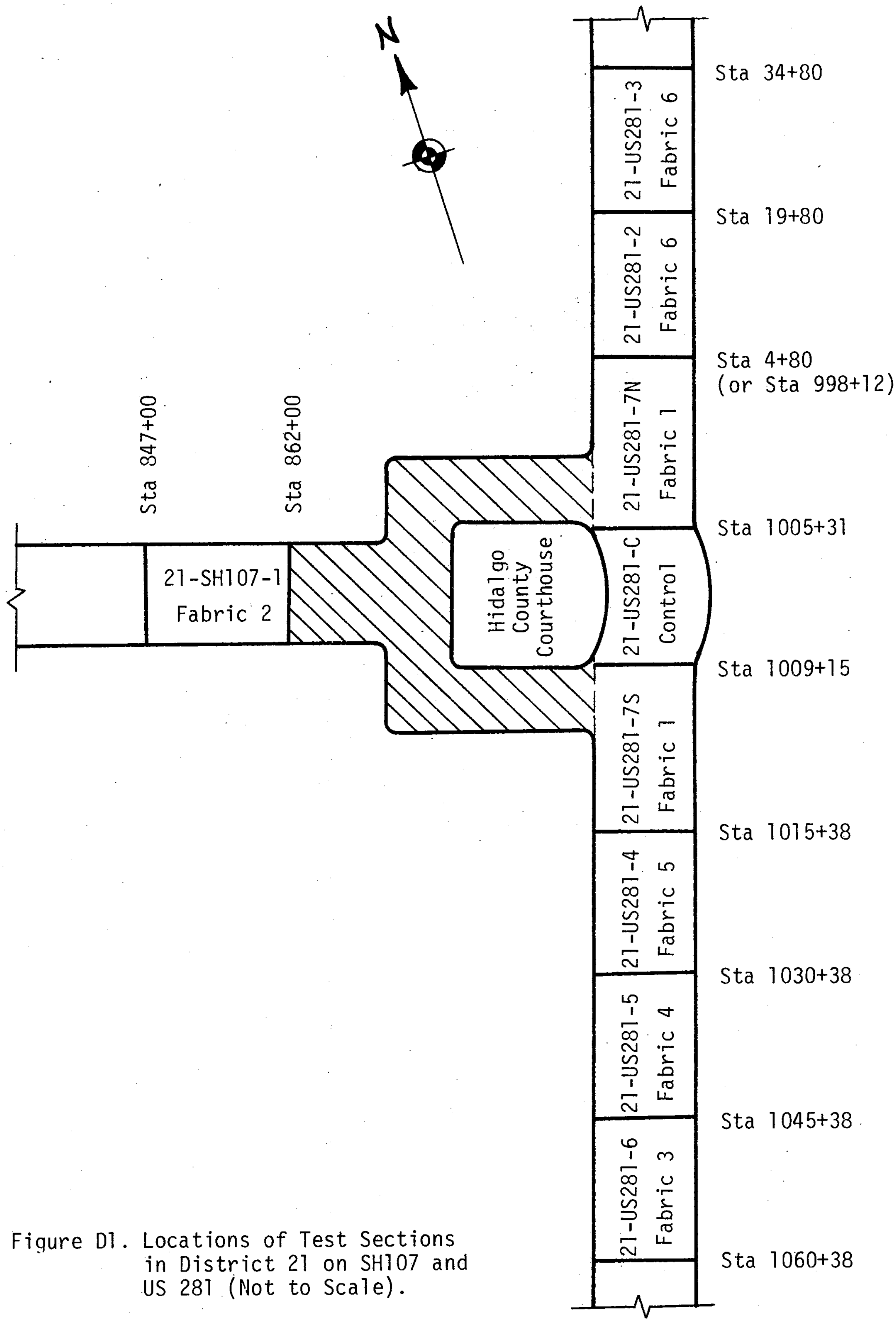
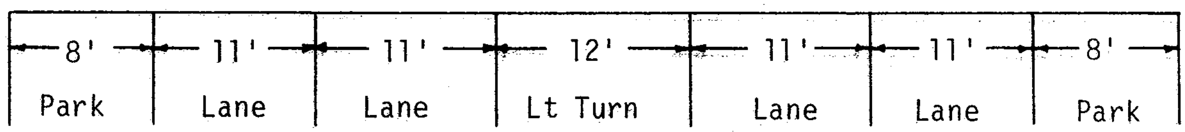
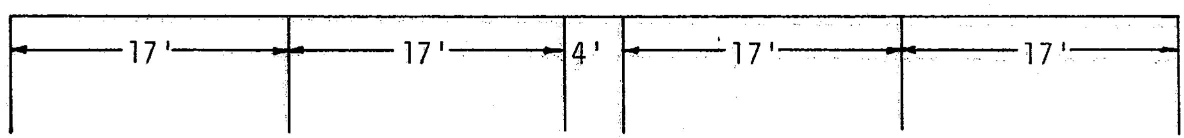


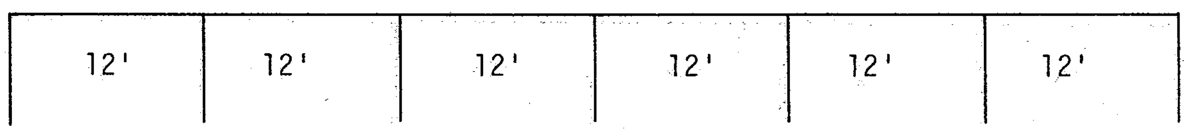
Figure D1. Locations of Test Sections in District 21 on SH107 and US 281 (Not to Scale).



Lane Configuration



Widths of Fabric 1 and 2



Widths of Fabric 3, 4 and 5

Figure D2. Lane Configuration and Fabric Installation Patterns used in District 21.

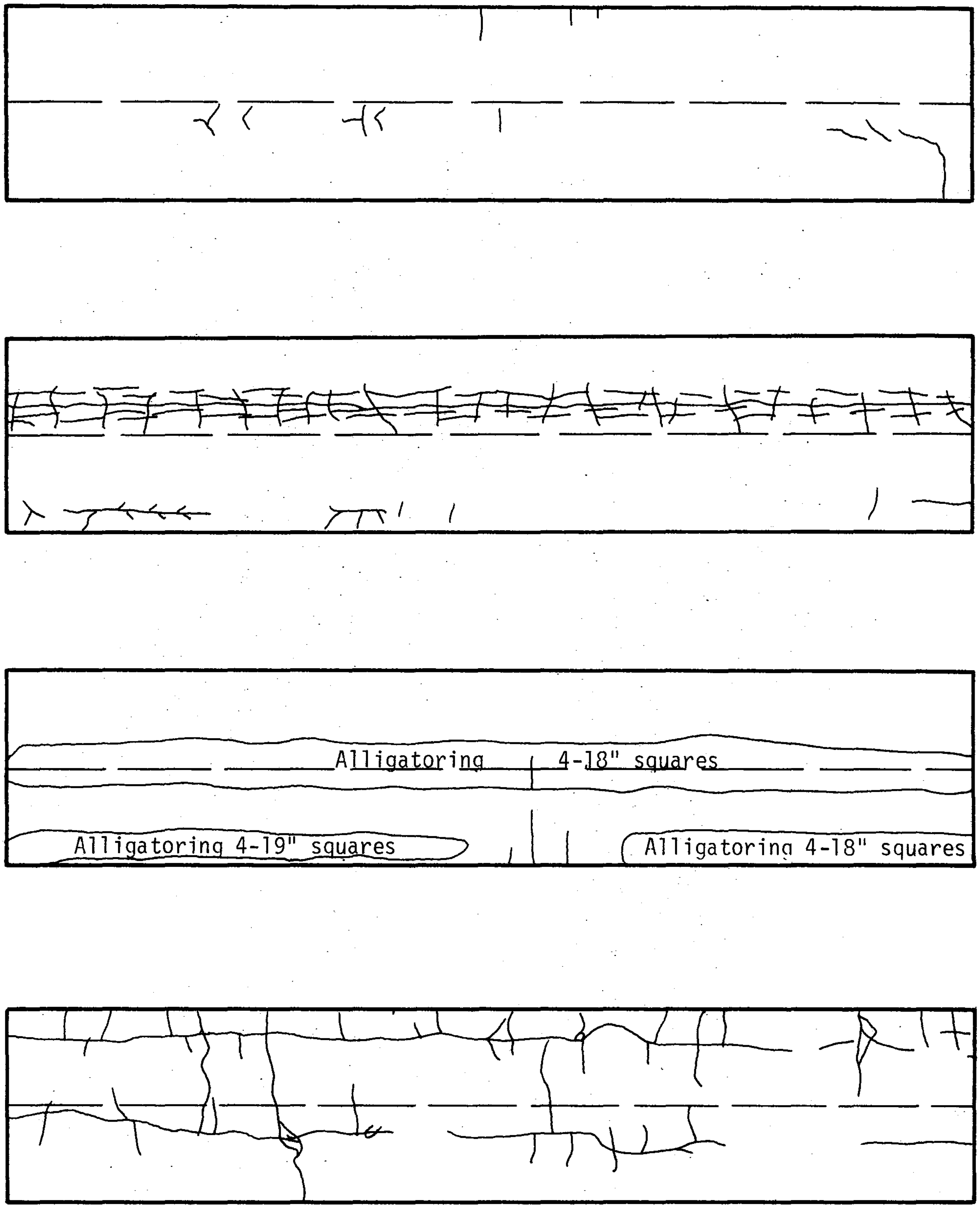


Figure D3. Typical Cracking Patterns on US 281 in Edinburg (District 21) Prior to Overlaying. (Maps are typically 100 ft. x 24 ft.).

Table D1. Dynaflect Data from District 21*

Test Section ID	Maximum Deflection, mils			Surface Curvature Index, mils		
	Mean	Std Dev	Coef Var	Mean	Std Dev	Coef Var
21-SH107-1	2.29	0.930	41%	0.70	0.246	35%
21-US281-2	1.82	0.397	22%	0.63	0.280	45%
21-US281-3	1.75	0.259	15%	0.58	0.155	27%
21-US281-4	2.29	0.932	41%	0.78	0.452	58%
21-US281-5	3.44	0.618	18%	0.66	0.114	17%
21-US281-6	3.36	0.664	20%	0.99	0.37	37%
21-US281-7	-	-	-	-	-	-

*Dynalfect data was obtained after surface milling was completed

Table D2. Typical Surface Texture Measurements from District 21 Test Sections after Milling.

Section I.D.	Travel Lane Texture Depth, inches			
	OWP	BWP	IWP	Mean
21-SH107-1	0.107	0.130	0.135	0.124
21-US281-6	0.144	0.146	0.169	0.153
21-SH107-1*	0.067	0.117	0.067	0.084

*Area where ACP was completely removed by milling.

Table D3. Temperature Data from McAllen (Edinburg) District 21

Month	Average Monthly Temperatures				Maximum Drop in 24 hours
	Maximum	Minimum	Highest	Lowest	
1980					
Feb	72	51	90	33	35
Mar	83	60	93	31	35
Apr	87	62	99	43	39
May	90	71	95	60	28
June	97	76	104	72	24
July	100	76	101	72	31
Aug	95	77	100	73	28
Sept	96	74	100	68	27
Oct	85	64	97	31	30
Nov	72	51	88	36	33
Dec	70	50	83	38	35
1981					
Jan	68	48	82	36	37
Feb	73	53	90	34	33
Mar	78	57	90	43	35
Apr	85	69	93	56	23
May	90	70	98	58	25
June	94	75	99	71	-
July	97	75	101	73	26
Aug	98	77	103	74	28
Sept	92	71	99	54	25
Oct	90	65	95	44	36
Nov	82	57	89	44	35
Dec	76	49	90	35	35
1982					
Jan	74	48	90	27	48
Feb	70	49	92	31	38
Mar	80	58	90	37	33
Apr	85	65	100	52	35
May					
June					
July					
Aug					

APPENDIX E

Test Results in District 10 (IH 20)

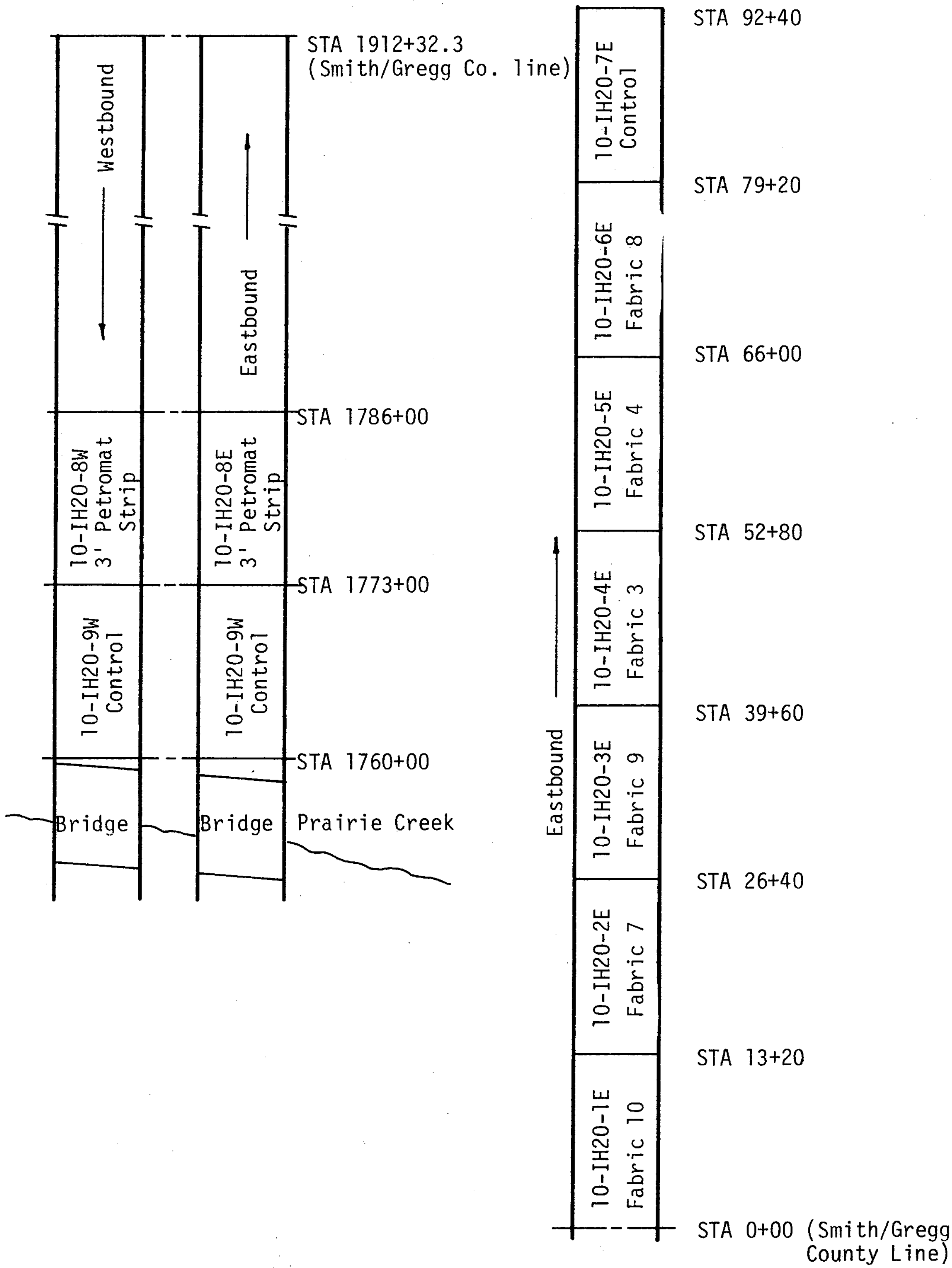


Figure E1. Location of Fabric Test Sections on IH20 in District 10 (Not to scale).

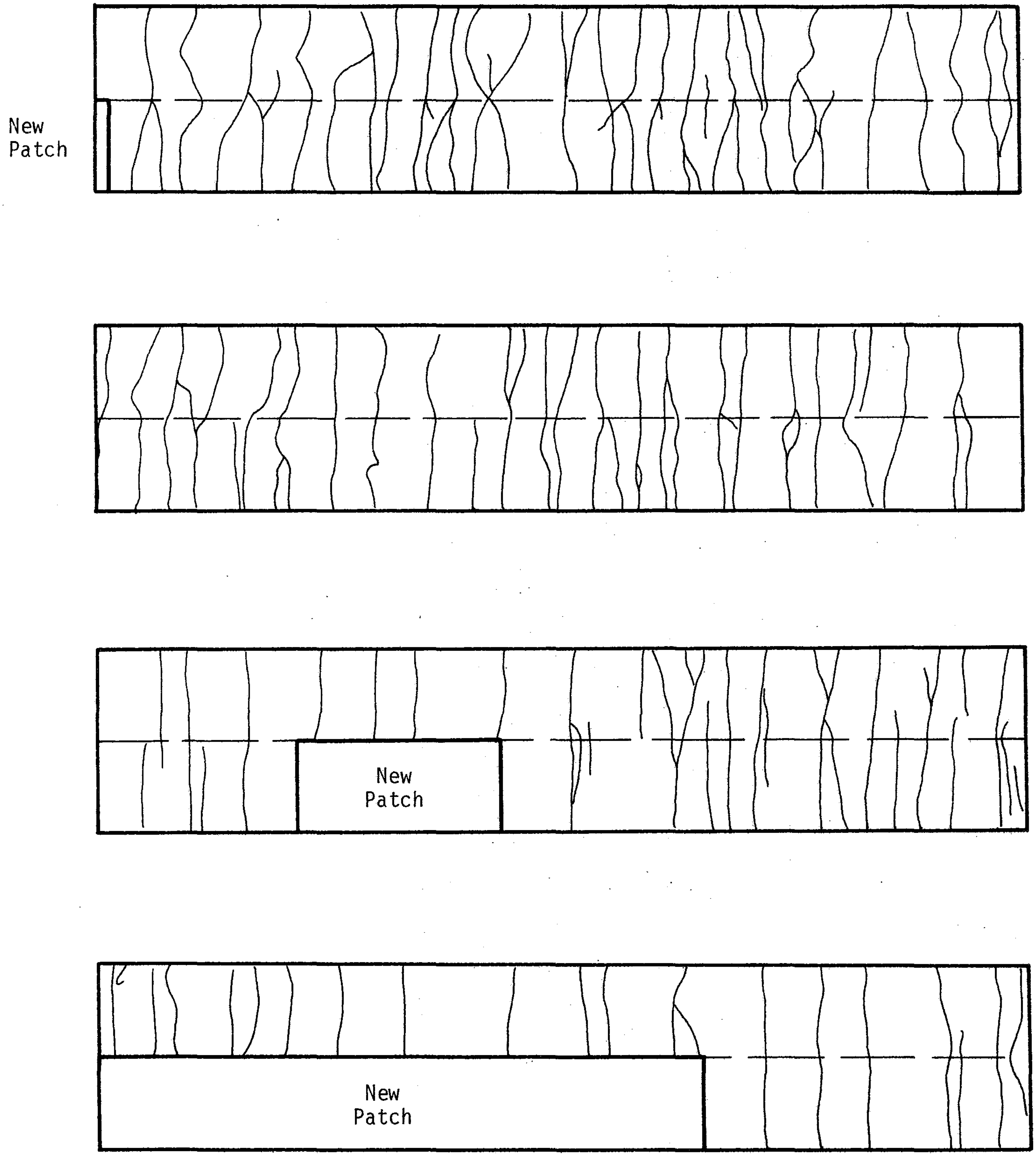


Figure E2. Typical Cracking Patterns on IH 20 East of Tyler (District 10) Prior to Overlaying. (Maps are typically 100 ft. x 24 ft.).

Table E1. Dynaflect Data from District 10.

Test Section I.D.	Maximum Deflection, mils			Surface Curvature Index (SCI), mils		
	Mean	Std Dev	Coef Var	Mean	Std Dev	Coef Var
10-IH20-1E	0.366	0.008	. 24%	0.028	0.008	30%
10-IH20-2E	0.365	0.065	18%	0.048	0.10	20%
10-IH20-3E	0.528	0.097	18%	0.050	0.026	52%
10-IH20-4E	0.478	0.144	30%	0.058	0.043	74%
10-IH20-5E	0.378	0.083	22%	0.035	0.010	29%
10-IH20-6E	0.305	0.049	16%	0.035	0.010	29%
10-IH20-7E						
10-IH20-8E	0.473	0.085	18%	0.053	0.017	33%
10-IH20-8W	0.455	0.052	11%	0.043	0.222	52%
10-IH20-9E	0.348	0.050	14%	0.035	0.006	16%
10-IH20-9W	0.413	0.038	9%	0.038	0.126	34%

Table E2. Surface Texture Measurements from IH20 (District 10).

Test Section Identification	Surface Texture Depth*, inches		
	Travel Lane		
	OWP	BWP	IWP
10-IH20-1E	0.023		-
10-IH20-2E	0.022	0.025	-
10-IH20-3E	0.016	0.027	-
10-IH20-4E	0.018	0.014	-
10-IH20-6E	0.014	0.011	-

*Due to inclement weather conditions during testing and excessive traffic volume, the surface texture measurements using the silicon putty method are rather limited. However, the surface texture of this portland cement concrete pavement was quite uniform.

Table E3. Temperature Data from Tyler District 10

Month	Average Monthly Temperatures				Maximum Drop in 24 hours
	Maximum	Minimum	Highest	Lowest	
1981					
July	93	71	99	67	28
Aug	94	68	102	59	34
Sept	86	60	94	41	35
Oct	76	53	94	31	34
Nov	69	42	80	26	36
Dec	58	33	79	16	37
1982					
Jan	57	30	78	1	49
Feb	55	34	87	16	40
Mar	70	50	87	26	33
Apr	73	51	86	32	46
May					
June					
July					
Aug					

APPENDIX F

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