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16. Abstract

A five-year study has been performed to investigate the behavior of binders and asphalt mixtures containing polymer modifiers. The polymers were SBS, SBR, EVA, Ground Rubber, and polyolefin. These materials were used separately and in combinations with each other to change the characteristics of the binders and asphalt mixtures. The research included laboratory experiments to characterize the materials, and field projects to ascertain their performance. Four hot mix asphalt projects were conducted in Districts 15, 11, 25, and 10 in Texas, and two seal coat projects were constructed in Districts 6 and 17 in Texas.

The testing results of the field and laboratory samples are presented in this report.

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MIX DESIGN PROCEDURES AND CONSIDERATIONS FOR POLYMER MODIFIED ASPHALT COMPATIBILITY AND STABILITY

by

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Research Report Number 492-1F

Research Project 3-9-87/1-492

Mix Design Procedures and Considerations for Polymer Modified
Asphalt Compatibility and Stability

conducted for

Texas Department of Transportation

in cooperation with the

U. S. Department of Transportation
Federal Highway Administration

by the

CENTER FOR TRANSPORTATION RESEARCH
Bureau of Engineering Research
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PREFACE

This is the final report for project 3-9-87/1-492, "Mix Design Procedures and Considerations for Polymer Modified Asphalt Compatibility and Stability." This report presents the information and findings based upon laboratory, plant and initial field performance of HMAC mixtures and seal coats designed, produced and placed in six TxDOT districts. Findings based upon the field performance of these test sections will be presented on the final report for project 1306 (continuation of 492).

The assistance and close cooperation of the Texas Department of Transportation, especially personnel from those Districts directly involved and Donald O'Connor of the Materials and Tests Division, is acknowledged.

Appreciation is also expressed to the Center for Transportation Research staff; Maghsoud Tahmoressi, James Anagnos, and Eugene Betts.

ABSTRACT

A five year study has been performed to investigate the behavior of binders and asphalt mixtures containing polymer modifiers. The polymers were SBS, SBR, EVA, Ground Rubber and polyolefin. These materials were used separately and in combinations with each other to change the characteristics of the binders and asphalt mixtures. The research included laboratory experiments to characterize the materials, and field projects to ascertain their performance. Four hot mix field projects were conducted in Districts 15, 11, 25 and 10 in Texas and two seal coat projects were constructed in Districts 6 and 17 in Texas.

The testing results of the field and laboratory samples are presented in this report.

SUMMARY

The use of polymer modified binders has gained importance in road construction over the past few years. The objectives of polymer addition are to improve mechanical properties of binders which result in reducing thermal and fatigue cracking, moisture damage and permanent deformation.

A five year study has been performed to investigate the behavior of asphalt mixtures containing polymer modifiers. Seven different polymers including SBS, SBR, EVA and SBR/Polyolefin were utilized in this study. Twenty eight test sections were constructed in six districts of the Texas Department of Transportation. A comprehensive testing program was designed and carried out to determine whether improved asphalt concrete pavement performance could be gained through polymer modification of the asphalt binder. In addition, the effects of polymers on the properties of asphalt and HMAC mixtures were evaluated.

Samples of all aggregates, binders and mixtures were collected during construction. Laboratory tests were conducted on the binders, field-prepared mixtures, and laboratory-prepared mixtures. A comparison was made between various test methods which are commonly used to predict thermal cracking, permanent deformation and temperature susceptibility. This comparison will help to identify tests which predict field performance after long-term field performance data are obtained. Furthermore, it was found that certain engineering properties of field-prepared mixtures could be predicted in the laboratory. In addition, statistical analyses were performed to predict engineering properties of plant-mixed mixtures from engineering properties of laboratory-prepared mixtures. In this analysis factors such as air voids, mixing temperature, test temperature, and aging indices were included.

Several tests were evaluated in order to determine their effectiveness in characterizing polymer-modified asphalts. Once the field performance of test sections is determined after long-term performance evaluations, the results presented in this report can be used to develop a comprehensive mixture design and analysis method for polymer-modified hot-mixed asphalt concrete.

IMPLEMENTATION

Regression equations have been developed to predict the engineering properties of plant-mixed mixtures from engineering properties in the laboratory. The properties of polymer-modified binder and HMAC evaluated in this study can be used in a data base which describes the properties of currently available commercial polymers. Also, a tensile creep compliance formula for indirect creep test was developed in this study.

Since test pavements constructed during this study have not had sufficient time to provide performance indications, it is recommended that the present mix design procedures and specifications in use by the Texas Department of Transportation be continued.

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CHAPTER 1

INTRODUCTION

Highway and airfield pavements are continuously subjected to ever increasing traffic loads, higher volumes of traffic, and higher tire pressures. In addition, these pavements are further distressed by the action of environmental factors such as temperature and moisture. These combined factors are causing a significant amount of distress resulting in shorter service lives, poorer performance and higher maintenance costs.

The basic types of pavement distress are:

- Thermal cracking
- Fatigue cracking
- Permanent deformation

In addition, the severity of these distresses is increased by the following related factors:

- Moisture damage
- Aging

Thermal cracking occurs in two forms, low temperature cracking and thermal fatigue. Thermal cracks are transverse cracks which generally run perpendicular to the direction of traffic and are often spaced equidistant from each other. As the temperature is reduced the pavement structure tends to shrink. This shrinkage is resisted by friction which is developed between the pavement section and the underlaying layer. Development of frictional forces cause tensile stresses to develop in the pavement. The magnitude of these stresses is dependent on the stiffness, coefficient of expansion of the material, the rate of temperature change and the magnitude of the temperature change. Low temperature cracking takes place when the tensile stress induced by a single drop in temperature exceeds the tensile strength of the asphalt mixtures. Similarly repeated thermal cycles may cause the pavement to crack as the result of thermal fatigue.

Fatigue cracking, also called alligator cracking, is caused by the action of repeated loads induced by moving traffic. Fatigue cracking susceptibility increases with higher loads, increased repetitions of loads, or inadequate support in one of the pavement layers which causes the HMAC pavement to experience higher strains. The problem of fatigue cracking is further compounded because the desirable mixture properties for increased fatigue life are different for thick and thin pavements. Thick sections require stiffer materials for minimal fatigue cracking and thin sections require less stiff or more flexible materials.

Permanent deformation on rural highways is manifested by wheelpath rutting. However in urban areas and at the intersections, where heavy vehicles move slowly or stop frequently, both rutting and shoving can occur. Rutting in HMAC can be caused by either densification from traffic or shear flow of the mixture. Shoving is only caused by shear flow of the mixture. In general, the more severe premature rutting failures and distortion problems of HMAC are related to lateral flow of asphalt or shear distortion, rather than to one-dimensional densification. These types of distress (rutting and shoving) are a function of the shearing resistance of the materials. The shearing resistance of HMAC is a function of the interparticle cohesion and friction as well as the amount of stress applied to the material. The cohesion of the mix depends on the amount and properties of the asphalt cement in the mix.

Moisture damage occurs in two forms, loss of cohesion and loss of adhesion. Loss of adhesion or stripping involves the physical separation of the asphalt cement and the aggregate, primarily due to the action of moisture and traffic. Loss of cohesion involves failure of the asphalt film itself. Both forms of damage are characterized by a reduction in strength and stiffness of the asphalt mixture.

Aging occurs primarily as the result of oxidation, which causes hardening of the asphalt. This increased stiffness (due to the hardening) can cause increased cracking due to temperature changes or repeated loads.

To reduce the stresses discussed above, an ideal asphalt binder should possess several desirable characteristics such as:

1) Low stiffness (or viscosity) during the construction phase to expedite pumping of the liquid binder and mixing and compaction of hot mix asphaltic concrete.

2) High stiffness at high temperatures (summer) to reduce rutting and shoving, and to improve fatigue life of HMAC pavements.

3) Low stiffness at low temperatures to reduce thermal cracking and fatigue cracking.

4) Adequate adhesion between the binder and aggregate in the presence of moisture and traffic to reduce stripping.

5) Low aging susceptibility to resist changes in properties with aging.

These objectives may not be achievable simultaneously in conventional asphalt cements. However the advent of asphalt modifiers has opened up new means of satisfying the above objectives.

Since the engineering properties of current asphalt modifiers are dependent on the asphalt cement, it is important to provide a means of determining asphalt-additive compatibility, binder characteristics, and mixture design procedures that will be sensitive to the modified asphaltic binders.

BACKGROUND

The concept of modifying asphalt binders and mixtures is certainly not new, but has become much more prominent during the past fifteen years. One reason for this resurgence in interest has been the changing process of how oil refineries obtain and process crude oil. Following the 1973 Arab oil embargo, the traditional crude sources changed. Many refineries that were accustomed to a single crude source were faced with processing oil from multiple sources. These changes made it more difficult to meet specifications for paving grade asphalt cement. This situation provided additional opportunities for enhancing asphalt cement performance through modification.

PROJECT OBJECTIVES

To study some of the concepts of asphalt modification, the Texas Department of Transportation (TxDOT) funded a research study at the University of Texas at Austin. The primary objectives of the research program were as follows:

1. To define the properties desired in a polymer modified binder.
2. To select tests which best measure or quantify these properties in materials for hot mixed asphaltic concrete.
3. To evaluate proper design procedures for hot mix asphaltic concrete.
4. To establish specifications for modified binders for each application.

The work and activities required to achieve the overall objectives of the project were as follows:

1. To select materials.
2. To determine properties of polymer modified binders in the laboratory.
3. To determine engineering properties of polymer modified mixtures in the laboratory.
4. To construct field test sections for polymer modified mixtures and control mixtures .
5. To monitor field performance for future long-term evaluation.

REPORT ORGANIZATION

This report summarizes the characteristics of unmodified and modified binders and mixtures using different polymers, asphalt cements and aggregates. In addition, information related to the construction of four hot mix and two seal coat test projects in Texas are reported. The subsequent findings of the long-term field monitoring program will provide both information related to the field performance of mixtures and the relationship between performance and the predicted performance based on the laboratory test results.

Chapter 1 describes the research objectives of this project. The experimental laboratory program, experimental field program and test methods are discussed in Chapter 2. Test results for binders and mixtures are presented in Chapter 3 and Chapter 4, respectively. Test methods are evaluated and discussed in chapter 5. The conclusions and recommendations based on the findings of this study are presented in Chapter 6. Information related to the field projects along with the test results are summarized in Appendices A through E. The relationships to determine tensile creep compliance were developed in this study, and are documented in detail in Appendix F.

CHAPTER 2

EXPERIMENTAL PROGRAM

Laboratory and field studies were developed in cooperation with the Texas Department of Transportation (TXDOT) to achieve the objectives of this study. The field and laboratory experimental programs including test methods and engineering properties which were evaluated are described in the following sections.

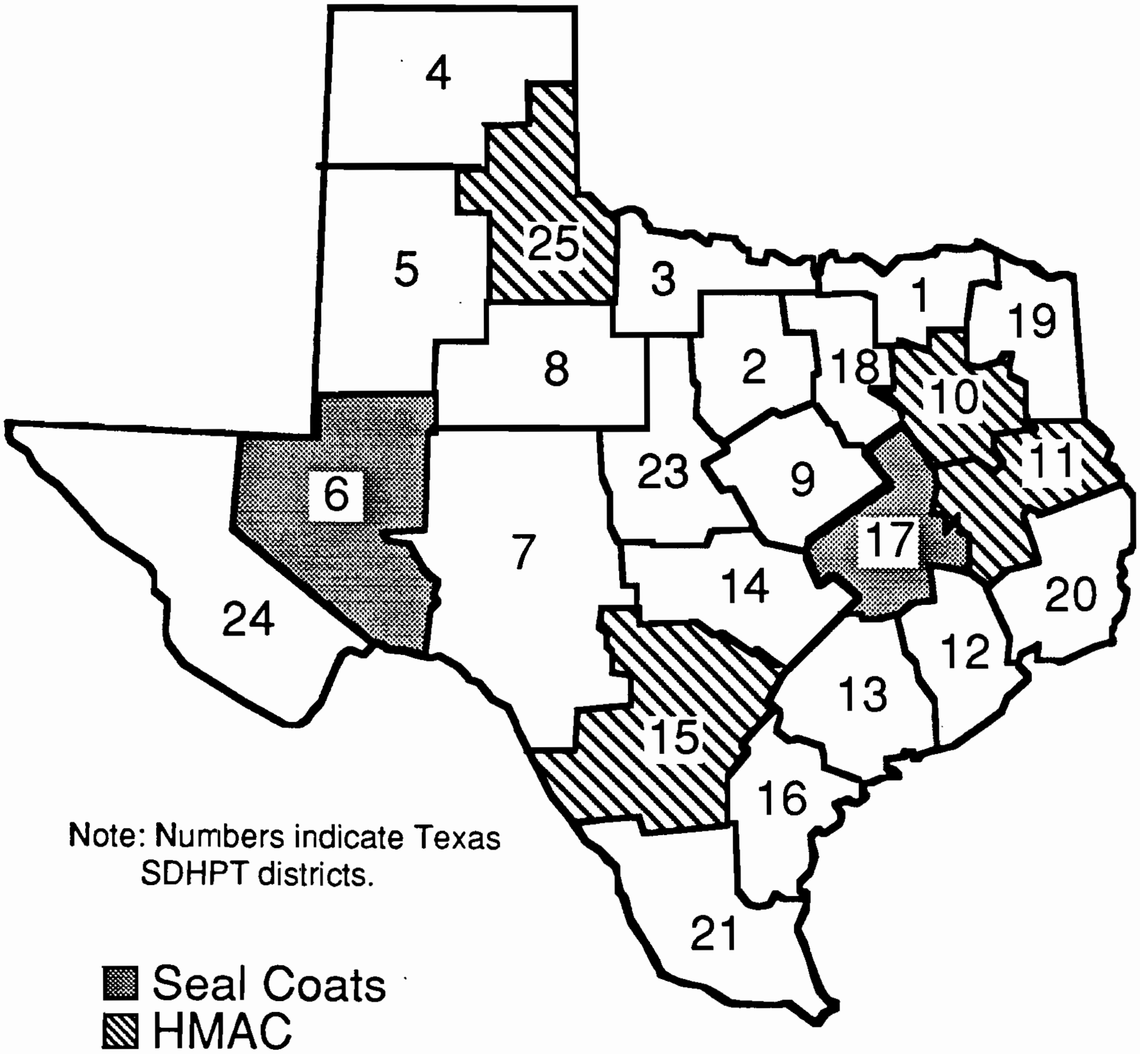
EXPERIMENTAL FIELD PROGRAM

The experimental field program involved the construction and evaluation of highway test sections (four hot mix and two seal coat field projects) in six different districts of the TXDOT (Fig 2.1). These test sections involved different traffic and climatic conditions, aggregates, asphalt cements, and polymers. The experimental field programs were designed in conjunction with the Materials and Tests Division of TXDOT (D-9), and in cooperation with the districts in which the test sections were constructed. Field construction was supervised by District Personnel, with technical assistance provided by project personnel from the Center for Transportation Research.

The purpose of building the test sections was to determine what changes were necessary in construction processes when using polymer modified binders. In addition, long-term performance of polymer modified pavements were to be evaluated. Condition surveys after construction were obtained to determine whether use of polymer modified binders is beneficial in terms of long term pavement performance.

Construction of Test Sections

The six field projects involved a total of twenty eight test sections containing different aggregates, asphalt cements, and polymers. The field operations and test variables for each test



Note: Numbers indicate Texas SDHPT districts.

Fig 2.1 Location of field test sections.

section, along with a description of the asphalts, aggregates, polymers, and construction techniques are described in detail in Appendices A through E. The information related to field construction is summarized below.

Materials. Aggregates, asphalts and polymers utilized in the six test projects are identified in Table 2.1. Identical aggregates were utilized for all test sections in a given district. One percent lime by weight of aggregate was used for all test sections in District 25. In several cases, the actual binder contents used in the field mixtures deviated from preliminary laboratory design values due to field construction requirements or the recommendations of polymer suppliers.
Seven different polymers were used: Goodyear UP 70 (SBR), Polysar NS 175 (SBR), Styrelf (SBS), Polybilt 103 (EVA), Dow (SBR/Polyolefin), Kraton D1101 (SBS), and Crafco rubber C107 (recycled tires). Percentage of polymer, by weight of binder, was recommended by the manufacturers.

Construction Techniques. Three of the hot mix field projects (Districts 11, 25 and 10) utilized drum mix plants and the fourth field project (District 15) utilized a batch plant. All polymer modified binders were preblended. The mixing temperatures were between 310°F and 350°F. The initial breakdown compaction occurred between 250 and 280°F. Compaction of each test section was achieved using a vibratory roller, a pneumatic roller, and a static steel wheel roller. Location and length of the test sections are described in the appendices.

Field Sampling Program

Plant mixed samples of control and polymer modified mixtures utilized in each test section were obtained. In addition, samples of asphalt cements, polymer modified binders, and aggregates were obtained and shipped to the asphalt research laboratory at the University of Texas at Austin.

TABLE 2.1 Summary of Materials for Field Test Projects

Location of Field Project	Test Section Number	Aggregates	Asphalt Source & Grade	Binder Content, % Field +	Binder Content, % Design ++	Polymer Source	Polymer Type	Polymer Designation	Polymer Content %	Appendix*
	1		TFA AC-10	4.6	-	Goodyear	SBR	UP 70	3%	A
	2	Sandstone 31%	TFA AC-10	4.6	-	Elf	SBS	Styrelf-13	3%	A
District 15	3	Limestone 27%	TFA AC-20	4.6	4.8	-	-	-	-	A
	4	Limestone	TFA AC-20	4.6	-	Exxon	EVA	Polybilt 103	3%	A
San Antonio	5	Screenings 19%	TFA AC-10	6.3	6.3	Crafco	Recy. tires	Genstar C107	18%	A
	6	Field Sand 23%	TFA AC-10	4.6	-	Polysar	SBR	NS 175	3%	A
	7		TFA AC-20	4.6	-	Dow	SBR/Polyolefin		5%	A
		LtWt. Type D 56%								
District 11	1	Coarse Sandstone	Texaco AC-20	6.8	6.8	-	-	-	-	B
Lufkin	2	Screenings 10%	Texaco AC-10	6.8	-	Elf	SBS	Styrelf-13	3%	B
	3	Fine Sndstone	Texaco AC-10	6.8	-	Goodyear	SBR	UP 70	3%	B
		Screenings 15%								
		Field Sand 19%								
	1		Shamrock AC-20	5.0	5.4	-	-	-	-	C
District 25	2	Crushed Gravel 51%	Fina AC-10	5.0	5.8	Goodyear	SBR	UP 70	3%	C
Childress	3	Screenings 49%	Fina AC-10	5.0	5.4	Elf	SBS	Styrelf-13	3%	C
	4	Lime 1% by weight	Fina AC-10	5.0	5.0	Shell	SBS	Kraton D1101	3%	C
	5	of aggregates	Fina AC-10	5.0	5.4	Shell	SBS	Kraton D1101	6%	C
	1		Total AC-20	4.6	4.9	-	-	-	-	D
District 10	2	Crushed Stone 65%	Fina AC-10	4.6	-	Goodyear	SBR	UP 70	3%	D
Tyler	3	Screenings 15%	Fina AC-10	4.6	-	Elf	SBS	Styrelf-13	3%	D
	4	Field Sand 20%	Exxon AC-10	4.6	-	Exxon	EVA	Polybilt 103	3%	D
	5		Gulf AC-10	4.6	-	Shell	SBS	Kraton D1101	3%	D
	1		Fina AC-5	0.35 Gal/SqYd		Goodyear	SBR	UP 70	2%	E
District 17	2	Pre- Coated	Fina AC-10	0.35 Gal/SqYd		-	-	-	-	E
Bryan	3	Aggregates	Exxon AC-10	0.35 Gal/SqYd		Shell	SBS	Kraton D1101	3%	E
	4		Exxon AC-10	0.35 Gal/SqYd		Elf	SBS	Styrelf-13	3%	E
	1		Fina AC-5	0.35 Gal/SqYd		Exxon	EVA	Polybilt 103	3.2%	E
District 6	2	Pre- Coated	Fina AC-5	0.35 Gal/SqYd		Shell	SBS	Kraton D1101	4.5%	E
Odessa	3	Aggregates	Fina AC-5	0.35 Gal/SqYd		Goodyear	SBR	UP 70	2%	E
	4		Fina AC-5	0.35 Gal/SqYd		-	-	-	-	E

* Details are contained in the indicated Appendices
\+ Binder content used for the field test project mixtures
\++ Laboratory design optimum binder content

Field cores were taken immediately following construction and each year for a period of five years. These cores were approximately 4-inches in diameter and 1 to 2 inches in thickness. Twelve cores were obtained from each test section in the wheel path at approximately 100-foot intervals, with the first and last cores located approximately 200 feet from the beginning and the end of the test section.

TEST METHODS

Laboratory binder and mixture tests were conducted in accordance with applicable Texas Test Methods or ASTM standards. The binder and mixture tests used in this study are described in the following sections.

Binder Laboratory Testing

Binder tests conducted and parameters measured on unmodified and modified asphalt binders are as follows:

Conventional Binder Tests

- Penetration (ASTM D5) @ 77°F and 39.2°F
- Kinematic Viscosity (ASTM D2170) @ 275°F
- Viscosity (ASTM D2171) @ 140°F
- Softening Point (ASTM D2398)
- Rolling Thin Film Oven (ASTM D2872)

The following materials properties were obtained for each binder.

Temperature Susceptibility:

- Penetration Index, PI (Ref 5)
- Penetration - Viscosity Number, PVN (Ref 6)

Durability Indicators:

- Penetration Ratio (77°F)
- Kinematic Viscosity Ratio (275°F)
- Absolute Viscosity Ratio (140°F)

Stiffness Modulus
- Stiffness-Temperature Susceptibility

Cracking Temperature
- Limiting Stiffness Method
- Critical Stress Method

Force Ductility (Refs 3, 4,16)
- Asphalt Modulus
- Asphalt - Polymer Modulus
- Maximum True Stress
- Maximum True Strain
- Area under Stress-Strain Curve

Schweyer Constant Stress Rheometer (Ref 2)
- Shear susceptibility
- Apparent Viscosity
- Constant Power Viscosity
- Constant Power Viscosity-Temperature Susceptibility

Compatibility
- Hot Storage Stability Test

Penetration. The penetration test is an empirical measure of consistency. In this test a standard needle penetrates into the asphalt sample under known conditions of loading, time and temperature. The distance in tenths of a millimeter which the needle penetrates into the sample is the 'penetration'. The test procedure for measuring penetration at 77°F and lower temperatures is given in ASTM D5. Higher values of penetration indicate softer asphalts. Penetration values are also used to determine the temperature susceptibility of binders in terms of penetration index (PI) or penetration-viscosity number (PVN)

Kinematic Viscosity. The ratio between the applied shear stress and shear rate of a liquid is called the viscosity. Kinematic viscosity is the ratio of the viscosity to the density of a liquid. It is a measure of resistance to flow of a liquid under gravity. The standard ASTM D2170 test method uses a capillary viscometer to determine Kinematic viscosity at 275°F. In this test the time in seconds required for the binder to flow under gravity between two timing marks is measured. Multiplying this measured time by the calibration factor for the viscometer gives a value for viscosity in centistokes, which is the standard unit for measurement of kinematic viscosity.

Absolute Viscosity. Viscosity grading of asphalts is based on viscosity at 140°F. The ASTM D2171 method was used to determine viscosity at 140°F using a Cannon-Manning vacuum viscometer. The 140°F temperature is selected because it approximates the maximum HMAC pavement surface temperature during summer in the United States. Since asphalt binders at 140°F are too viscous to flow through capillary tube viscometers, a partial vacuum is applied to the efflux (small) side of the viscometer to induce flow. The time in seconds required for the binder to flow under vacuum between the timing marks is measured. Multiplying this measured time by the calibration factor for the viscometer gives a value for viscosity in poises, which is the standard unit for absolute viscosity.

Softening Point. Softening point is measured by the ring and ball (R & B) method in accordance with ASTM D2398. It can be defined as the temperature at which an asphalt cement cannot support its own weight and starts flowing. Its purpose is to determine the temperature at which a phase change occurs in the asphalt. Softening point is also used to determine the temperature susceptibility of binders in terms of penetration index (PI).

<u>Rolling Thin Film Oven Test (RTFOT).</u> A moving film of asphalt cement is heated in an oven for 75 minutes at 325°F. The combined effect of heat and air cause oxidative aging of the asphalt. The degree of oxidative aging is determined by measurement of physical properties before and after oven treatment. The test method is described in ASTM D2872. This test approximates the change in properties of asphalt during conventional hot-mixing at approximately 310°F as indicated by viscosity measurement.

<u>Penetration Index (PI).</u> Penetration index has been used as a means of estimating temperature susceptibility of asphalts for many years. There are several methods of determining PI.
Penetration index was first proposed as a method of estimating temperature susceptibility by Pfeiffer and Van Doormaal (Ref 5), based on penetration at two temperatures. The following relationship is used to calculate PI:

$$\frac{20-PI}{10-PI} = 50\ X\ \frac{\delta \log(pen)}{\delta T}$$

or

$$PI = \frac{20-500A}{1+50A}$$

where

$$A = \frac{logPen\ @\ T2\ -\ logPen\ @\ T1}{T2\ -\ T1}$$

and,
T1 and T2 are two temperatures at which penetration is measured.

Penetration index determined from the above relationship will be referred to as PI(Pen/Pen) in the remainder of this report.

Penetration index can also be determined using penetration and softening point (Ref 5). By this procedure an assumption is made that all asphalts have a penetration of 800 at their softening point. The relationship between penetration and softening point that can be used to define PI is:

$$PI = \frac{30}{1 + 90(PTS)} - 10$$

where,

$$PTS = \frac{\log(800) - \log(Pen)}{T_{R\&B} - T_{Pen}}$$

PTS = Penetration Temperature Susceptibility
$T_{R\&B}$ = Softening Point, F
Pen = Penetration at 77°F

From the above equation it is apparent that an increase in the PI value indicates a decrease in the apparent temperature susceptibility of the material. Penetration Index by this method will be referred to as PI(Pen/SP) in the remainder of this report.

Penetration Viscosity Number (PVN). The Penetration-Viscosity Number is another method of estimating the temperature susceptibility of asphalt cements. PVN was developed by McLeod (Ref 6) when penetration Index (PI) failed to provide good correlation with observed pavement cracking at low temperatures in Canada. The PVN used in this research is based upon penetration at 77°F and viscosity at 275°F. PVN can also be determined for penetration at 77°F and viscosity at 140°F.

PVN can be calculated using the following relationship:

$$PVN = \frac{4.258-0.7967(\log(Pen))-\log(Vis)}{0.7591-0.1858(\log(Pen))} X(-1.5)$$

where,

Pen = Penetration at 77°F

Vis = Kinematic Viscosity at 275°F

Both PI and PVN parameters were calculated because the data needed to generate these values are easily obtained, and PVN and PI are believed to correlate to low temperature performance of HMAC pavements. Although the correlation of PVN and PI to pavement performance may occasionally yield contradictory data, recent research indicates that both methods of predicting temperature susceptibility may have merit (Ref 7).

Penetration and Viscosity Ratios. These parameters are the ratio of the measured property after aging in the rolling thin film oven test to the property before aging. For conventional materials, the ratio should always provide a value greater than one for viscosity data, and a value less than one for penetration data because of the oxidative hardening which takes place during the RTFOT. Values close to one by either method for paving binders indicate better resistance to oxidative hardening during plant mixing and service life.

Stiffness Modulus. Stiffness modulus is the ratio of stress to strain. For asphalt binders and HMAC mixtures, this modulus is dependent on both test temperature and the duration of applied stress. Stiffness modulus may be used to estimate low-temperature cracking susceptibility of HMAC mixtures. Low-temperature cracking occurs when the stresses caused by temperature drop exceed the tensile strength of HMAC mixtures. It is generally believed that at low temperatures, stiffness of HMAC mixtures is controlled primarily by the properties of the asphalt binder (Refs 8, 9). Therefore, low temperature properties of the asphalt pavements can be improved by controlling the stiffness of the asphalt binder.

Van der Poel developed a nomograph (Ref 10) which Heukolem later revised (Ref 11) to estimate bitumen stiffness as a function of loading rate, temperature susceptibility, and softening point.

The nomograph is based on laboratory measurements of many asphalts from a wide assortment of sources and refining techniques. Stiffness is easily determined from the nomograph, and can be estimated over a wide temperature or rate of loading range.

To measure stiffness-temperature susceptibility, stiffness vs. test temperature is plotted on a semilogarithmic scale. The slope of the best fit line resulting from such a plot is termed the stiffness-temperature susceptibility.

Limiting Stiffness Method. One of the simplest means of predicting the cracking temperature of asphalt binders is to estimate the temperature at which the asphalts reach a critical "limiting stiffness". Canadian researchers (Refs 12, 13) adopted a limiting Stiffness of 29,000 psi at 2-hour loading time based on field observations from the St. Anne Test Road. The new SHRP binder specifications will also consider the issue of stiffness and low temperature performance, and specifiy the temperature at which the binder may achieve the same 29,000 psi stiffness. The St. Anne Road Test was a joint research project of the Manitoba Department of Transportation and Shell Canada Limited designed to study low temperature cracking of asphalt pavements. Further study on the St. Anne Test Road asphalts has resulted in establishing the stiffness of approximately 145,000 psi at a one-half hour loading time as the limiting stiffness (Ref 14). Thus the temperature at which the asphalt stiffness reaches 145,000 psi at a half-hour loading time is considered to be the predicted cracking temperature. Stiffness can be determined using the Van der Poel nomograph.

Critical Stress Method. Hills (Ref 15) introduced a procedure for predicting cracking temperatures of pavements based on the estimation of thermal stresses developed in the asphalt binder. In this procedure, it is assumed that the thermal stress, σ_t, developed in asphalt as it cools, can be calculated from the following relationship:

$$\sigma_t - \Sigma(Si \; x \; \alpha_A \; x \; \Delta T)$$

where,

Si = Asphalt stiffness at a one hour loading time at a series of temperature intervals, ΔT.

α_A = Coefficient of linear thermal contraction. It is assumed to be 2 x 10E-4 in/in/°C

Using asphalt penetration data, asphalt stiffness at 18°F (10°C) intervals from 32°F down to -58°F is determined. When required, the temperature range can be modified to accommodate various asphalt grades. The thermal stress, σ_t, is calculated by summing the individual stress increments.

Hills concluded from semi-theoretical considerations and from mix cracking observations that pavement cracking occurred at a temperature corresponding to a calculated thermal stress, σ_t, of about 73 psi. The calculated cracking temperature is taken as the temperature at which a stress of 73 psi is induced.

Force Ductility. The force ductility test is a modification of the asphalt ductility test (ASTM D113). The principal alteration of the test consists of adding a load cell in the loading chain. Specimens are maintained at 39.2°F by circulating water through the ductility bath during testing. A second major alteration of the standard ASTM procedure involves the test specimen shape. A standard ASTM specimen is as shown in Figure 2.2. The mold is modified for force ductility testing by fabricating new pieces a and a' (Fig 2.3). This mold fabricates a test specimen with a constant cross-section area for a distance of approximately 3 cm which produces a deformation rate of 0.74±0.01 cm/min between the gage marks of the test specimen at a fixed loading rate of 1 cm/min (Ref 4).

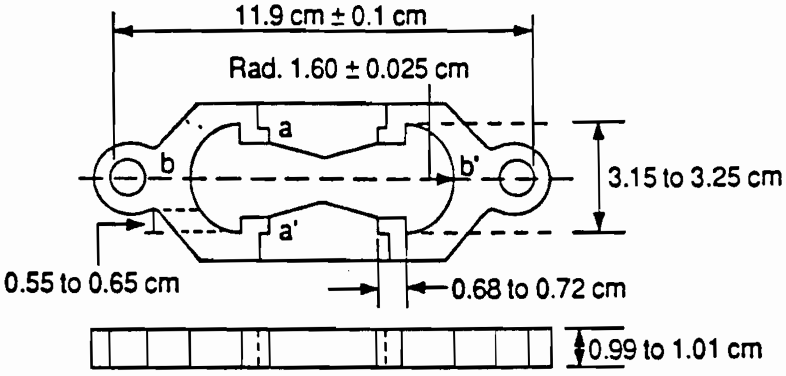


Figure 2.2 ASTM DII3 Ductility Mold

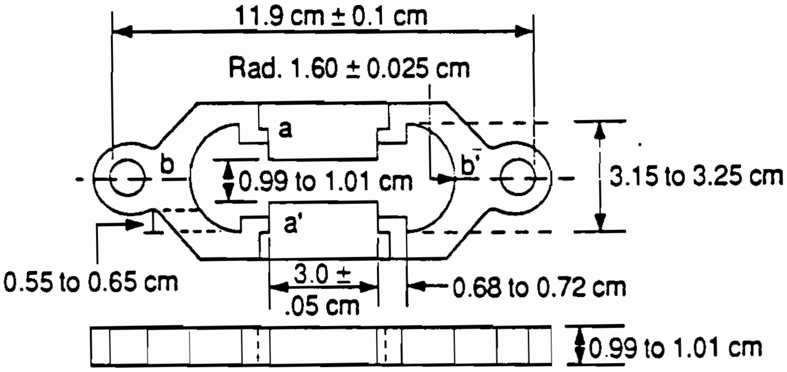


Figure 2.3 Force - Ductility Mold

The following properties are measured from a force ductility test:

- Asphalt Modulus
- Asphalt - Polymer Modulus
- Maximum True Stress
- Maximum True Strain
- Area under Stress - Strain Curve

Raw data obtained from the force ductility machine are initially in terms of a force-time relationship. However, the constant deformation rate of 0.74 cm/min allows conversion of force-time information to force-strain data. Stress data are calculated using the initial one square centimeter cross sectional area. True stress is obtained by calculating the change in cross-section as the specimen increases in length. Engineering strain is obtained by dividing the change in gauge length by the original length as follows:

$$\epsilon_e = \frac{\Delta Lo}{Lo}$$

where,

ϵ_e = Engineering strain

ΔLo = Change in gage length

Lo = Initial gage length

True strain, ϵ_t, is obtained by summing all engineering strains and evaluating the limit as dL approaches zero or,

$$\epsilon_t = \int_{Lo}^{L} \frac{dLo}{Lo} = \ln(L) - \ln(Lo) = \ln((Lo+\Delta Lo)/Lo)$$

$$\epsilon_t = \mathrm{Ln}(1+\epsilon_e)$$

The data were gathered when the areas of the cross sections were relatively constant. This greatly reduced variation due to sample configuration, and improved the repeatability of the test. Modulus of elasticity was determined by evaluating the slope of the true stress-strain curve. Two slopes were evaluated. The initial slope of the stress-strain curve in the linear region under primary loading is referred to as the 'asphalt modulus'. A second slope was observed for certain blends of asphalt and polymer which is characterized by secondary loading and will be referred to as 'asphalt-polymer modulus'. Other parameters measured using this test were ultimate tensile stress and strain, and work energy applied to the specimen during testing, as determined by the area under the true stress-strain curve. An example of a typical stress-strain curve which is used to obtain these parameters is shown in Figure 2.4.

Schweyer Rheometer. The Schweyer Rheometer is described as a constant stress rheometer (Ref 2) that produces a rheogram of apparent viscosity versus shear rate. The principle of operation of the Schweyer constant stress rheometer is relatively simple and involves the following:

1. Force sample through precision capillary by constant load on plunger (Fig 2.5).
2. Measure movement of sample through orifice using LVDT and chart recorder.

The movement of the plunger is nonlinear until flow equilibrium is established. At flow equilibrium the constant velocity of the plunger is recorded. The force applied to the plunger is related to shear stress as a function of sample and capillary tube geometry. Shear rate is a function of sample velocity through the capillary tube. Apparent viscosity is defined as the ratio of shear stress to shear rate:

$$\text{Apparent Viscosity} = \frac{\text{Shear Stress}}{\text{Shear Rate}}$$

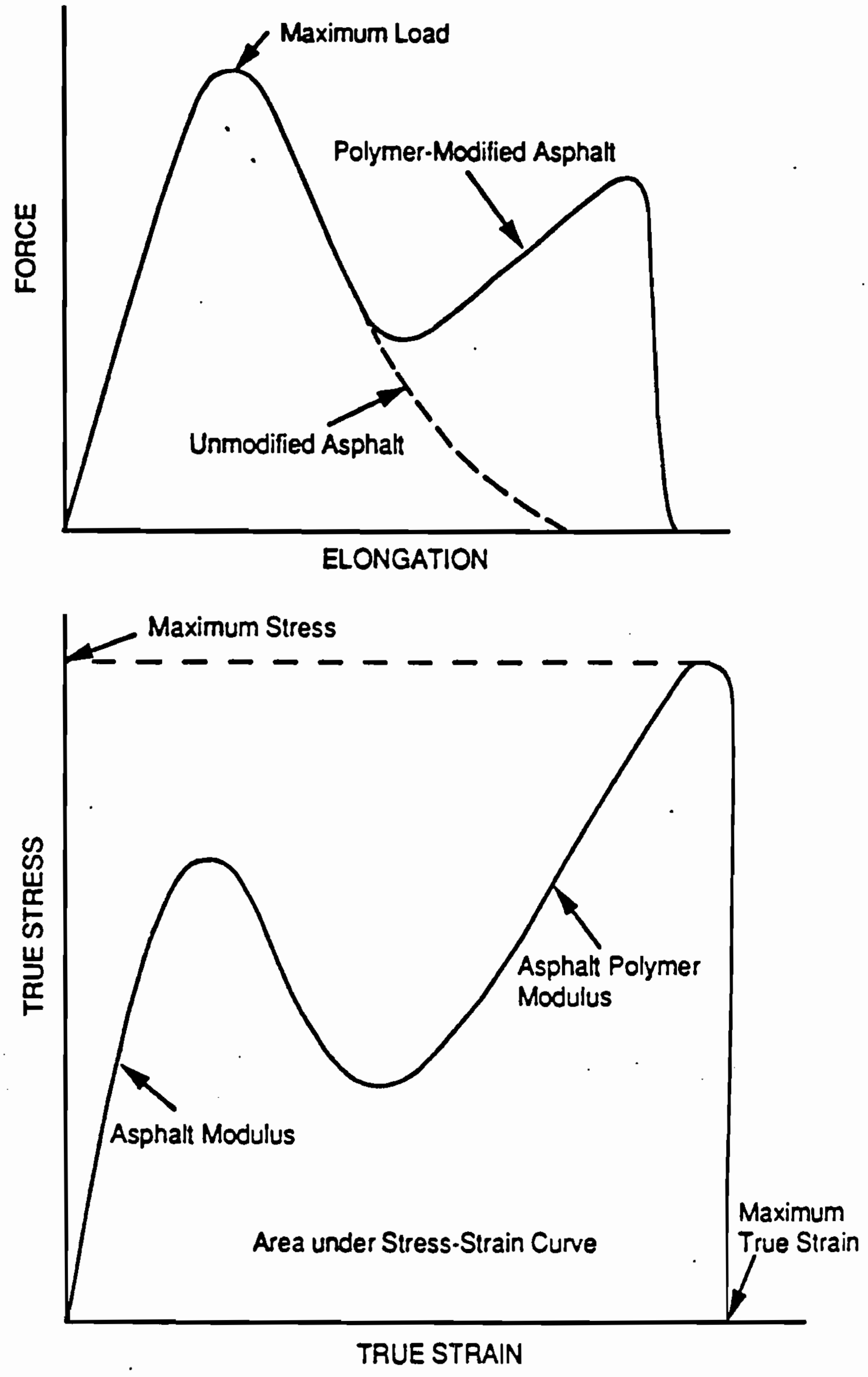


Fig 2.4 Typical Force Ductility Characteristics of Neat Asphalt and Polymer-Modified Asphalt.

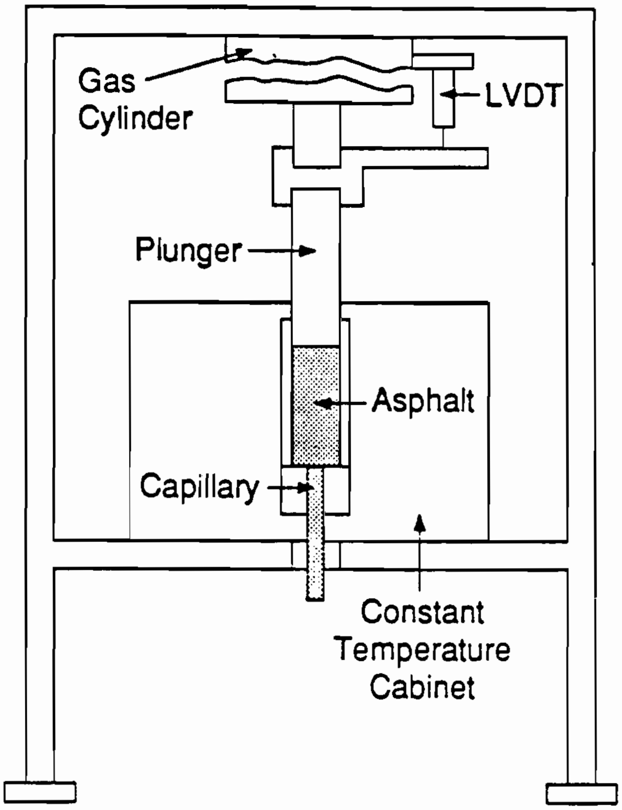


Fig 2.3 Schematic of Schweyer Rheometer Assembly.

Units of shear stress (τ) , rate of shear (γ) and apparent viscosity (η) are in Pascal, reciprocal second and Pascal-second, respectively. (1 Pascal-second = 10 Poises). Generally, the plot of shear stress vs. rate of shear on a logarithmic scale will describe a straight line which may be represented by a power formula:

$$\tau = A\gamma^{C}$$

where

C = Slope of the straight line of the log-log plot
A = Apparent viscosity at shear rate 1 reciprocal second.

The Schweyer 'C' parameter (slope) is used as a measure of shear susceptibility or deviation from Newtonian behavior. Materials with slopes equal to one are defined as a Newtonian fluid and hence are not shear susceptible (Fig 2.6). For these materials the apparent viscosity is constant over a range of shear rates. Materials with slopes less than 1 ($C<1$) are defined as "shear thinning" fluids (Fig 2.7) , and materials with slopes greater than 1 ($C>1$) are termed "shear thickening" fluids (Fig 2.8).

Schweyer rheology measurements were obtained at different temperatures ranging from 39°F to 140°F. Several runs at varying shear stresses are made to develop a plot (rheogram) of log (apparent viscosity) versus log (shear rate) for a given test temperature. The log-log plot of apparent viscosity and shear rate is linear, theoretically allowing calculation of apparent viscosity at any shear rate. In this study, shear susceptibility and apparent viscosity at a shear rate of 1 reciprocal second are reported at 39°F, 77°F, and 140°F for aged and unaged materials used in the District 15 project. These properties were obtained at 39°F, 60°F, 77°F, 90°F, and 140°F test temperatures for unaged materials used in Districts 11 and 25. In addition constant power viscosity at a constant power input of 100 W/m3 ($\tau \cdot \gamma = 10^5$) was computed. To measure the viscosity-temperature susceptibility, viscosity vs.

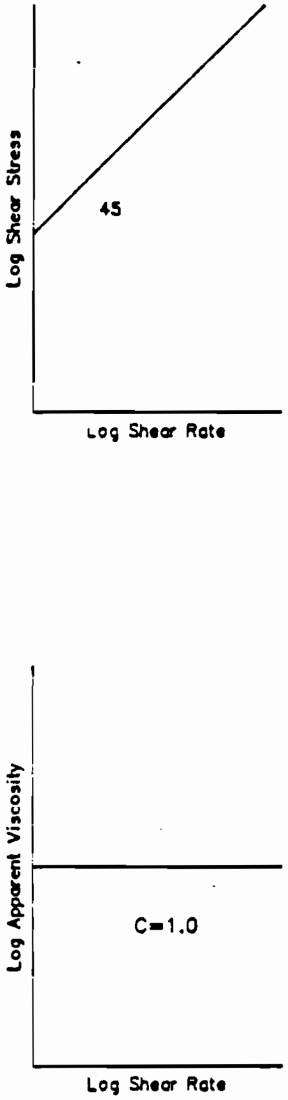


FIG. 2.6 Newtonian Behavior

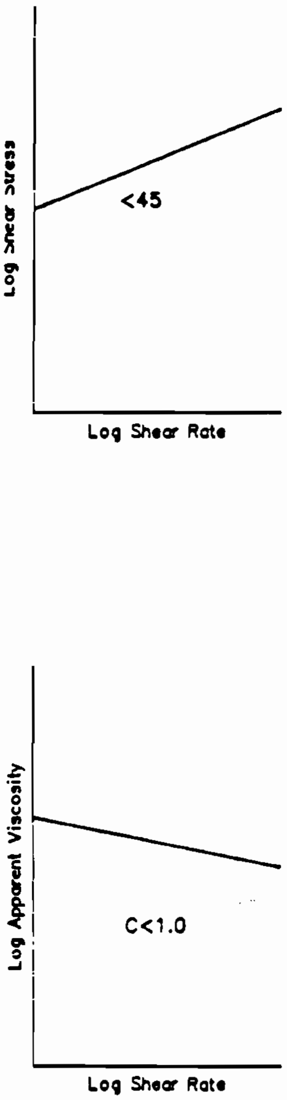


FIG. 2.7 Shear Thinning

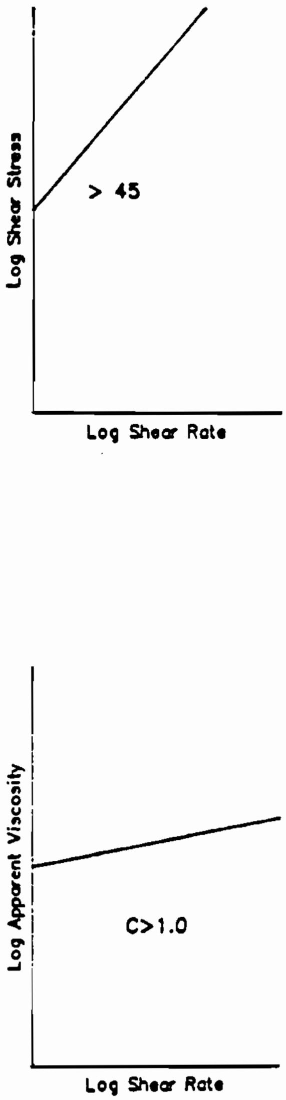


FIG. 2.8 Shear Thickening

test temperature is plotted on a semilogarithmic scale. The slope of the best fitted line resulting from such a plot is termed viscosity-temperature susceptibility.

Compatibility Test. Polymer compatibility with asphalt is of utmost concern to both contractors and state officials. If polymer separation occurs during shipping and storage at elevated temperatures, problems associated with inconsistent binder quality will develop. Material with low polymer content will not exhibit the desired enhanced properties. This is a particular problem if the base asphalt is intentionally softened to maximize flexibility or cracking resistance. Most procedures for monitoring polymer separation involve storing the material at an elevated temperature for a reasonable period of time (one day to two weeks) and then running an identification test on samples taken from the top and bottom of the container. Any test which identifies differences in polymer concentration can be used. In this study a hot storage stability test was used. Samples of modified binders were stored for two days at 160°C in 50 mm diameter cans. Following a cooling period the top and bottom parts were separated and penetration was determined for each portion. Based on this test, the blends can be categorized as follows:

- Compatible - less than 10% difference in penetration between the top and bottom.
- Incompatible - more than 10% difference in penetration between the top and bottom.

Mixture Laboratory Testing

Several tests were performed on unmodified and modified asphalt mixtures to measure their engineering properties. The following engineering properties were measured:

- Marshall Stability Test (ASTM D1559)
    - Marshall Stability
    - Marshall Flow or Flow Index

- Hveem Stability Test (Tex-208-F)
    - Hveem Stability

- Indirect Tensile Strength Test (Tex-226-F)
    - Indirect Tensile Strength
    - Tensile Strain at Failure
    - Secant Modulus

- Indirect Tension Test for Resilient Modulus (ASTM D1423)
    - Resilient Modulus
    - Poisson's Ratio

- Indirect Tensile Fatigue Test
    - Fatigue Constants, K1 and K2
    - Permanent Deformation Characteristic Parameters (Alpha and Gnu)

- Indirect Tensile Creep Test
    - Tensile Creep Compliance

- Moisture Sensitivity Test (Tex-531-C)
    - Tensile Strength Ratio (TSR)

Marshall Stability Test. The Marshall test was developed by the Corps of Engineers in the early 1960s based on methods and concepts formulated by Bruce Marshall of the Mississippi State Highway Department. This test is used to estimate asphalt content as a part of the Marshall mixture design procedure.

Marshall stability and flow values were determined using a Marshall loading apparatus as described in ASTM D1559. The compacted specimens (4 inches in diameter with a 2.5 inch height) were loaded at 140°F at a constant deformation rate of 2 inches per minute and the load and corresponding vertical deformation were recorded on an X-Y plotter. The maximum load, expressed in pounds, is the Marshall stability and the vertical deformation corresponding to the maximum load, expressed in units of 0.01 inches, is the flow value.

Hveem Stability Test. The Hveem stabilometer was developed by Francis Hveem of the California Division of Highways. The stabilometer is an empirical measure of aggregate interlock within HMAC mixtures.

Hveem stability was determined using the Hveem stabilometer as described in Tex-208-F (Ref 20). The compacted specimens (4 inches in diameter with a 2.0 inch height) were loaded at 140 F at a constant deformation rate of 0.05 inches per minute to a vertical load of 5000 pounds. The resultant horizontal force at 5000 lbs was measured as the pressure on the stabilometer wall and was used to calculate the Hveem stability as follows:

$$S = \frac{22.2}{P_h D_2/(P_v - P_h) + 0.222}$$

where

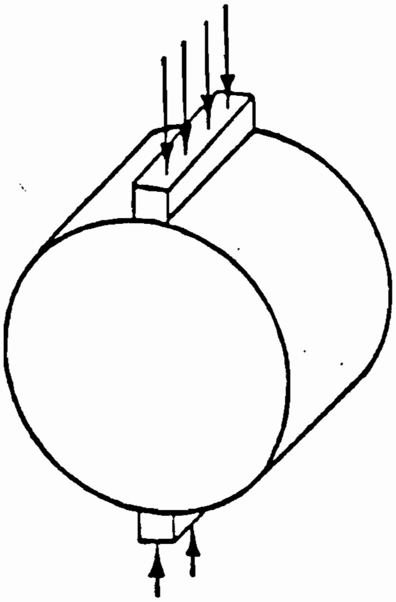
S = Hveem Stability, %

P_v = Applied vertical pressure (160 psi)

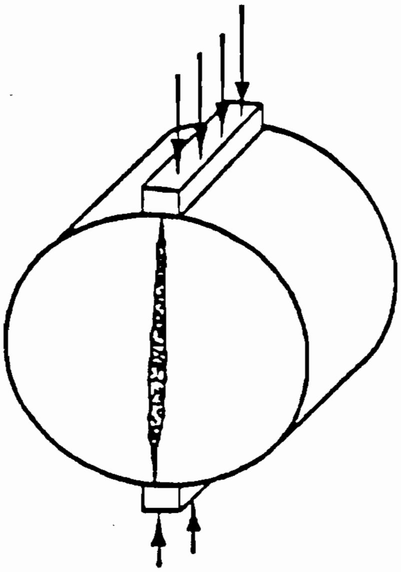
P_h = Transmitted horizontal pressure at P_v=160 psi, psi

D_2 = Displacement of the stabilometer fluid to increase the horizontal pressure from 5 to 100 psi, measured in revolutions of a calibrated pump handle.

Indirect Tensile Test. The indirect tensile test is performed by loading a cylindrical specimen with a single or repeated compressive load which acts parallel to and along the vertical diametral plane (Fig 2.9(a)). The load, which is distributed through a 0.5-inch wide steel loading strip curved (for a 4-inch diameter specimen) to fit the specimen, produces a relatively uniform tensile stress perpendicular to the direction of the applied load and along the vertical diametral plane, which ultimately causes the specimen to fail by splitting along the



(a) Compressive load being applied.



(b) Specimen failing in tension.

Fig 2.9 Indirect Tensile Loading and Failure.

vertical diameter. (Fig 2.9(b)).

The development of equations that permitted the computation of the tensile strength, the tensile strain at failure, the modulus of elasticity, and Poisson's ratio are reported in Refs (21,22). The equation to compute the tensile creep compliance has been developed during this study, and presented in Appendix F.

Indirect tensile strength. Indirect tensile strength was measured in accordance with Tex-226-F (Ref 20). Although only one test temperature is specified (77°F) in the test method Tex-226-F, two additional test temperatures (39°F and 104°F) were used to determine the effect of temperature on tensile strength of mixtures. Tensile strength was calculated using the following equation for four-inch diameter specimens:

$$S_t = 0.156 \frac{P_{\max}}{t}$$

where,

S_t = Tensile strength, psi

$P_{\max}$ = Total applied vertical load at failure, lbs

t = Thickness or height of the specimen, in.

Tensile strain at failure. The tensile strain at failure was calculated using the following equation (Ref 23) for four-inch diameter specimens:

$$\epsilon_f = \Delta H \frac{0.1185\upsilon+.03896}{0.02494\upsilon + 0.0673}$$

where,

ϵ_f = Strain at failure

ΔH = Horizontal deformation in inches at failure or deformation at maximum or peak load

υ = Poisson's ratio

<u>Resilient Modulus.</u> Resilient modulus was determined using the repeat-load indirect tensile test as described in ASTM D4123. A small preload was applied to the specimen to prevent impact damage of loading, and to minimize the effect of seating of the loading strip. The repeated load, which was approximately 20 percent of the static failure load, was then applied at a frequency of one cycle per second (1 HZ) with 0.1-second load duration and 0.9-second rest period. The load, vertical deformation, and horizontal deformations were recorded on a pair of X-Y plotters. A typical load pulse and the resulting deformation relationships are shown in Figure 2.10.

The resilient modulus was calculated using the resilient, or instantaneously recoverable, horizontal and vertical deformations after approximately 200 load cycles. The equation used to calculate the resilient modulus was

$$E_R = \frac{P_R}{t\ H_R}(0.27+\upsilon_R)$$

where,

E_R = Resilient modulus, psi
P_R = Applied repeated load, lbs (Fig 2.10)
t = Specimen thickness, in
H_R = Horizontal resilient deformation, in
υ_R = Resilient Poisson's ratio

<u>Poisson's Ratio.</u> Poisson's ratio (υ) was calculated from both horizontal and vertical movements in accordance with ASTM D1423 using the following relationship:

$$\upsilon = 3.59\ DR - 0.27$$

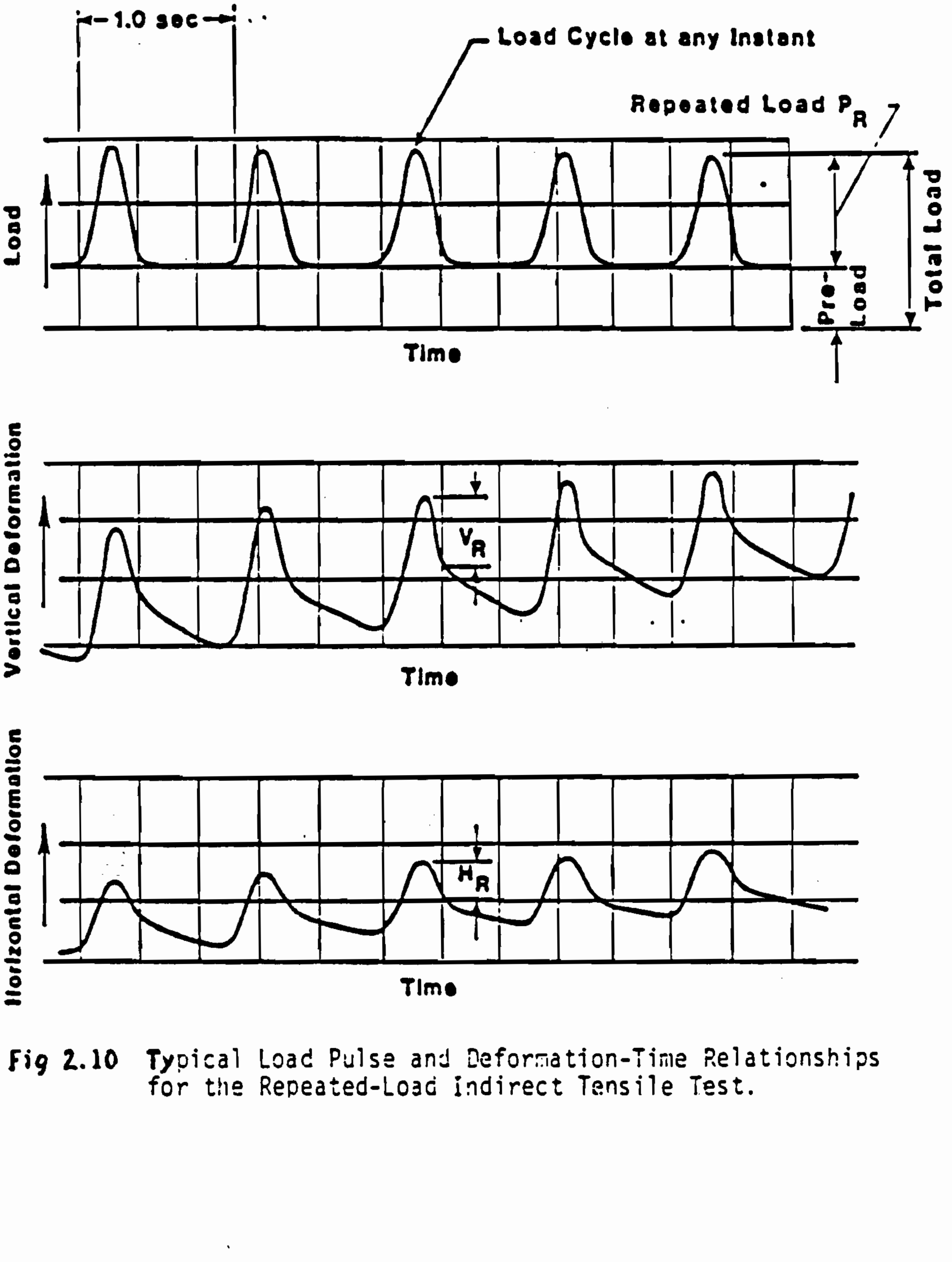


Fig 2.10 Typical Load Pulse and Deformation-Time Relationships for the Repeated-Load Indirect Tensile Test.

where

DR = $\Delta H / \Delta V$ = The deformation ratio measured during the indirect tensile test.

ΔH = The recoverable horizontal deformation measured during the resilient modulus test.

ΔV = The recoverable vertical deformation measured during the resilient modulus test.

<u>Indirect Tensile Fatigue Test.</u> The indirect tensile test configuration was used to measure the fatigue properties of HMAC mixtures. The test was performed at a frequency of one cycle per second (1 HZ) with 0.1-second load duration and 0.9-second rest period. Previous research by Kennedy (Ref 24), and more recently Baladi (Ref 25), have concluded that the indirect tensile test is a good tool for measuring the fatigue characteristics of asphalt concrete materials. The reasoning used is that the indirect tensile test simulates the state of stress in the lower portion of asphalt concrete layer (or tension zone).

Fatigue life relationships are often expressed in terms of initial strain for the controlled-stress test as follows:

$$N_f = K_1(1/\epsilon_{mix})\hat{\ }K_2$$

where

N_f = Number of repetitions or load applications to failure.

K_1 and K_2 = Fatigue constants (Regression constants).

ϵ_{mix} = Initial strain in the mixture.

Initial strain is estimated by three different methods:

1) By projecting the relationship between resilient strain and the number of load applications to the first load application.
2) By dividing the applied dynamic stress by the average repeated-load resilient modulus.
3) By dividing the applied dynamic stress by the average

static modulus of elasticity.

Kennedy (Ref 26) has concluded that the third method is better than the other two methods since it produces the highest correlation coefficients between the logarithm of number of load repetitions and the logarithm of initial strain. Consequently, the third method was used in this study. The fatigue equation describes a straight line on a log-log plot of cycles to failure versus initial strain, where k_1 is the intercept of Y-axis and $-K_2$ is the slope of the straight line.

Alpha and Gnu. The alpha and gnu functions were originally developed by Brademeyer et al (Ref 27) to describe the permanent deformation characteristics of asphalt concrete mixtures, and are two input parameters required for the VESYS program (Ref 28). Both values are mathematically defined below:

$$\text{alpha} = 1-S$$
$$\text{Gnu} = IS/\epsilon_r$$

where

S = Slope of the logarithm of number of load repetitions (N) versus logarithm of the accumulated permanent strain (Ep).

I = Intercept of the straight line (arithmetic strain value) with the accumulated permanent strain axis, i.e. value at which number of load repetitions scale equals 1.

ϵ_r = Resilient or recoverable strain.

Alpha and gnu are typically measured from testing cylindrical specimens in compression. Rauhut (Ref 28) suggests that reasonable values of alpha and gnu can only be calculated from compression samples after 100,000 load repetitions. However, Kennedy (Ref 29) found that using the indirect tensile test to calculate alpha and gnu during the first one thousand load cycles gave comparable results to the compression loading after 100,000 cycles. Von Quintus (Ref 30) has also used the indirect tensile test to measure permanent strain at 10,000 load cycles to compare different asphalt grades over a range of asphalt contents. Therefore, the indirect tensile test was used to calculate alpha and gnu for each of the mixtures.

<u>Creep Test.</u> Normally a creep test is conducted by applying a constant uniaxial stress to a cylindrical specimen and measuring the time-dependent deformation which occurs. Creep compliance D_t is then calculated by dividing the strain by the applied stress as follows:

$$D_t = \frac{\epsilon_t}{\sigma_o} \text{ at any test temperature } T$$

where,

ϵ_t = Strain at time t

σ_o= Applied stress

The indirect tensile test configuration was used to measure creep compliance of HMAC mixtures. The creep compliance equation for the indirect tensile creep test was developed during this study and is shown in Appendix F.

The Creep compliance is not only an important property in itself, it is also related to and is an indicator of several important properties such as permanent deformation, temperature susceptibility and fracture properties (Ref 31). Since the creep test is simple and quick to run at a variety of test temperatures, it is useful to run a series of these tests to assist in interpreting the expected performance of asphalt concrete pavements. In this study indirect tensile creep tests were conducted at three different temperatures (39, 60, 90°F). A constant stress that was less than 5 percent of the expected failure stress was applied for one hour. Horizontal deformation of the specimens was measured by linear variable differential transducers (LVTD's). After removal of the load, the specimen recovered to some extent. The amount of recovery was measured after one hour. The tensile creep compliance, D(t), was calculated using equation 9 in Appendix F, which was developed in this study.

Averages of the tensile creep compliance measured at each temperature were fitted with a curve of the form

$$D(t) = D_1 t^m$$

where

$D(t)$ = Tensile creep compliance, in x in/lb

t = Time, sec

m and D1 = The slope and intercept of creep curve on log-log plot

Several investigators have shown that asphalt mixtures exhibit simple thermo-rheological behavior, which means that an interchangeability exists between time and temperature. This relationship was investigated experimentally by carrying out creep tests at three different temperatures (60, 77, and 90°F). The average creep compliance curves for each temperature were shifted horizontally parallel to the time axis until each lined up with the curve for 77°F, which is designated as the "master" creep curve. The amount of the shift in time with changing temperature is expressed as a ratio, a_T, as follows:

$$a_T = \frac{t}{t_{T0}}$$

where

t_{T0} = The time at which a given compliance is reached when the material is at the "master" temperature, T0. In this study the master temperature is 77°F.

t = The time at which the same compliance is reached when material is at some other temperature.

Two commonly-used functions which produce numerical comparison of the temperature susceptibility of the materials were utilized. The first of these is commonly used in the VESYS program developed by the Federal Highway Administration (Ref 32). The function is

$$\log(a_T) = -\beta(T-T_0)$$

where

β = The temperature susceptibility constant

T_0 = The master curve temperature

T = any other temperature

The second function which is commonly used to describe the time-temperature shift of viscosity in polymers is known as the "WLF" equation (Ref 33). The equation is

$$\log(a_T) - \frac{-C_1(T-T_0)}{(C_2 + T - T_0)}$$

where

C_1 and C_2 = The material constants. The constant C_2 serves as a temperature susceptibility constant.

In this study the values of shift factor, $\log(a_T)$, did not fit the WLF equation.

<u>Tensile Strength Ratio.</u> The indirect tensile test was utilized to determine the tensile strength ratio (TSR) of wet and dry specimens as follows:

$$TSR = \frac{St(conditioned)}{St(unconditioned)}$$

where

St = Indirect tensile strength

The Texas test method Tex-531-C method (Ref 20) was selected for conditioning specimens as described below.

Specimens with air voids content of approximately 7 percent were conditioned by vacuum saturation with water. A partial vacuum (approximately 15 to 17 inches of mercury) was applied long enough to achieve a degree of saturation of about 70 percent. The specimens were placed in a freezer at 0°F for 15 hours. After the 15 hour freeze cycle, the specimens were removed from the freezer and placed in a 140°F water bath for 24 hours. After a complete freeze-thaw cycle, the moisture-conditioned specimens were cooled to room temperature in a 77°F water bath for approximately three hours prior to testing. The specimens were then tested to determine their indirect tensile strength (St conditioned). Paired specimens were kept at room condition and tested to measure the dry strength (St unconditioned)

EXPERIMENTAL LABORATORY PROGRAM

Laboratory mixture tests were performed on mixtures which were 1) mixed and compacted in the laboratory (laboratory mixtures), and 2) mixed in the plant and compacted in the laboratory (plant mixtures), and 3) mixed in the plant and compacted in the field (field cores). In addition, laboratory binder tests were performed on neat asphalt and modified asphalt binders which were obtained from the plants.

Asphalt and Modified Asphalt Binders

The asphalt cements (controls) and polymer modified asphalts were obtained at the asphalt mixing plants. The samples were transported to the laboratory and subsequently tested. The testing programs for the unmodified and modified asphalt binders are outlined in Tables A-2, B-2, C-2 and D-2. The test results are summarized in Appendices A through D.

Laboratory Mixed / Laboratory Compacted Mixtures

The neat asphalt and modified asphalt binders and aggregates were obtained from each project. These materials were mixed and samples prepared for testing in the laboratory in accordance with the mixture design used for the field construction.

The Texas-Gyratory shear compactor was utilized for two compaction procedures , described as standard and modified compactions. The standard compaction procedure specified by the Texas State Department of Highways and Public Transportation would normally produce 3 percent air voids in the mixtures containing optimum asphalt content. Since 7 percent air voids is generally obtained in the construction process, a modified compaction process was also used. For the modified compaction process, the compactive effort was reduced to produce an air void content of approximately 7 percent.

The testing programs for laboratory mixed / laboratory compacted mixtures utilized for the field project materials is outlined in Tables A-3, B-3, C-3 and D-3. The test results are summarized in Appendices A through D.

Plant Mixed / Laboratory Compacted Mixtures

Samples of field mixtures were obtained at the asphalt mixing plants. The samples were transported to the laboratory and subsequently compacted using the standard and modified compaction procedures. It was necessary to reheat the samples to achieve a compaction temperature of 250°F. The testing program for the plant mixed / laboratory compacted mixtures are outlined in Tables A-4, B-4, C-4 and D-4. The test results are summarized in Appendices A through D.

Plant Mixed / Field Compacted Mixtures

Plant mixed and field compacted specimens (4 inch diameter pavement cores) were obtained immediately and in one year intervals following construction of the test sections over a period of five years. The field cores were measured for thickness and air voids content, and subsequently tested in the laboratory. Since the heights of cores were less than 2 inches, the Hveem stability tests were not performed. The testing programs for the field cores are outlined in Tables A-5, B-5, C-5 and D-5.

CHAPTER 3

ANALYSIS OF TEST RESULTS ON UNMODIFIED AND MODIFIED ASPHALTS

Results of laboratory tests conducted on unmodified and polymer-modified asphalt binders for Districts 15, 11, 25 and 10 are listed and illustrated in Appendices A, B, C and D, respectively. Summaries of the test results for unmodified and polymer-modified asphalt binders are presented in Tables 3.1 through 3.13.

Where appropriate, Analysis of Variance (ANOVA) techniques were utilized to determine if significant differences exist between material types for each test parameter. In cases where significant difference was indicated, the Newman-Keul multiple range test (Ref 18) was used to determine which means were significantly different. The lower case letters in parentheses in Tables 3.1 through 3.13 indicate whether means are significantly different. Letters of the same type for each parameter indicate no significant difference in means at alpha = 0.05.

PENETRATION at 39.2°F

Results of penetration at 39.2°F are shown in Table 3.1 and are plotted in Figure 3.1. Table 3.1 contains the average penetration obtained from two replicate tests conducted for each material.

The results showed no significant difference between the mean values of the modified AC-10 asphalt binders and the control TFA AC-10 binder which was supplied by Texas Fuel and Asphalt, and between the modified AC-20 and the control AC-20 binders. However, the control and modified AC-20 asphalt binders demonstrated significantly lower values of penetration than the modified AC-10 asphalt binders.

<u>Effect of Polymer.</u> As shown in Figure 3.1, addition of the polymers changed penetration of the TFA asphalt cements by one or two points, which was not significant.

Table 3.1 **Summary of Test Results of Penetration, Viscosity and Softening Point for Unmodified and Polymer-Modified Asphalt Binders**

Test Parameter	TFA AC-10	TFA AC-10 & UP 70	TFA AC-10 & ELF	TFA AC-10 & NS 175	TFA AC-10 & C107	TFA AC-20	TFA AC-20 & Polybilt	TFA AC-20 & DOW	TEXACO AC-20	TEXACO AC-10 & UP 70	TEXACO AC-10 & ELF
Penetration @ 39.2 F, 100g, 5 Sec.											
before RTFOT	15	14	16	13	15	9	10	10	9	13	15
	(b)	(b)	(b)	(b)	(b)	(a)	(a)	(a)	(a)	(b)	(b)
Penetration @ 77 F, 100g, 5 Sec.											
before RTFOT	102	100	101	93	79	70	70	66	71	87	93
	(k)	(j,k)	(k)	(h)	(d)	(b)	(b)	(a)	(b)	(f)	(h)
after RTFOT	65	67	73	70	-	46	49	43	46	50	67
	(g,h)	(h)	(j)	(i)		(a,b,c)	(c,d)	(a)	(b,c)	(d)	(h,i)
Pen. Ratio (Pen. Retained)	0.63	0.67	0.72	0.75	-	0.65	0.70	0.65	0.65	0.58	0.72
Viscosity @ 140 F, Poises											
before RTFOT	1131	1311	3332	1318	-	2087	3296	5198	2375	2330	3060
	(a)	(b)	(i)	(b)		(d)	(i)	(k)	(e)	(e)	(h)
after RTFOT	3000	3932	6331	3780	-	7401	26266	31592	7002	4327	5882
	(a)	(b)	(g)	(b)		(i)	(k)	(l)	(h)	(c)	(f)
Viscosoty Ratio @ 140 F	2.65	3.00	1.90	2.87	-	3.55	7.97	6.08	2.95	1.86	1.92
Viscosity @ 275 F, Centistokes											
before RTFOT	297	503	754	495	-	416	919	1202	496	822	715
	(a)	(c)	(g)	(c)		(b)	(i)	(k)	(c)	(h)	(f)
after RTFOT	464	729	967	682	-	697	1830	2329	751	1049	897
	(a)	(c)	(f)	(b)		(b)	(k)	(l)	(c)	(h)	(d)
Viscosoty Ratio @ 275 F	1.56	1.45	1.28	1.38	-	1.68	1.99	1.94	1.51	1.28	1.26
Softening Point, F											
before RTFOT	117	122	132	122	138	126	133	139	126	127	130
	(a)	(b)	(g,h)	(b)	(j))	(c)	(h,i)	(j,k)	(c)	(c,d,e)	(f,g,h)

Note: Letters of the same type in parentheses indicate no significant difference exists between binders for a given test parameter at alpha = 0.05

Table 3.1 (Continued)

Test Parameter	FINA AC-10 & ELF	FINA AC-10 & 3% D1101	FINA AC-10 & 6% D1101	TOTAL AC-20	FINA AC-10 & UP 70	FINA AC-10 & ELF	EXXON AC-10 & Polybilt	GULF AC-10 & 3% D1101
Penetration @ 39.2 F, 100g, 5 Sec.								
before RTFOT	14	13	16	10	14	14	15	16
	(b)	(b)	(b)	(a)	(b)	(b)	(b)	(b)
Penetration @ 77 F, 100g, 5 Sec.								
before RTFOT	90	82	98	74	93	89	96	89
	(g)	(e)	(i,j)	(c)	(h)	(f,g)	(i)	(f,g)
after RTFOT	56	47	67	44	56	61	63	56
	(e)	(b,c,d)	(h,i)	(a,b)	(e)	(f)	(f,g)	(e)
Pen. Ratio (Pen. Retained)	0.63	0.57	0.69	0.59	0.60	0.69	0.66	0.63
Viscosity @ 140 F, Poises								
before RTFOT	2770	8127	-	2037	2373	2904	2375	3470
	(f)	(l)		(c,d)	(e)	(g)	(e)	(j)
after RTFOT	7481	13749	-	4798	5140	7416	5819	7280
	(i)	(j)		(d)	(e)	(i)	(f)	(i)
Viscosoty Ratio @ 140 F	2.70	1.69	-	2.36	2.17	2.55	2.45	2.10
Viscosity @ 275 F, Centistokes								
before RTFOT	781	584	1013	510	650	763	640	782
	(g)	(d)	(j)	(c)	(e)	(g)	(e)	(g)
after RTFOT	1009	736	1050	917.5	942.5	1097.5	1242.5	1055
	(g)	(c)	(h)	(d,e)	(e,f)	(i)	(j)	(h)
Viscosoty Ratio @ 275 F	1.29	1.26	1.04	1.80	1.45	1.44	1.94	1.35
Softening Point, F								
before RTFOT	129	141	148	127.5	129.5	134.5	140.5	146.5
	(d,e,f,g)	(k)	(l)	(c,d,e,f)	(e,f,g)	(i)	(k)	(l)

Note: Letters of the same type in parentheses indicate no significant difference exists between binders for a given test parameter at alpha = 0.05

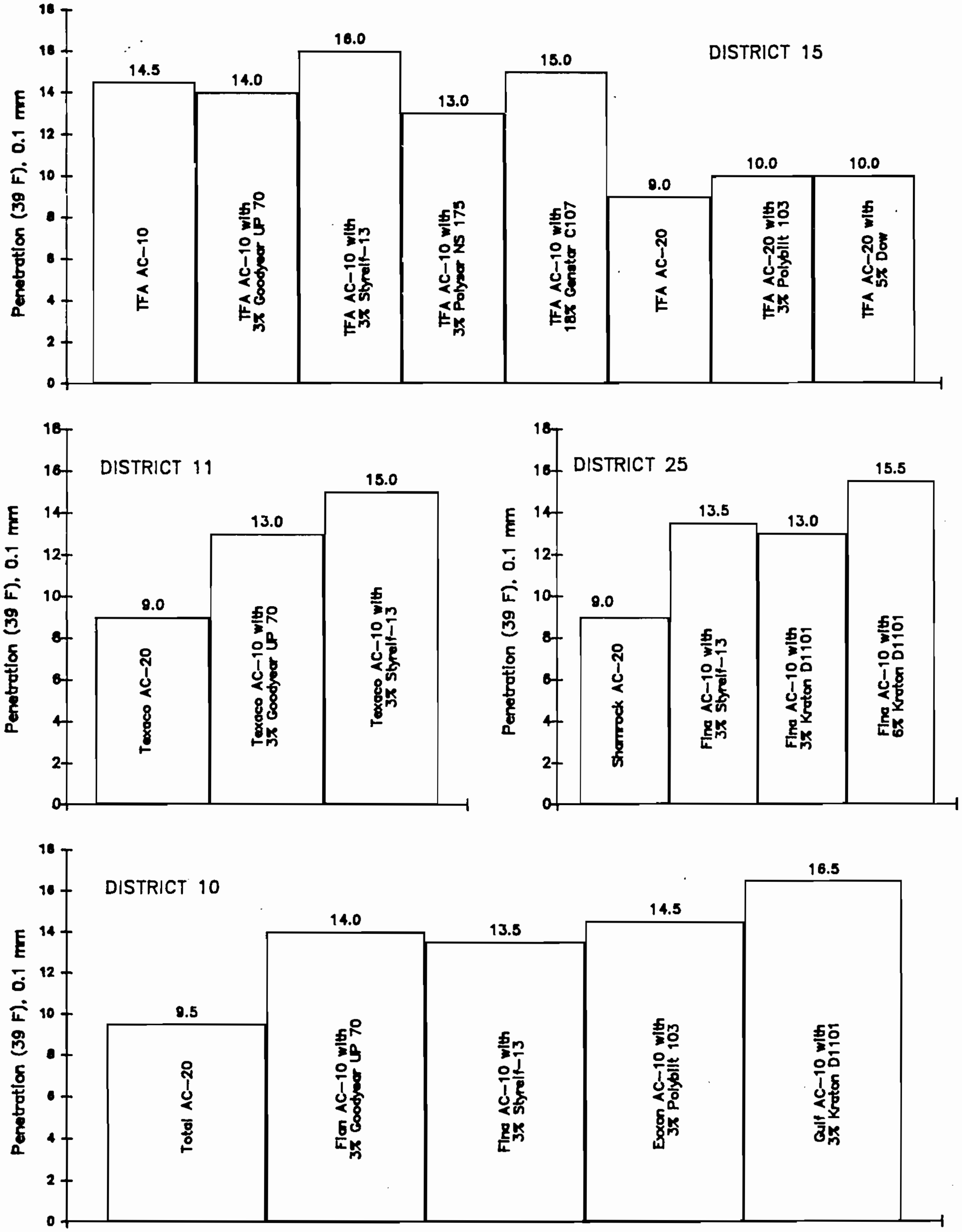


Fig. 3.1 Penetration at 39 F for Unmodified and Modified Binders before RTFOT Aging.

PENETRATION at 77°F

Average values of penetration test at 77°F before and after RTFOT aging are summarized in Table 3.1 and plotted in Figure 3.2. Both before and after RTFOT aging the mean values of penetration at 77°F for the AC-20 control asphalt binders were significantly lower than the mean values of the polymer-modified AC-10 asphalt binders, except for the aged 3% Kraton D1101 blend in District 25.

Effect of Polymer. The effects of polymer on penetration for the TFA asphalt cements before and after RTFOT aging are shown in Figure 3.2. In general, there is a trend for the polymer modified binders to decrease penetration (harden) before RTFOT aging, and increase penetration (soften) after aging by RTFOT. The Genstar C107 and Polysar NS 175 binders before RTFOT aging exhibited the greatest penetration decrease, 23 points and 9 points, respectively, while the other polymers exhibited equal or slightly smaller penetration values. The Dow modifier showed a 3 point decrease in pentration after the RTFOT.

Effect of Aging. The results of penetration at 77°F for the TFA asphalt binders indicate aging in the RTFOT may have less effect on penetration values for polymer-modified asphalt binders than for unmodified asphalts. To demonstrate this effect the percentage of penetration retained after aging by RTFOT (penetration ratio) for the unmodified and modified asphalt binders was evaluated. The results are shown in Table 3.1, and are plotted in Figure 3.3. This figure shows that aging by RTFOT had the greatest effect on penetration for the 3% Kraton binder in District 25 and the least effect for the Polysar and Styrelf binders.

VISCOSITY at 140°F

Average values of viscosity at 140°F before and after RTFOT aging are presented in Table 3.1 and plotted in Figure 3.4. Before RTFOT aging the AC-20 control asphalt binders were significantly less viscous than the modified binders except for the SBR polymer modified binders (Goodyear UP 70 and Polysar NS 175). However, after RTFOT all polymer modified AC-10 asphalt binders in

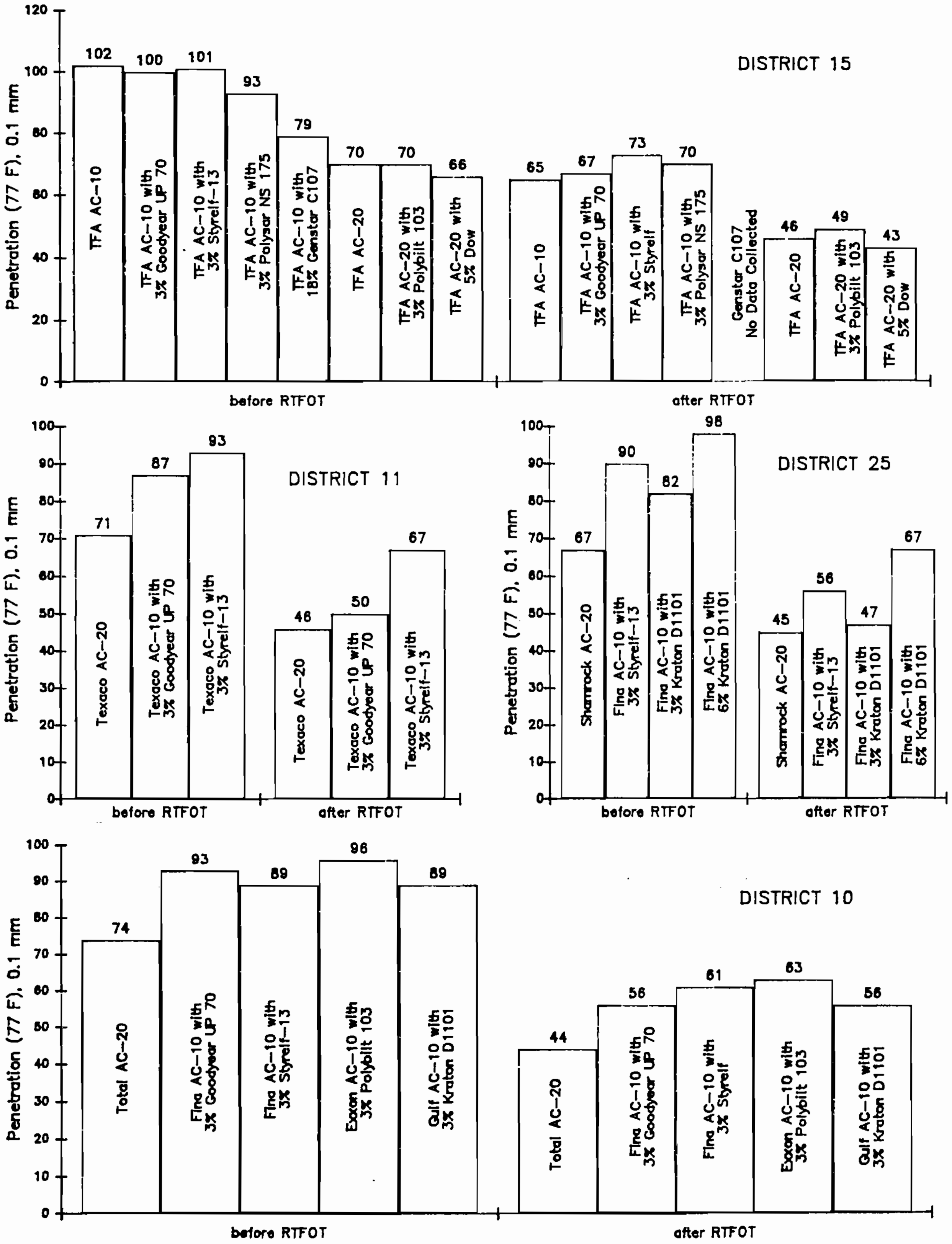


Fig 3.2 Penetration at 77 F for Unmodified and Modified Binders Before and After RTFOT Aging.

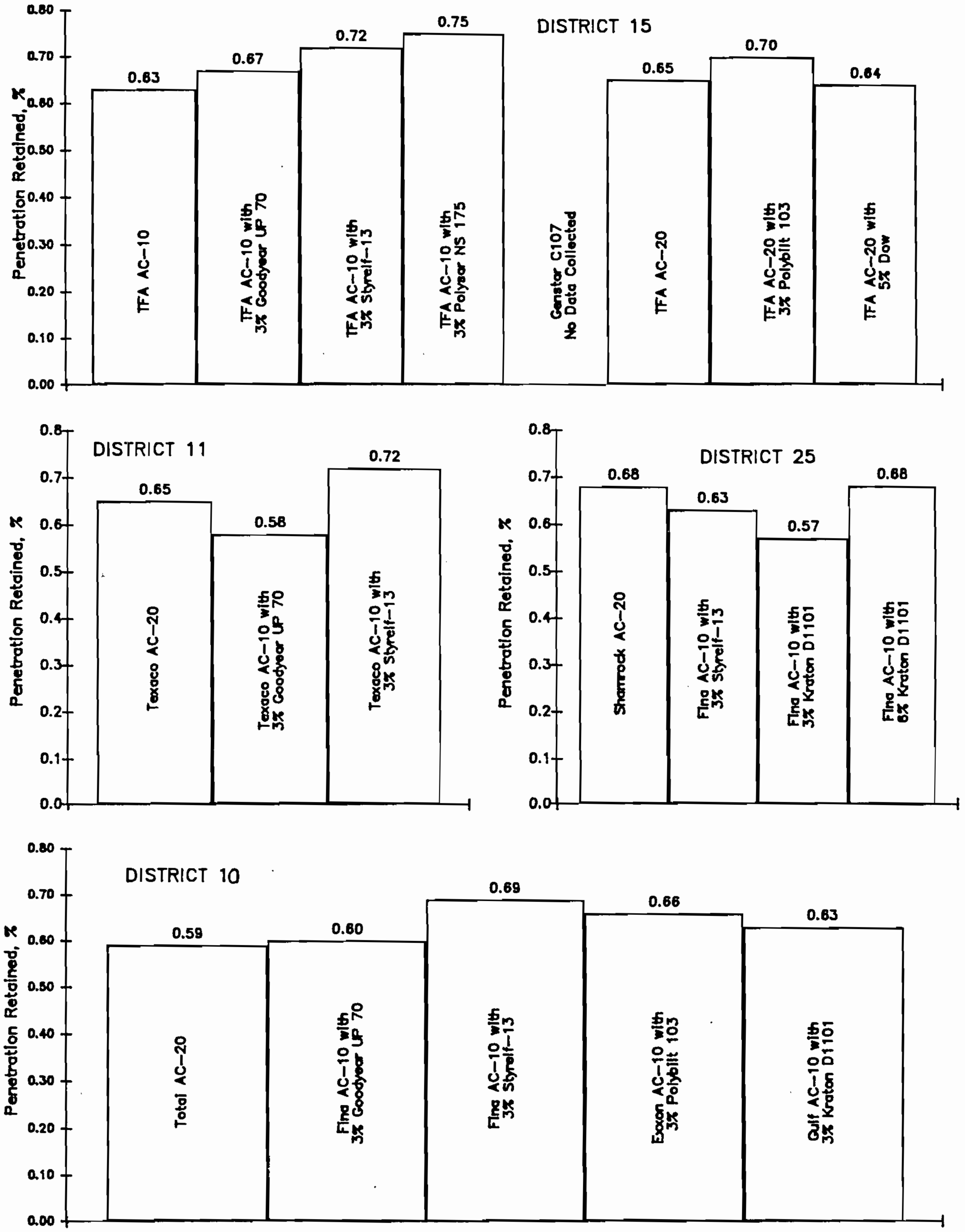


Fig 3.3 Retained Penetration at 77 F for Unmodified and Modified Binders.

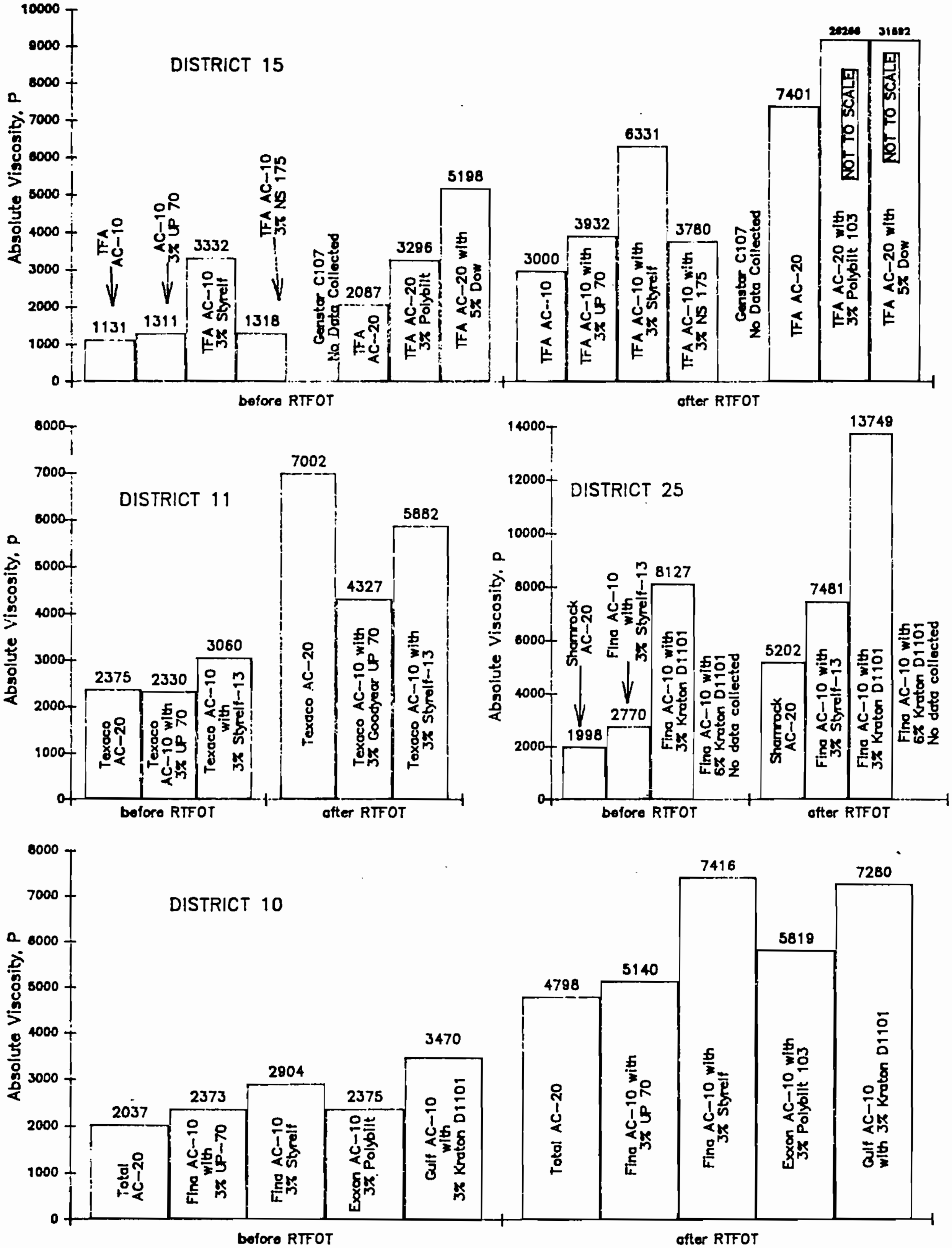


Fig 3.4 Viscosity at 140 F for Unmodified and Modified Binders Before and After RTFOT Aging.

Districts 15 and 11 demonstrated significantly lower values of viscosity than the AC-20 control binders. This trend was reversed in Districts 25 and 10.

Effect of Polymer. As shown in Figure 3.4 The polymer-modified asphalt binders showed an increase in viscosity at 140°F . This trend occurred before and after RTFOT aging. It is shown in Table 3.1 that before RTFOT aging the SBS polymers (Kraton and Styrelf) had the greatest effect on viscosity, followed by the Polyolefin (Dow) and EVA (Polybilt) polymers. The SBR polymers (Goodyear UP-70 and Polysar NS-175) had the least effect.

Effect of Aging. Viscosity ratios at 140°F are shown in Table 3.1 and are plotted in Figure 3.5. As shown in this figure aging by RTFOT has less effect on viscosity for the polymer-modified AC-10 asphalt binders compared with the modified AC-20 asphalt binders. Furthermore, aging had the least effect on viscosity for the Kraton binders.

KINEMATIC VISCOSITY at 275°F

Average values of kinematic viscosity before and after RTFOT aging are shown in Table 3.1 and plotted in Figure 3.6 . Before RTFOT aging all modified AC-10 asphalt binders except the 3% Kraton blend in District 25 showed significantly higher viscosity than the AC-20 control asphalt binders. The 3% Kraton blend was significantly less viscous than the Shamrock AC-20, but more viscous than the TFA AC-20, Texaco AC-20, and Total asphalt binders before RTFOT aging.

Effect of Polymer. Similar to viscosity at 140°F, polymer-modified asphalt binders showed an increase in viscosity before and after RTFOT aging compared with respective control asphalt binders (Fig 3.6). The Dow modifier, which increased viscosity by about a factor of 3.0 before and after RTFOT aging, had the greatest effect on kinematic viscosity.

Effect of Aging. Similar to viscosity at 140°F, kinematic viscosity was less affected by RTFOT aging for the modified AC-10 asphalt binders than the unmodified and modified AC-20 asphalt

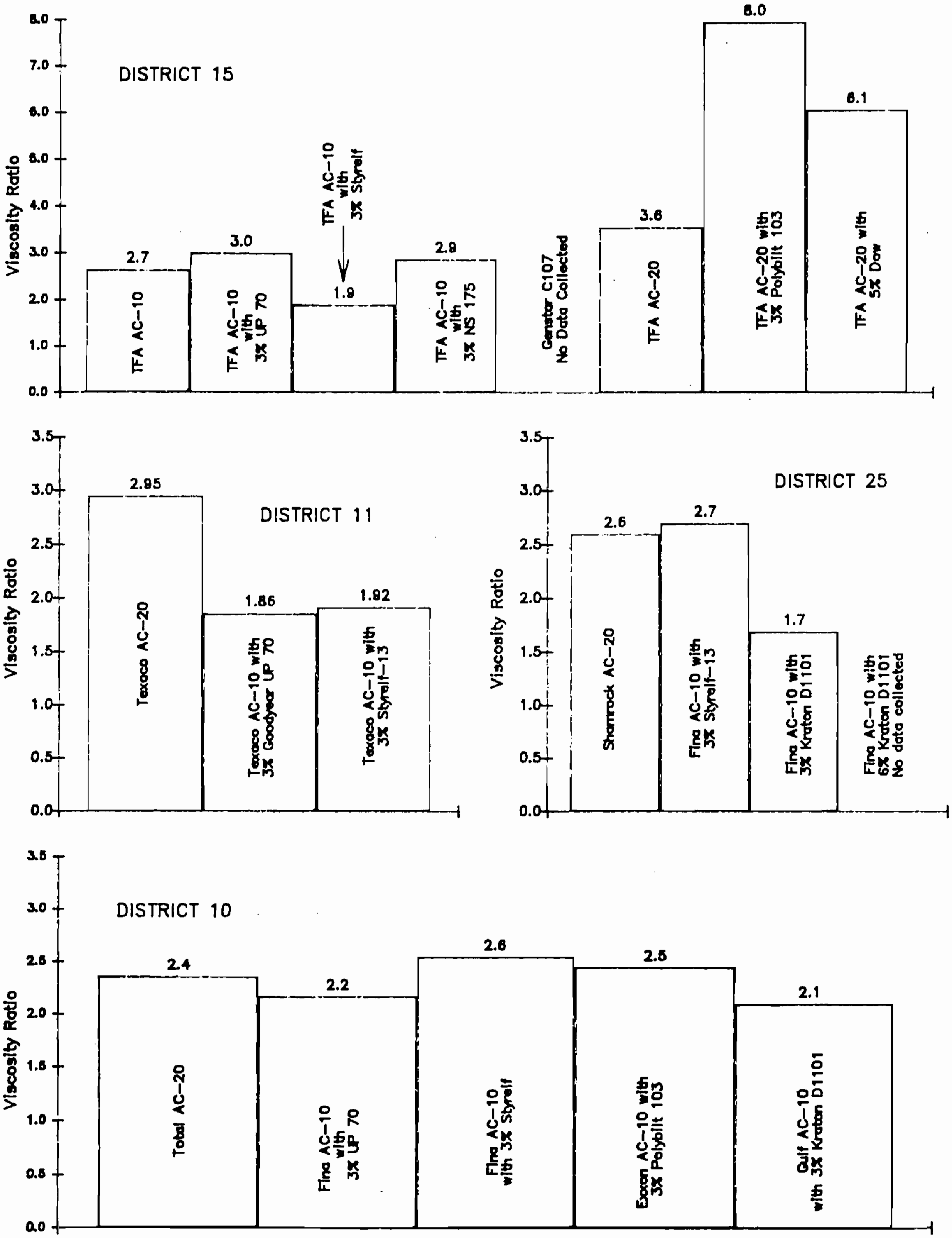


Fig 3.5 Viscosity Ratio at 140 F for Unmodified and Modified Binders.

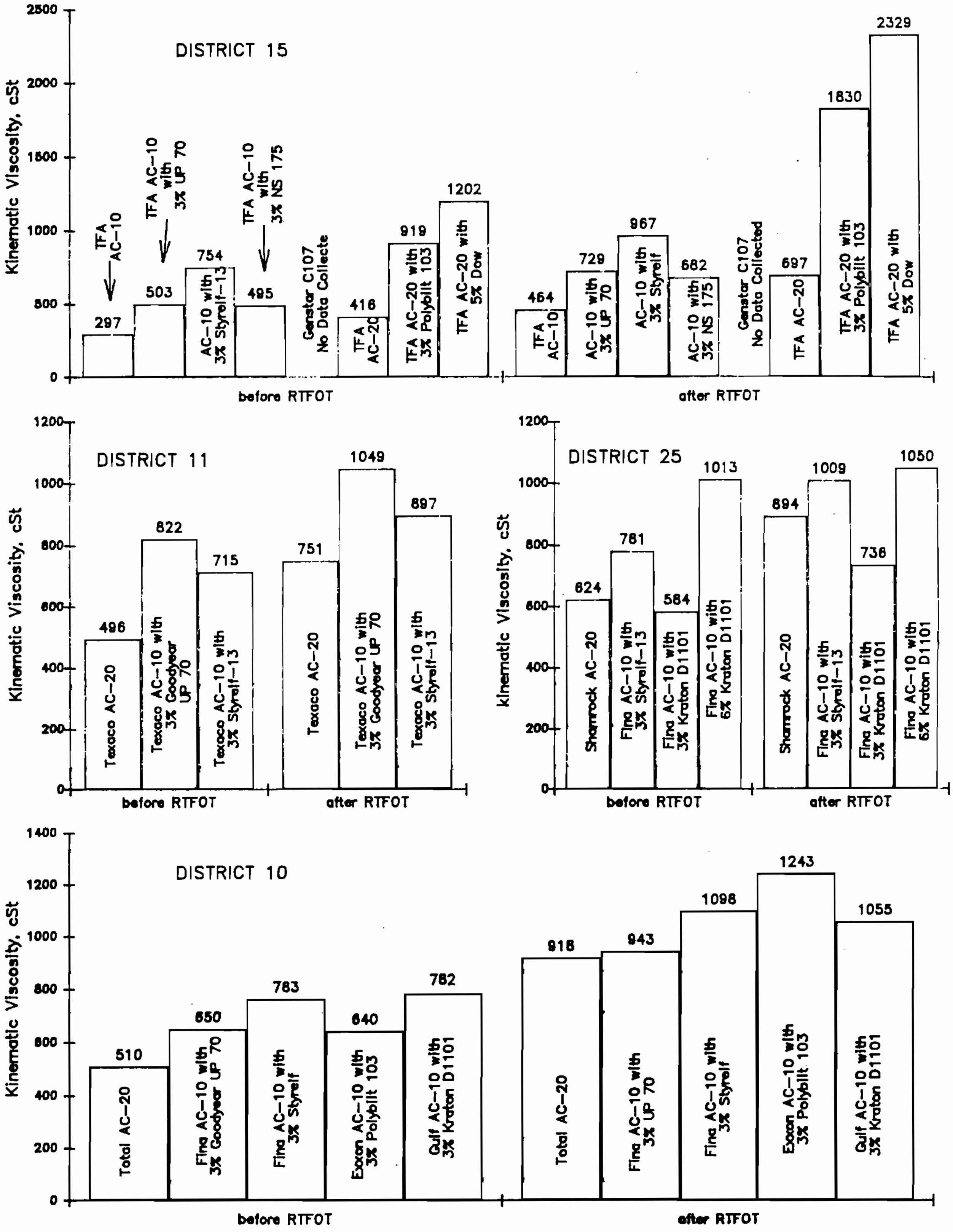


Fig 3.6 Viscosity at 275 F for Unmodified and Modified Binders Before and After RTFOT.

binders (Fig 3.7). The greatest effect of aging on kinematic viscosity was observed for the polybilt (Exxon) blends.

RING AND BALL SOFTENING POINT

Average values of softening point are shown in Figure 3.8, and listed in Table 3.1. Softening point for the Goodyear and Polysar TFA binders were significantly less than the AC-20 control asphalts. The 6% Kraton binder demonstrated a significantly higher softening point compared with the other modified binders.

Effect of Polymer. Softening point increased significantly for polymer-modified asphalt binders (Fig 3.8). Similar to viscosity, softening point was affected less by SBR polymers than SBS polymers. The Genstar exhibited the highest change for TFA asphalts, with an average increase of 22 degrees, while SBR polymers showed the lowest change with an average increase of 5 degrees.

PENETRATION INDEX AND PENETRATION VISCOSITY NUMBER

Table 3.2 presents the values of PI(Pen/Pen), PI(Pen/SP), and PVN for the unmodified and modified asphalt binders. The results are plotted in Figure 3.9. PI(Pen/Pen) Values were substantially lower than PI(pen/sp) values. This might have resulted from the assumption that all asphalts have a penetration of 800 at the softening point, a poor assumption for polymer modified binders. Penetration of asphalt binders at their softening points vary widely from 800, especially for modified asphalt binders which have high softening point and PI values. PVN values were generally lower than PI (Pen/SP), but comparable to PI(Pen/Pen). The average numerical difference between PI(pen/pen) and PVN was about .16; however, the average PI(Pen/SP) of the twenty binders under study was more than four times the average of PI(Pen/Pen) and PVN.

Effect of Polymer. Penetration indices (both PI(Pen/Pen) and PI (Pen/SP)) and PVN increased with addition of polymer (Fig 3.9).

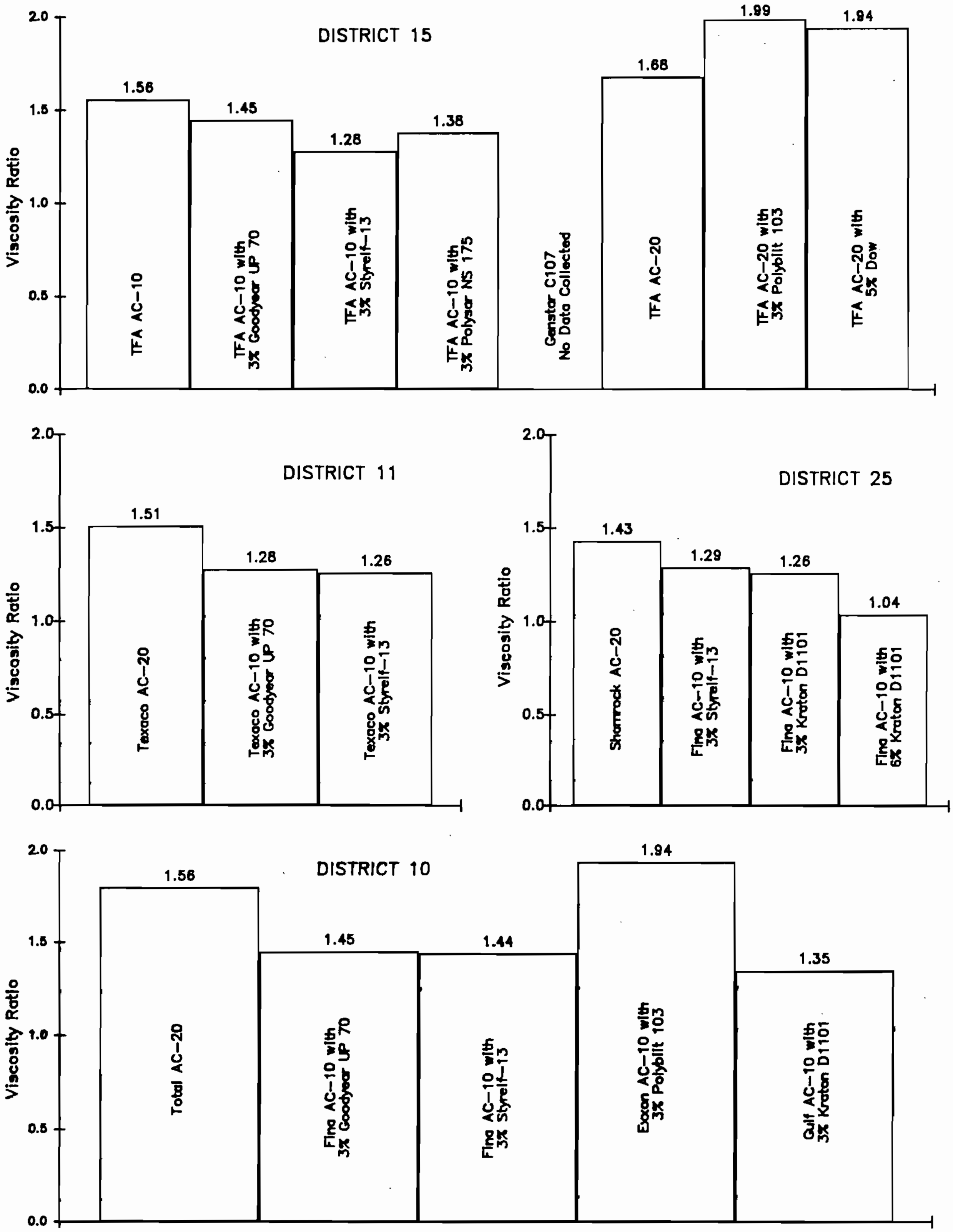


Fig 3.7 Viscosity Ratio at 275 F for Unmodified and Modified Binders.

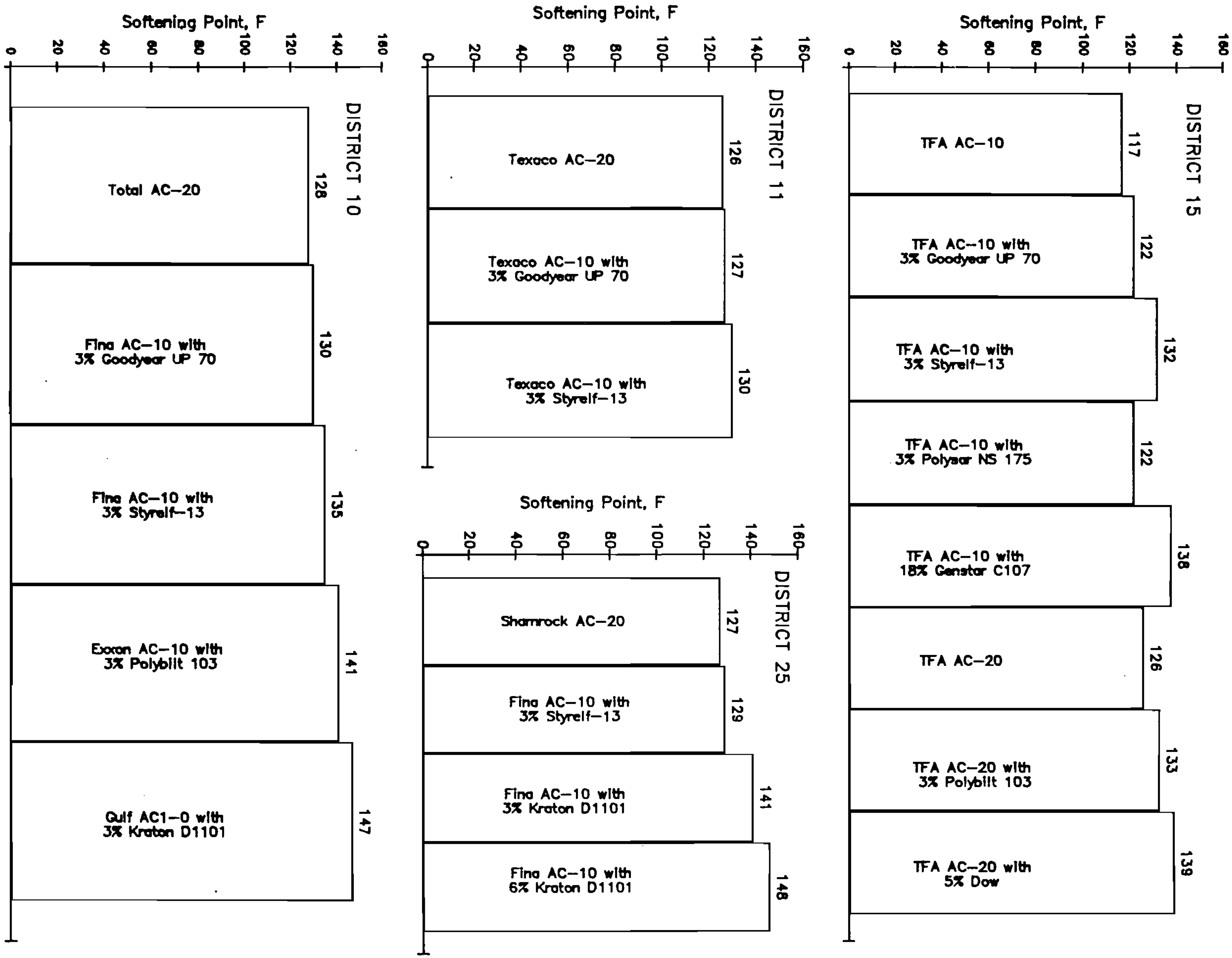


Fig 3.8 Softening Point for Unmodified and Modified Binder Before RTFOT.

Table 3.2 Penetration Index and Penetration Viscosity Number for Unmodified and Polymer-Modified Asphalt Binders.

Binder		Penetration Index		
Asphalt	Polymer	PI(Pen/Pen)	PI(Pen/SP)	PVN
TFA AC-10	-	-0.18	-0.04	-0.72
TFA AC-10	Goodyear UP 70	-0.11	0.69	0.14
TFA AC-10	Styrelf-13	0.33	2.01	0.79
TFA AC-10	Polysar NS 175	-0.11	0.46	0.02
TFA AC-10	Genstar C107	1.04	2.08	-
TFA AC-20	-	-0.39	0.19	-0.6
TFA AC-20	Polybilt 103	-0.04	0.98	0.62
TFA AC-20	Dow	0.17	1.66	0.96
Texaco AC-20	-	-0.43	0.23	-0.32
Texaco AC-10	Goodyear UP 70	0.12	0.97	0.76
Texaco AC-10	Styrelf-13	0.39	1.6	0.63
Shamrock AC-20	-	-0.25	0.21	-0.03
Fina AC-10	Styrelf-13	0.26	1.35	0.73
Fina AC-10	3% kraton D1101	0.33	2.55	0.12
Fina AC-10	6% kraton D1101	0.44	3.92	1.25
Total AC-20	-	-0.23	0.62	-0.22
Fina AC-10	Goodyear UP 70	0.14	1.60	0.47
Fina AC-10	Styrelf-13	0.30	2.10	0.67
Exxon AC-10	Polybilt 103	0.28	3.07	0.49
Gulf AC-10	3% kraton D1101	1.06	3.48	0.71

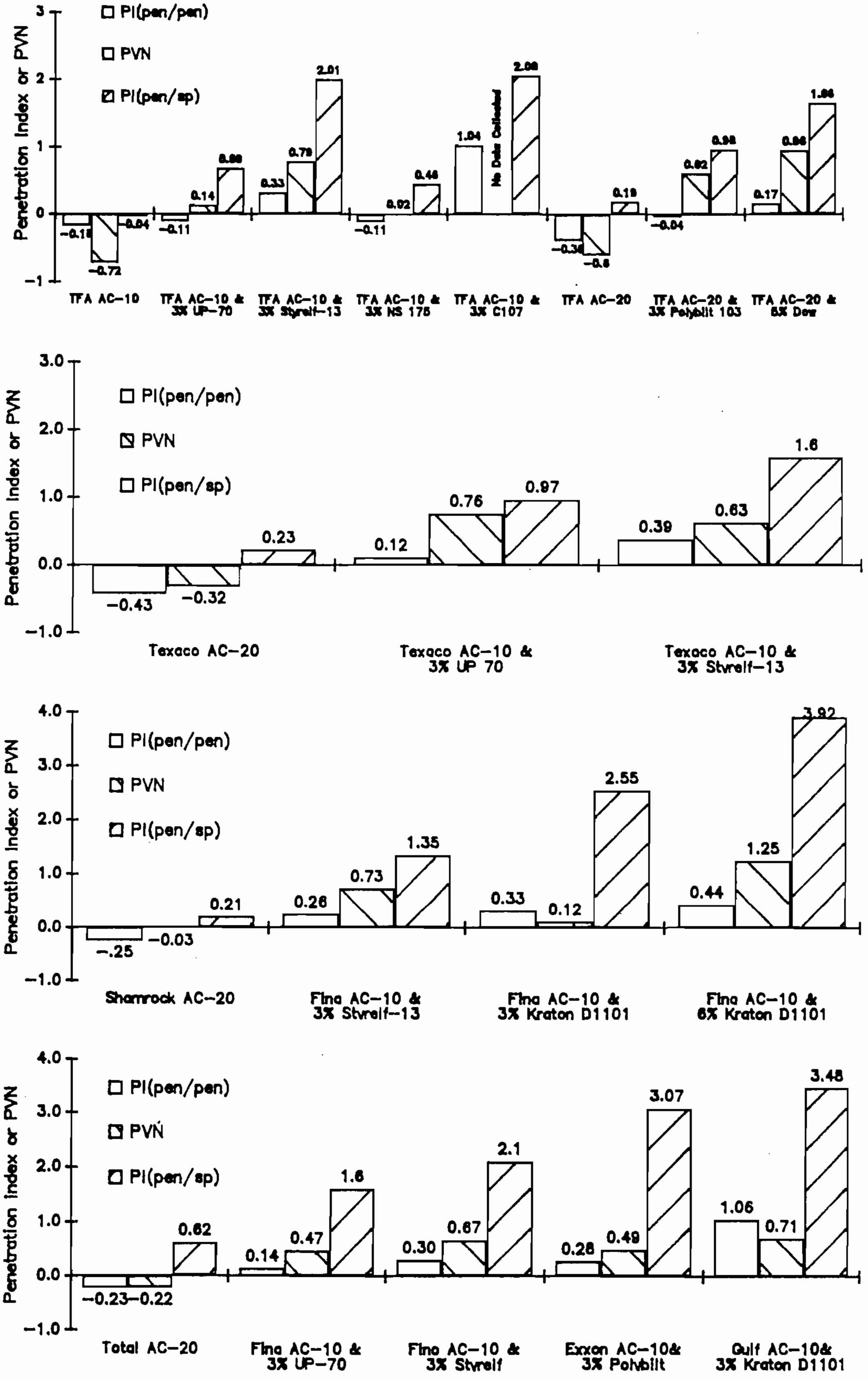


Fig 3.9 Penetration Index and PVN for Unmodified and Modified Binders Before RTFOT.

Table 3.3 Decreasing Order of Temperature Susceptibility Properties (PI, PVN).

PI(Pen/Pen)	PI(Pen/SP)	PVN
Texaco AC-20	TFA AC-10	TFA AC-10
TFA AC-20	TFA AC-20	TFA AC-20
Shamrock AC-20	Shamrock AC-20	Texaco AC-20
Total AC-20	Texaco AC-20	Total AC-20
TFA AC-10	TFA AC-10 + Polysar NS 175	Shamrock AC-20
TFA AC-10 + Goodyear UP 70	Total AC-20	TFA AC-10 + Polysar NS 175
TFA AC-10 + Polysar NS 175	TFA AC-10 + Goodyear UP 70	Fina AC-10 + 3% kraton D1101
TFA AC-20 + Polybilt 103	Texaco AC-10 + Goodyear UP 70	TFA AC-10 + Goodyear UP 70
Texaco AC-10 + Goodyear UP 70	TFA AC-20 + Polybilt 103	Fina AC-10 + Goodyear UP 70
Fina AC-10 + Goodyear UP 70	Fina AC-10 + Styrelf--13	Exxon AC-10 + Polybilt 103
TFA AC-20 + Dow	Texaco AC-10 + Styrelf-13	TFA AC-20 + Polybilt 103
Fina AC-10 + Styrelf--13	Fina AC-10 + Goodyear UP 70	Texaco AC-10 + Styrelf-13
Exxon AC-10 + Polybilt 103	TFA AC-20 + Dow	Fina AC-10 + Styrelf--13
Fina AC-10 + Styrelf-13	TFA AC-10 + Styrelf-13	Gulf AC-10 + 3% kraton D1101
Fina AC-10 + 3% kraton D1101	TFA AC-10 + Genstar C107	Fina AC-10 + Styrelf-13
TFA AC-10 + Styrelf-13	Fina AC-10 + Styrelf-13	Texaco AC-10 + Goodyear UP 70
Texaco AC-10 + Styrelf-13	Fina AC-10 + 3% kraton D1101	TFA AC-10 + Styrelf-13
Fina AC-10 + 6% kraton D1101	Exxon AC-10 + Polybilt 103	TFA AC-20 + Dow
TFA AC-10 + Genstar C107	Gulf AC-10 + 3% kraton D1101	Fina AC-10 + 6% kraton D1101
Gulf AC-10 + 3% kraton D1101	Fina AC-10 + 6% kraton D1101	

The decreasing order of temperature susceptibility obtained by PI(pen/pen) PI(Pen/SP) and PVN is shown in Table 3.3. The unmodified asphalt binders demonstrated more temperature susceptibility than the polymer modified asphalts binders according to the three methods. In addition, the Kraton D-1101 and the Genstar C-107 had the greatest effect on reducing temperature susceptibility. The least effect was observed for Polysar NS-175. In general, the SBS polymer modified binders were less temperature susceptible than the SBR modified ones.

LOW TEMPERATURE CRACKING

Table 3.4 and Figure 3.10 present the results of low temperature cracking. As shown, there was no substantial difference between cracking temperatures obtained by the two methods (Limiting Stiffness Method and Critical Stress Method). However, it should be noted that the criteria used for the limiting stiffness and critical stress methods have been established for conventional asphalt binders, and may not be acceptable for polymer modified asphalts. On the basis that failure criteria for asphalt binders can be used as a guide for polymer modified asphalt binders the following observations were made:

1) The addition of the Goodyear UP-70 and Polysar NS-175 (SBR Polymers) to the TFA asphalt did not appear to significantly alter the temperature at which thermally induced cracking is predicted to occur in the TFA asphalt. However, the addition of Goodyear UP-70 appeared to decrease the temperature at which low temperature cracking is predicted to occur for the Texaco and Fina asphalt binders (Table 3.4).

2) The rubber (Genstar C107), Styrelf-13 and Kraton D1101 (SBS polymers) appeared to be much more effective in lowering the predicted cracking temperatures than SBR polymers (Polysar and Goodyear).

3) Polymer modified asphalt binders generally had lower predicted cracking temperatures than respective control asphalts.

Table 3.4 Summary of Predicted Cracking Temperatures for Unmodified and Modified Asphalt Binders.

Binder		Cracking Temperature	
Asphalt	Polymer	Limitting Stiffness Method	Crtical Stress Method
TFA AC-10	-	-47	-49
TFA AC-10	Goodyear UP 70	-48	-46
TFA AC-10	Styrelf-13	-59	-59
TFA AC-10	Polysar NS 175	-46	-45
TFA AC-10	Genstar C107	-56	-55
TFA AC-20	-	-43	-42
TFA AC-20	Polybilt 103	-45	-43
TFA AC-20	Dow	-47	-48
Texaco AC-20	-	-43	-43
Texaco AC-10	Goodyear UP 70	-50	-52
Texaco AC-10	Styrelf-13	-52	-53
Shamrock AC-20	-	-41	-42
Fina AC-10	Styrelf--13	-54	-51
Fina AC-10	3% kraton D1101	-59	-61
Fina AC-10	6% kraton D1101	-74	-72
Total AC-20		-43	-44
Fina AC-10	Goodyear UP 70	-54	-55
Fina AC-10	Styrelf--13	-58	-57
Exxon AC-10	Polybilt 103	-66	-63
Gulf AC-10	3% kraton D1101	-68	-66

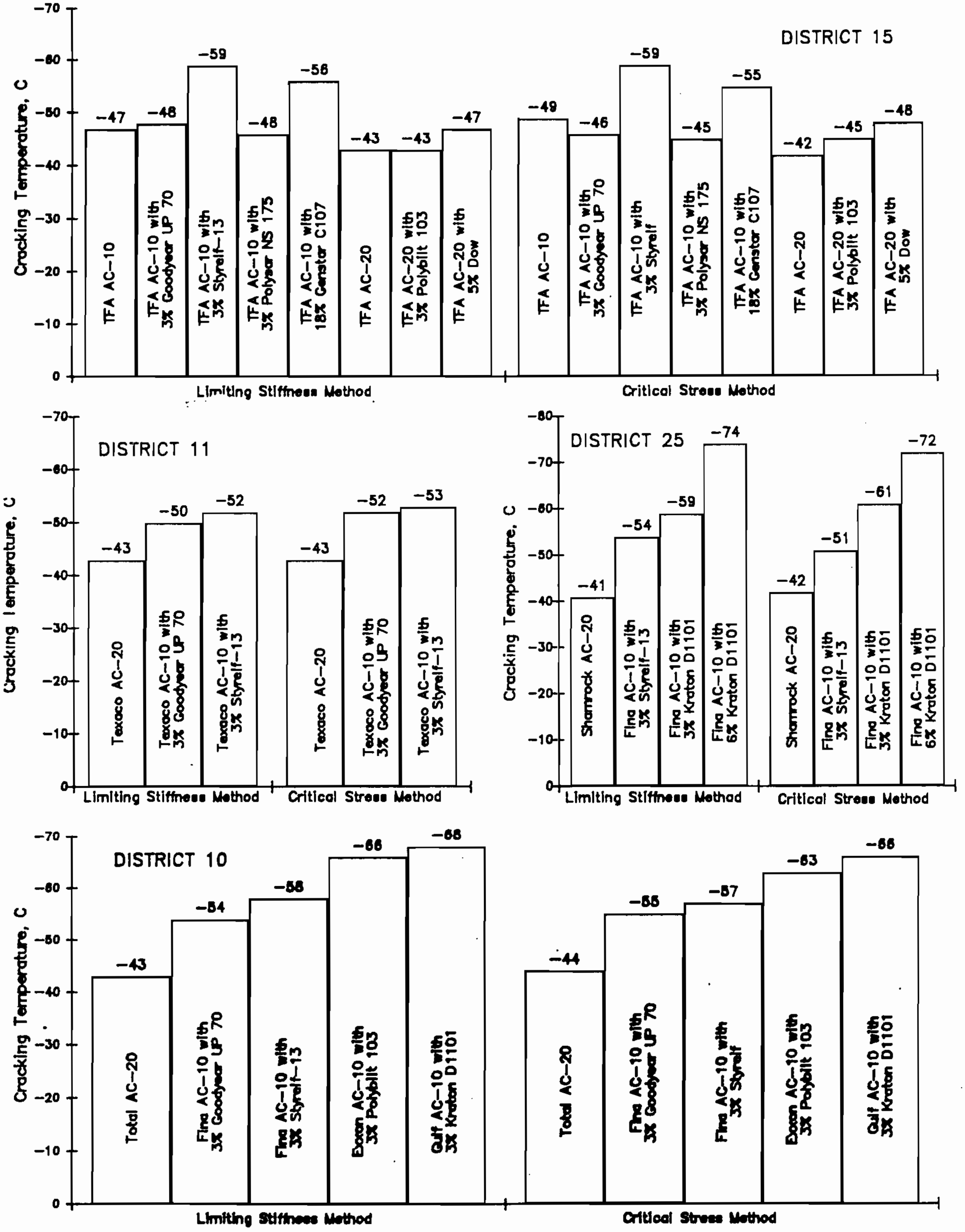


Fig 3.10 Cracking Temperature for Unmodified and Modified Binders.

PREDICTING STIFFNESS MODULUS

Results of stiffness modulus obtained from Van der Poel nomograph at different temperatures and loading times are presented in Table 3.5 and plotted in Figures A-13, B-13 and C-13. The polymer modified binders generally were softer at 39 F and stiffer at 77 F and 104 F than the control asphalt binders. This trend is most easily seen in Figure A-8. This effect can be described by stiffness temperature susceptibility obtained from the slope of fitted line of log stiffness vs. test temperature plot. Figures A-14, A-15, B-14, C-14 and D-14 show relationships between temperature and stiffness modulus for various polymers. The coefficients of correlation of fitted lines resulting from the data range from .99 to 1.0. This confirms a linear relationship between log stiffness modulus and test temperature. To confirm that the stiffness temperature susceptibilities (slopes) were significantly different from one another. A statistical test for parallel slopes in simple regression with two groups at alpha =0.05 (Ref 19) was utilized. A summary of the test results for each district is shown in Table 3.5. The lower case letter in parentheses indicates whether slopes are significantly different. Letters of the same type within a district indicate no significant difference in slope. The above analyses indicate that all the polymer modified TFA asphalt binders except NS-175 were significantly less temperature susceptible compared with their respective control asphalts. In addition, modified Texaco and Fina asphalt binders appeared to be significantly less temperature susceptible than the respective control asphalts.

The least effect on stiffness temperature susceptibility was observed for Polysar (SBR Polymer), while the other polymers improved temperature susceptibility significantly. The SBS, SBR/Polyolefin and rubber C107 improved temperature susceptibility more than the SBR and EVA polymers.

A comparison between Van der Poel stiffness modulus and asphalt modulus obtained from force ductility is shown in Figures A-16, B-15 and C-15. These figures suggest that the Van der Poel

Table 3.5 Summary of Predicted Stiffness Modulus and Stiffness-Temperature Susceptibility for Unmodified and Polymer-Modified Asphalt Binders.

Test Parameter	District 15								District 11		
	TFA AC-10	TFA AC-10 & UP 70	TFA AC-10 & ELF	TFA AC-10 & NS 175	TFA AC-10 & C107	TFA AC-20	TFA AC-20 & Polybilt	TFA AC-20 & DOW	TEXACO AC-20	TEXACO AC-10 & UP 70	TEXACO AC-10 & ELF
Stiffness Modulus, @39.2 F, psi											
5 Sec. Loading	450	435	305	493	522	725	725	754	1015	508	363
20 Sec. Loading	145	203	160	232	261	305	319	392	348	246	174
Stiffness Modulus @ 0.1 Sec											
39 F	5075	3625	2030	4785	2900	6960	5800	4640	7250	3190	2465
77 F	160	145	189	218	247	290	319	363	334	232	174
104 F	12	15	25	16	46	23	33	54	26	23	25
Stiffness/Temperature Slope	-0.073	-0.067	-0.053	-0.068	-0.050	-0.069	-0.062	-0.054	-0.068	-0.059	-0.056
Standard Error of Slope	0.0012 (a)	0.0000 (b)	0.0027 (d,e)	0.0033 (a,b,c)	0.0007 (e)	0.0021 (a,b)	0.0015 (c)	0.0007 (d)	0.0028 (a)	0.0035 (b)	0.0005 (b)

Test Parameter	District 25				District 10				
	SHAM. AC-20	FINA AC-10 & ELF	FINA AC-10 & 3% D1101	FINA AC-10 & 6% D1101	TOTAL AC-20	FINA AC-10 & UP 70	FINA AC-10 & ELF	EXXON AC-10 & Polybilt	GULF AC-10 & 3% D1101
Stiffness Modulus, @39.2 F, psi									
5 Sec. Loading	1160	464	435	232	-	-	-	-	-
20 Sec. Loading	508	218	218	131	-	-	-	-	-
Stiffness Modulus @ 0.1 Sec									
39 F	7540	2900	2320	943	6525	2465	2175	2320	1600
77 F	334	203	232	160	290	174	181	218	232
104 F	26	25	41	32	36	37	31	31	35
Stiffness/Temperature Slope	-0.068	-0.057	-0.049	-0.041	-0.063	-0.051	-0.051	-0.052	-0.046
Standard Error of Slope	0.0026 (a)	0.0016 (b)	0.0007 (c)	0.0028 (d)	0.0011 (a)	0.0028 (b)	0.0001 (b)	0.0021 (b)	0.0041 (c)

Note: Letters of the same type in parentheses within a district indicate no significant difference exists between binders for a given test parameter at alpha = 0.05

stiffness at 20 second loading and 39°F is the same as asphalt modulus measured by the force ductility test. However, the Van der Poel stiffness at 5 second loading and 39°F over-predicted the asphalt modulus by about a factor of 2.

FORCE DUCTILITY

A summary of the average values of the parameters obtained from force ductility test is presented in Table 3.6. Figures A-17 through A-21, B-16 through B-20 and C-16 through C-20 show the results of force ductility parameters and how they were affected by polymers and RTFOT aging .

MAXIMUM TRUE TENSILE STRENGTH. A significant increase in tensile strength occurred for all modified asphalt binders except for the Goodyear binders. Failure stress for the Goodyear modified binders was approximately equal to the control asphalt binders. The Kraton binders followed by Styrelf and Polybilt-103 demonstrated significantly higher tensile strength compared with the other modified binders. Goodyear UP-70, Polysar NS-175 and Crafco C-107 had the least effects on the tensile strength. After RTFOT aging all the modified asphalt binders, especially UP-70, presented significantly higher values of tensile strength than the control asphalt binders.

The effect of RTFOT aging on tensile strength is compared in Figures B-21 and C-21. From these figures it appears that the Kraton and Styrelf binders do not develop the increase in tensile strength occurring in the UP-70 and the control binders after RTFOT aging.

MAXIMUM TRUE TENSILE STRAIN. Addition of Goodyear UP-70 and Polysar NS-175 significantly increased maximum tensile strain of the TFA AC-10. However, the Dow, Polybilt, and Styrelf did not affect the tensile strain significantly. Failure strength for the binders modified with the Kraton and Styrelf was significantly higher than the AC-20 control binders. The Crafco binder showed

Table 3.6 Summary of Force Ductility Parameters for Unmodified and Polymer-Modified Asphalt Binders.

Parameter	TFA AC-10	TFA AC-10 & UP 70	TFA AC-10 & ELF	TFA AC-10 & NS 175	TFA AC-10 & C107	TFA AC-20	TFA AC-20 & Polybilt	TFA AC-20 & DOW	TEXACO AC-20	TEXACO AC-10 & UP 70	TEXACO AC-10 & ELF	SHAM. AC-20	FINA AC-10 & ELF	FINA AC-10 & 3% D1101	FINA AC-10 & 6% D1101
Maximum True Stress, psi															
before RTFOT	59 (a)	84 (a)	387 (f)	124 (b)	130 (b)	101 (b)	289 (e)	174 (c)	60 (a)	75 (a)	210 (d)	120 (b)	289 (e)	474 (g)	596 (h)
after RTFOT	-	-	-	-	-	-	-	-	154 (a)	522 (f)	265 (c)	204 (b)	456 (e)	424 (d)	416 (d)
Maximum True Stress Ratio									2.57	6.99	1.26	1.70	1.58	0.89	0.70
Maximum True Strain, in/in															
before RTFOT	2.95 (d)	3.51 (g)	2.77 (d)	3.53 (g)	1.39 (a)	2.40 (b,c)	2.46 (c)	2.28 (b,c)	2.44 (b,c)	3.73 (h)	3.38 (f)	2.23 (b)	2.94 (d)	3.13 (e)	2.78 (d)
after RTFOT	-	-	-	-	-	-	-	-	2.29 (b)	3.69 (e)	2.77 (d)	1.47 (a)	2.54 (c,d)	2.62 (d)	2.56 (d)
Maximum True Strain Ratio									0.94	0.99	0.82	0.66	0.86	0.84	0.92
True Area , psi															
before RTFOT	115 (b)	159 (d)	404 (i)	248 (f)	125 (b,c)	121 (b,c)	363 (h)	198 (e)	83 (a)	150 (c,d)	269 (f)	136 (b,c,d)	332 (g)	473 (j)	347 (g,h)
after RTFOT	-	-	-	-	-	-	-	-	181 (a)	689 (e)	322 (b)	163 (a)	485 (d)	511 (d)	364 (c)
True Area Ratio									2.19	4.60	1.20	1.20	1.46	1.08	1.05
Asphalt Modulus, psi															
before RTFOT	146 (a)	214 (b)	227 (b)	296 (c)	245 (b)	326 (c,d)	346 (d)	413 (e)	242 (b)	224 (b)	154 (a)	472 (f)	210 (b)	250 (b)	115 (a)
after RTFOT	-	-	-	-	-	-	-	-	453 (c)	410 (b,c)	248 (a)	428 (b,c)	349 (b)	390 (b,c)	204 (a)
Asphalt Modulus Ratio									1.87	1.83	1.62	0.91	1.66	1.56	1.77
Asphalt-Polymer Modulus, psi															
before RTFOT	n/a	89 (b)	392 (g)	131 (c)	50 (a)	n/a	205 (e)	n/a	n/a	105 (b)	169 (d)	n/a	279 (f)	452 (h)	819 (i)
after RTFOT	-	-	-	-	-	-	-	-	n/a	456 (d)	232 (a)	n/a	400 (c)	365 (b)	417 (c)
Asphalt-Polymer Modulus Ratio										4.33	1.37		1.43	0.81	0.51

Note: Letters of the same type in parentheses indicate no significant difference exists between binders for a given test parameter at alpha = 0.05.

the lowest failure strain of 1.39 in/in. After RTFOT all the modified AC-10 binders showed significantly higher failure strain than the AC-20 control binders. The effect of aging on failure strain was compared in Figures B-21 and C-21 by strain ratio before and after RTFOT aging. These figures indicate the aging had least effect on the UP-70 binders. The greatest effect was observed for Shamrock AC-20 binder.

AREA UNDER STRESS-STRAIN CURVE. Addition of the polymers except Genstar C-107 increased area under the curve significantly. The UP-70, Dow, and NS-175 modifiers had relatively less effect compared with Kraton and Styrelf. Area increased by approximately four times for the Styrelf and doubled for the SBR polymers.

After RTFOT aging all the modified binders presented significantly greater area than the AC-20 control binders. Similar to maximum tensile strength, The SBS polymer binders (Kraton and Styrelf) were affected less than the Goodyear and control binders (Figs B-21 and C-21). Area increased by about a factor of four for the Goodyear and by a factor of 1.5 for the Styrelf and Kraton binders after RTOFT.

ASPHALT MODULUS. Asphalt modulus of the modified AC-10 asphalt binders were significantly less than that of respective control AC-20 asphalt binders and significantly greater than the TFA AC-10 asphalt binder. Polybilt-103 did not change the modulus of TFA AC-20 whereas Dow increased the modulus by 30 percent. Comparison of asphalt modulus between the binders indicates that Styrelf and 6% Kraton binders had lower modulus of asphalt than UP-70, NS-175 and Crafco C-107 binders.

After RTFOT the asphalt modulus of the Styrelf with Texaco and 6% Kraton with Fina were significantly less than the other modified and the control AC-20 asphalt binders. By examining Figures B-21 and C-21, it is apparent that the effects of aging on asphalt modulus for the modified binders were approximately the same.

ASPHALT-POLYMER MODULUS. None of the control asphalt binders demonstrated the presence of an asphalt-polymer modulus. This was no surprise , since it is believed this secondary increase in load (see Fig 2.4) is due to the presence of the polymer in the binder. The Kraton, Styrelf, and Polybilt binders demonstrated significantly higher polymer-asphalt modulus than the UP-70 and NS-175. Dow did not show the presence of an asphalt-polymer modulus.

After RTFOT aging the UP-70 binder showed the highest asphalt-polymer modulus, followed by the Kraton and Styrelf binders. Figures B-21 and C-21 show the ratio of asphalt polymer modulus after and before RTFOT aging. Aging affected the UP-70 binders the most, and the Styrelf and Kraton binders very little.

SCHWEYER RHEOLOGY

Rheological data obtained from the Schweyer constant stress rheometer were rate of shear in reciprocal seconds and shear stress in Pascals. The data are presented in Tables A-8, B-8 and C-8 . Figures A-22 through A-37, B-22 through B-27 and C-22 through C-29 show shear stress-shear rate and apparent viscosity-shear rate diagrams for the materials used in Districts 15, 11, and 25 respectively. These figures contain shear susceptibility 'C', standard error of shear susceptibility 'Se' and coefficient of correlation 'R'. Values of shear susceptibility, apparent viscosity at a shear rate of 1 reciprocal second, and apparent viscosity at constant power input (10^5 units) are reported in Tables A-6, A-7, B-6 and C-6.

SHEAR SUSCEPTIBILITY. Shear susceptibility was measured before and after RTFOT aging at 39°F, 77°F, 140°F for the modified and unmodified asphalt binders used in District 15, and before RTFOT aging at 39°F, 60°F, 77°F, 90°F, and 140°F for the binders used in Districts 11, and 25. Shear rates were approximately 0.001 to 0.1, 0.1 to 10, and 10 to 1000 in reciprocal seconds for test temperatures of 39°F, 77°F, and 140°F respectively. A statistical t-test was utilized to compare shear susceptibility values (slope of shear stress-shear rate diagram) with 1.0. All the binders, including unmodified asphalt cements, demonstrated non-Newtonian behavior at all test temperatures since their slopes were significantly different from 1. The Styrelf modified binders displayed shear thickening behavior except in one case at 140°F. The other binders demonstrated shear thinning behavior at all test temperatures.

A statistical test for parallel slopes was utilized to compare shear susceptibility. A summary of the effects of polymers, temperature, and aging on shear susceptibility is shown on Tables 3.7 through 3.9 respectively. Shear susceptibility closer to unity indicates less degree of non-Newtonian behavior (less shear susceptible). Table 3.7 and Figures A-38 and A-39 indicate the addition of Dow and Polybilt-103 significantly increased the degree of non-Newtonian behavior of the TFA AC-20 asphalt binders at all test temperatures. This trend was observed after RTFOT aging. In addition, most modified AC-10 binders were less shear susceptible compared with their respective control AC-20 asphalt binders. Furthermore, an increase of Kraton content from 3 percent to 6 percent in Fina AC-10 significantly increased shear susceptibility at all test temperature above 60°F.

The effects of aging on shear susceptibility are shown in Figures A-40 and Table 3.8. It appears that either aged binders were significantly more shear susceptible than corresponding unaged ones, or there was no significant difference.

The effects of temperature on shear susceptibility are presented in Table 3.9 and Plotted in Figures A-38, B-28 and C-30. All binders except 6 percent Kraton displayed higher shear susceptibility at 39°F than at 140°F. In general, these figures suggest that as test temperature increased, the non-Newtonian constant 'C' became closer to unity, showing a decrease in shear susceptibility.

Table 3.7 Summary of Shear Susceptibility for Unmodified and Polymer Modified Asphalt Binders

Test Parameter	District 15								District 11			District 25			
	TFA AC-10	TFA AC-10 & UP 70	TFA AC-10 & ELF	TFA AC-10 & NS 175	TFA AC-10 & C107	TFA AC-20	TFA AC-20 & Polybilt	TFA AC-20 & DOW	TEXACO AC-20	TEXACO AC-10 & UP 70	TEXACO AC-10 & ELF	SHAM. AC-20	FINA AC-10 & ELF	FINA AC-10 & 3% D1101	FINA AC-10 & 6% D1101
Shear Susceptibility @ 39 F															
Before RTFOT	0.602 (c,d)	0.747 (b)	1.135 (a)	0.770 (b)	0.535 (d,e)	0.638 (c)	0.507 (e)	0.511 (e)	0.646 (c)	0.747 (b)	1.277 (a)	0.490 (c)	1.235 (a)	0.799 (b)	0.777 (b)
after RTFOT	0.584 (c)	0.612 (c)	1.213 (a)	0.697 (b)	-	0.607 (c)	0.508 (d)	0.485 (d)	-	-	-	-	-	-	-
Shear Susceptibility @ 60 F															
Before RTFOT	-	-	-	-	-	-	-	-	0.804 (c)	0.892 (b)	1.167 (a)	0.696 (d)	1.215 (a)	0.876 (b)	0.828 (c)
Shear Susceptibility @ 77 F															
Before RTFOT	0.879 (b)	0.816 (c)	1.069 (a)	0.858 (b)	0.678 (e)	0.778 (d)	0.627 (f)	0.519 (g)	0.804 (b)	0.803 (b)	1.152 (a)	0.664 (d)	1.076 (a)	0.889 (b)	0.772 (c)
after RTFOT	0.796 (b)	0.720 (d)	1.156 (a)	0.764 (c)	-	0.715 (d)	0.614 (e)	0.486 (f)	-	-	-	-	-	-	-
Shear Susceptibility @ 90 F															
Before RTFOT	-	-	-	-	-	-	-	-	0.830 (b)	0.794 (b)	1.131 (a)	0.761 (c)	1.089 (a)	0.886 (b)	0.809 (c)
Shear Susceptibility @ 140 F															
Before RTFOT	0.938 (c)	0.952 (c)	1.019 (a)	0.967 (b)	0.699 (f)	0.840 (d)	0.713 (f)	0.777 (e)	0.832 (c)	0.880 (b)	0.971 (a)	0.894 (b)	1.018 (a)	0.885 (b)	0.772 (c)
after RTFOT	0.850 (c)	0.856 (c)	1.016 (a)	0.913 (b)	-	0.803 (d)	0.623 (f)	0.690 (e)	-	-	-	-	-	-	-

Note: Letters of the same type in parentheses within a district indicate no significant difference exists between binders for a given test parameter at alpha = 0.05

Table 3.8 Effect of Aging by RTFOT on Shear Susceptibility for Unmodified and Modified Asphalt Binders.

Binder		Shear Susceptibility		Shear Susceptibility		Shear Susceptibility	
Asphalt	Polymer	Before RTFOT	After RTFOT	Before RTFOT	After RTFOT	Before RTFOT	After RTFOT
		Test Temperature 39 F		Test Temperature 77 F		Test Temperature 140 F	
TFA AC-10	-	6.024E-01 (a)	5.836E-01 (a)	8.786E-01 (a)	7.957E-01 (b)	9.378E-01 (a)	8.498E-01 (b)
TFA AC-10	Goodyear UP 70	7.470E-01 (a)	6.116E-01 (b)	8.159E-01 (a)	7.200E-01 (b)	9.518E-01 (a)	8.563E-01 (b)
TFA AC-10	Styrelf-13	1.135E+00 (b)	1.213E+00 (a)	1.069E+00 (b)	1.156E+00 (a)	1.019E+00 (a)	1.016E+00 (a)
TFA AC-10	Polysar NS 175	7.699E-01 (a)	6.968E-01 (b)	8.576E-01	7.637E-01	9.670E-01 (a)	9.128E-01 (b)
TFA AC-10	Genstar C107	5.349E-01	-	6.778E-01	-	6.990E-01	-
TFA AC-20	-	6.376E-01 (a)	6.067E-01 (a)	7.778E-01 (a)	7.154E-01 (b)	8.400E-01 (a)	8.034E-01 (a)
TFA AC-20	Polybilt 103	5.070E-01 (a)	5.075E-01 (a)	6.269E-01 (a)	6.143E-01 (a)	7.133E-01 (a)	6.226E-01 (b)
TFA AC-20	Dow	5.107E-01 (a)	4.853E-01 (a)	5.189E-01 (a)	4.863E-01 (a)	7.773E-01 (a)	6.899E-01 (b)

Note: Letters of the same type in parentheses within a test temperature indicate no significant difference exists between shear susceptibility before and after RTFOT at alpha = 0.05

Table 3.9 Effect of Test Temperature on Shear Susceptibility for Unmodified and Modified Asphalt Binders.

Binder		Shear Susceptibility									
Asphalt	Polymer	39 F	60 F	77 F	90 F	140 F	39 F	60 F	77 F	90 F	140 F
		before RTFOT					after RTFOT				
TFA AC-10	-	0.602 (c)	-	0.879 (b)	-	0.938 (a)	0.584 (c)	-	0.796 (b)	-	0.850 (a)
TFA AC-10	Goodyear UP 70	0.747 (c)	-	0.816 (b)	-	0.952 (a)	0.612 (c)	-	0.720 (b)	-	0.856 (a)
TFA AC-10	Styrelf-13	1.135 (c)	-	1.069 (b)	-	1.019 (a)	1.213 (c)	-	1.156 (b)	-	1.016 (a)
TFA AC-10	Polysar NS 175	0.770 (c)	-	0.858 (b)	-	0.967 (a)	0.697 (c)	-	0.764 (b)	-	0.913 (a)
TFA AC-10	Genstar C107	0.535 (b)	-	0.678 (a)	-	0.699 (a)	-	-	-	-	-
TFA AC-20	-	0.638 (c)	-	0.778 (b)	-	0.840 (a)	0.607 (c)	-	0.715 (b)	-	0.803 (a)
TFA AC-20	Polybilt 103	0.507 (c)	-	0.627 (b)	-	0.713 (a)	0.508 (b)	-	0.614 (a)	-	0.623 (a)
TFA AC-20	Dow	0.511 (b)	-	0.519 (b)	-	0.777 (a)	0.485 (b)	-	0.486 (b)	-	0.690 (a)
Texaco AC-20		0.646 (b)	0.804 (a)	0.804 (a)	0.830 (a)	0.832 (a)	-	-	-	-	-
Texaco AC-10	Goodyear UP 70	0.747 (b)	0.892 (a)	0.803 (b)	0.794 (b)	0.880 (a)	-	-	-	-	-
Texaco AC-10	Styrelf-13	1.277 (a)	1.167 (b)	1.152 (b)	1.131 (b)	0.971 (c)	-	-	-	-	-
Shamrock AC-20		0.490 (e)	0.696 (c)	0.664 (d)	0.761 (b)	0.894 (a)	-	-	-	-	-
Fina AC-10	Styrelf-13	1.235 (a)	1.215 (a)	1.076 (b)	1.089 (b)	1.018 (c)	-	-	-	-	-
Fina AC-10	3% Kraton D1101	0.799 (b)	0.876 (a)	0.889 (a)	0.886 (a)	0.885 (a)	-	-	-	-	-
Fina AC-10	6% Kraton D1101	0.777 (b)	0.828 (a)	0.772 (b)	0.809 (a,b)	0.772 (b)	-	-	-	-	-

Note: Letters of the same type in parentheses indicate no significant difference exists between test temperatures at alpha = 0.05

CONSTANT POWER VISCOSITY. Figures A-22 through A-37, B-22 through B-27 and C-22 through C-29 show that computing apparent viscosity for a fixed shear rate of 1 reciprocal second for the modified and unmodified asphalt binders necessitates excessive extrapolation of the data at either of the extremes of temperature. Therefore, the method of constant power input which offers the advantage that very little or no extrapolation of data is necessary was utilized. A constant power of 100 W/m^3 (τ x γ = 10^5) was chosen as convenient. The power constant viscosity values at three test temperatures for the aged and unaged materials used in District 15, and at five test temperatures for the unaged materials used in Districts 11, and 25 are presented in Table 3.10 and plotted in Figures A-41, B-27 and C-29. Figure A-41 indicates addition of polymer to the TFA AC-10 increased constant power viscosity at all test temperatures. However the trend is not the same for the TFA AC-20 asphalt cements. Figures B-27 and C-29 show that the modified Fina and Texaco AC-10 asphalt binders showed higher apparent viscosity than the respective controls.

It was desirable to compare absolute viscosity at 140°F test temperature obtained by the capillary tubes (ASTM D2171) with apparent viscosity obtained on the Schweyer constant stress rheometer at shear rates occurring in tube viscometers. Table 3.11 shows the comparison of absolute viscosity and apparent viscosity at the same shear rate. This indicates there is no significant difference between viscosity values obtained by different viscometers if they are measured at the same rate of shear and very little or no extrapolation of data is made.

To evaluate the degree of temperature susceptibility of the binders, power constant viscosity vs. absolute test temperature are plotted in semilogarithmic scale. The slope of the straight line resulting from such a plot is a measure of temperature susceptibility of the power constant viscosity. Power constant viscosity - test temperature relationships for the aged and unaged materials used in District 15 are shown in Figures A-44 through A-47. These relationships for unaged materials used in Districts

Table 3.10 Summary of Constant Power Viscosity for Unmodified and Modified Asphalt Binders.

Binder		Constant Power Viscosity				
Asphalt	Polymer	39 F	60 F	77 F	90 F	140 F
				before RTFOT		
TFA AC-10	-	2.760E+07	-	1.123E+05	-	9.651E+01
TFA AC-10	Goodyear UP 70	3.736E+07	-	2.143E+05	-	1.256E+02
TFA AC-10	Styrelf-13	7.610E+07	-	5.844E+05	-	3.691E+02
TFA AC-10	Polysar NS 175	6.072E+07	-	2.289E+05	-	1.236E+02
TFA AC-10	Genstar C107	6.464E+07	-	4.518E+05	-	1.003E+03
TFA AC-20	-	7.183E+07	-	3.343E+05	-	1.731E+02
TFA AC-20	Polybilt 103	1.007E+08	-	3.599E+05	-	2.738E+02
TFA AC-20	Dow	5.759E+07	-	7.548E+05	-	3.683E+02
Texaco AC-20		5.126E+07	2.854E+06	3.699E+05	7.854E+04	1.949E+02
Texaco AC-10	Goodyear UP 70	6.359E+07	2.519E+06	2.634E+05	5.046E+04	2.090E+02
Texaco AC-10	Styrelf-13	4.014E+07	7.308E+06	3.945E+05	5.694E+04	2.891E+02
Shamrock AC-20		7.153E+07	3.372E+06	2.871E+05	5.491E+04	1.680E+02
Fina AC-10	Styrelf-13	5.839E+07	8.621E+06	5.003E+05	7.223E+04	3.077E+02
Fina AC-10	3% Kraton D1101	4.692E+08	8.506E+06	6.009E+05	9.326E+04	6.016E+02
Fina AC-10	6% Kraton D1101	4.667E+08	7.754E+06	4.969E+05	9.921E+04	6.500E+02
				after RTFOT		
TFA AC-10	-	6.993E+07	-	4.034E+05	-	2.533E+02
TFA AC-10	Goodyear UP 70	1.309E+08	-	6.826E+05	-	3.683E+02
TFA AC-10	Styrelf-13	2.300E+08	-	1.488E+06	-	6.220E+02
TFA AC-10	Polysar NS 175	9.859E+07	-	7.168E+05	-	3.771E+02
TFA AC-10	Genstar C107	-	-	-	-	-
TFA AC-20	-	2.443E+08	-	1.504E+06	-	5.304E+02
TFA AC-20	Polybilt 103	1.104E+08	-	1.175E+06	-	1.160E+03
TFA AC-20	Dow	7.906E+07	-	1.678E+06	-	1.672E+03

Table 3.11 Comparison of Viscosity at 140 F between Cannon Manning Viscometer and Schweyer Constant Stress Rheometer.

Binder		Rate of Shear 1/sec	Vis. 140 F, poises	Vis. 140 F, poises
Asphalt	Polymer		Cannon Manning Viscometer	Constant Stress Rheometer
			before RTFOT	
TFA AC-10	-	4.60	1131	1089
TFA AC-10	Goodyear UP 70	8.17	1311	1333
TFA AC-10	Styrelf-13	4.15	3332	3597
TFA AC-10	Polysar NS 175	11.39	1318	1274
TFA AC-10	Genstar C107	-	-	-
TFA AC-20	-	7.20	2087	2099
TFA AC-20	Polybilt 103	8.44	3296	3461
TFA AC-20	Dow	2.89	5198	5428
Texaco AC-20		4.61	2375	2546
Texaco AC-10	Goodyear UP 70	5.88	2330	2448
Texaco AC-10	Styrelf-13	4.54	3060	3011
Shamrock AC-20		5.72	1998	1959
Fina AC-10	Styrelf-13	5.00	2770	3007
Fina AC-10	3% Kraton D1101	1.70	8127	7592
Fina AC-10	6% Kraton D1101	-	-	-
			after RTFOT	
TFA AC-10	-	4.60	3000	3156
TFA AC-10	Goodyear UP 70	7.10	3932	4157
TFA AC-10	Styrelf-13	4.41	6331	6114
TFA AC-10	Polysar NS 175	7.39	3780	4040
TFA AC-10	Genstar C107	-	-	-
TFA AC-20	-	2.03	7401	7724
TFA AC-20	Polybilt 103	1.06	26266	26312
TFA AC-20	Dow	0.88	31592	32815

11, and 25 are shown in Figures B-28 and C-30. The coefficients of correlation of fitted lines resulting from the data range from .99 to 1.0. This confirms a good linear relationship between log power constant viscosity and absolute test temperature.

A statistical analysis was performed to confirm whether the viscosity temperature susceptibilities (slopes) are different from one another. A summary of the test results is shown in Table 3.12. The results indicate no significant difference in the viscosity temperature susceptibility was observed between the materials within the same district. Furthermore, Table 3.13 shows that aging the modified and unmodified TFA asphalt binders did not have any significant effect on viscosity temperature susceptibility.

COMPATIBILITY

Figure 3.11 presents the results of storage stability test for binders used in Districts 15, 11, 25 and 10. As shown in this figure, there was no substantial difference in penetration between the top and bottom of the samples except for the Dow and Polybilt blends. This may indicate that TFA AC-20 is not completely compatible with the Dow and Polybilt polymers. A note should be added here that the Dow blend also did not demonstrate the presence of asphalt-polymer modulus in the force ductility test. Some researchers believe that the presence of asphalt-polymer modulus is due to presence of the polymer in binders.

Table 3.7 Summary of Shear Susceptibility for Unmodified and Polymer Modified Asphalt Binders

Test Parameter	District 15								District 11			District 25			
	TFA AC-10	TFA AC-10 & UP 70	TFA AC-10 & ELF	TFA AC-10 & NS 175	TFA AC-10 & C107	TFA AC-20	TFA AC-20 & Polybilt	TFA AC-20 & DOW	TEXACO AC-20	TEXACO AC-10 & UP 70	TEXACO AC-10 & ELF	SHAM. AC-20	FINA AC-10 & ELF	FINA AC-10 & 3% D1101	FINA AC-10 & 6% D1101
Temperature Susceptibility															
Before RTFOT	-0.096	-0.097	-0.095	-0.101	-0.085	-0.098	-0.098	-0.093	-0.096	-0.097	-0.095	-0.100	-0.097	-0.103	-0.102
	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
after RTFOT	-0.097	-0.099	-0.105	-0.096		-0.401	-0.089	-0.084	-	-	-	-	-	-	-
	(a)	(a)	(a)	(a)		(a)	(b)	(b)							

Note: Letters of the same type in parentheses within a district indicate no significant difference exists between binders for a given test parameter at alpha = 0.05

Table 3.13 Effect of Aging by RTFOT on Viscosity Temperature Susceptibility for Unmodified and Modified Asphalt Binders.

Binder		Temperature Susceptibility	
Asphalt	Polymer	Before RTFOT	After RTFOT
TFA AC-10	-	-0.096 (a)	-0.097 (a)
TFA AC-10	Goodyear UP 70	-0.097 (a)	-0.099 (a)
TFA AC-10	Styrelf-13	-0.095 (a)	-0.105 (a)
TFA AC-10	Polysar NS 175	-0.101 (a)	-0.096 (a)
TFA AC-10	Genstar C107	-0.085	-
TFA AC-20	-	-0.100 (a)	-0.101 (a)
TFA AC-20	Polybilt 103	-0.098 (a)	-0.089 (a)
TFA AC-20	Dow	-0.093 (a)	-0.084 (a)

Note: Letters of the same type in parentheses indicate no significant difference exists between temperature susceptibility at alpha = 0.05

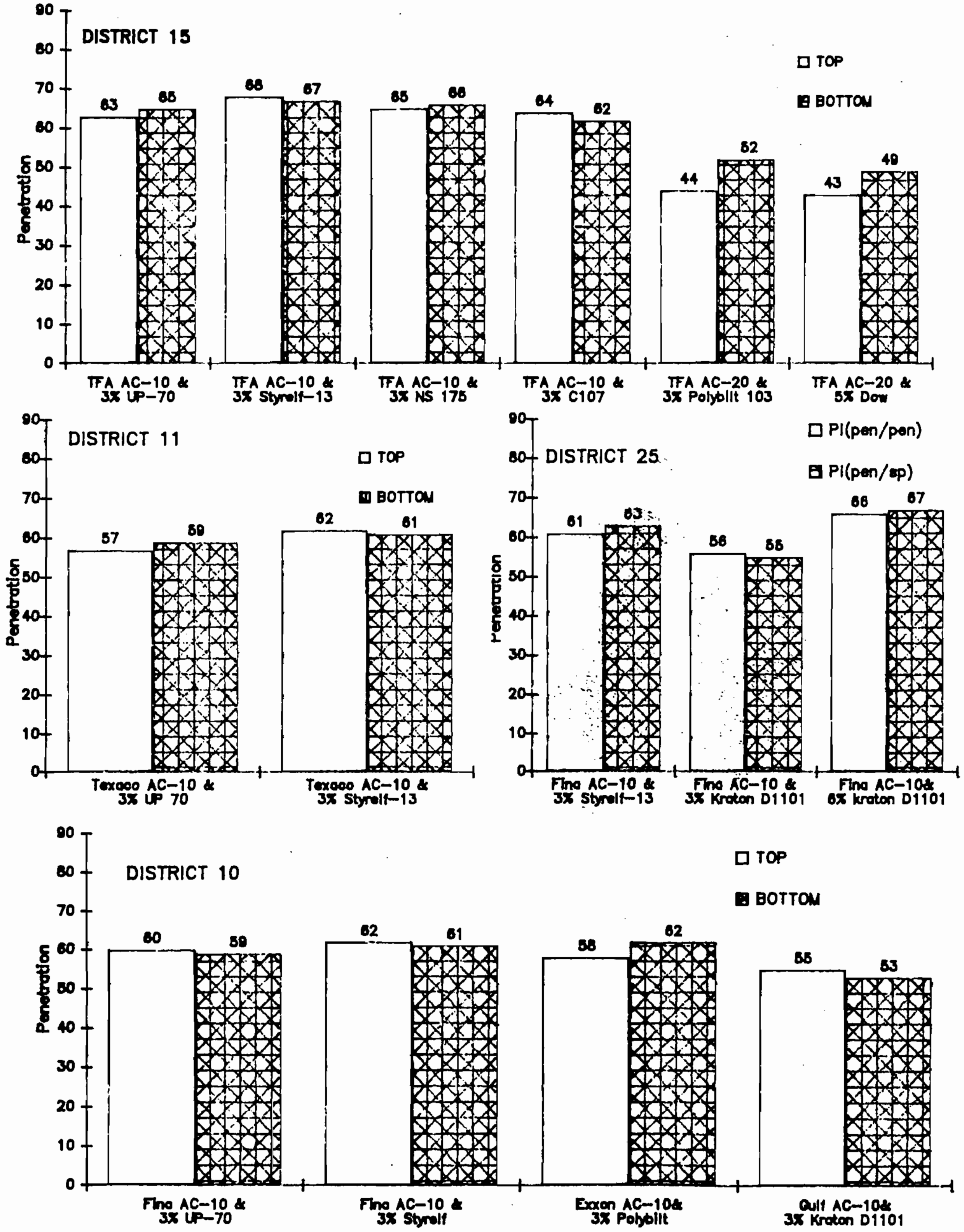


Fig 3-11 Results of Penetation for Modified Binders after Storage Stability Test.

CHAPTER 4

ANALYSIS OF TEST RESULTS ON UNMODIFIED AND MODIFIED MIXTURES

Results of laboratory tests conducted on unmodified and polymer-modified mixtures used in Districts 15, 11, 25 and 10 are listed and illustrated in Appendices A, B, C and D respectively. Summaries of certain test results for unmodified and modified mixtures prepared in the laboratory are presented in Tables 4.1 and 4.2.

Where appropriate, analysis of variance (ANOVA) techniques were utilized to determine if significant differences exist between control and modified asphalt mixtures for each test parameter. In each case when a significant difference was indicated, the Newman-Keul multiple range test (Ref 18) was used to determine which means were significantly different. The lower case letters in parentheses in Tables 4.1 and 4.2 indicate whether means are significantly different. Letters of the same type for each parameter indicate no significant difference in means at alpha = 0.05. In this chapter individual engineering properties for laboratory mixtures are discussed. Furthermore a comparison between plant mixture (plant-mixed/laboratory-compacted mixtures) properties and laboratory mixture (laboratory-mixed/laboratory-compacted mixtures) properties is made.

EVALUATION OF LABORATORY MIXTURES (STANDARD COMPACTION)

A standard compaction specimen would normally produce 3 percent air voids in the mixtures containing optimum asphalt content. Engineering properties measured for laboratory prepared mixtures utilized in Districts 15, 11, 25 and 10 using standard compactions are as follows:

- Marshall Stability and Flow at 140°F
- Hveem Stability at 140°F

Table 4.1 Engineering Properties of Laboratory Mixed / Laboratory Compacted Mixtures Using Standard Compaction

Test Parameter	District 15								District 11		
	TFA AC-10	UP 70	Styrelf	NS 175	C107	TFA AC-20	Polybilt	Dow	TEXACO AC-20	UP 70	Styrelf
Marshall Stability, lb	1044 (a)	2305 (d)	2056 (c)	1591 (b)	-	1985 (c)	2750 (e)	2412 (d)	2303 (a)	2722 (b)	2339 (a)
Marshall Flow, 0.01 in	9.5 (a)	12.7 (b,c)	13.0 (c)	11.7 (b)	-	12.0 (b,c)	12.0 (b,c)	9.8 (a)	12.0 (a)	13.7 (b)	12.8 (a,b)
Hveem Stability, %	41 (a)	41 (a)	44 (a,b)	41 (a)	-	43 (a)	47 (b)	51 (c)	43 (a)	41 (a)	42 (a)
Tensile Strength at 39 F, psi	378 (a)	391 (a)	483 (c)	388 (a)	-	464 (b,c)	439 (b)	487 (c)	452 (a)	486 (b)	530 (c)
Tensile Strength at 77 F, psi	64 (a)	104 (b)	132 (c)	96 (b)	-	128 (c)	133 (c)	137 (c)	117 (a)	152 (c)	126 (b)
Tensile Strength at 104 F, psi	19 (a)	46 (c)	49 (c,d)	36 (b)	-	52 (d)	61 (e)	64 (e)	40 (a)	49 (b)	37 (a)
Tensile Strain at 39 F, %	0.37 (d)	0.25 (c)	0.36 (d)	0.28 (c)	-	0.10 (a)	0.21 (b)	0.19 (b)	0.25 (a)	0.21 (a)	0.53 (b)
Tensile Strain at 77 F, %	0.97 (c,d)	0.85 (c)	1.17 (d)	0.90 (c)	-	0.64 (b)	0.49 (a,b)	0.39 (a)	1.07 (a)	1.20 (b)	1.53 (c)
Tensile Strain at 104 F, %	1.04 (d)	1.05 (d)	1.46 (e)	1.13 (d)	-	0.86 (c)	0.71 (b)	0.45 (a)	1.04 (a)	1.23 (b)	1.53 (c)
Secant Modulus at 39 F, ksi	209 (a)	316 (a)	270 (a)	281 (a)	-	902 (c)	428 (b)	523 (b)	355 (b)	469 (c)	205 (a)
Secant Modulus at 77 F, ksi	14 (a)	25 (b)	23 (b)	22 (b)	-	40 (c)	54 (d)	71 (e)	22 (b)	26 (c)	17 (a)
Secant Modulus at 104 F, ksi	4 (a)	9 (a,b)	7 (a)	6 (a)	-	12 (b)	17 (c)	29 (d)	8 (b)	8 (b)	5 (a)
Resilient Modulus at 39 F, ksi	1512 (a,b)	1384 (a,b)	2231 (b)	1394 (a,b)	-	2121 (b)	1651 (a,b)	1076 (a)	667 (a)	952 (a)	651 (a)
Resilient Modulus at 77 F, ksi	337 (a)	420 (a,b)	434 (a,b)	467 (b,c)	-	550 (c)	547 (c)	646 (d)	232 (a)	353 (b)	213 (a)
Resilient Modulus at 104 F, ksi	107 (a)	168 (a,b)	193 (a,b,c)	165 (a,b)	-	239 (b,c)	289 (c)	239 (b,c)	86 (a)	102 (a)	69 (a)
Poisson's Ratio at 39 F	-	-	-	-	-	-	-	-	0.17	0.01	0.16
Poisson's Ratio at 77 F	-	-	-	-	-	-	-	-	0.26	0.20	0.25
Poisson's Ratio at 104 F	-	-	-	-	-	-	-	-	0.44	0.40	0.32

Note: Letters of the same type in parentheses within a district indicate no significant difference exists between mixtures for a given test parameter at alpha = 0.05

Table 4.1 (Continued)

	District 25				District 10				
Test Parameter	SHAM. AC-20	Styrelf	3% D1101	6% D1101	TOTAL AC-20	UP-70	Styrelf	POLYBILT	3% D1101
Marshall Stability, lb	2400 (a)	3182 (b)	3136 (b)	3513 (c)	1359 (b)	955 (a)	1305 (b)	987 (a)	880 (a)
Marshall Flow, 0.01 in	14.7 (a)	17.3 (b)	16.3 (b)	18.7 (c)	10.3 (a)	10.0 (a)	10.3 (a)	9.5 (a)	9.7 (a)
Hveem Stability, %	43 (a)	43 (a)	43 (a)	43 (a)	45 (a)	45 (a)	45 (a)	43 (a)	42 (a)
Tensile Strength at 39 F, psi	569 (b)	684 (d)	625 (c)	512 (a)	446 (b)	489 (c)	516 (c)	396 (a)	454 (b)
Tensile Strength at 77 F, psi	121 (a)	176 (c)	168 (c)	132 (b)	135 (c)	108 (b)	149 (d)	73 (a)	83 (a)
Tensile Strength at 104 F, psi	38 (a)	61 (c)	58 (c)	51 (b)	39 (c)	26 (b)	39 (c)	19 (a)	19 (a)
Tensile Strain at 39 F, %	0.22 (a)	0.46 (c)	0.36 (b)	0.93 (d)	0.24 (a)	0.22 (a)	0.28 (a)	0.55 (c)	0.47 (b)
Tensile Strain at 77 F, %	0.87 (a)	1.64 (c)	1.24 (b)	2.41 (d)	1.14 (a)	1.48 (b)	1.58 (b)	1.10 (a)	1.46 (b)
Tensile Strain at 104 F, %	1.25 (a)	2.10 (b)	1.96 (b)	3.45 (c)	1.08 (a)	1.53 (b)	1.82 (c)	1.14 (a)	1.80 (c)
Secant Modulus at 39 F, ksi	525 (d)	297 (b)	348 (c)	110 (a)	378 (c)	441 (d)	372 (c)	146 (a)	195 (b)
Secant Modulus at 77 F, ksi	27 (c)	21 (b)	27 (c)	11 (a)	23 (c)	15 (a,b)	19 (b)	13 (a)	11 (a)
Secant Modulus at 104 F, ksi	6 (b)	6 (b)	6 (b)	3 (a)	7.2 (d)	3.5 (b)	4.3 (c)	3.3 (b)	2.1 (a)
Resilient Modulus at 39 F, ksi	1067 (b)	1032 (b)	933 (a,b)	663 (a)	2588 (a,b)	1490 (a)	2097 (a)	1934 (a)	3708 (b)
Resilient Modulus at 77 F, ksi	319 (b)	296 (b)	316 (b)	169 (a)	873 (c)	455 (a,b)	553 (b)	428 (a,b)	351 (a)
Resilient Modulus at 104 F, ksi	101 (b)	80 (a,b)	71 (a)	62 (a)	171 (a)	103 (a)	143 (a)	115 (a)	95 (a)
Poisson's Ratio at 39 F	0.16	0.19	0.17	0.26	-	-	-	-	-
Poisson's Ratio at 77 F	0.30	0.33	0.30	0.32	0.11	0.49	0.37	0.43	0.41
Poisson's Ratio at 104 F	0.44	0.53	0.60	0.46	-	-	-	-	-

Note: Letters of the same type in parentheses within a district indicate no significant difference exists between mixtures for a given test parameter at alpha = 0.05

Table 4.2 Engineering Properties of Laboratory Mixed / Laboratory Compacted Mixtures Using Modified Compaction

Test Parameter	District 15								District 11		
	TFA AC-10	UP 70	Styrelf	NS 175	C107	TFA AC-20	Polybilt	Dow	TEXACO AC-20	UP 70	Styrelf
Marshall Stability, lb	500 (a)	878 (b)	845 (b)	1070 (b)	953 (b)	1072 (b)	1067 (b)	1067 (b)	908 (b)	951 (b)	684 (a)
Marshall Flow, 0.01 in	8.2 (a)	12.0 (c,d)	13.5 (d)	12.2 (c,d)	26.3 (e)	11.2 (b,c)	10.8 (b,c)	9.8 (b)	13.7 (a)	15.7 (b)	16.0 (b)
Hveem Stability, %	37 (a,b,c)	33 (a)	35 (a,b)	40 (c)	37 (a,b,c)	41 (c)	38 (b,c)	39 (b,c)	38 (b)	35 (a)	33 (a)
Tensile Strength at 39 F, psi	318 (b)	285 (b)	319 (b)	286 (b)	112 (a)	320 (b)	284 (b)	305 (b)	303 (a)	363 (b)	304 (a)
Tensile Strength at 77 F, psi	52 (b)	67 (c)	76 (c,d)	70 (c,d)	36 (a)	79 (d)	80 (d)	74 (c,d)	70 (b)	84 (c)	64 (a)
Tensile Strength at 104 F, psi	13 (a)	24 (b)	25 (b)	28 (b,c)	15 (a)	32 (c,d)	31 (c,d)	36 (d)	20 (b)	20 (b)	15 (a)
Tensile Strain at 39 F, %	0.37 (c)	0.30 (b)	0.50 (d)	0.32 (b)	0.56 (e)	0.18 (a)	0.19 (a)	0.21 (a)	0.36 (a)	0.35 (a)	0.73 (b)
Tensile Strain at 77 F, %	1.07 (d)	0.94 (c)	1.38 (e)	0.90 (c)	1.80 (f)	0.55 (b)	0.55 (b)	0.36 (a)	1.28 (a)	1.51 (b)	2.15 (c)
Tensile Strain at 104 F, %	1.01 (b,c)	1.34 (d)	1.92 (e)	1.05 (c)	2.73 (f)	0.79 (b)	0.78 (b)	0.43 (a)	1.31 (a)	1.58 (b)	2.43 (c)
Secant Modulus at 39 F, ksi	177 (b)	191 (b)	127 (b)	183 (b)	40 (a)	350 (c)	302 (c)	298 (c)	172 (b)	206 (b)	83 (a)
Secant Modulus at 77 F, ksi	9.8 (b)	14.3 (b,c)	11.0 (b,c)	15.7 (c)	4.0 (a)	29.2 (d)	29.5 (d)	41.2 (e)	11.0 (b)	11.1 (b)	5.9 (a)
Secant Modulus at 104 F, ksi	2.6 (b)	3.6 (b)	2.6 (b)	5.3 (c)	1.1 (a)	8.1 (d)	8.0 (d)	16.8 (e)	3.0 (c)	2.6 (b)	1.2 (a)
Resilient Modulus at 39 F, ksi	1236 (b,c)	1132 (b,c)	1414 (b,c)	907 (b)	428 (a)	1217 (b,c)	1497 (c)	903 (b)	623 (a)	615 (a)	564 (a)
Resilient Modulus at 77 F, ksi	212 (a)	327 (b,c,d)	284 (b,c)	352 (b,c,d)	131 (a)	352 (b,c,d)	414 (c,d)	475 (d)	138 (a)	209 (a)	115 (a)
Resilient Modulus at 104 F, ksi	89 (a,b)	160 (b,c)	104 (a,b)	150 (b,c)	71 (a)	190 (c)	149 (b,c)	207 (c)	81 (a)	70 (a)	53 (a)
Poisson's Ratio at 39 F	-	-	-	-	-	-	-	-	0.06	0.14	0.07
Poisson's Ratio at 77 F	-	-	-	-	-	-	-	-	0.31	0.22	0.29
Poisson's Ratio at 104 F	-	-	-	-	-	-	-	-	0.15	0.36	0.40

Note: Letters of the same type in parentheses within a district indicate no significant difference exists between mixtures for a given test parameter at alpha = 0.05

Table 4.2 (Continued)

Test Parameter	District 25				District 10				
	SHAM. AC-20	Styrelf	3% D1101	6% D1101	TOTAL AC-20	UP-70	Styrelf	POLYBILT	3% D1101
Marshall Stability, lb	1179 (a)	1644 (b)	1646 (b)	1462 (b)	493 (b)	525 (b)	533 (b)	227 (a)	491 (b)
Marshall Flow, 0.01 in	16.3 (a)	20.3 (b)	20.0 (b)	22.7 (c)	10.8 (a)	11.7 (a,b)	14.0 (c)	11.3 (a,b)	12.8 (b)
Hveem Stability, %	36 (b)	36 (b)	36 (b)	33 (a)	35 (a)	36 (a)	36 (a)	34 (a)	35 (a)
Tensile Strength at 39 F, psi	399 (b)	467 (c)	414 (b)	286 (a)	332 (a,b)	435 (c)	397 (b,c)	273 (a)	374 (b,c)
Tensile Strength at 77 F, psi	88 (a,b)	123 (c)	98 (b)	80 (a)	86 (c)	79 (c)	100 (d)	37 (a)	60 (b)
Tensile Strength at 104 F, psi	27 (a)	42 (b)	31 (a)	28 (a)	21 (d)	18 (c)	20 (d)	8 (a)	11 (b)
Tensile Strain at 39 F, %	0.28 (a)	0.40 (b)	0.41 (b)	1.03 (c)	0.23 (a)	0.22 (a)	0.25 (a)	0.75 (c)	0.62 (b)
Tensile Strain at 77 F, %	0.58 (a)	1.76 (b)	1.84 (c)	3.38 (d)	1.23 (a)	1.33 (a)	2.25 (c)	1.33 (a)	1.79 (b)
Tensile Strain at 104 F, %	1.27 (a)	2.28 (b)	2.49 (c)	3.85 (d)	1.59 (a)	1.53 (a)	2.88 (c)	1.32 (a)	2.10 (b)
Secant Modulus at 39 F, ksi	293 (c)	231 (b)	204 (b)	55 (a)	299 (b)	395 (c)	317 (b)	72 (a)	121 (a)
Secant Modulus at 77 F, ksi	20.1 (d)	14.0 (c)	10.7 (b)	4.7 (a)	14 (c)	12 (c)	9 (b)	6 (a)	7 (a,b)
Secant Modulus at 104 F, ksi	4.2 (d)	3.7 (c)	2.5 (b)	1.5 (a)	2.6 (b)	2.4 (b)	1.4 (a)	1.3 (a)	1.0 (a)
Resilient Modulus at 39 F, ksi	758 (a)	579 (a)	728 (a)	573 (a)	2120 (b)	1827 (a,b)	2643 (b)	1238 (a)	2064 (b)
Resilient Modulus at 77 F, ksi	313 (b)	254 (b)	221 (b)	98 (a)	394 (a)	495 (a)	425 (a)	270 (a)	405 (a)
Resilient Modulus at 104 F, ksi	117 (b)	60 (a)	51 (a)	46 (a)	174 (a)	119 (a)	95 (a)	132 (a)	145 (a)
Poisson's Ratio at 39 F	0.03	0.15	0.17	0.21	-	-	-	-	-
Poisson's Ratio at 77 F	0.18	0.21	0.24	0.41	0.44	0.32	0.43	0.36	0.36
Poisson's Ratio at 104 F	0.26	0.54	0.51	0.40	-	-	-	-	-

Note: Letters of the same type in parentheses within a district indicate no significant difference exists between mixtures for a given test parameter at alpha = 0.05

- Tensile Strength at 39°F, 77°F and 104°F
- Tensile Strain at Failure at 39°F, 77°F and 104°F
- Secant Modulus at 39°F, 77°F and 104°F
- Resilient Modulus at 39°F, 77°F and 104°F
- Poisson's Ratio at 39°F, 77°F and 104°F

Marshall Stability and Flow

Results of Marshall stability are shown in Table 4.1 and plotted in Figure 4.1. Table 4.1 contains average values of the Marshall stability and flow obtained from three replicate tests conducted for each material. The modified mixtures containing TFA AC-10 and TFA AC-20 exhibited significantly higher values of Marshall stability than their respective control mixtures. In District 11 Marshall stability of the UP-70 mixture was significantly higher than the control (Texaco AC-20) mixture, and no significant difference was observed between the Styrelf and the control mixtures. The modified Fina AC-10 mixture in District 25 exhibited a significantly higher value of Marshall stability than the control mixture (Shamrock AC-20). In District 10 the modified AC-10 mixtures generally showed lower values of Marshall stability than the control mixture (Total AC-20). It appears that addition of the polymers to the asphalt cements increases Marshall stability of the mixtures. The Kraton at 6 percent, UP-70, and Styrelf exhibited the greatest improvement.

Marshall flow values are shown in Table 4.1 and plotted in Figure 4.2. Figure 4.2 shows that addition of polymer to the TFA AC-10 significantly increased the Marshall flow of the mixtures; however, this trend was not observed for the TFA AC-20 mixtures. In Districts 11 and 25, the modified AC-10 mixtures generally exhibited significantly higher values for Marshall flow than the respective controls. No significant difference in Marshall flow was observed between the control (Total AC-20) and the modified mixtures in District 10.

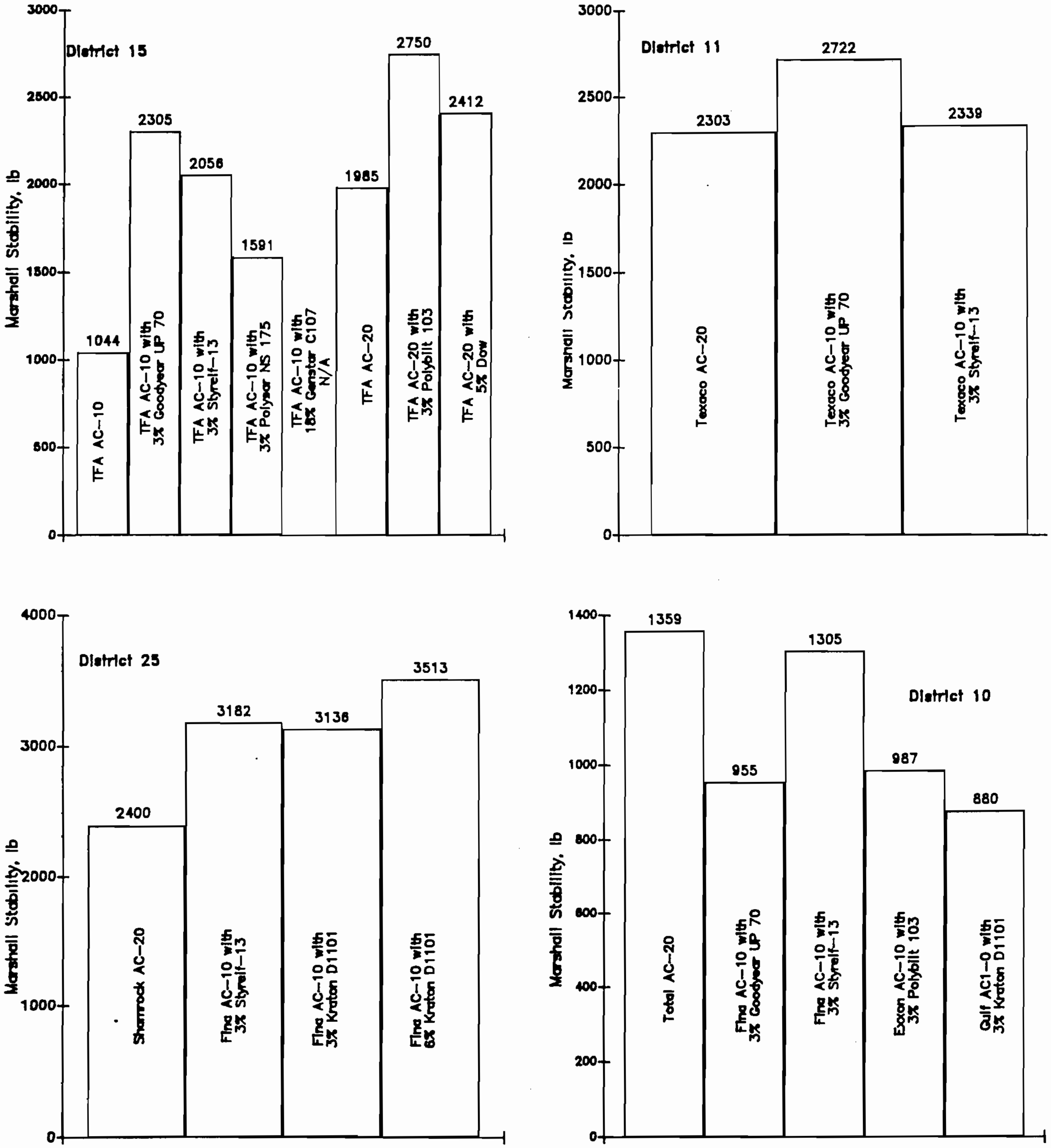


Fig 4.1 Marshall Stability for Laboratory Mixtures Using Standard Compaction.

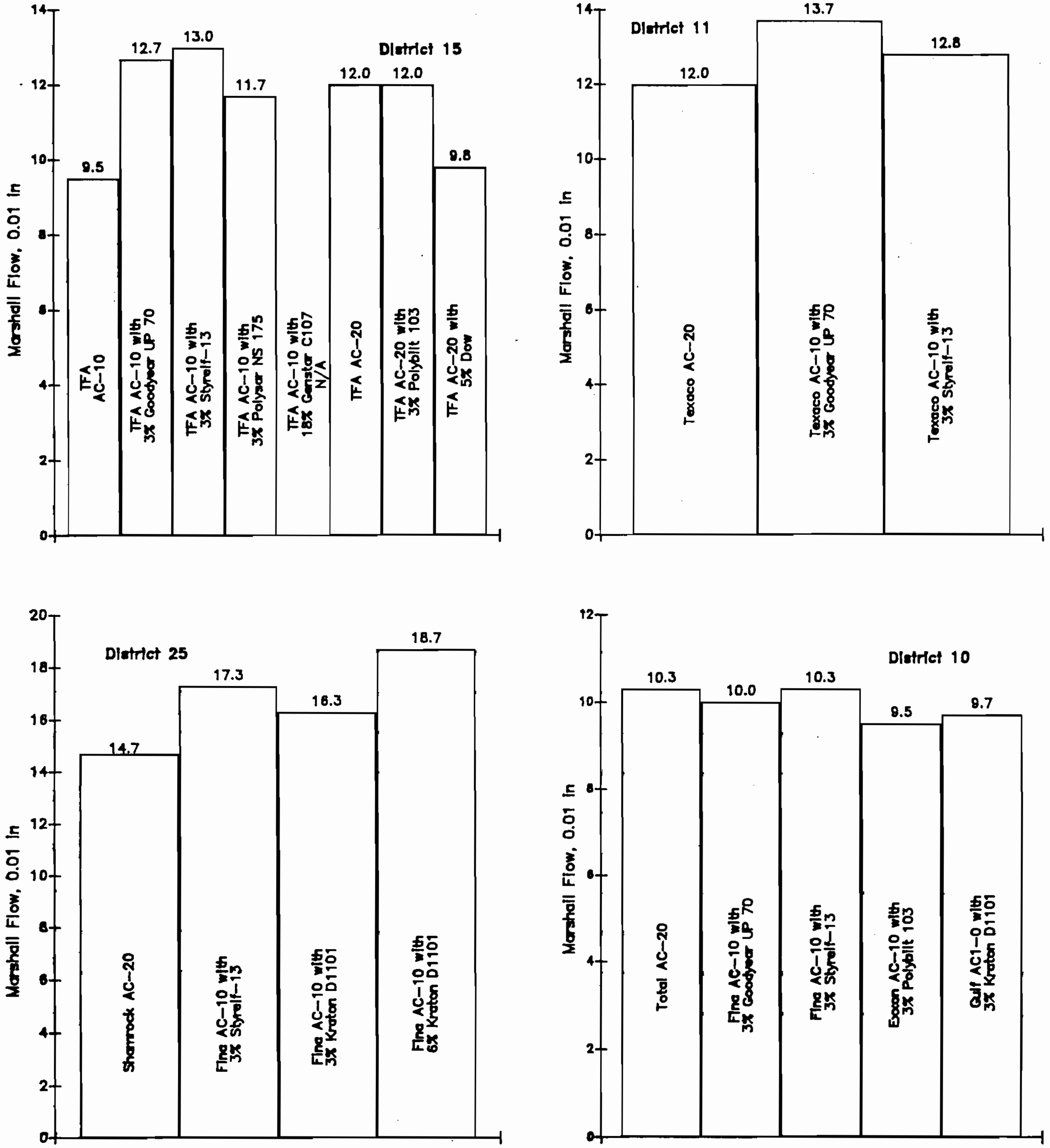


Fig 4.2 Marshall Flow for Laboratory Mixtures Using Standard Compaction.

Hveem Stability

Average values of Hveem Stability are presented in Table 4.1 and plotted in Figure 4.3. Analysis of variance using alpha=0.05 and Newman Keul multiple range test showed that there was no significant difference between the modified AC-10 mixtures and the AC-20 control mixture in a given district. Furthermore, the effect of the polymers on Hveem stability for mixtures containing TFA AC-10 was not significant. This may be due to the fact that Hveem stability is largely dependent upon interparticle friction of the aggregate and does not correlate particularly well with binder properties.

Tensile Strength

Average values of tensile strength at three different test temperatures (39°F, 77°F, and 104°F) are shown in Table 4.1, and relationships between tensile strength and temperature are shown in Figure 4.4. Regarding the mixtures containing TFA asphalt cement (District 15), the polymer modified mixtures exhibited higher tensile strength than the respective control mixtures with the exception of Polybilt mixture at 39°F. This effect was more pronounced at higher temperatures. In Districts 11 and 25, tensile strength of modified AC-10 mixtures with two exceptions (the 6 percent Kraton mixtures at 39°F and the Styrelf mixtures at 104°F) were significantly higher than the respective AC-20 controls. The 6 percent Kraton mixture showed significantly lower tensile strength at 39°F and higher tensile strength at 104°F compared with the Shamrock AC-20 control. Therefore, the Kraton could be expected to reduce thermal cracking and rutting since based on tensile strength, mixtures containing 6 percent kraton would be more flexible (less brittle) at colder temperatures and stiffer at higher temperatures. It should be noted that historical data have shown that Shamrock asphalt cement is a low temperature susceptible binder. In District 10 the Modified AC-10 mixtures except for the

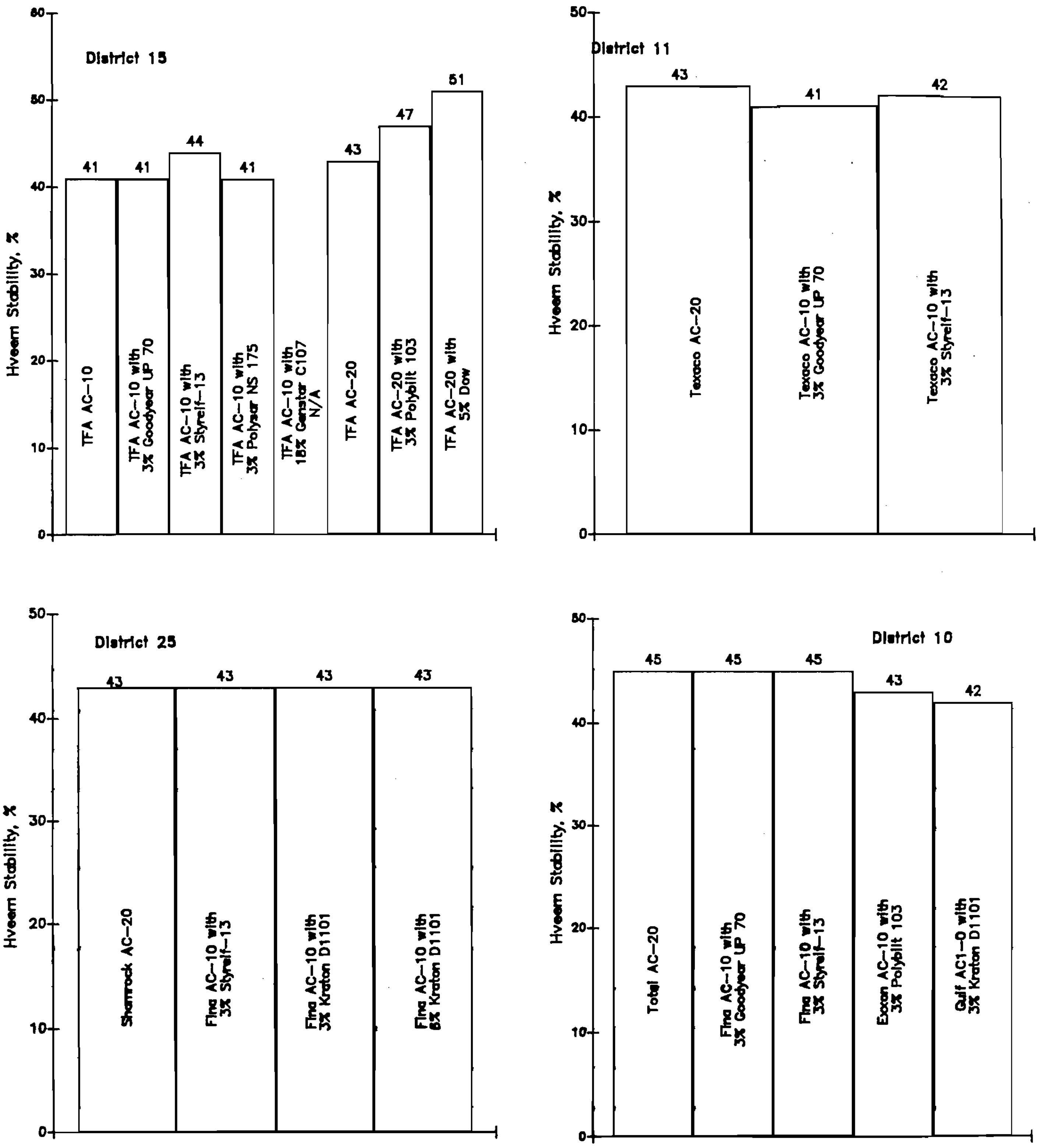


Fig 4.3 Hveem Stability for Laboratory Mixtures Using Standard Compaction.

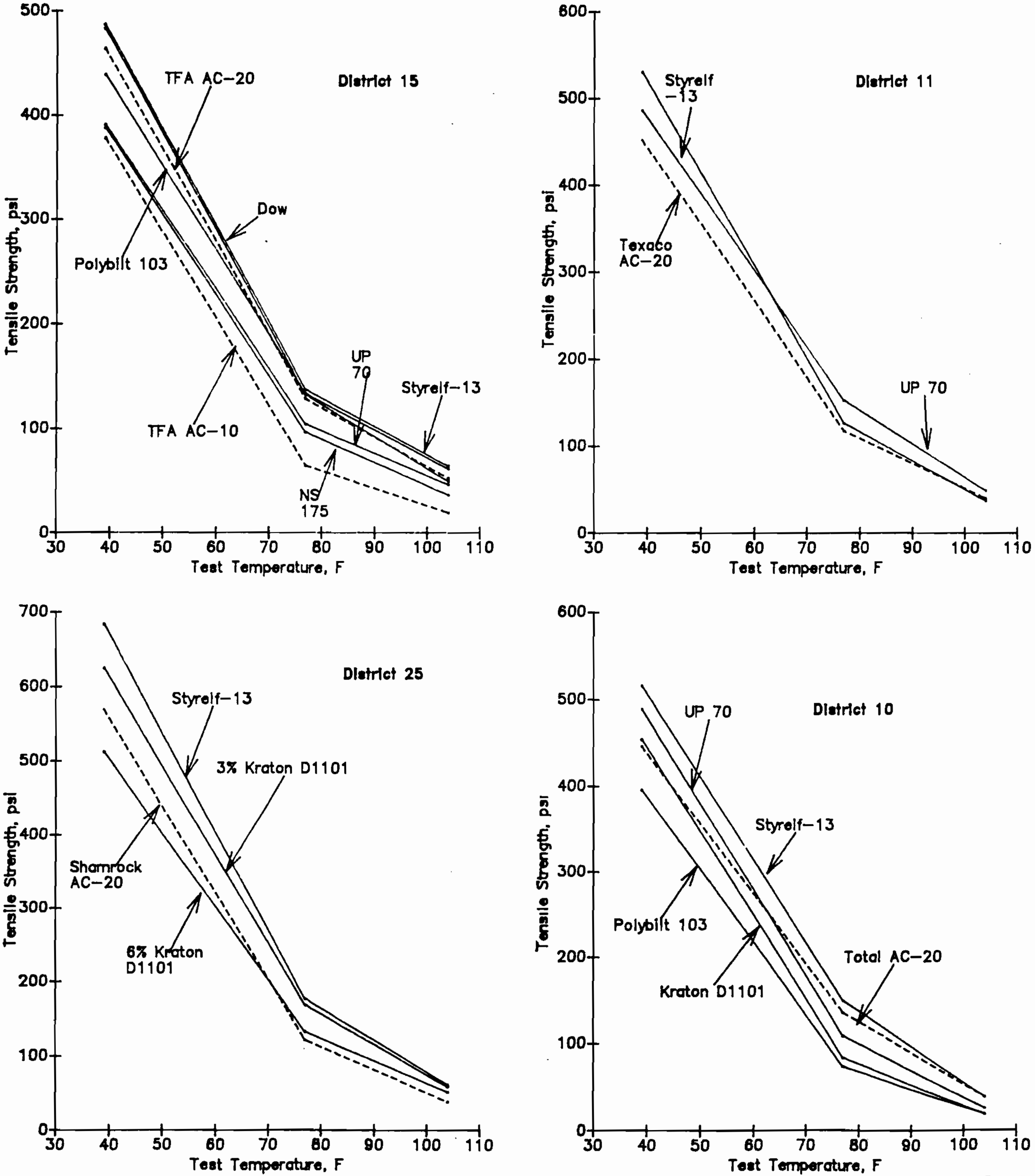


Fig 4.4 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

Styrelf exhibited lower tensile strength than the control mixture (Total AC-20) at 104°F.

Tensile Strain at Failure

The relationships between tensile strain at failure and test temperature are shown in Figure 4.5. The average values are presented in Table 4.1. The effect of polymers on tensile strain was different for TFA AC-10 and TFA AC-20 mixtures (Fig 4.5). In general, addition of polymer to TFA AC-10 mixtures increased the tensile strain at 104°F and decreased it at 39°F. This trend was the opposite for stiffer mixtures (TFA AC-20 mixtures). However, strain at failure for all modified AC-10 mixtures with the exception of the UP 70 at 39°F was significantly higher than that of the respective AC-20 control mixtures. Furthermore Figure 4.5 indicates that the Styrelf and Kraton (SBS polymer) mixtures were less brittle than the UP 70 and NS 175 (SBR polymers) mixtures.

Secant Modulus

Results of secant modulus are shown in Table 4.1 and plotted in Figure 4.6. As shown in this figure, addition of the Polybilt and Dow to TFA AC-20 mixtures significantly increased secant modulus at 77°F and 104°F and significantly decreased it at 39°F. Also, the modified TFA AC-10 mixtures exhibited higher secant modulus than the AC-10 control mixture at all test temperatures. However the difference between the secant modulus of the modified TFA AC-10 mixtures and TFA AC-10 mixture was statistically significant at 77°F (Table 4.1). In Districts 11 and 10 secant modulus of the control mixtures was higher than that of the modified mixtures except for the UP-70 mixture at 39°F and 77°F. All modified mixtures in District 25 showed significantly lower values of secant modulus than the Shamrock AC-20 mixture.

There were generally large differences between secant modulus of the AC-20 control mixtures and modified AC-10 mixtures at 39°F

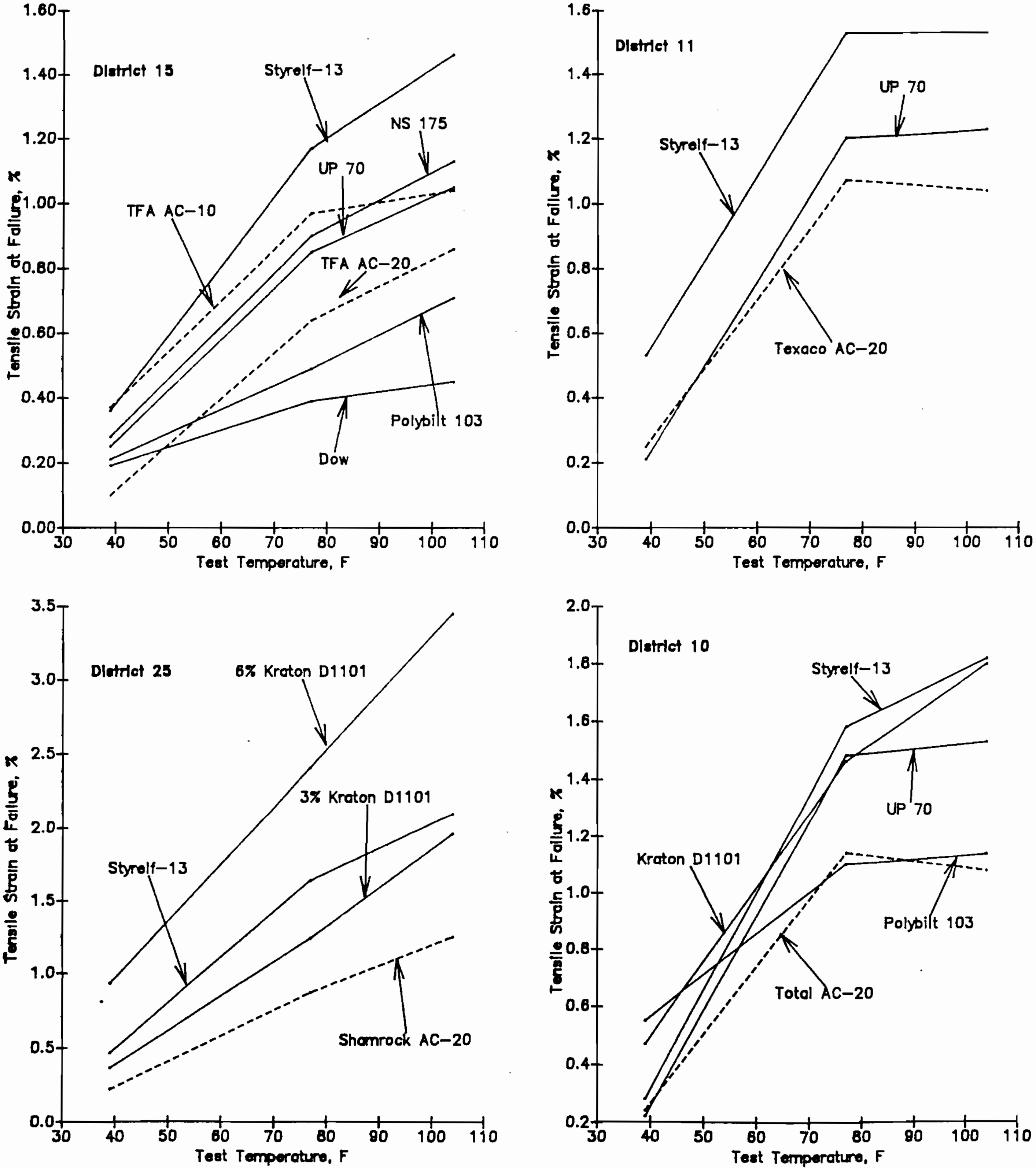


Fig 4.5 Tensile Strain vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

(Fig 4.6). These differences decreased as the test temperature increased. This may be an indication that the modified AC-10 mixtures are less temperature susceptible than the AC-20 controls.

Resilient Modulus

The relationships between resilient modulus and test temperature are shown in Figure 4.7. The average values are presented in Table 4.1. As shown in Figure 4.7, resilient modulus of the polymer-modified mixtures (except for the Styrelf) increased at 104°F and decreased at 39°F compared with the control mixtures (TFA AC-10 and TFA AC-20). In Districts 25 and 10 the resilient modulus of the modified mixtures was consistently lower than that of the respective controls at all temperatures except for the Kraton mixture in District 10. Also, resilient modulus of the control Texaco mixture in District 11 were lower than the UP-70 mixture and higher than the Styrelf mixture. It should be noted that there was no statistically significant difference between resilient modulus of the modified AC-10 and the respective AC-20 control mixtures in most cases.

Ideally polymers should decrease mixture stiffness at low temperatures to improve flexibility and reduce cracking, and increase mixture stiffness at high temperatures in order to reduce permanent deformation. Based on the above statement the Dow and Kraton (at 6 percent) were more effective in reducing low temperature cracking than the other polymers.

Poisson's Ratio

Average values of Poisson's ratio are presented in Table 4.1. The Poisson's ratio values ranged from 0.01 to 0.60. Values less than 0.2 and greater than 0.45 are unrealistic and impractical for HMAC mixtures. One of the reasons for the unrealistic values obtained in Table 4.1 is a result of the formula given in ASTM D4123 for calculation of Poisson's ratio. The formula is based on

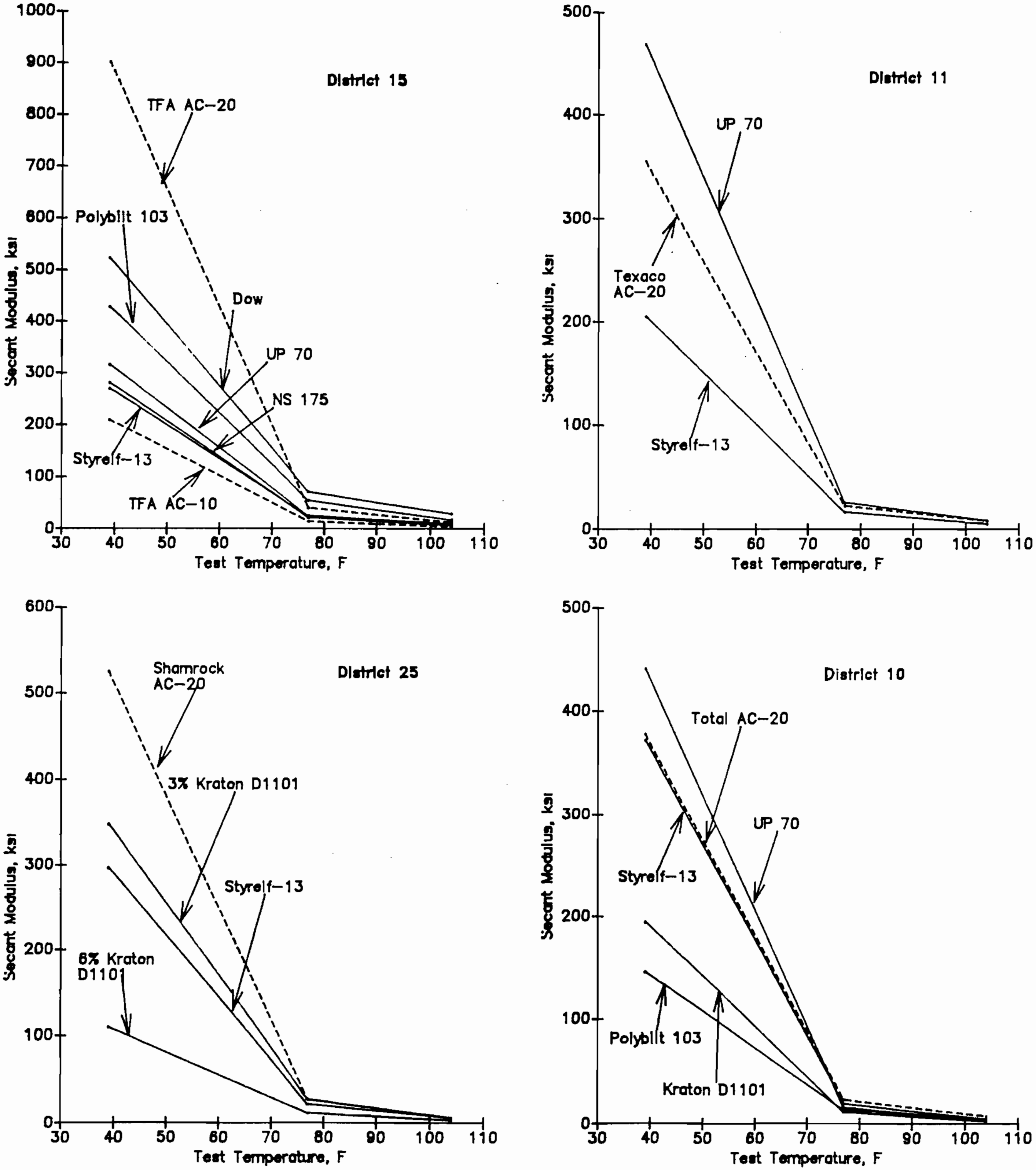


Fig 4.6 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

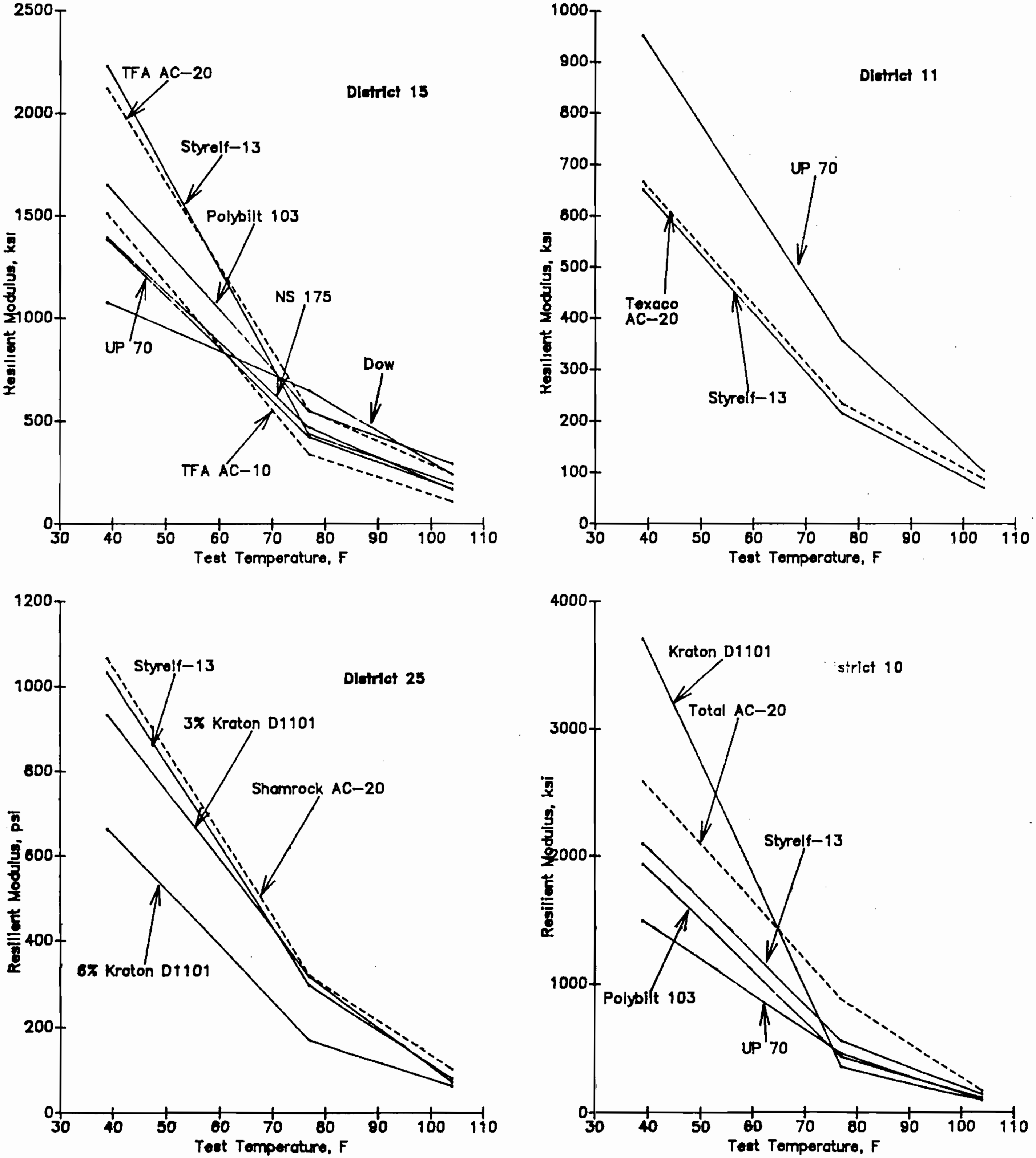


Fig 4.7 Resilient Modulus vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

the assumption that asphalt mixtures are homogeneous, isotropic and elastic. However, values of Poisson's ratio obtained at 77°F appeared to be more realistic than those obtained at 39°F and 104°F. Furthermore, Poisson's ratio increased with increasing test temperatures. Since the engineering properties of asphalt mixtures considered in this study are not very sensitive to Poisson's ratio, a Poisson 's ratio of 0.33 is assumed for all the mixtures at 77°F.

EVALUATION OF LABORATORY MIXTURES (MODIFIED COMPACTION)

Modified compaction specimens contain 7 percent air voids, which is generally obtained in the construction process. Engineering properties measured for laboratory mixtures utilized in Districts 15, 11, 25 and 10 using modified compaction are as follows:

- Marshall Stability and Flow at 140°F
- Hveem Stability at 140°F
- Tensile Strength at 39°F, 77°F and 104°F
- Tensile Strain at Failure at 39°F, 77°F and 104°F
- Secant Modulus at 39°F, 77°F and 104°F
- Resilient Modulus at 39°F, 77°F and 104°F
- Poisson's Ratio at 39°F, 77°F and 104°F
- Fatigue Life at Different Stress Level at 77°F
- Fatigue Constants, K1 and K2 at 77°F
- Alpha and Gnu at 77°F
- Creep Compliance at 60°F, 77°F and 90°F
- Tensile Strength Ratio (TSR)

Marshall Stability and Flow

Results of Marshall stability testing are shown in Table 4.2 and plotted in Figure 4.8. Table 4.2 contains average values of Marshall stability and flow obtained from three replicate tests

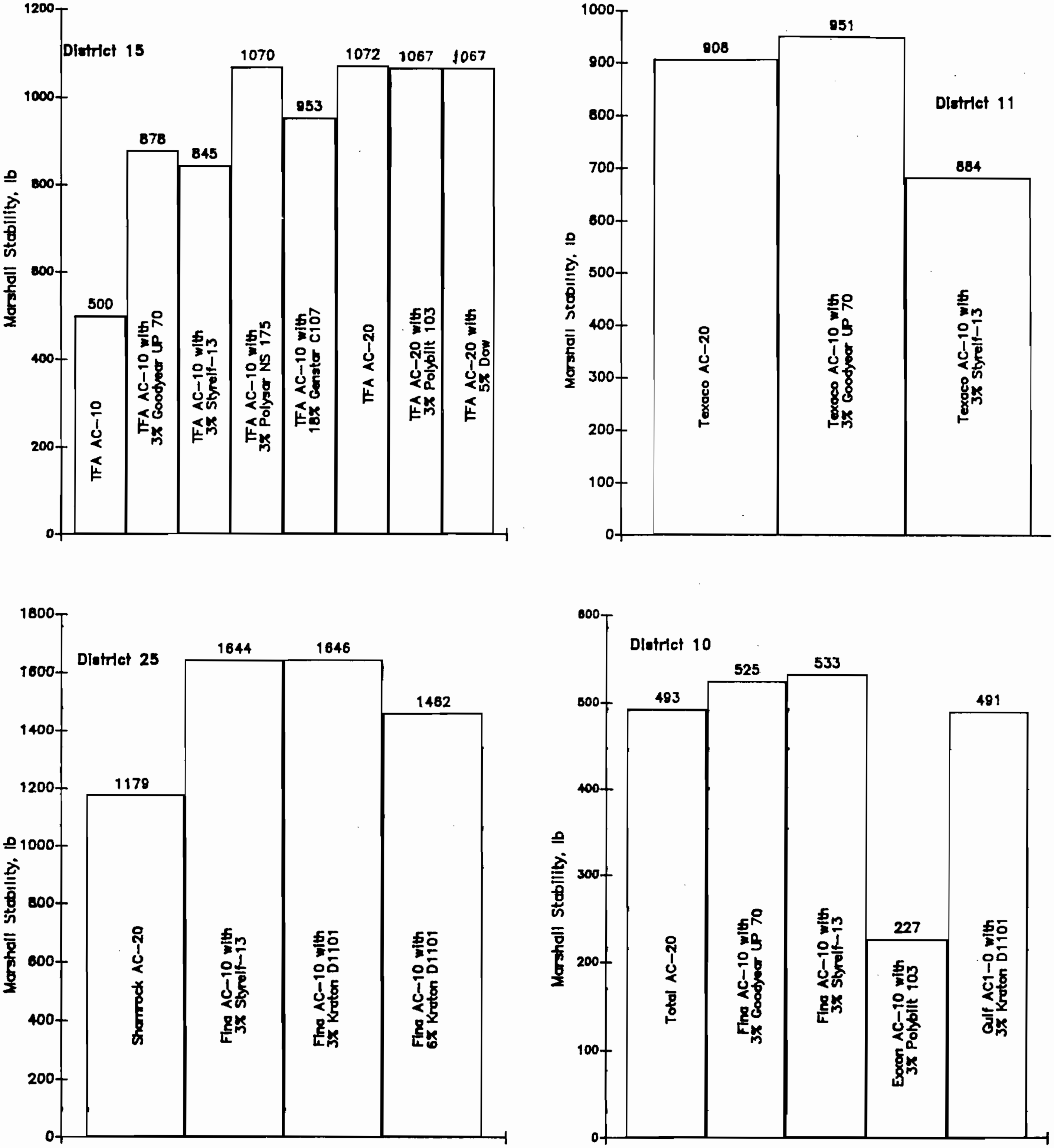


Fig 4.8 Marshall Stability for Laboratory Mixtures Using Modified Compaction.

conducted for each material. The modified mixtures containing TFA AC-10 exhibited significantly higher values of Marshall stability than the TFA AC-10 control mixture. There was no significant difference between the modified AC-20 mixtures and the TFA AC-20 control. In District 11 Marshall stability of the Styrelf mixture was significantly lower than the control (Texaco AC-20), but no significant difference was observed between the UP 70 and the control mixtures. The modified Fina AC-10 mixture in District 25 exhibited a significantly higher value of Marshall stability than the control mixture (Shamrock AC-20). This trend was not observed for the modified Fina mixtures in District 10. Similar to standard compaction specimens, addition of polymers to the AC-10 asphalt cement increased Marshall stability of the mixtures.

Marshall flow values are shown in Table 4.2 and plotted in Figure 4.9. This figure shows that addition of polymer to the TFA AC-10 significantly increased the Marshall flow of the mixtures; however, this trend was not observed for the TFA AC-20 mixtures. In Districts 11, 25 and 10 the modified AC-10 mixtures exhibited higher Marshall flow than the respective controls. The Kraton had the greatest effect on Marshall flow. These trends were similar to the trends observed in the standard compaction specimens.

Hveem Stability

Average values for the Hveem Stability of the mixtures are presented in Table 4.2 and plotted in Figure 4.10. Analysis of variance using alpha=0.05 and the Newman-Keul multiple range test (Ref 18) showed that the effect of the polymers on Hveem stability for mixtures containing TFA AC-10 and AC-20 was not significant. This may be due to the fact that Hveem stability is largely dependent upon interparticle friction of the aggregate and does not correlate particularly well with binder properties. In District 11 the modified AC-10 mixtures showed significantly lower Hveem Stability than the AC-20 control. The 6 percent Kraton mixture in

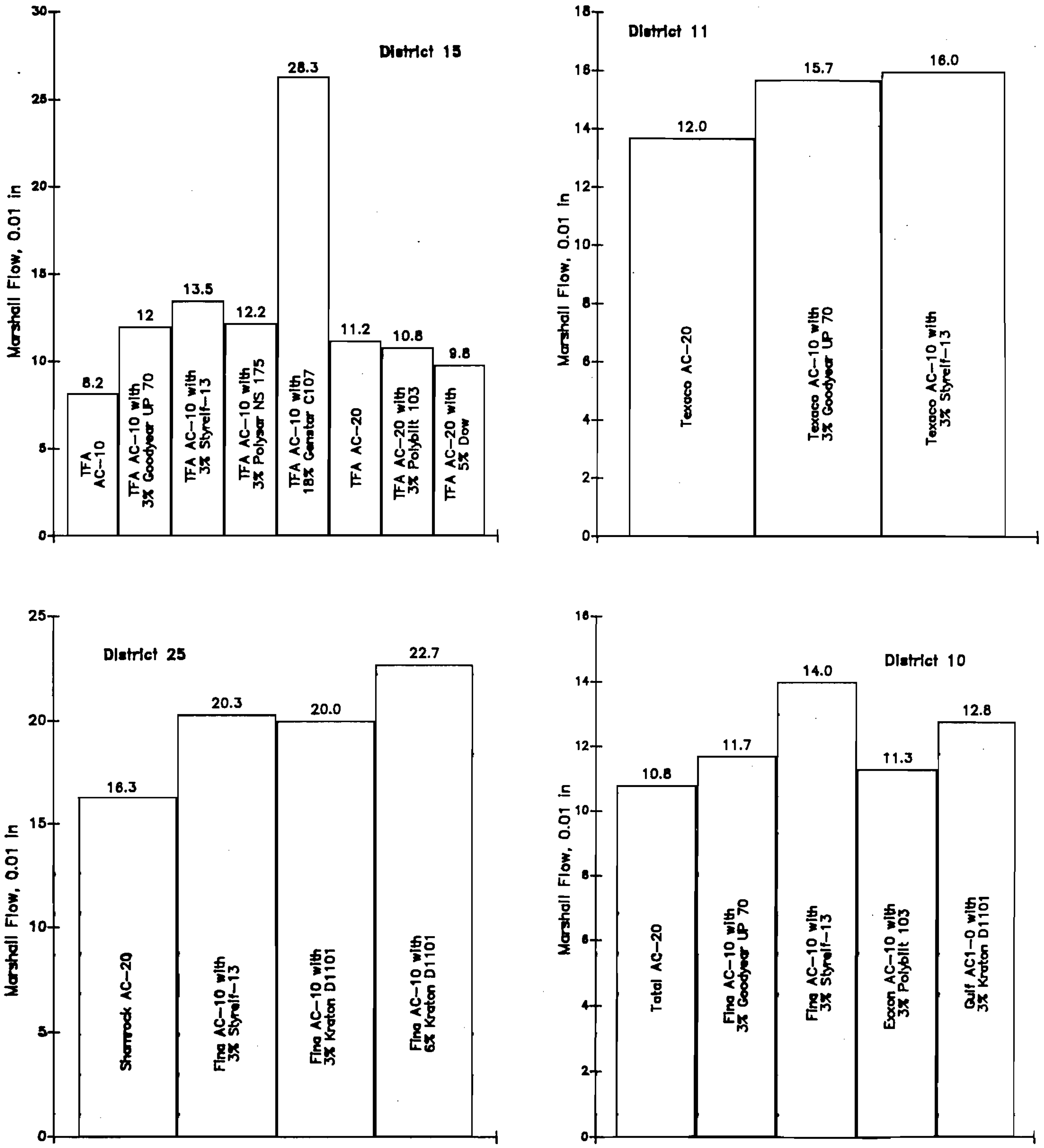


Fig 4.9 Marshall Flow for Laboratory Mixtures Using Modified Compaction.

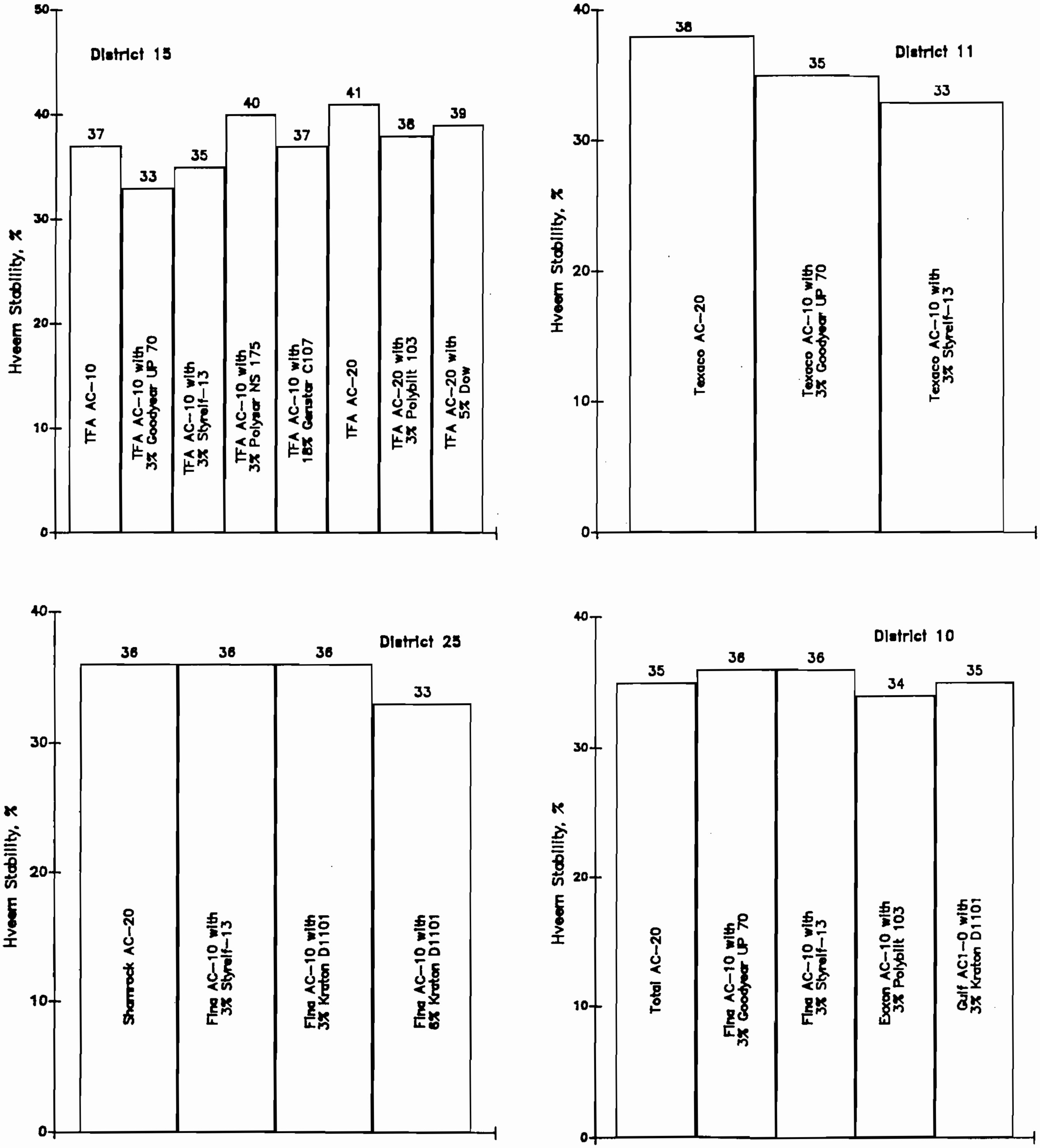


Fig 4.10 Hveem Stability for Laboratory Mixtures Using Modified Compaction.

District 25 had significantly lower values of Hveem stability than other mixtures. There was no significant difference in Hveem stability between the control and modified mixtures in District 10.

Tensile Strength

Average values of tensile strength at three different test temperatures (39°F, 77°F, and 104°F) are shown in Table 4.2, and relationships between tensile strength and temperature are plotted in Figure 4.11. Regarding the mixtures containing TFA asphalt cement (District 15), the polymer modified mixtures generally exhibited higher tensile strength than the respective control mixtures at 77°F and 104°F, and lower tensile strength at 39°F. This effect was more pronounced for the AC-10 than AC-20 mixtures. In District 11 the UP 70 mixture showed higher values of tensile strength at 39°F and 77°F than the control and the same value of tensile strength at 104°F. However the Styrelf exhibited the lowest values of tensile strength among the mixtures at all test temperatures. In District 25 the tensile strength of the Styrelf and 3 percent kraton mixtures were generally higher than the AC-20 control (Shamrock). However the 6 percent Kraton mixtures showed significantly lower tensile strength at 39°F and the same tensile strength at 104°F compared with the Shamrock AC-20 control. Therefore, the Kraton could be expected to reduce thermal cracking, since based on tensile strength, mixtures containing 6 percent Kraton would be more flexible (less brittle) at colder temperatures. In District 10 all modified mixtures except for the Styrelf exhibited lower tensile strength than the AC-20 control mixture at 77°F and 104°F. The Polybilt mixture showed more flexibility than the control at low temperatures.

Tensile Strain at Failure

The relationships between tensile strain at failure and test

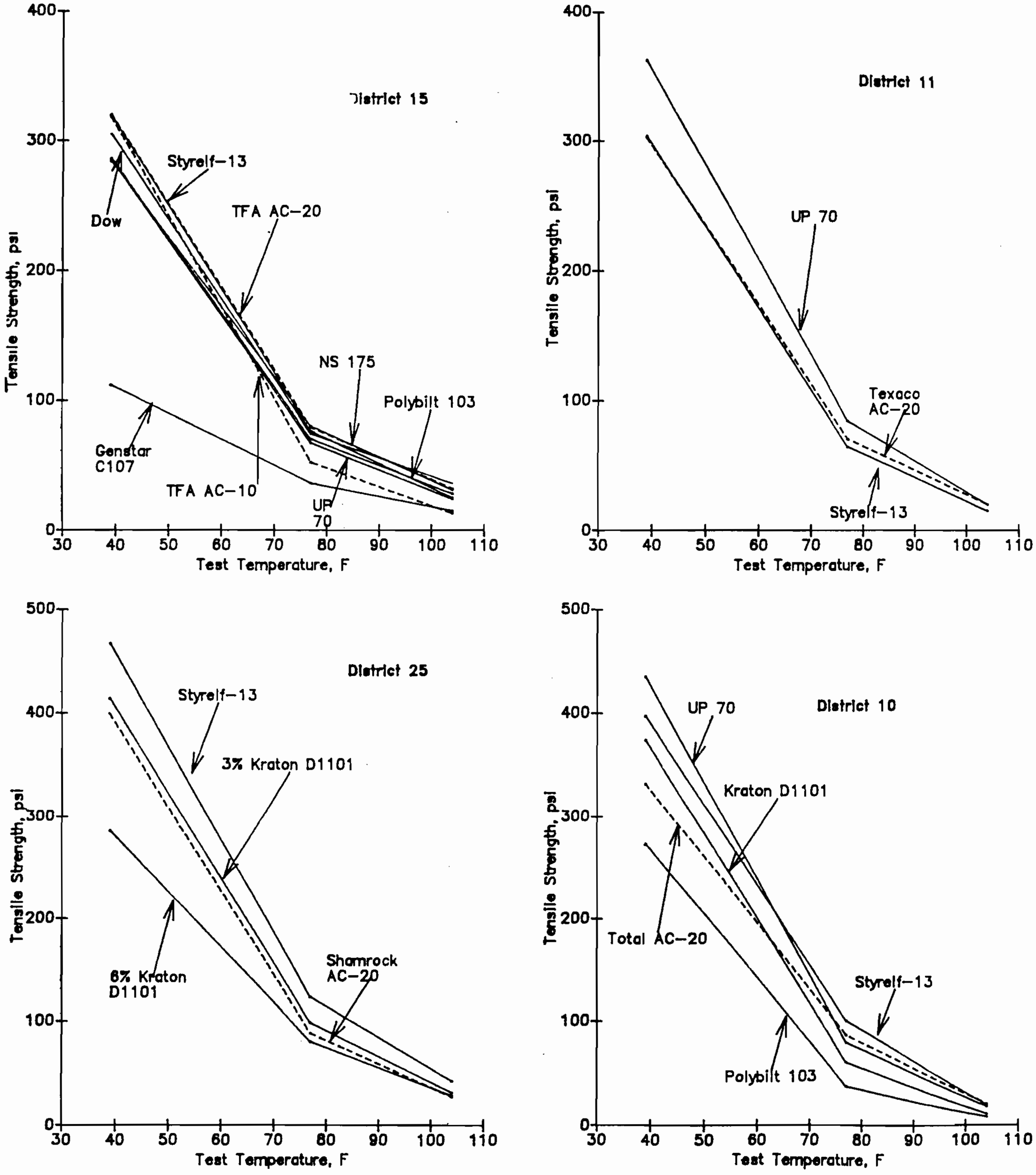


Fig 4.11 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

temperature are shown in Figure 4.12. The average values are presented in Table 4.2. The effect of polymers on tensile strain was different for TFA AC-10 and TFA AC-20 mixtures (Fig 4.12). In general, addition of SBR polymer to the TFA AC-10 mixtures increased tensile strain at 104°F and decreased it at 39°F. However, the SBS polymer and Genstar C107 significantly increased the tensile strain. There was no significant difference between the Polybilt and the control AC-20 mixture. The Dow polymer reduced tensile strain at high temperatures. The modified mixtures utilized in District 11, 25 and 10 generally had higher tensile strain values than the respective controls. Similar to standard compaction specimens, the Styrelf and Kraton (SBS polymer) mixtures were less brittle than the SBR mixtures (UP-70 and NS-175).

Secant Modulus

Results of secant modulus measurements are shown in Table 4.2 and plotted in Figure 4.13. The modified TFA AC-10 and AC-20 mixtures (except for Genstar C107) exhibited higher secant modulus than the respective control mixtures at all test temperatures. However the difference between secant modulus of the modified and control mixtures was statistically significant only for the Dow and NS 175 mixtures at 77°F and 104°F (Table 4.1). In District 11 the secant modulus of the control mixture was higher than that of the modified mixtures except for the UP-70 mixtures at 39°F and 77°F. All modified mixtures in District 25 showed significantly lower values of secant modulus than the Shamrock AC-20 mixture. In District 10 mixtures containing the Kraton and Polybilt were more flexible than the control at 39°F. The modified mixtures exhibited lower secant modulus than the control at 77°F and 104°F.

Resilient Modulus

The relationships between resilient modulus and test temperature are shown in Figure 4.14. The average values are

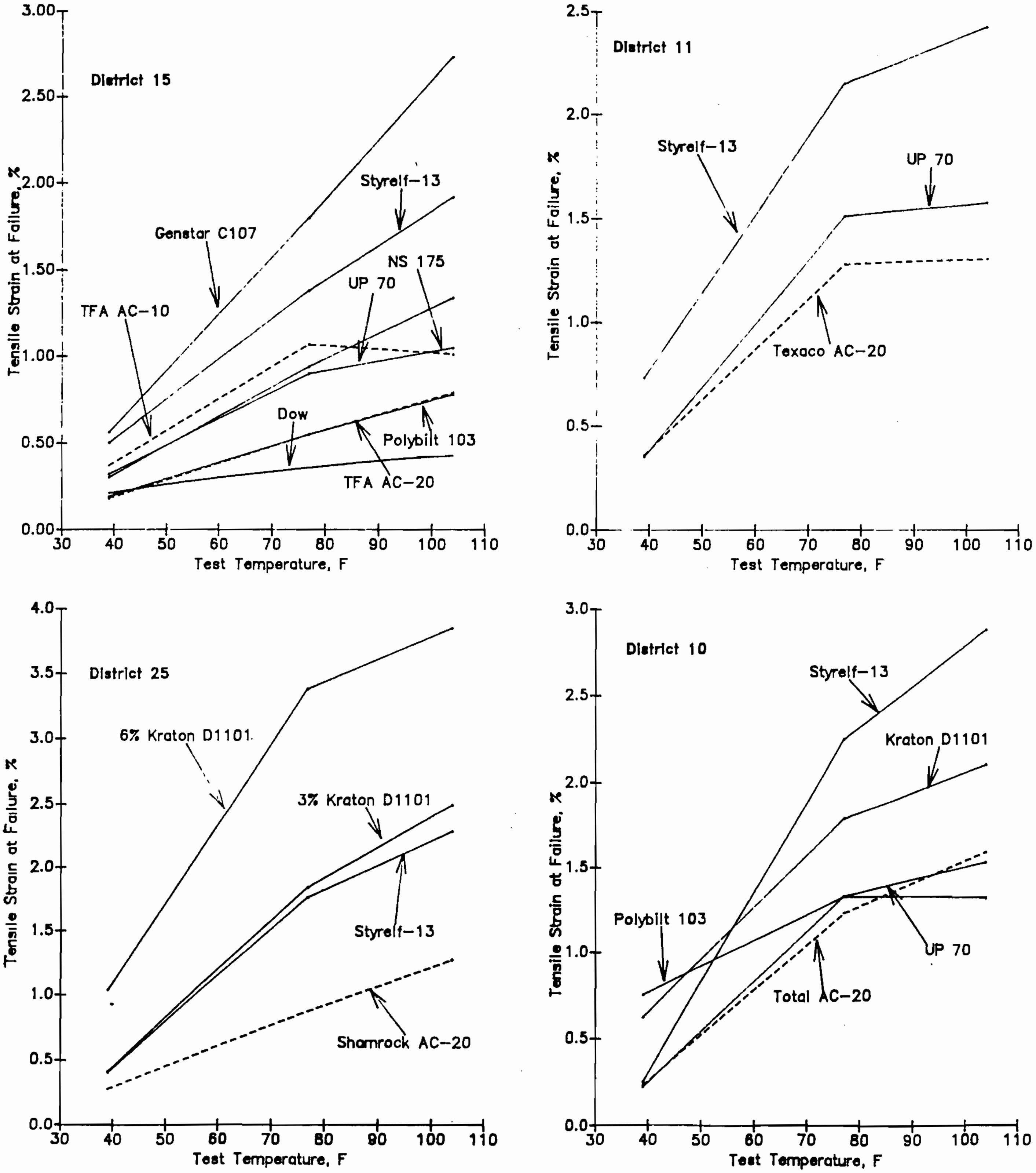


Fig 4.12 Tensile Strain vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

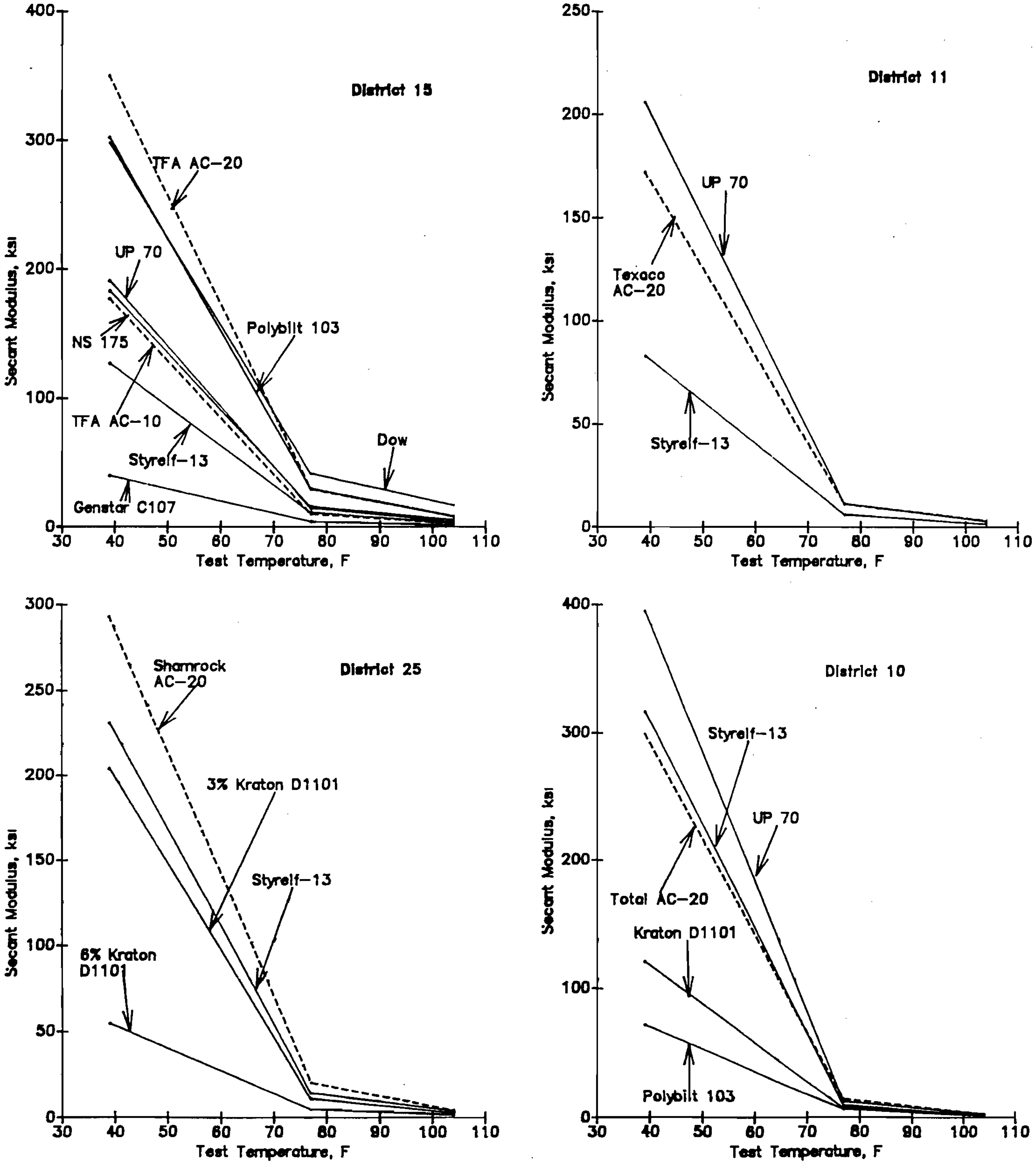


Fig 4.13 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

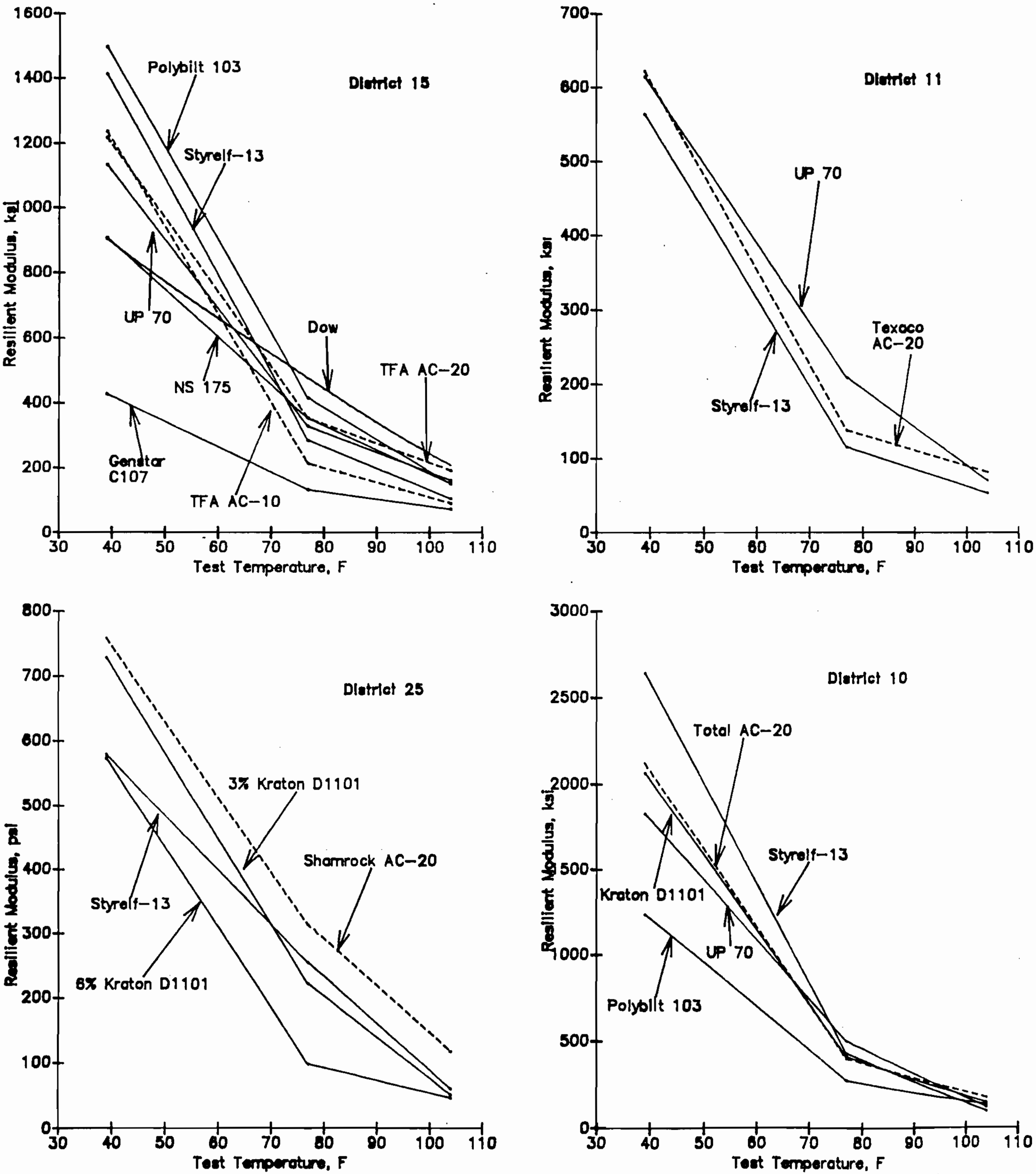


Fig 4.14 Resilient Modulus vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

presented in Table 4.2. As shown in Figure 4.14 addition of the UP-70, NS-175, Styrelf and Dow to TFA mixtures increased resilient modulus at 77°F and decreased it at 39°F. However the effect was not statistically significant. The Genstar C107 and Dow mixtures exhibited significantly lower resilient modulus than the control at 39°F and no significant difference was observed at 77°F and 104°F. In Districts 11 and 10 no significant difference was observed between resilient modulus of the modified and the control mixtures except for the Polybilt mixture. In District 25 resilient modulus of the Shamrock AC-20 mixture was consistently higher than resilient modulus of the modified Fina mixtures at all temperatures.

Since polymers under this study generally reduce mixture stiffness at low temperature, they may also reduce low-temperature cracking. Based on the above statement the Dow, Kraton (at 6 percent) and Genstar C107 were more effective in reducing low-temperature cracking than the other polymers.

Poisson's Ratio

Average values of Poisson's ratio are presented in Table 4.2. The Poisson's ratio values ranged from 0.0.3 to 0.54. Values less than 0.2 and greater than 0.45 are unrealistic and impractical for HMAC mixtures. One of the reasons for the unrealistic values obtained in Table 4.2 is a result of the formula given in ASTM D4123 for calculation of Poisson's ratio. The formula is based on the assumption that asphalt mixtures are homogeneous, isotropic and elastic. Similar to the standard compacted specimens, values of Poisson's ratio obtained at 77°F appeared to be more realistic than those obtained at 39°F and 104°F, and Poisson's ratio increased with increasing test temperature. Since the engineering properties of asphalt mixtures considered in this study are not very sensitive to Poisson's ratio, a Poisson's ratio of 0.33 is assumed for all the mixtures at 77°F.

Fatigue Life

Results of the indirect fatigue test are given in Appendices A, B, C and D for the mixtures used in District 15, 11, 25 and 10 respectively. In order to more easily evaluate the relative fatigue response at 77°F, the fatigue life versus tensile strain graphs for the laboratory mixtures are plotted in logarithmic scale in Figure 4.15. Based on this figure the following trends were apparent:

1. For mixtures used in District 15, the polymer modified AC-10 mixtures provided more favorable results than controls, the TFA AC-10 and TFA AC-20 mixtures. Furthermore, the modified mixtures containing AC-20 (Polybilt and Dow) produced superior fatigue characteristics compared to the TFA AC-20 control mixture at low stress level (low strain). This trend possibly can be explained in terms of the viscosity or stiffness of the binder. A stiffer binder would be expected to produce a longer fatigue life under the controlled-stress fatigue test.
2. The Styrelf mixtures used in Districts 11 and 10 had statistically superior fatigue properties compared to their respective controls (Texaco AC-20 and Total AC-20). Although the plots of the Texaco AC-20 and UP-70 mixtures in District 11 were statistically different (alpha = 0.05), they were closely grouped. Statistical difference is defined when either the intercept or slope or both are different.
3. In District 25, the Styrelf, 3 percent Kraton and 6 percent Kraton mixtures were not significantly different. These mixtures exhibited superior fatigue responses to the control at high stress level.
4. Generally, each additive blend with AC-10 in Districts 15, 25 and 10 produced a mixture which was statistically superior to the AC-20 control mixtures. The Styrelf and Genstar C107 had the greatest improvement.

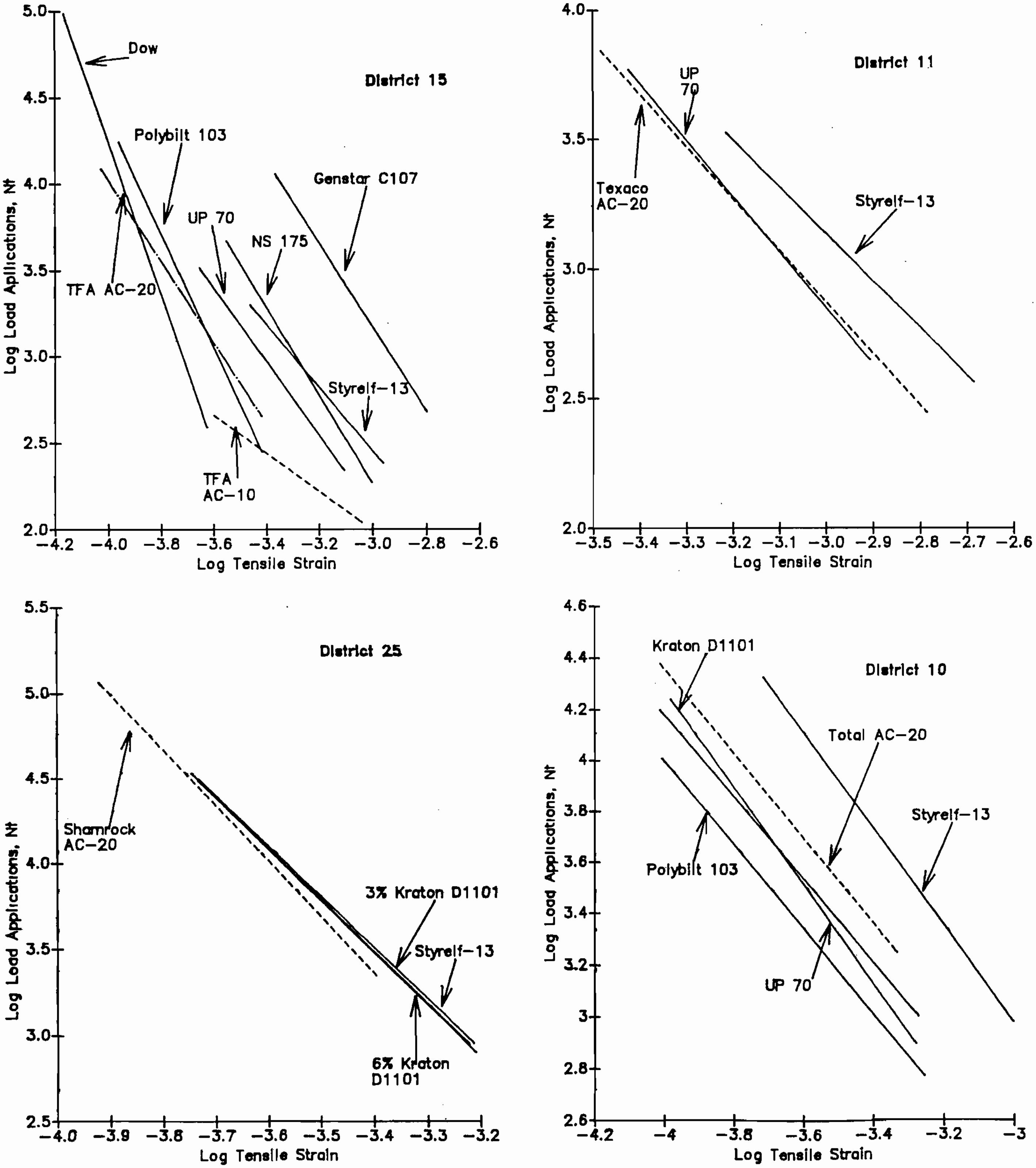


Fig 4.15 Relationship between Fatigue Life and Applied Strain for Laboratory Mixtures Using Modified Compaction.

Fatigue Constants, K1 and K2

Several researchers have postulated that a linear relationship exists between K2 and log K1 irrespective of mixture properties and test procedures (Refs 33, 34). This relationship was investigated by plotting log K1 versus K2 obtained from laboratory and plant mixtures (Fig 4.16). The equation of the best fitted line resulting from this plot is as follows:

$$K2 = 1.100 - 0.270 \, \mathrm{Log}(K1) \quad (R=0.986 \quad Se=0.135)$$

Kennedy (Ref 34) developed the following linear regression relationships from combining several sets of data:

$$K2 = 1.350 - 0.252 \, \mathrm{Log}(K1) \quad (R = 0.95 \quad Se = 0.29)$$

A comparison between Kennedy's equation and the equation obtained in this study was made in Table 4.3. It was shown that Kennedy's equation over-predicted the values of K2 by an average of approximately 0.16.

ALPHA and GNU

Values of alpha and gnu for the laboratory mixtures obtained by indirect tensile test are presented in Figures 4.17 and 4.18. As shown in Figure 4.17 alpha values of the modified mixtures were significantly higher than those of the respective controls. This trend was reversed for gnu values (Fig 4.18). It should be noted that alpha and gnu are parameters which are difficult to define in terms of their significance on mixture performance. However the extensive sensitivity analysis of the VESYS program by Rauhut, et al, provided a great step toward understanding the significance of these values. The most important finding in the Rauhut study with respect to this research in terms of alpha and gnu are as follows:

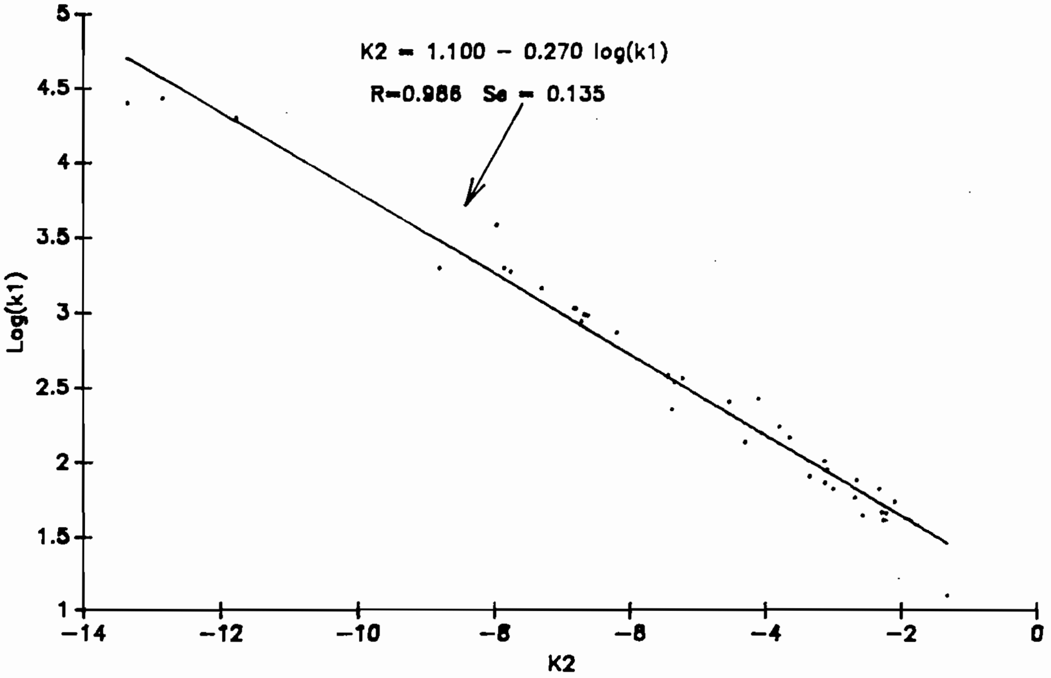


Fig 4.16 Relationship between Log K1 and K2 for Laboratory and Plant Mixtures Using Modified Compaction.

Table 4.3 Comparison of the Fatigue Parameter K2 from Laboratory Tests Conducted in this Study to the Parameter K2 Calculated from the Regression Equation Developed by Kennedy (Ref 33).

MIXTURE	FATIGUE CONSTANT From Lab Test		K2 From Regression Equation In This Study	K2 From Kennedy's Equation K2	DELTA K2
	K1	K2			
District 15 Laboratory Mixtures					
TFA AC-10	4.74E-02	1.11	1.46	1.68	0.23
TFA AC-10 + 3% UP 70	4.96E-05	2.14	2.26	2.43	0.17
TFA AC-10 + 3% Styrelf	9.68E-04	1.82	1.91	2.11	0.20
TFA AC-10 + 3% NS 175	4.36E-06	2.54	2.55	2.70	0.16
TFA AC-10 + 18% C107	7.75E-05	2.43	2.21	2.39	0.18
TFA AC-20	4.02E-06	2.35	2.55	2.71	0.15
TFA AC-10 + 3% Polybilt	1.54E-09	3.30	3.48	3.57	0.09
TFA AC-10 + 3% Dow	4.31E-14	4.40	4.70	4.72	0.01
District 11 Laboratory Mixtures					
Texaco AC-20	7.18E-04	2.01	1.95	2.14	0.19
Texaco AC-10 + 3% UP 70	2.21E-04	2.17	2.09	2.27	0.19
Texaco AC-10 + 3% Styrelf	4.65E-03	1.82	1.73	1.94	0.21
District 25 Laboratory Mixtures					
Shamrock AC-20	1.72E-08	3.27	3.19	3.31	0.11
Fina AC-10 + 3% Styrelf	1.59E-07	3.02	2.93	3.06	0.13
Fina AC-10 + 3% D1101	2.39E-07	2.98	2.89	3.02	0.13
Fina AC-10 + 6% D1101	1.49E-07	3.03	2.94	3.07	0.13
District 10 Laboratory Mixtures					
Total AC-20	5.04E-03	1.66	1.72	1.93	0.21
Fina AC-10 + 3% UP 70	4.32E-04	1.91	2.01	2.20	0.19
Fina AC-10 + 3% Styrelf	2.13E-03	1.88	1.82	2.02	0.20
Exxon AC-10 + 3% Polybilt	2.65E-03	1.64	1.79	2.00	0.20
Gulf AC-10 + 3% D1101	5.36E-03	1.61	1.71	1.92	0.21
District 15 Plant Mixtures					
TFA AC-10 + 3% UP 70	5.75E-06	2.57	2.51	2.67	0.16
TFA AC-10 + 3% Styrelf	8.52E-05	2.20	2.20	2.38	0.18
TFA AC-10 + 3% NS 175	3.54E-06	2.59	2.57	2.72	0.15
TFA AC-10 + 18% C107	1.07E-08	3.58	3.25	3.36	0.11
TFA AC-20	4.99E-08	3.16	3.07	3.19	0.12
TFA AC-10 + 3% Polybilt	1.66E-12	4.30	4.28	4.32	0.04
TFA AC-10 + 3% Dow	1.38E-13	4.43	4.57	4.59	0.02
District 11 Plant Mixtures					
Texaco AC-20	2.89E-05	2.40	2.32	2.49	0.17
Texaco AC-10 + 3% UP 70	6.31E-07	2.87	2.77	2.91	0.14
Texaco AC-10 + 3% Styrelf	1.57E-04	2.24	2.13	2.31	0.18
District 25 Plant Mixtures					
Fina AC-10 + 3% Styrelf	1.89E-07	2.95	2.91	3.04	0.13
Fina AC-10 + 3% D1101	2.11E-07	2.99	2.90	3.03	0.13
Fina AC-10 + 6% D1101	1.38E-08	3.30	3.22	3.33	0.11
District 10 Plant Mixtures					
Total AC-20	7.84E-04	1.95	1.94	2.13	0.20
Fina AC-10 + 3% UP 70	5.89E-03	1.66	1.70	1.91	0.21
Fina AC-10 + 3% Styrelf	7.90E-03	1.74	1.67	1.88	0.21
Exxon AC-10 + 3% Polybilt	2.01E-03	1.77	1.83	2.03	0.20
Gulf AC-10 + 3% D1101	7.23E-04	1.86	1.95	2.14	0.19

Kennedy's Regression Equation:

$K2 = 1.350 - 0.252 \log(K1)$ (R = 0.95; Se = 0.29)

Regression Equation Developed in this Study:

$K2 = 1.100 - 0.270 \log(K1)$ (R = 0.99; Se = 0.135)

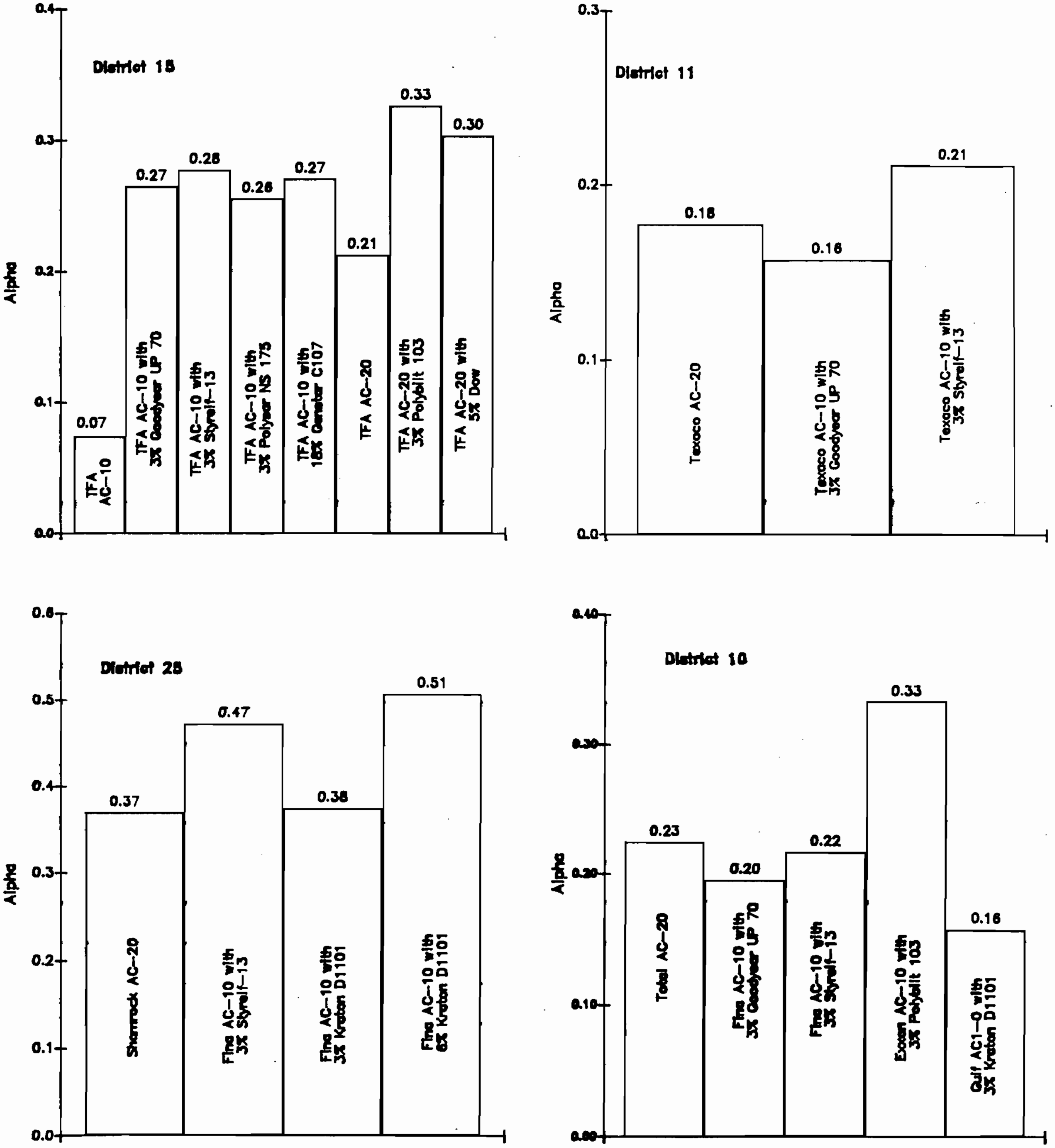


Fig 4.17 Alpha Values for Laboratory Mixtures Using Modified Compaction.

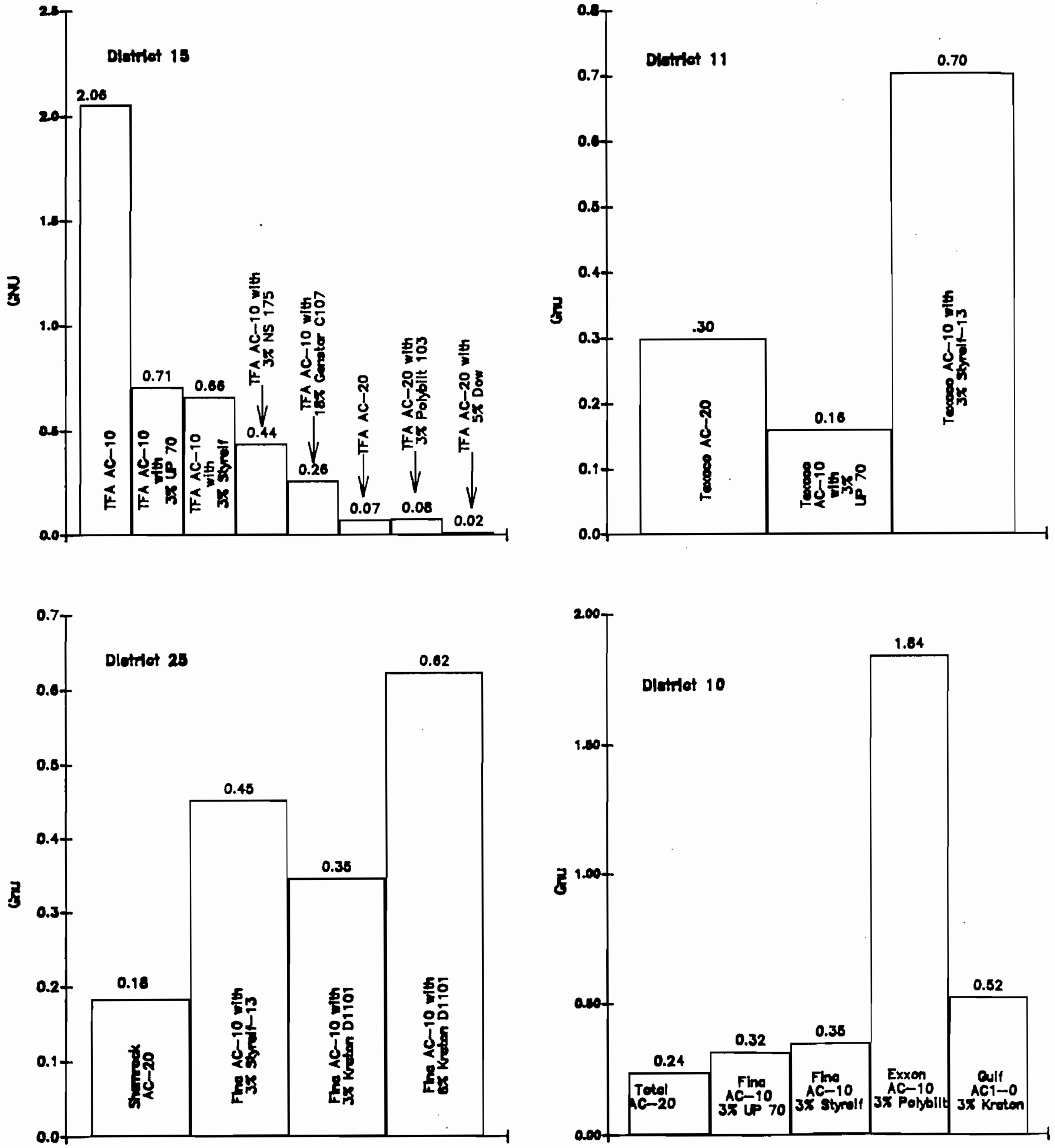


Fig 4.18 Gnu Values for Laboratory Mixtures Using Modified Compaction.

1. The alpha parameter for HMAC normally occurs within the range of 0.07 to 0.63, and gnu is quite variable and may be as high as 2.0. In this study the alpha and gnu ranged from 0.07 to 0.51 and 0.02 to 2.06, respectively.
2. Alpha and gnu are very stress-sensitive. Both decreased with increasing deviator stress. In this study all values were obtained at the stress level of about 15 percent of tensile strength.
3. Temperature is an important parameter in testing for alpha and gnu. The test temperature for fatigue test was 77°F in this study. Since alpha and gnu are assumed to predict the permanent deformation characteristics of the mixtures, a time-temperature shift function for creep compliance may be used to compute the alpha and gnu in other test temperatures.
4. A low alpha and a high gnu indicates increased rutting and vice versa.

Creep Compliance

The results of creep compliance testing for laboratory mixtures bound with blends of TFA asphalt cements and additives (District 15) are shown in Table A-19 and plotted in Figures 4.19. The following trends were observed from Figure 4.19, which presents the average tensile creep compliance at 60°F, 77°F and 90°F:

1. All modified AC-10 mixtures responded with a higher creep compliance than the AC-20 mixture at 60°F test temperature.
2. The modified AC-20 mixtures showed lower compliance than AC-20 at all test temperature. Therefore addition of Polybilt or Dow to the TFA AC-20 greatly improved high temperature deformation susceptibility.
3. The Polysar NS-175 mixtures had higher creep compliance

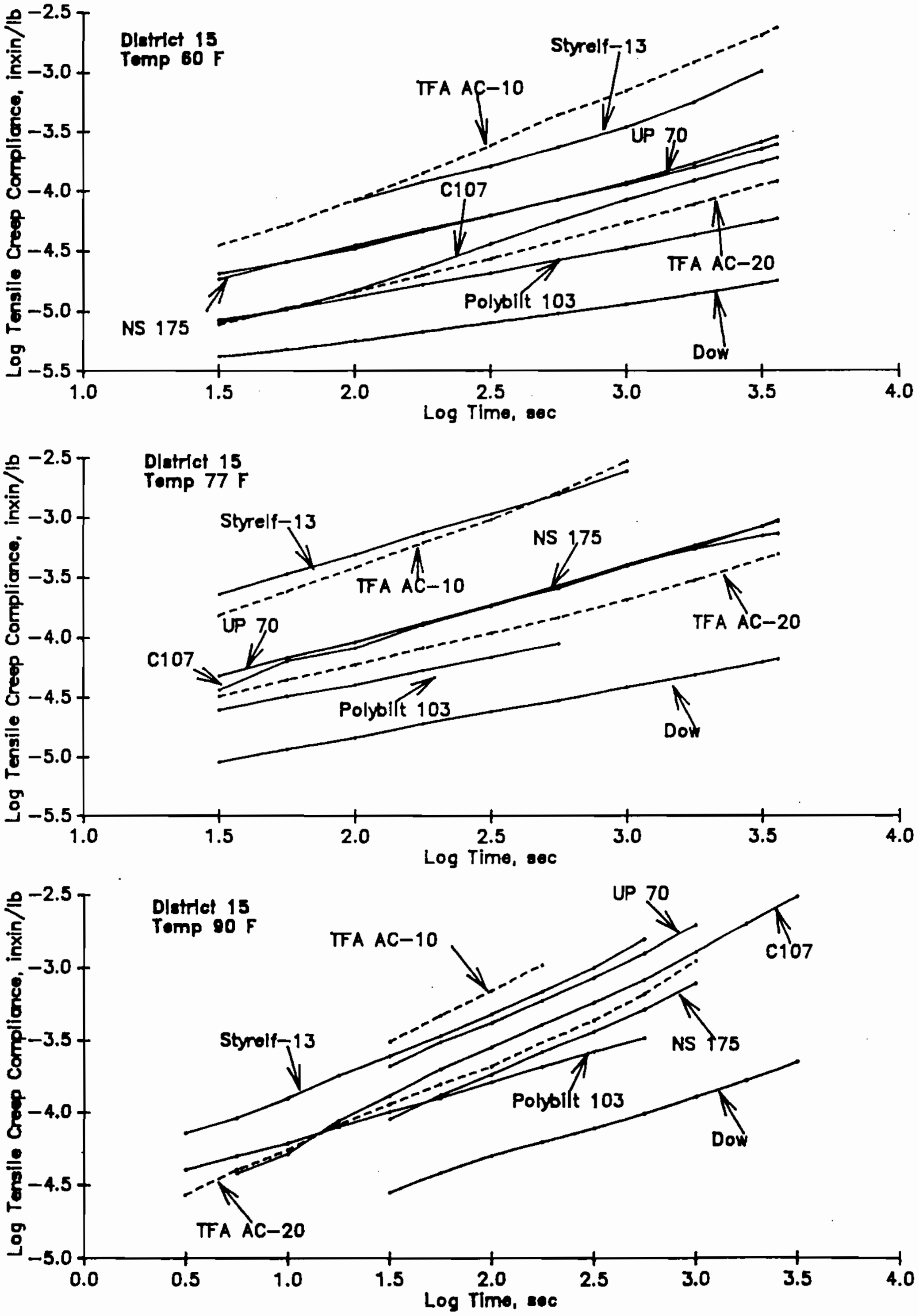


Fig 4.19 Creep Compliance Curve for Laboratory Mixtures Using Modified Compaction (District 15).

than the TFA AC-20 mixture at low temperature and lower creep compliance than the TFA AC-20 at high temperature.

4. Addition of polymer to the TFA AC-10 or AC-20 improved resistance to permanent deformation of the mixtures.
5. Values of the temperature susceptibility constant (beta) of the TFA mixtures are shown in Table A-21. On the basis of the beta values the laboratory TFA mixtures were ranked in order of ascending temperature susceptibility:

a) TFA AC-10
b) TFA AC-10 with Styrelf
c) TFA AC-10 with NS-175
d) TFA AC-10 with C107
e) TFA AC-10 with UP-70
f) TFA AC-20
g) TFA AC-20 with Dow
h) TFA AC-20 with Polybilt

It appears that the modified TFA AC-10 mixtures maintained a more stable compliance during temperature change than the TFA AC-20 mixtures.

Creep compliance data for laboratory mixtures composed of additive blends of the Texaco asphalt cement at 60°F, 77°F, and 90°F are shown in Figure 4.20 and tabulated in Table B-19. Here the additives were blended with an AC-10 Texaco asphalt cement, and the control mixture was blended with Texaco AC-20. When comparing the modified AC-10 mixtures with the AC-20 control, the following observations were made:

1. The creep compliance of the Styrelf mixture was greater than that of the control at all test temperatures. However, the difference between creep compliance of the Styrelf and control mixtures was more significant at low temperatures than at high temperatures.

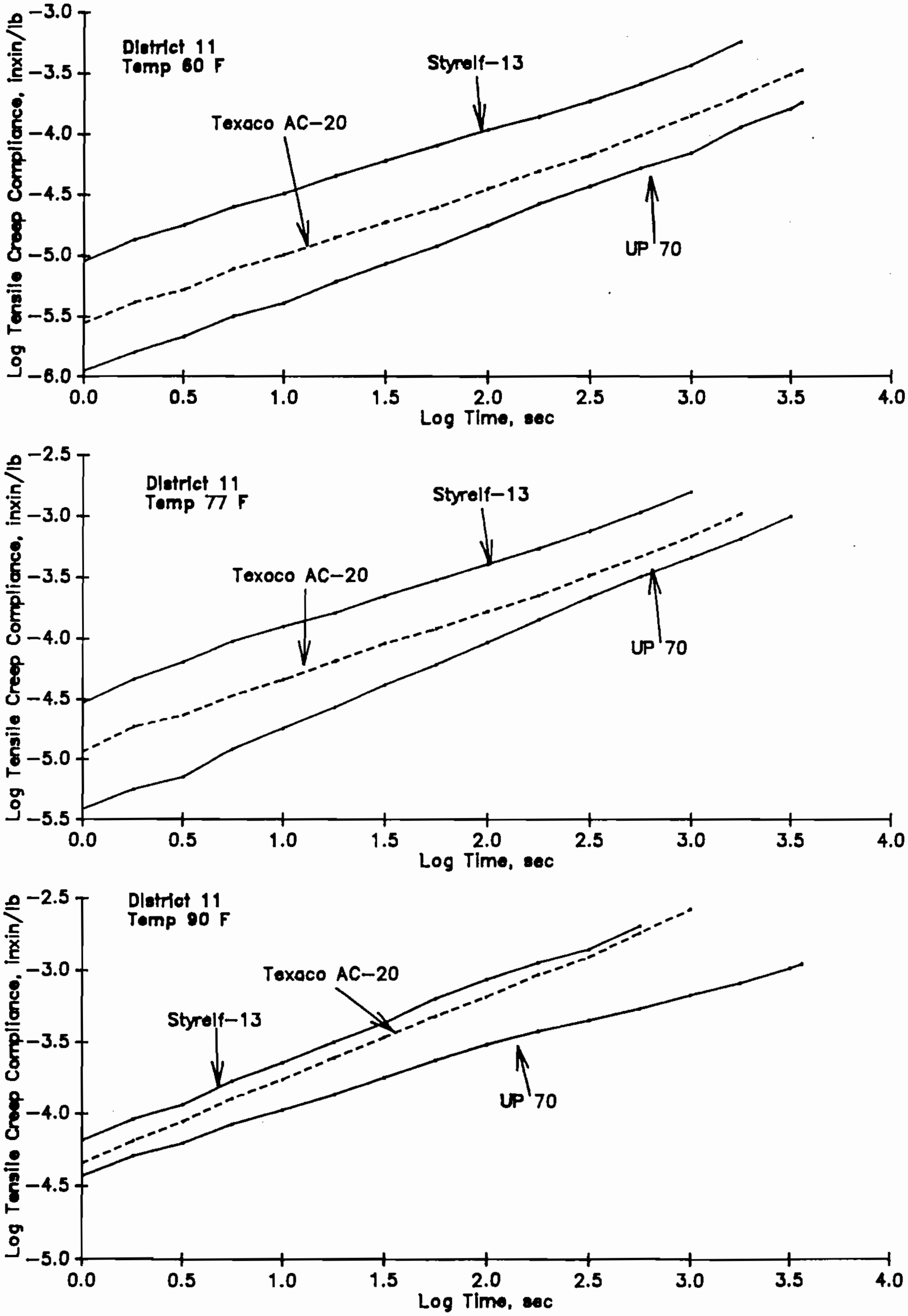


Fig 4.20 Creep Compliance Curve for Laboratory Mixtures Using Modified Compaction (District 11).

2. The mixture containing UP-70 had less creep compliance than the control at all test temperatures. This difference was more significant at 90°F at relatively long load duration (greater than 10 minutes). This is an indication that the UP-70 mixtures have lower permanent deformation at high pavement service temperature than the controls.
3. The values of beta (temperature susceptibility constant) are shown in Table B-21. Similar to the TFA mixtures, the creep compliance of modified Texaco mixtures are less affected by temperature change than the control (Texaco AC-20).

Creep compliance data for laboratory mixtures utilized in Districts 25 and 10 are shown in Tables C-19 D-19 and plotted in Figures 4-21 and 4-22. From these figures the following trends were observed:

1. A review of Figures 4-21 and 4-22 indicates that at short loading times at 90°F the modified Fina AC-10 mixture exhibited compliance values greater than the control mixture (Shamrock AC-20), and the compliance relationships tended to converge at longer loading time at 90°F.
2. At low temperatures the compliance values of modified mixtures were all higher compared to the AC-20 controls. This may be an indication that the modified mixtures better relieve the temperature-induced stress than the control.
3. Beta values in Table C-21 show that the control (Shamrock AC-20) was less temperature susceptible than the modified mixtures. This trend was not observed in Districts 15, 11 and 10. This result might be due to the fact that Shamrock asphalt cement is less temperature susceptible than Fina's asphalt.

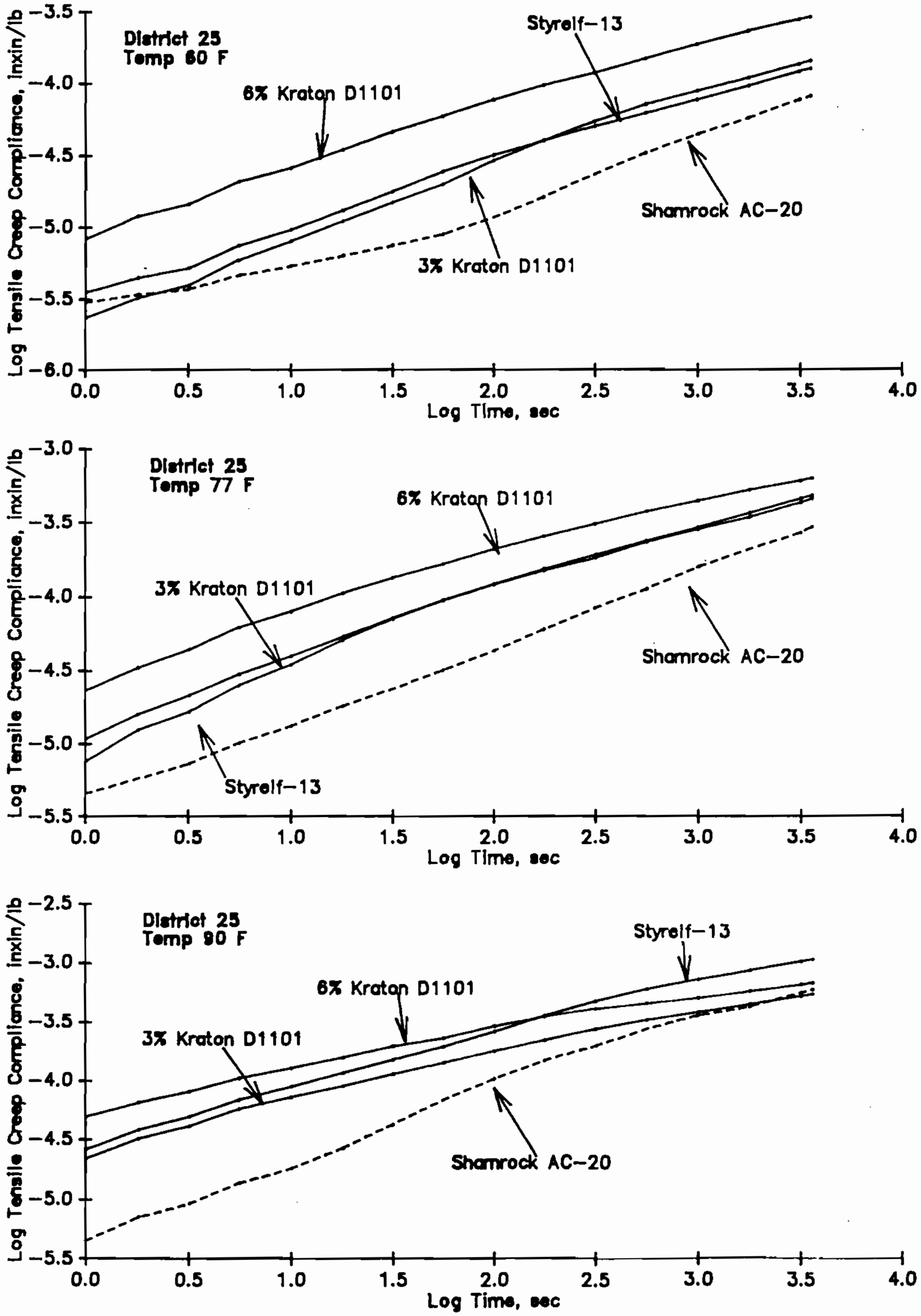


Fig 4.21 Creep Compliance Curve for Laboratory Mixtures Using Modified Compaction (District 25).

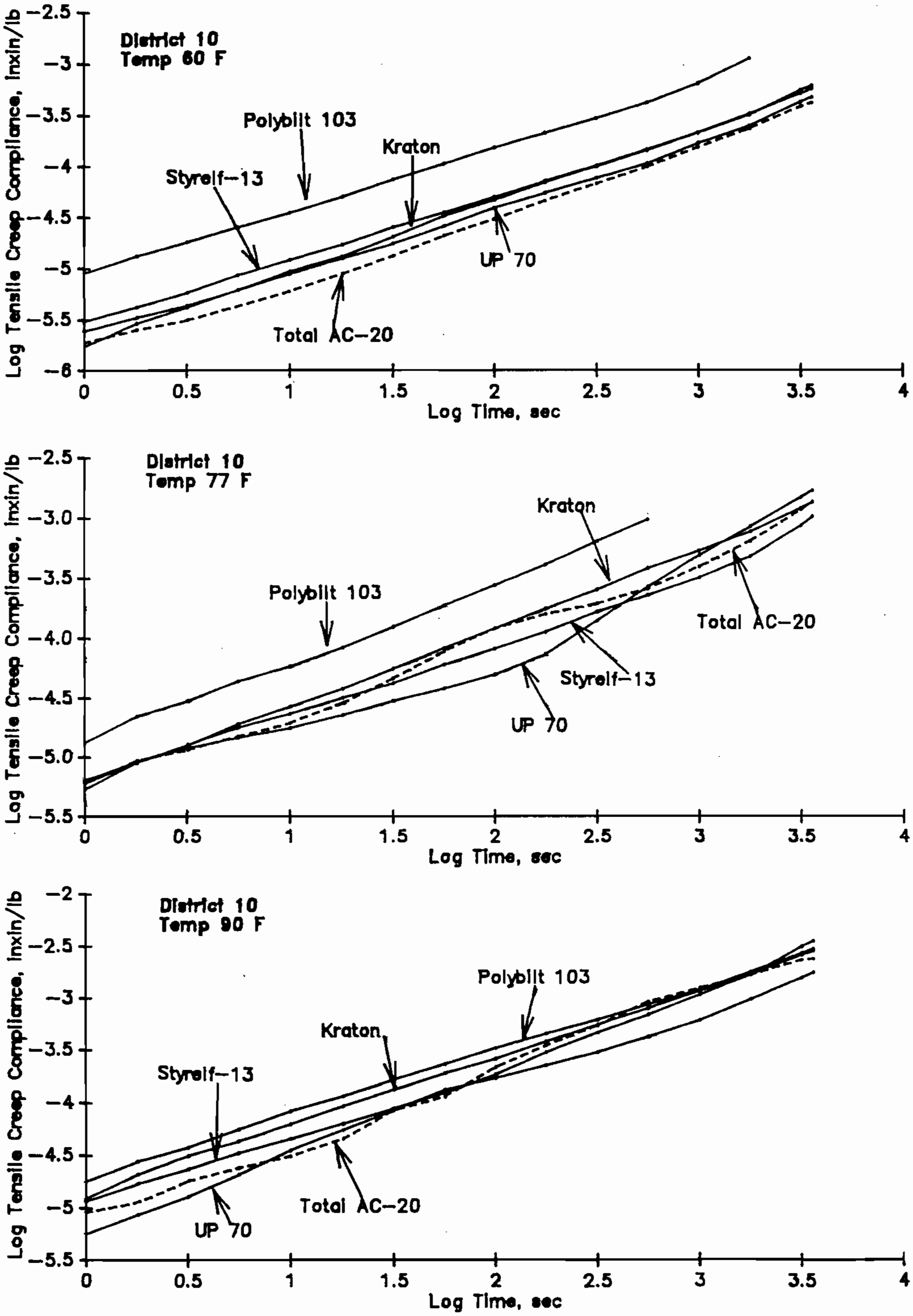


Fig 4.22 Creep Compliance Curve for Laboratory Mixtures Using Modified Compaction (District 10).

Tensile Strength Ratio (TSR)

Results of tensile strength ratio for mixtures used in Districts 15, 11, 25 and 10 are shown in Tables A-25, B-25, C-25 and D-25 respectively. The average values of TSR are plotted in Figure 4.23. As shown in this figure, addition of polymers improved moisture damage susceptibility of the mixtures used in District 15, 11 and 10. However, the addition of one percent lime to the mixtures in District 25 masked any moisture effects due to the polymers.

COMPARISON BETWEEN LABORATORY MIXTURES AND PLANT MIXTURES

Considerable differences exist between the HMAC production processes used in the laboratory and those used in a batch or drum mix plant. It is important to look at those differences and understand how and why engineering properties of laboratory-prepared mixtures might differ from engineering properties of plant-mixed mixtures. Those are as follows:

1) The degree of hardening of the asphalt cement in the laboratory is much less than that which occurs during mix production at the asphalt plant. Furthermore, the amount of asphalt cement hardening which typically occurs in a drum mix plant is less than that in a pugmill at a batch plant. Of course, the degree of hardening is quite variable and is a function of many factors such as mixing temperature, moisture content of aggregates and rate of production.
2) If a collector or baghouse is used as an air pollution control device, in either of the two types of plants, and sends ultrafine aggregates back into the plant, a stable mix in the laboratory can be soft and tender in the field.

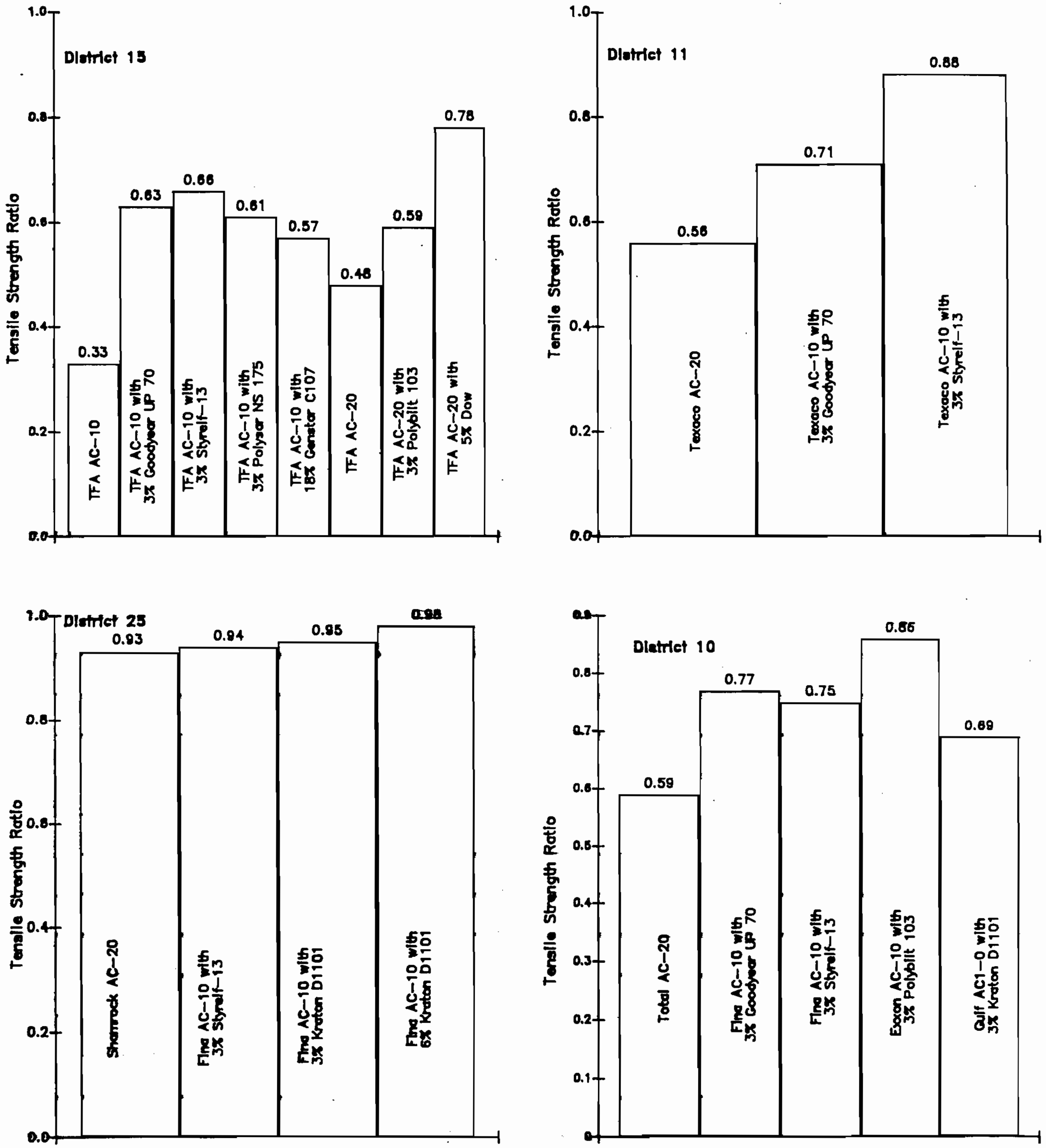


Fig. 4.23 Tensile Strength Ratio for Laboratory Mixtures Using Modified Compaction.

3) The aggregates are uniformly heated in the laboratory. However in the plant the coarse aggregates are usually heated to a lower temperature than are the fine aggregates.

This study attempted to determine engineering properties of plant mixtures as a function of engineering properties of laboratory prepared mixtures, test temperature, air voids, mixing temperature and aging indices. Multiple regression analysis was used to achieve that objective. In the process of establishing the regression equations, stepwise regression methods were used to identify variables which had significant effects on the accuracy of the prediction of properties of plant-mixed mixtures from the properties of laboratory-prepared mixtures. Correlations between the laboratory-prepared and plant-mixed results were established for the following engineering properties:

- Marshall Stability and Flow
- Hveem Stability
- Tensile Strength
- Tensile Strain at Failure
- Secant Modulus
- Resilient Modulus
- Fatigue Constants, K1 and K2
- Slope and Intercept of Creep Compliance Curve

Since nonconstant variance was diagnosed at different test temperatures for certain engineering properties, a square root transformation was utilized. Table 4.4 presents the results of the stepwise regression analysis to determine the properties which had significant effects on the accuracy of the prediction of plant-mixed properties from the properties of laboratory-prepared mixtures. Table 4.5 presents the regression equations which were derived to predict plant mixed properties. The regression equations contain only the variables which are identified as significant.

Table 4.4 Identification of variables which have significant effect on prediction of plant mixed properties.

Measured Property	PROPERTY OF LABORATORY MIXTURE	TEST TEMP.	AIR VOIDS	MIXING TEMP.	AGING INDEX
Marshall Stability	XXX	N/A	---	---	---
Marshall Flow	XXX	N/A	---	---	---
Hveem Stability	XXX	N/A	---	---	---
Tensile Strength	XXX	XXX	XXX	---	---
Tensile Strain	XXX	XXX	---	XXX	---
Secant Modulus	XXX	XXX	XXX	XXX	---
Resilient Modulus	XXX	XXX	---	---	---
Fatigue Constant, K1	XXX	N/A	N/A	---	---
Fatigue Constant, K2	XXX	N/A	N/A	---	---
Intercept of Creep Curve, D1	XXX	---	N/A	---	---
Slope of Creep Curve, M	XXX	XXX	N/A	---	---

Note: (XXX) indicates variables which are significant.
(---) indicates variables which are not significant at alpha=0.05.

Table 4.5 Regression Equations for Plant Mixed Properties.

MARSHALL-P = 98 + 0.837 (MARSHALL-L)
R = 83.8% Se = 482 DF = 33

MARSHALL FLOW-P = 2.68 + 0.848 (MARSHALL FLOW-L)
R = 85.3% Se = 2.087 DF = 33

HVEEM-P = 11.0 + 0.724 (HVEEM-L)
R = 70.8% Se = 3.287 DF = 33

SQRT(St-P) = 18.6 + 0.0187 (St-L) - 0.359 AV - 0.103 (TEMP)
R = 98.4% Se = 1.085 DF = 101

SQRT(Ef-P) = 0.410 + 0.291 (Ef-L) - 0.0033 (TEMP) - 0.0024 (300 - Tmix)
R = 89.8% Se = 0.145 DF = 101

SQRT(Es-P)=17.3 + 0.0202(Es-L) - 0.336 AV - 0.123 (TEMP) - 0.0336(300-Tmix)
R = 96.7% Se = 1.638 DF = 100

SQRT(Er-P) = 28.6 + 0.0103 (Er-L) -0.170 (TEMP)
R = 94.4% Se = 3.884 DF = 102

LOG(K1-P) = -1.11 + 0.963 (LOG(K1-L))
R = 90.6% Se = 1.332 DF = 16

K2-P = 0.312 + 1.01 (K2-L)
R = 88.5% Se = 0.399 DF = 16

LOG(D1-P) = -1.07 + 0.803 LOG(D1-L)
R = 89.4% Se = 0.197 DF = 52

M-P = -0.292 + 1.03 M-L + 0.00295 (TEMP)
R = 83.4% Se = 0.080 DF = 51

LEGEND
P = PLANT
L = LABORATORY
St = Indirect Tensile Strength
Ef = Tensile Strain at Failure
Es = Secant Modulus
Er = Resilient Modulus
K1 and k2 = Fatigue Constants
M and D1 = Slope and Intercept of Creep Curve

COMPARISON OF HAND AND MECHANICALLY MIXED LABORATORY MIXTURES

The primary objective of this section was to investigate the basic mix design procedure, and take into account the type of mixing (hand vs. mechanical) that will take place during the preparation of mixtures in the laboratory, and examine any possible effects due to mixing methods. This study was carried out in order to determine the difference between engineering properties of hand-mixed and mechanically mixed mixtures, and to determine the best correlation between mixtures prepared in the laboratory, and the asphaltic concrete being made during actual plant production.

The testing program for hand versus mechanically-mixed polymer modified asphalt mixtures is outlined in Table 4.6. As shown in this table, four mixtures were selected from districts 10 and 11. These mixtures contain four different polymers and two types of aggregate (light-weight and crushed stone). Additionally, two mixing and compaction temperatures were used for the hand-mixed mixtures.

Specimen Preparation

Aggregates were batched by dry weight to meet the specified gradation. Dry aggregates were preheated to the specified mix temperature, and the asphalt cement was heated to 275 ± 5°F. The specified amount of asphalt was then added to the heated aggregates. The combined mixture was placed in an oven to bring the temperature to the required mixing temperature. Two mixing temperatures (275° and 295°F) were used for hand-mixed mixtures. The mixtures were then mixed either mechanically for approximately 3 minutes in an automatic 12-quart capacity Hobert mixer, or by hand using a trowel. Blending of aggregates and polymer modified asphalt cement was continued until aggregates were thoroughly coated. All hand-mixed mixtures required at least two cycles of heating and mixing to coat the aggregate particles thoroughly. The mixtures were then placed in preheated ovens and brought to the proper compaction temperatures (250 ± 5 or 270 ± 5°F). Mixtures

Table 4.6 Experimental Design for Hand vs. Mechanical Mixing Study (Number of Samples per Data Point)

Type of Mix	Mechanical Mixing Com. Temp=250 Mix.Temp=275			Hand Mixed Com. Temp=250 Mix.Temp=275			Hand Mixed Com. Temp=270 Mix.Temp=295			Plant Mix		
	St 77	Marshall 140	Hveem 140	St 77	Marshall 140	Hveem 140	St 77	Marshall 140	Hveem 140	St 77	Marshall 140	Hveem 140
Texaco AC-10	-	-	-	-	-	-	-	-	-	-	-	-
Styrelf-13	3	3	3	3	3	3	3	3	3	3	3	3
Light-Weight Agg.	-	-	-	-	-	-	-	-	-	-	-	-
Texaco AC-10	-	-	-	-	-	-	-	-	-	-	-	-
Goodyear SBR	3	3	3	3	3	3	3	3	3	3	3	3
Light-Weight Agg.	-	-	-	-	-	-	-	-	-	-	-	-
Exxon AC-10	-	-	-	-	-	-	-	-	-	-	-	-
3% EVA	3	3	3	3	3	3	3	3	3	3	3	3
Crushed Stone Agg.	-	-	-	-	-	-	-	-	-	-	-	-
Gulf AC-10	-	-	-	-	-	-	-	-	-	-	-	-
3% D1101 SBS	3	3	3	3	3	3	3	3	3	3	3	3
Crushed Stone	-	-	-	-	-	-	-	-	-	-	-	-

were compacted using the Texas Gyratory Shear Compactor, and standard compaction techniques were utilized. The standard compaction procedure specified by TXDOT would normally produce 3% air voids in the design mixture containing optimum asphalt cement. After compaction all specimens were cured at room temperature for 2 days. The specimens were then placed in environmental chambers for 15 hours to attain the desired testing temperature.

Specimens were tested using the indirect tensile test, Marshall stability and Hveem stability tests. The test results are summarized in Table 4.7.

Results of laboratory tests conducted on hand-mixed, mechanically-mixed and plant mixtures are listed in Table 4.7 and plotted in Figures 4.24 through 4.26. Analysis of variance (ANOVA) techniques were utilized to determine if significant differences exist between different mixing procedures for each test parameter. In addition, the correlation coefficients between mixing procedures were calculated.

Hveem Stability

Average values of the Hveem stability for the tested mixtures are plotted in Figure 4.24. Analysis of variance using Alpha = 0.05 and the Newman Keul multiple range test showed that there was no significant difference between the mixing procedures. However, the mechanical mixing procedure exhibited higher values of Hveem stability by an average 3% than the hand-mixing procedure.

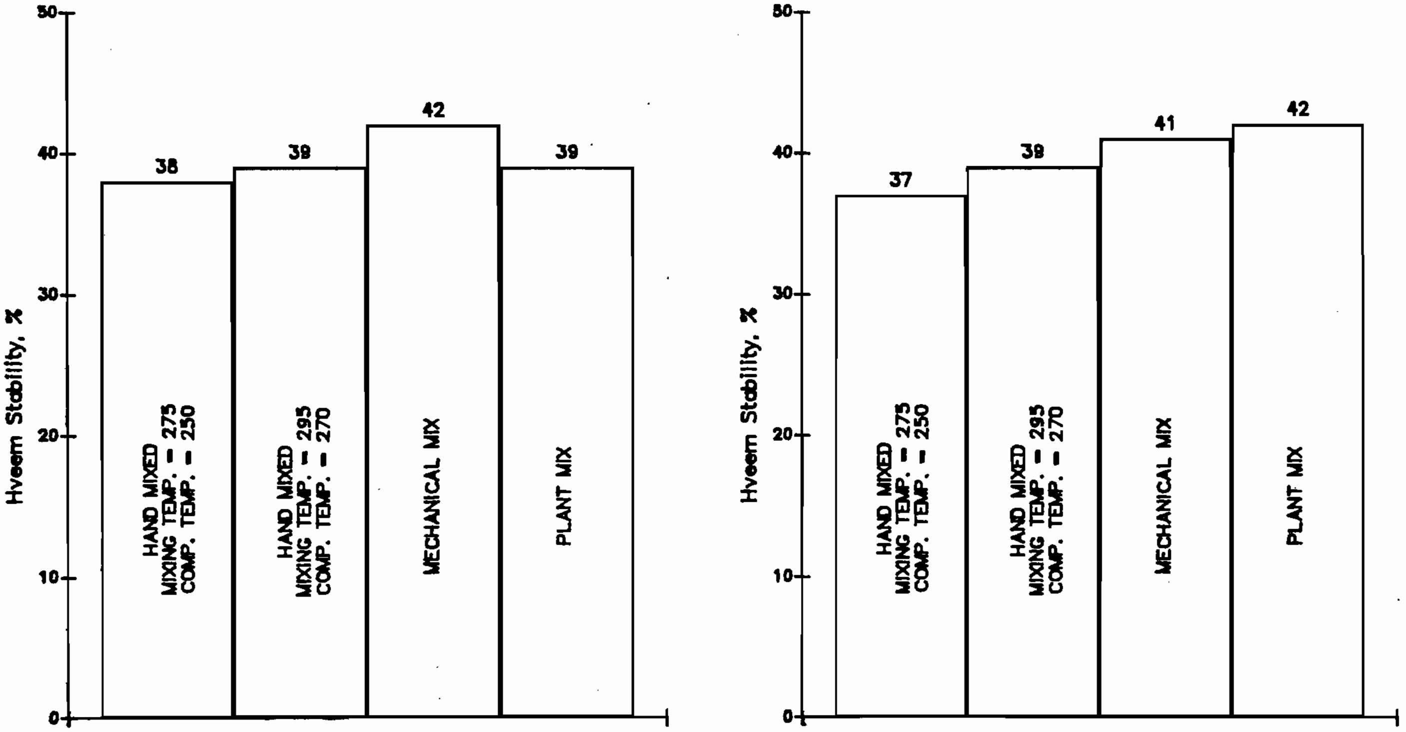
Marshall Stability

Results of Marshall Stability testing are shown in Table 4.7 and plotted in Figure 4.25. As shown in the figure, mechanical mixtures containing Styrelf and UP-70 exhibited significantly higher values of Marshall Stability than the hand-mixed mixtures containing the same polymers. This trend was not observed for mixtures containing Exxon and Kraton polymers. In addition, no significant difference was observed between those samples hand-mixed at 275°F and plant mixtures.

Table 4.7 Engineering Results of Hand vs. Mechanical Mixing Study

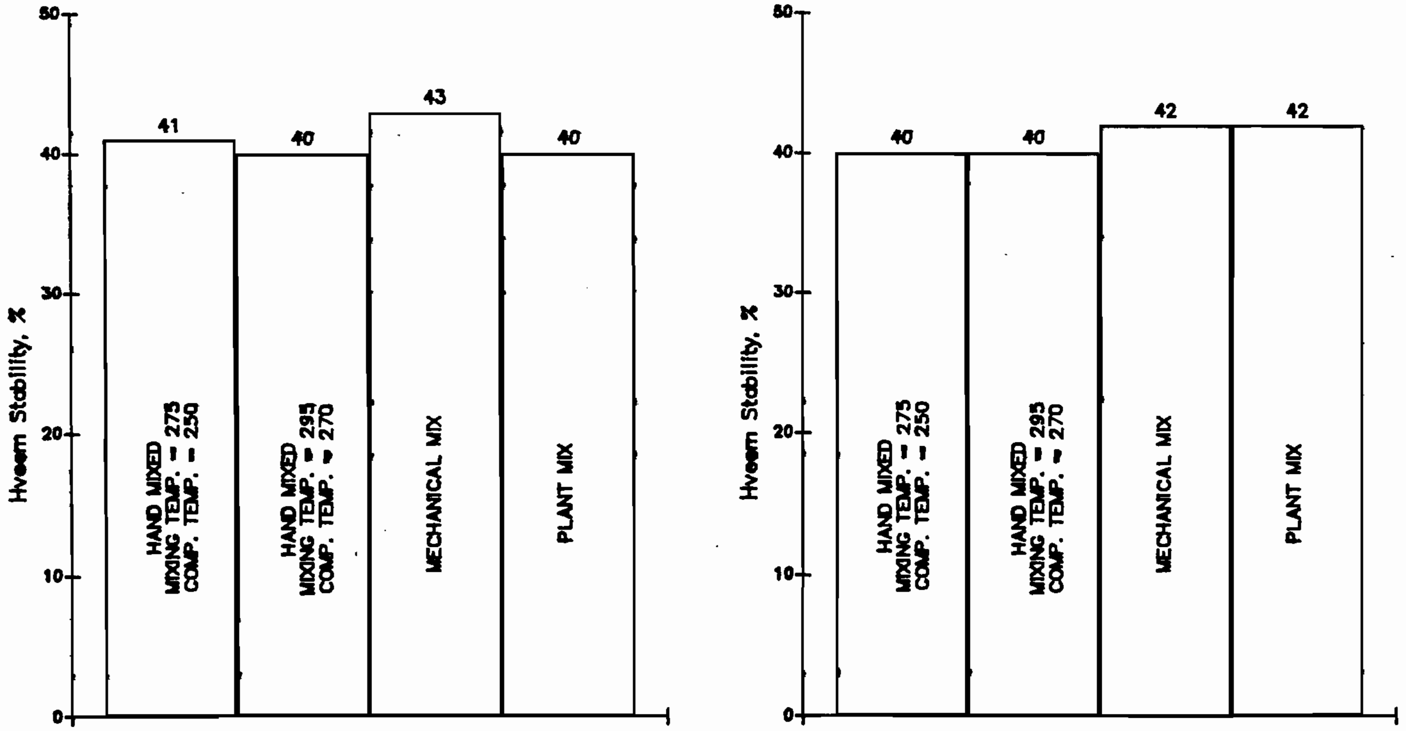
	Hand Mixed Com. Temp=250 Mix.Temp=275			Hand Mixed Com. Temp=270 Mix.Temp=295			Mech. Mix Com. Temp=250 Mix.Temp=275			Plant Mix		
	Hveem	Marshall	St 77°F	Hveem	Marshall	St.	Hveem	Marshall	St.	Hveem	Marshall	St.
Texaco AC-10	39	1805	98	40	1968	125	42	2206	125	40	2197	155
3% Styrelf-13	37	1710	95	39	2102	132	40	2350	124	40	2002	156
Light-Weight Agg.	38	1812	100	39	2205	109	44	2462	129	38	2214	150
Average	38	1776	98	39	2092	122	42	2339	126	39	2138	153
Texaco AC-10	36	1710	88	39	1950	127	41	2407	159	42	1948	162
Goodyear SBR	37	1711	92	40	1728	110	42	2935	150	42	1928	164
Light-Weight Agg.	38	1653	93	37	2210	132	41	2823	148	42	1743	159
Average	37	1691	91	39	1963	123	41	2722	152	42	1873	162
Exxon AC-10	40	871	51	41	925	65	43	983	70	41	865	77
3% EVA	41	1181	50	40	980	49	44	990	77	39	792	73
Crushed Stone Agg.	41	811	44	40	820	72	41	-	70	39	950	72
Average	41	959	48	40	908	62	43	987	73	40	869	74
Gulf AC-10	39	1027	64	41	1140	75	42	865	78	42	1294	97
3% D1101 SBS	39	1001	65	37	1065	70	40	931	83	43	1122	100
Crushed Stone Agg.	40	1142	62	41	1195	59	45	845	87	41	1043	91
Average	40	1057	63	40	1133	68	42	880	83	42	1153	96

Figure 4.24
Comparison of Hveem Stability
for Various Types of Mixing



Hveem Stability of Styrelf Mixtures containing Lightweight Aggregate

UP-70 Mixtures



Exxon Mixtures containing crushed Stone Aggregate

Kraton D1101 Mixtures containing Crushed Stone Aggregate

Figure 4. 25
Comparison of Marshall Stability for
Various Types of Mixing

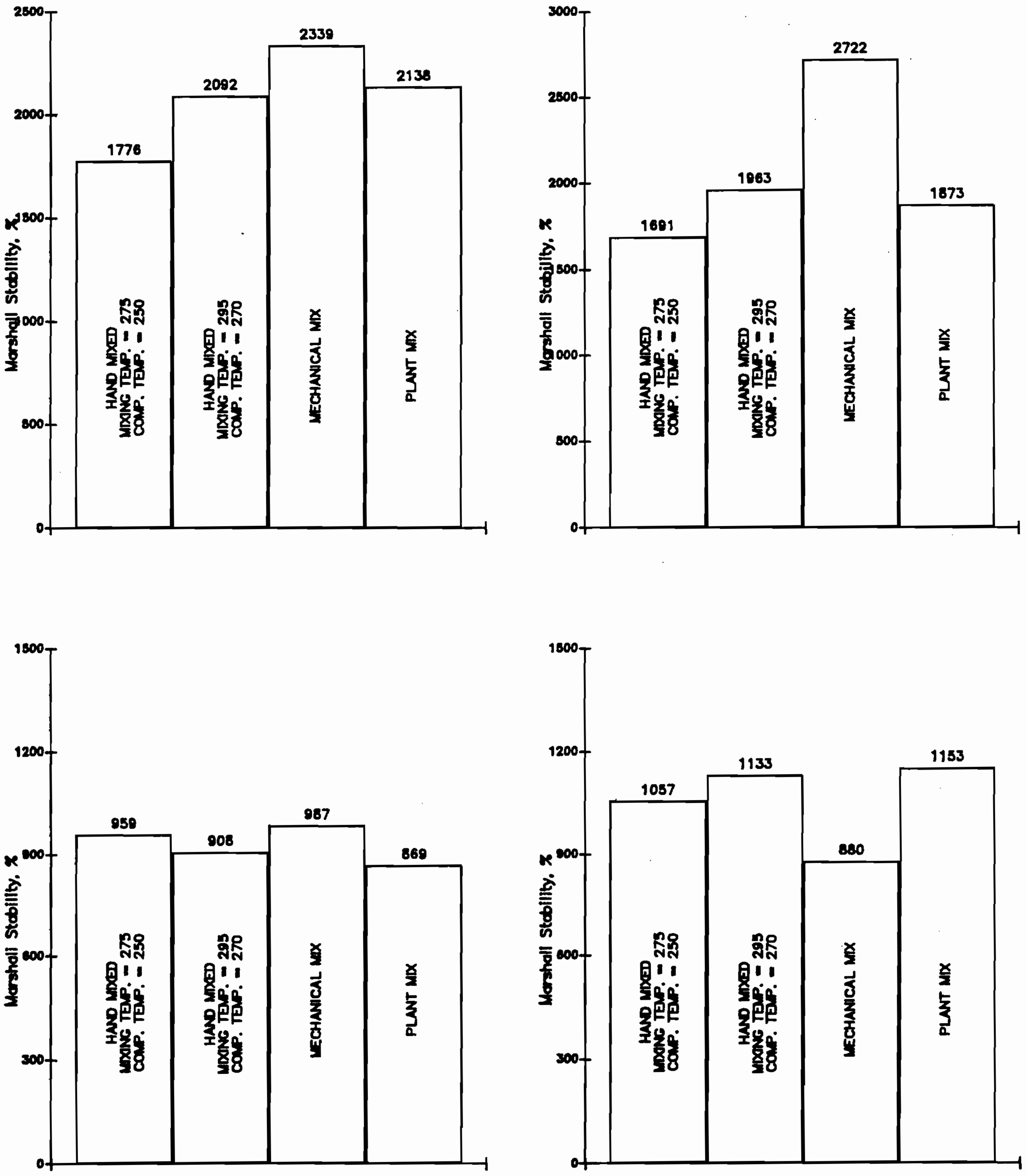
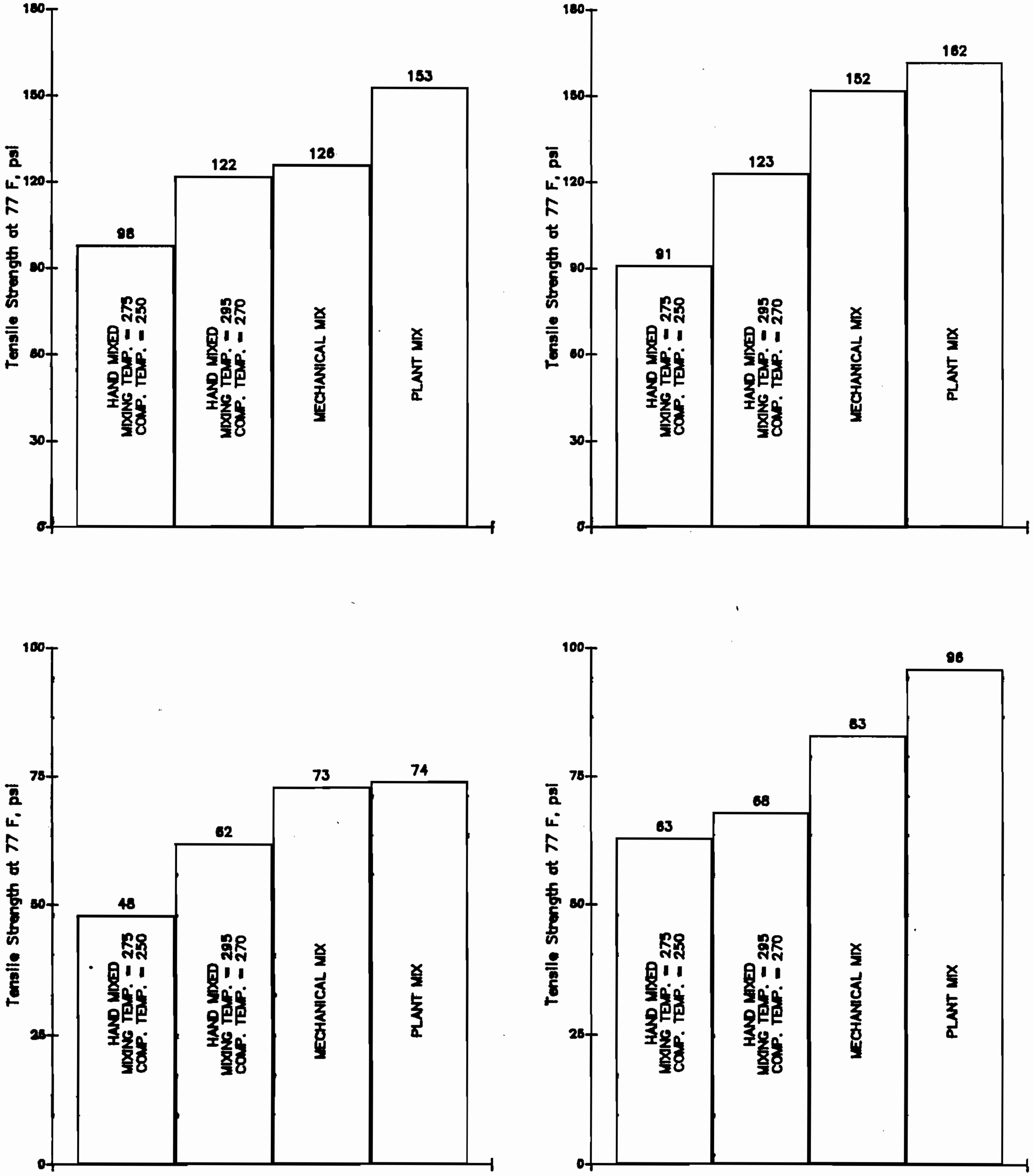


Figure 4.26
Comparison of Tensile Strength Measurements
for Various Types of Mixing



Tensile Strength

Average values of tensile strength for different mixing procedures are plotted in Figure 4.26. In all cases, the plant mixtures exhibited higher values of tensile strength than other mixtures. On the basis of the descending tensile strength values the mixing procedures can be ranked as follows:

1. Plant Mixing
2. Mechanical Mixing
3. Hand-Mixing at 295°F
4. Hand-Mixing at 275°F

It appears that to a certain extent the higher mixing temperature will improve the tensile strength of the hand-mixed mixtures. The coefficients of correlation between different mixing procedures for Hveem, Marshall Stability and tensile strength are shown in Table 4.8. Based on the correlation between hand-mixing and plant mixed materials being generally higher than the correlation between mechanical mixing and plant mixing, one is tempted to recommend hand-mixing at 295°F. However, this conclusion is based only on tensile strength and Marshall Stability measurements, and is not strongly supported by Hveem stability. The data in this study are limited, however, and are not supported by the very extensive Engineering data comparing plant versus mechanically mixed mixtures. These results (which are discussed earlier in this chapter), clearly demonstrate the positive correlations between the engineering properties of plant mixtures and mechanically mixed laboratory mixtures. Regression equations to allow prediction of plant mixed properties from mechanically-mixed samples are shown in Table 4.5. Due to the very labor-intensive nature of the hand-mixing process, and the need for repetitive hand-mixing sessions to achieve adequate asphalt coating of aggregates, the opportunity for excessive aging of hand-mixed samples is very real. High variability between different technicians and different laboratories would also be expected due to differences in hand-mixing techniques. This will lead to high variability, and make meaningful comparisons between technicians or

Table 4.8 Correlation Study of Mixing Methods Using ANOVA Techniques

R-Squared for Hveem Stability

	Hand-Mixed Temp. 275°F	Hand-Mixed Temp. 295°F	Mechanically Mixed	Plant Mixed
Hand-Mixed Temp. 275°F	1	0.90	0.80	0.01
Hand-Mixed Temp. 295°F	-	1	0.50	0.04
Mechanically Mixed	-	-	1	0.30
Plant Mixed	-	-	-	1

R-Squared for Marshall Stability

	Hand-Mixed Temp. 275°F	Hand-Mixed Temp. 295°F	Mechanically Mixed	Plant Mixed
Hand-Mixed Temp. 275°F	1	1.00	0.92	0.98
Hand-Mixed Temp. 295°F	-	1	0.90	0.99
Mechanically Mixed	-	-	1	0.83
Plant Mixed	-	-	-	1

R-Squared for Indirect Tensile

	Hand-Mixed Temp. 275°F	Hand-Mixed Temp. 295°F	Mechanically Mixed	Plant Mixed
Hand-Mixed Temp. 275°F	1	0.95	0.82	0.96
Hand-Mixed Temp. 295°F	-	1	0.92	0.98
Mechanically Mixed	-	-	1	0.95
Plant Mixed	-	-	-	1

laboratories more difficult. For these reasons, the use of hand-mixing techniques for preparing laboratory mixtures is not recommended.

CHAPTER 5

EVALUATION OF EFFECTS OF POLYMERS AND COMPARISON OF TEST METHODS

Several binder and mixture tests were used to evaluate properties of the binders and mixtures used in this study. The following three distress categories were evaluated:

1) Thermal cracking
2) Permanent deformation
3) Fatigue cracking

Currently several different binder and mixture properties are used by researchers to evaluate the susceptibility of an asphalt pavement to each of these distresses. In the course of this study eleven binder or mixture properties were measured for evaluation of thermal cracking susceptibility. Nine binder or mixture properties were measured for evaluation of permanent deformation. Only one test, the repeated load (indirect), was used for fatigue cracking evaluation due to equipment limitations at the University of Texas laboratories.

The effect of polymers on each test parameter and range of values measured for each test parameter were determined. In addition a comparison was made between various test methods in each distress category. Results of these analyses are presented in this chapter.

EFFECTS OF POLYMERS ON MEASURED PROPERTIES

Results of numerous binder laboratory tests have been presented in Chapter 3 for both control and polymer modified asphalts. These results suggest that certain tests may be better than others in identifying the presence of polymers in asphalt cement. More importantly, some of these tests should be better predictors of modified pavement performance when correlation between field performance and laboratory test results are obtained. Table 5.1 is a summary of the average range of values obtained for each test parameter for control and modified binders. Table 5.2 presents the effects of polymers on the test parameters. By reviewing Table 5.2, it can be easily determined whether addition of a given polymer causes an increase (I), decrease (D) or has no effect (E) on the asphalt cement. A brief discussion of results shown in Tables 5.1 and 5.2 will follow.

Penetration. The effect of polymer on penetration at 39°F was not statistically significant. At 77°F, certain polymers decreased penetration. Therefore, this test is not effective in characterizing polymer modified binders at 39°F. However, this test is required for determination of parameters such as Penetration index (PI) and Penetration viscosity number (PVN) which do distinguish between control and modified binders.

Viscosity. All materials tested demonstrated non-Newtonian behavior. Therefore unless the shear rate during testing is known, viscosity comparison between materials cannot be performed. In an attempt to determine the viscosity at a constant rate of shear, the shear susceptibility and viscosity at a shear rate of 1 reciprocal second were measured at different temperatures using a constant stress rheometer. The power law formula, $\eta=\eta_{01}\gamma^{c-1}$ was used to determine viscosity at a desired shear rate. The other method to compare viscosity is the constant power viscosity, which was described in Chapter 2. As shown in Tables 5.1 and 5.2, addition of polymer caused an increase

Table 5.1 Parameter Range for Modified and Control Asphalts before RTFOT

Test Parameter	TFA AC-10	AC-20	Modified AC-10	Modified AC-20
Penetration , 77 F	102	67-74	79-101	66-70
39 F	15	9-10	13-16	10
Viscosity, 140 F	1131	1998-2375	1311-8127	3296-5198
Kinematic Viscosity, 275	297	416-624	495-1013	919-1202
Constant Power Viscosity, 39 F	2.76E+07	5.13E07-7.18E07	3.74E07-4.69E08	5.76E07-1.01E8
77 F	1.12E+05	2.87E05-3.70E05	2.14E05-6.01E05	3.6E05-7.55E05
140 F	9.65E+01	1.68E02-1.95E02	1.24E02-1.00E03	2.74E02-3.68E02
Viscosity-Temp. Susceptibility	-0.096	(-0.100)-(-0.096)	(-0.103)-(-0.085)	(-0.098)-(-0.093)
Softening Point	117	126-128	122-147	133-139
Penetration Index PI(pen/pen)	-0.18	(-0.43)-(-0.23)	(-0.11)-(1.06)	(-0.04)-(0.17)
Penetration Index PI(pen/sp)	-0.04	0.19-0.62	0.46-3.92	0.98-1.66
Penetration Viscosity Number	-0.72	(-0.60)-(-0.03)	0.02-1.25	0.62-0.96
Shear Susceptibility, 39 F	0.60	0.49-0.65	0.53-1.28	0.51-0.51
77 F	0.88	0.66-0.80	0.68-1.15	0.52-0.63
140 F	0.94	0.83-0.89	0.70-1.02	0.71-0.78
Asphalt Stiffness @ 0.1 sec, 39 F	5075	6525-7540	943-4785	4640-5800
77 F	160	290-334	145-247	319-363
104 F	12	23-36	15-46	33-54
Stiffness-Temp. Susceptibility	-0.073	(-0.69)-(-0.063)	(-0.068)-(-0.041)	(-0.062)-(-0.054)
Penetration Retained	0.63	0.59-0.68	0.57-0.75	0.65-0.70
Viscosity Ratio	2.65	2.60-3.55	1.69-3.00	6.08-7.97
Kinematic Viscosity Ratio	1.56	1.43-1.80	1.04-1.94	1.94-1.99
Cracking Temperature	-48	(-44)-(-41)	(-74)-(-45)	(-48)-(-43)
Maximum True Stress	60	60-120	75-595	174-289
Maximum True Strain	2.95	2.23-2.44	1.39-3.73	2.28-2.46
Area under Stress-Strain Curve	115	83-136	125-473	198-363
Asphalt Modulus	146	242-472	115-296	346-413
Asphalt-Polymer Modulus	-	-	50-819	0.0-205

Table 5.2 Effect of Polymers on the Properties of TFA Asphalt Cement before RTFOT

Test Parameter	SBS	SBR	SBR/Polyolefin	EVA	Rubber C107
Penetration , 77 F	E	E,D	D	E	D
39 F	E	E	E	E	E
Viscosity, 140 F	I	I	I	I	I
Kinematic Viscosity, 275	I	I	I	I	I
Constant Power Viscosity, 39 F	I	I	D	I	I
77 F	I	I	I	I	I
140 F	I	I	I	I	I
Viscosity-Temp. Susceptibility	E	E	D	D	E
Softening Point	I	I	I	I	I
Penetration Index	I	I	I	I	I
Penetration Viscosity Number	I	I	I	I	-
Shear Susceptibility, 39 F	I	I	D	D	E
77 F	I	E,D	D	D	D
140 F	I	E,I	D	D	D
Stiffness Modulus, 39 F	D	D	D	D	D
77 F	I	I,D	I	I	I
104 F	I	I	I	I	I
Stiffness-Temp. Susceptibility	D	E,D	D	D	D
Penetration Retained	I	I	E	I	-
Viscosity Ratio	D	I	I	I	-
Kinematic Viscosity Ratio	D	D	I	I	-
Power Viscosity Ratio, 39 F	I	I,D	D	D	-
77 F	D	D	D	D	-
140 F	D	I	I	I	-
Cracking Temperature	I	E	I	E	I
Maximum True Stress	I	E,I	I	I	I
Maximum True Strain	E	I	E	E	D
Area under Stress-Strain Curve	I	I	I	I	E
Asphalt Modulus	I	I	I	E	I
Asphalt-Polymer Modulus	I	I	E	I	I

in viscosity at all test temperatures. In addition, temperature susceptibility, as measured by changes in viscosity with changes in test temperature, was evaluated. Only EVA and Dow polymers caused a decrease in the Viscosity-temperature susceptibility. Other polymers did not change this parameter significantly.

Softening Point. All polymers caused an increase in the softening point. Therefore, this test parameter may be used to determine characteristics of polymer modified binders.

Penetration Index (PI) and Penetration Viscosity Number (PVN). Penetration Index and Penetration Viscosity Number increased through the addition of polymers. This indicates that modified asphalt binders are less temperature susceptible than the controls. The range of penetration index and penetration-viscosity number values for modified and unmodified binders are shown in Table 5.1.

Shear Susceptibility. Polymer modified binders evaluated in this study were generally shear thinning liquids. However, not all combinations of the materials tested demonstrated this behavior. This behavior is a desirable trait during construction. Polymer modified binders showed high viscosity at the low shear rates applied in the laboratory. If these materials were not shear thinning, mixing temperature during construction would have to be significantly increased to ensure proper handling. However, the shear thinning characteristics will cause a significant reduction in viscosity at high shear rates experienced during construction. Therefore, mixing temperatures do not need to be increased significantly.

Stiffness modulus. It would be desirable for paving binder to have low stiffness at low temperatures and high stiffness at high temperatures. Polymers used in the study generally reduced stiffness at low temperatures and increased stiffness at high temperatures. Therefore, stiffness-temperature susceptibility of the polymer modified binders were less than the controls. This effect is shown in Table 5.2. The range of stiffness and stiffness-temperature susceptibility values for modified and control binders are shown in Table 5.1.

Aging Index. SBS polymers generally reduced the aging index. The effect of other polymers on aging index is not as clear. Table 5.1 shows the range of aging indices for modified and control binders.

Cracking Temperature. Thermal cracking was improved by the addition of SBS, Dow and Genstar C107 polymers. Low temperature cracking obtained by the critical stress method or limiting stiffness method did not seem to be realistic as related to performance. These methods indicated extremely low cracking temperatures such as -60°F. However, these methods may be utilized when comparison between materials is desired.

Maximum Tensile Stress and Strain. Maximum tensile stress and strain should be very useful in identifying characteristics of modified binders. The limits of tensile strength and tensile strain for modified and control binders are shown in Table 5.2. The modified binders studied generally had much higher tensile strength and tensile strain than their control asphalts. This may indicate high performance binders for use in paving construction.

Area Under Stress-Strain Curve. All polymers except the rubber (C107) increased the amount of work required (area under stress-strain curve) to break the binder at 39°F in force-ductility testing. This parameter is the force-ductility counterpart to "toughness" in the toughness and tenacity test.

Asphalt Modulus. The polymers studied generally caused an increase in asphalt modulus. However, polymer modified AC-10 binders generally demonstrated lower asphalt modulus than AC-20 controls. Desirable cold temperature properties would include a material with low modulus, high tensile strength and high strain at failure.

Asphalt-Polymer Modulus. This parameter may be useful in determining whether an asphalt has been polymer modified. The control asphalts did not demonstrate secondary loading during the force-ductility test. Existence of secondary loading during the force-ductility test generally indicates that the asphalt has been polymer modified. The range of values are shown in Table 5.1.

COMPARISON OF TEST METHODS

Several different tests were used to evaluate the thermal cracking, permanent deformation and temperature susceptibility of binders and corresponding mixtures. These tests are currently used in the paving industry for determining performance characteristics of paving binders and mixtures. However, they do not always give the same performance prediction. In this portion of the study each binder or mixture in a given district was ranked according to its influence on pavement performance as predicted by each test property. Results of the ranking are shown in Table 5.3 through 5.5 for thermal cracking, permanent deformation and temperature susceptibility, respectively.

Table 5.3 Comparison of Test Methods Used in Temperature Susceptibility Evaluation.

DISTRICT	PI(pen/pen)	PI(pen/sp)	PVN	STIFFNESS TEMP SUSCEP.	VIS. TEMP. SUSCEP.
15	AC-20	AC-10	AC-10	AC-10	NS-175
15	AC-10	AC-20	AC-20	AC-20	AC-20
15	NS-175	NS-175	NS-175	NS-175	POLYBILT
15	UP-70	UP-70	UP-70	UP-70	UP-70
15	POLYBILT	POLYBILT	POLYBILT	POLYBILT	AC-10
15	DOW	DOW	STYRELF	DOW	STYRELF
15	STYRELF	STYRELF	DOW	STYRELF	DOW
15	GENSTAR	GENSTAR		GENSTAR	GENSTAR
11	AC-20	AC-20	AC-20	AC-20	UP-70
11	UP-70	UP-70	STYRELF	UP-70	AC-20
11	STYRELF	STYRELF	UP-70	STYRELF	STYRELF
25	AC-20	AC-20	AC-20	AC-20	3% KRATON
25	STYRELF	STYRELF	3% KRATON	STYRELF	6% KRATON
25	3% KRATON	3% KRATON	STYRELF	3% KRATON	AC-20
25	6% KRATON	6% KRATON	6% KRATON	6% KRATON	STYRELF
10	AC-20	AC-20	AC-20	AC-20	-
10	UP 70	UP 70	UP 70	POLYBILT	-
10	POLYBILT	STYRELF	POLYBILT	STYRELF	-
10	STYRELF	POLYBILT	STYRELF	UP 70	-
10	KRATON	KRATON	KRATON	KRATON	-

Note: Binders and mixtures are listed in ascending order of reducing temperature susceptibility as measured by each test method in a given district.

Table 5.4 Comparison of Test Methods used in Thermal Cracking Evaluation.

DISTRICT	VISCOSITY 39 F	MAXIMUM TRUE STRESS 39 F	MAXIMUM TRUE STRAIN 39 F	CURVE AREA 39 F	ASPHALT MODULUS 39 F	STIFFNESS MODULUS 39 F	CRACKING TEMPERATURE	TENSILE STRENGTH 39 F	TENSILE STRAIN 39 F	SECANT MODULUS 39 F	RESILIENT MODULUS 39 F
15	POLYBILT	AC-10	GENSTAR	AC-10	DOW	AC-20	AC-20	AC-20	AC-20	AC-20	POLYBILT
15	STYRELF	UP-70	DOW	AC-20	POLYBILT	POLYBILT	POLYBILT	STYRELF	POLYBILT	POLYBILT	STYRELF
15	AC-20	AC-20	AC-20	GENSTAR	AC-20	AC-10	NS-175	AC-10	DOW	DOW	AC-10
15	GENSTAR	NS-175	POLYBILT	UP-70	NS-175	NS-175	AC-10	DOW	UP-70	UP-70	AC-20
15	NS-175	GENSTAR	STYRELF	DOW	GENSTAR	DOW	DOW	NS-175	NS-175	NS-175	UP-70
15	DOW	DOW	AC-10	NS-175	STYRELF	UP-70	UP-70	UP-70	AC-10	AC-10	NS-175
15	UP-70	POLYBILT	UP-70	POLYBILT	UP-70	GENSTAR	GENSTAR	POLYBILT	STYRELF	STYRELF	DOW
15	AC-10	STYRELF	NS-175	STYRELF	AC-10	STYRELF	STYRELF	GENSTAR	GENSTAR	GENSTAR	GENSTAR
11	UP-70	AC-20	AC-20	AC-20	AC-20	AC-20	AC-20	UP-70	UP-70	UP-70	AC-20
11	AC-20	UP-70	STYRELF	UP-70	UP-70	UP-70	UP-70	STYRELF	AC-20	AC-20	UP-70
11	STYRELF	STYRELF	UP-70	STYRELF	STYRELF	STYRELF	STYRELF	AC-20	STYRELF	STYRELF	STYRELF
25	3% KRATON	AC-20	AC-20	AC-20	AC-20	AC-20	AC-20	STYRELF	AC-20	AC-20	AC-20
25	6% KRATON	STYRELF	6% KRATON	STYRELF	3% KRATON	STYRELF	STYRELF	3% KRATON	STYRELF	STYRELF	3% KRATON
25	AC-20	3% KRATON	STYRELF	6% KRATON	STYRELF	3% KRATON	3% KRATON	AC-20	3% KRATON	3% KRATON	STYRELF
25	STYRELF	6% KRATON	3% KRATON	3% KRATON	6% KRATON	6% KRATON	6% KRATON	6% KRATON	6% KRATON	6% KRATON	6% KRATON
10	-	-	-	-	-	AC-20	AC-20	UP 70	UP 70	UP 70	STYRELF
10	-	-	-	-	-	UP 70	UP 70	STYRELF	AC-20	STYRELF	AC-20
10	-	-	-	-	-	POLYBILT	STYRELF	KRATON	STYRELF	AC-20	KRATON
10	-	-	-	-	-	STYRELF	POLYBILT	AC-20	KRATON	KRATON	UP 70
10	-	-	-	-	-	KRATON	KRATON	POLYBILT	POLYBILT	POLYBILT	POLYBILT

Note: Binders and mixtures are listed in ascending order of reducing thermal cracking susceptibility as measured by each test method in a given district.

Table 5.5 Comparison of Test Methods used in Permanent Deformation Evaluation.

DISTRICT	VISCOSITY 140 F	STIFFNESS 104 F	MARSHALL STABILITY	HVEEM STABILITY	TENSILE STRENGTH 104 F	SECANT MODULUS 104 F	RESILIENT MODULUS 104 F	ALPHA 77 F	CREEP COMPLIANCE 1000 sec.
15	AC-10	AC-10	AC-10	UP-70	AC-10	GENSTAR	GENSTAR	AC-10	AC-10
15	NS-175	UP-70	STYRELF	STYRELF	GENSTAR	AC-10	AC-10	AC-20	STYRELF
15	UP-70	NS-175	UP-70	AC-10	UP-70	STYRELF	STYRELF	NS-175	NS-175
15	AC-20	AC-20	GENSTAR	GENSTAR	STYRELF	UP-70	NS-175	UP-70	UP-70
15	POLYBILT	STYRELF	POLYBILT	POLYBILT	NS-175	NS-175	UP-70	GENSTAR	GENSTAR
15	STYRELF	POLYBILT	DOW	DOW	POLYBILT	POLYBILT	POLYBILT	STYRELF	AC-20
15	DOW	GENSTAR	NS-175	NS-175	AC-20	AC-20	AC-20	POLYBILT	POLYBILT
15	GENSTAR	DOW	AC-20	AC-20	DOW	DOW	DOW	DOW	DOW
11	AC-20	UP-70	STYRELF	STYRELF	STYRELF	STYRELF	STYRELF	UP-70	STYRELF
11	UP-70	STYRELF	AC-20	UP-70	AC-20	UP-70	UP-70	AC-20	AC-20
11	STYRELF	AC-20	UP-70	AC-20	UP-70	AC-20	AC-20	STYRELF	UP-70
25	AC-20	STYRELF	AC-20	6% KRATON	AC-20	6% KRATON	6% KRATON	AC-20	6% KRATON
25	STYRELF	AC-20	6% KRATON	STYRELF	6% KRATON	3% KRATON	3% KRATON	3% KRATON	STYRELF
25	3% KRATON	3% KRATON	STYRELF	AC-20	3% KRATON	STYRELF	STYRELF	STYRELF	3% KRATON
25	6% KRATON	6% KRATON	3% KRATON	3% KRATON	STYRELF	AC-20	AC-20	6% KRATON	AC-20
10	AC-20	STYRELF	POLYBILT	POLYBILT	POLYBILT	KRATON	STYRELF	KRATON	AC-20
10	UP 70	POLYBILT	KRATON	KRATON	KRATON	POLYBILT	UP 70	UP 70	POLYBILT
10	POLYBILT	KRATON	AC-20	AC-20	UP 70	STYRELF	POLYBILT	STYRELF	KRATON
10	STYRELF	AC-20	UP 70	STYRELF	STYRELF	UP 70	KRATON	AC-20	STYRELF
10	KRATON	UP 70	STYRELF	UP 70	AC-20	AC-20	AC-20	POLYBILT	UP 70

Note: Binders and mixtures are listed in ascending order of reducing permanent deformation susceptibility as measured by each test method in a given district.

Temperature Susceptibility. Table 5.3 shows the ranking of binders which reflect their temperature susceptibility. Five parameters, PI (Pen/Pen), PI (Pen/Sp), PVN, stiffness-temperature slope and viscosity-temperature slope were used in determining temperature susceptibility. As shown in Table 5.3, PI (Pen/Pen), PI (Pen/Sp) PVN and the stiffness temperature slope will generally produce the same ranking or performance prediction. Therefore, only one of these parameters needs to be evaluated in future studies.

Thermal Cracking. Table 5.4 shows the ranking of binders and their corresponding mixtures as related to thermal cracking. Eleven parameters were used in determining thermal cracking susceptibility. As shown in Table 5.4, maximum strength at 39°F and the area under the stress strain curve yielded approximately the same ranking. In addition, stiffness at 39°F and cracking temperature also yielded approximately the same ranking. For mixture tests, tensile strain and secant modulus at 39°F produced exactly the same ranking.

Permanent Deformation. Table 5.5 shows the ranking of binders and mixtures as related to permanent deformation. The nine parameters shown in Table 5.5 were used to determine the susceptibility to permanent deformation . Viscosity at 140°F and stiffness at 104°F yielded approximately the same ranking. In addition, tensile strength at 104°F and secant modulus at 104°F also produced approximately the same ranking.

At the present time, the actual field performance of these binders has not been determined due to the short in-service life of the test sections. When actual field performance evaluations are completed, it will be possible to identify tests which best predict field performance. After identifying tests which predict pavement performance, mix design criteria can be established with the aid of the data presented in previous chapters.

CHAPTER 6

CONCLUSIONS

During the course of this study, 20 hot mix test sections were constructed in four districts of the Texas Department of Transportation. Seven different polymers were utilized in the study. The polymer modified asphalt binders and their corresponding HMAC mixtures were evaluated in a comprehensive testing program. These materials were studied to evaluate the effects of polymers on the properties of both the asphalt and HMAC mixtures. In addition, several tests were evaluated in order to determine the effectiveness of these test methods in characterizing polymers. Once the field performance of the test sections is determined after long-term performance evaluations, the results presented in this report can be used to develop a comprehensive mixture design and analysis method for polymer-modified hot-mixed asphalt concrete.

Based on the conditions of this study and the results of the data analysis the following conclusions appear warranted:

A. Test Method

1. Both the empirical and the fundamental tests evaluated in this study may be useful for identifying polymer-modified binder properties. However, viscosity tests (ASTM D2170 and ASTM D2171) are inadequate in characterizing the polymer modified binders unless the shear rate is measured. All modified binders demonstrated non-Newtonian behavior.
2. Conventional capillary viscometer tests may provide misleading results for mixing and compaction temperatures of asphalt concrete due to the differences in shear rate which exist between mixing plants and capillary

viscometers. Most polymer-modified binders show shear-thinning behavior. Therefore these binders exhibited low viscosity at the high shear rates which exist in plant production processes.

3. The Schweyer constant stress rheometer is a reliable testing device for the evaluation of rheological properties of binders. It is possible to construct flow diagrams over a wide range of shear stress, rate of shear, and test temperature using this rheometer.
4. Constant power viscosity eliminates the need for excessive extrapolation of viscosity from one shear rate to another. This parameter can be used for comparison of binder viscosity, particularly at low temperatures.
5. The flow behavior of the binders used in this study can be described by the power law formula.
6. At a given shear rate viscosities obtained with the capillary tube viscometer and the Schweyer Rheometer are comparable.
7. As a result of this study, a comparison is made between various test methods which are commonly used to predict thermal cracking, permanent deformation and temperature susceptibility. This comparison may help to identify tests which predict field performance after actual field performance data is obtained.

B. Binder Properties

1. Temperature susceptibility is significantly decreased for modified binders as measured by either penetration index or penetration viscosity number.
2. The addition of polymers decreased stiffness temperature susceptibility. The effect was very pronounced for both the SBS and Genstar C107.
3. The Genstar C107 and SBS polymers appear to be very

effective in lowering the predicted pavement cracking temperature, but for the asphalt rubber this may not be directly linked to the polymer itself. This is due to the presence of up to 30% light oils in the ground tire rubber.

4. Rolling thin film oven aging generally affected properties of SBS binders less than SBR binders.
5. The addition of polymers significantly increased tensile strength and the area under stress-strain curves of the binder. This may indicate a higher resistance to cracking of these binders.
6. Of all polymer-modified binders evaluated, only Dow did not exhibit the second slope in the stress-strain curve. This may indicate the non-compatibility of the polymer and asphalt cement.
7. The binders tested in this study exhibited non-Newtonian flow behavior. The degree of non-Newtonian flow increased with RTFOT aging, and decreased as the test temperature increased.

C. Mixture Properties

1. Hveem stability of mixtures was not significantly affected by the polymers. Although Hveem stability is quite sensitive to changes in binder quantity, it is not sensitive to changes in rheological properties of the binder.
2. Polymers generally increased the Marshall Stability of mixtures containing AC-10 asphalt cements up to that of the AC-20 control mixtures.
3. Indirect tension test results showed that polymers generally increased the mixture tensile strength and secant modulus at the high temperatures. This may indicate an improved resistance to permanent deformation.

However, resilient modulus of mixtures was not significantly affected by the addition of polymers. Tensile strain at failure of modified AC-10 mixtures were significantly higher than that of the AC-20 controls at low temperatures. This may be indicative of improved resistance to thermal cracking where modified AC-10 is used instead of AC-20 asphalt cement.

4. The polymers used in this study, especially SBS, improved moisture damage resistance of the mixture. Addition of 1% lime to the mixtures in District 25 masked the effect of the polymers due to the high tensile strength ratio (TSR) exhibited by mixtures due to lime addition.
5. Fatigue response of mixtures containing AC-10 plus a polymer was generally superior or equal to the control mixtures which contain AC-20 with no polymer. The Styrelf and Genstar C107 had the greatest improvement in fatigue response among the polymers used in this study.
6. A linear regression relationship between log K_1 and K_2 (fatigue constants) was developed as follows:

   $K_2 = 1.110 - 0.270 \log K_1$

   $R = 0.986 \quad Se = 0.135$
7. Indirect tensile creep testing showed that addition of polymer to mixtures improved permanent deformation resistance. SBR modified binders showed more improvement than SBS modified binders.

D. Plant Mixed vs. Laboratory Mixed Properties

1. Stepwise regression analysis was performed to predict engineering properties of plant mixed mixtures from engineering properties of laboratory prepared mixtures. Other factors such as mixing temperature, air voids, test temperature and aging indices were also included in the regression analysis. It was found that for engineering

properties such as Marshall Stability, Marshall Flow, Hveem Stability, Tensile Strength, Tensile strain at failure, secant modulus, resilient modulus, fatigue constants and intercept and slope of creep compliance curve, the laboratory prepared mixture properties may be used to predict properties of plant mixed HMAC.

APPENDIX A

PRESENTATION OF TEST RESULTS - DISTRICT 15

APPENDIX A

PRESENTATION OF TEST RESULTS - DISTRICT 15

The objectives of Appendix A are twofold: (1) to describe the site-specific field operations of the test sections along with a description of the materials, polymers, and construction techniques used for this field project, and (2) to present the laboratory test results of the unmodified and modified binders and laboratory mixed and plant mixed mixtures for the experimental field study in District 15 of the Texas Department of Transportation (TxDOT).

EXPERIMENTAL FIELD PROGRAM

The test pavements were constructed on US 281 in Comal County, Texas, in April 1987, and involved pavement overlay of one lane of the highway. The test sections are shown schematically in Figure A-1. Each test section was approximately one to one and a half inches thick, twelve feet wide, and 1500 feet long. A total of seven test sections were constructed with six different polymers plus a control. Field construction was conducted by District 15 of the TxDOT and assisted by the Center for Transportation Research, the University of Texas at Austin. The average daily traffic (ADT) was estimated at 2650 vehicles for the test pavement.

MATERIALS

ASPHALT CEMENT. AC-10 and an AC-20 asphalt cements were supplied by Texas Fuel and Asphalt of Corpus Christi, Texas, and used throughout this project.

AGGREGATE. Four aggregates, a grade No. 4 sandstone, a grade No. 5 limestone, a limestone screening, and a field sand, were combined to produce the project gradation. Gradations of individual aggregates, the project gradation, percentage of each aggregate, and the gradation specifications are given in Table A-1. The project gradation is plotted on a 0.45 power graph in Figure A-2.

POLYMER. Six polymers included in this field project consisted of two types of Styrene Butadiene Rubber (SBR), one type of Styrene block copolymer (SBS), a combination of SBR latex and functionalized Polyolefin, an Ethylene Vinyl Acetate (EVA), and recycled tires (rubber). Sources of these polymers and designations used for this study are shown below.

SOURCE	TYPE	DESIGNATION
Goodyear	SBR	UP 70
Polysar	SBR	NS 175
Elf	SBS	Styrelf-13
Dow	SBR/Polyolefin	-
Exxon	EVA	Polybilt 103
Crafco	Recycled tires	Genstar C107

Blending of the asphalts and the polymers was performed by the polymer manufacturers or processors in the refinery or in a distributor truck. No polymer was introduced into the asphalt in-line injection system of the plant.

Styrene Butadiene Rubber. Styrene Butadiene latices are available in a wide variety of monomer proportions, molecular weight ranges, emulsifier types and other variations. Two products specifically recommended for use in hot mix asphalt concrete, UP-70 and NS- 175, were included in this field project. The latex UP-70 and the polysar NS-175 were supplied by Textile Rubber and Chemical Co. and BASF Co., respectively. The total amount of the UP-70 and the NS-175 used in the TFA AC-10 was 3 percent in each blend.

Styrene Butadiene Styrene. The Styrelf-13 utilized was a copolymer of Styrene and Butadiene. The Styrelf modified binder was blended by Elf Asphalt Co. with the TFA AC-10 at 3% polymer by weight of total binder.

SBR/Polyolefin. This polymer, a combination of a SBR latex and a functionalized polyolefin, was supplied by Dow Chemical Co. The modified binder contained 5 percent polymer (2 percent polyolefin and 3 percent SBR solids) and 95 percent TFA AC-20.

Ethylene Vinyl Acetate. The polybilt 103, a copolymer of Ethylene Vinyl Acetate (EVA), was obtained from Exxon Chemical Co. This polymer had a permanent polarity which was associated with the acetate group. The modified binder contained 97 percent TFA AC-20 and 3 percent polybilt 103.

Rubber. The Genstar C107 obtained from Crafco Co. consisted of chiefly vulcanized SBR or polyisoprene. Blending of the TFA AC-10 and the Genstar C107 was done in a distributor truck in the plant at 350°F at high shear. The blend which contained 18 percent rubber (Genstar C017) by the weight of binder resulted in a highly viscous and tacky asphalt binder.

FIELD OPERATION

Approximately 600 tons of each mix was produced using a batch plant. Identical aggregates were utilized throughout the experiment. Two grades , AC-10 and AC-20, of TFA asphalt cement were utilized. The Ultra Pave 70 (3 percent), Genstar C107 (18 percent), Polysar NS-175 (3 percent) and Styrelf-13 (3 percent) were blended with the TFA AC-10. The Dow (5 percent) and Polybilt 103 (3 percent) were preblended with the TFA AC-20.

Mixing temperature for the Polybilt 103, NS 175, Styrelf-13 and Dow mixtures was about 320°F and was increased to about 340°F for the Genstar C107 and UP-70 mixtures. The control asphalt, TFA

AC-20, was mixed at 315°F. The initial breakdown compaction occurred between 250°F and 270°F except for the Polybilt 103 mixtures. The polybilt modified mixtures were allowed to cool down to between 220°F and 230°F before rolling, and at these temperatures the mixtures exhibited good handling characteristics. The Genstar C107 modified mixtures were noticeably stiffer than the other mixtures and did not lay as smoothly. The mixtures containing UP-70 showed problems during construction. These problems were confined to the mixture sticking to the dump trucks during delivery and workability through the paver. Compaction of each test section was achieved using a vibratory roller, a pneumatic roller and a steel wheel roller. Environmental conditions during construction were favorable, with early morning temperatures of approximately 70°F and afternoon temperatures of 95°F.

Twelve field cores were obtained from each test section soon after the construction. These cores were approximately 4-inches in diameter and one to one and a half inches in thickness. The field cores were transported to the Center for Transportation Research immediately after sampling.

PRESENTATION OF TEST RESULTS

Summaries of test results for the unmodified and modified binders are presented in Tables A-6 through A-8 and are plotted in Figures A-3 through A-47.

Summaries of test results for the unmodified and modified mixtures are presented in Tables A-9 through A-26 and are plotted in Figures A-48 through A-67.

Table A-1 AGGREGATE GRADATION (DISTRICT 15)

	Sandstone		Limestone		Limestone Screenings		Field Sand			
	Sieve Analysis	31%	Sieve Analysis	27%	Sieve Analysis	19%	Sieve Analysis	23%	Combined Gradation	SDHPT Specification
Plus 1/2 in.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1/2 to 3/8 in	33.0	10.2	0.0	0.0	0.0	0.0	0.0	0.0	10.2	0-15
3/8 to No. 4	57.1	17.7	50.5	13.6	0.0	0.0	0.0	0.0	31.3	21-53
No. 4 to No. 10	7.5	2.3	47.1	12.7	18.3	3.5	0.1	0.0	18.5	11-32
Plus No. 10									60.1	54-74
No. 10 to No.40	0.5	0.2	1.3	0.4	54.4	10.3	12.2	2.8	13.6	6-32
No. 40 to No. 80	0.1	0.0	0.1	0.0	16.5	3.1	62.6	14.4	17.6	4-27
No. 80 to No. 200	0.3	0.1	0.5	0.1	7.6	1.4	21.4	4.9	6.6	3-27
Minus No. 200	1.5	0.5	0.5	0.1	3.2	0.6	3.7	0.9	2.1	1-8
Total	100.0	31.0	100.0	27.0	100.0	19.0	100.0	23.0	100.0	

TABLE A-2 Experimental Testing Program for Unmodified and Polymer-Modified Asphalt Binders
Number of Test Repetitions (District 15)

Binder		Penetration			Viscosity				Softening Point	Force Ductility	Schweyer Rheology					
		Before RTFOT		After RTFOT	Before RTFOT		After RTFOT		Before RTFOT	Before RTFOT 39.2 F	Before RTFOT			After RTFOT		
Asphalt	Polymer	39.2 F	77 F	77 F	140 F	275 F	140 F	275 F			39 F	77 F	140 F	39 F	77 F	140 F
TFA AC-10	-	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-10	Goodyear UP 70	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-10	Styrelf-13	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-10	Polysar NS 175	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-10	Crafco Genstar C107	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-20	-	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-20	Exxon Polybilt 103	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-20	Dow	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1

TABLE A-2 Experimental Testing Program for Unmodified and Polymer-Modified Asphalt Binders
Number of Test Repetitions (District 15)

Binder		Penetration			Viscosity				Softening Point	Force Ductility	Schweyer Rheology					
		Before RTFOT		After RTFOT	Before RTFOT		After RTFOT		Before RTFOT	Before RTFOT 39.2 F	Before RTFOT			After RTFOT		
Asphalt	Polymer	39.2 F	77 F	77 F	140 F	275 F	140 F	275 F			39 F	77 F	140 F	39 F	77 F	140 F
TFA AC-10	-	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-10	Goodyear UP 70	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-10	Styrelf-13	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-10	Polysar NS 175	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-10	Crafco Genstar C107	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-20	-	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-20	Exxon Polybilt 103	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
TFA AC-20	Dow	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1

TABLE A-3 Experimental Testing Program for Laboratory Compacted-Laboratory Mixed Mixtures
Number of Test Repetitions (District 15)

Binder		Modified Compaction												Standard Compaction				
		Resilient Modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F	Creep @			Fatigue Stress levels			Moisture Resistance	Resilient Modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F
Asphalt	Polymer	39F	77F	104F			60F	77F	90F	15%	25%	50%		39F	77F	104F		
TFA AC-10	Goodyear UP 70	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-10	Styrelf-13	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-20	-	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-20	Exxon Polybilt 103	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-10	Crafco Genstar C107	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-10	Polysar NS 175	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-20	Dow	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-10	-	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3

* TFA AC-10 mixture was not placed in the field test section.

TABLE A-4 Experimental Testing Program for Laboratory Compacted-Plant Mixed Mixtures
Number of Test Repetitions (District 15)

Binder		Modified Compaction												Standard Compaction				
		Resilient Modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F	Creep @			Fatigue Stress levels			Moisture Resistance	Resilient Modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F
Asphalt	Polymer	39F	77F	104F			60F	77F	90F	15%	25%	50%		39F	77F	104F		
TFA AC-10	Goodyear UP 70	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-10	Styrelf-13	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-20	-	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-20	Exxon Polybilt 103	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-10	Crafco Genstar C107	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-10	Polysar NS 175	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
TFA AC-20	Dow	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3

TABLE A-5 Experimental Testing Program for Field Cores. District 15

Binder		Resilient Modulus & Indirect Tensile Strength			Marshall 140F
Asphalt	Polymer	39F	77F	104F	
TFA AC-10	Goodyear UP 70	3	3	3	3
TFA AC-10	Styrelf-13	3	3	3	3
TFA AC-20	-	3	3	3	3
TFA AC-20	Polybilt 103	3	3	3	3
TFA AC-10	Genstar C107	3	3	3	3
TFA AC-10	Polysar NS 175	3	3	3	3
TFA AC-20	Dow	3	3	3	3

Table A-6 Unmodified and Modified Asphalt Properties before RTFOT.

Parameter		TFA AC-10	TFA AC-10 & 3% Goodyear	TFA AC-10 & 3% Styrelf	TFA AC-10 & 3% Polysar	TFA AC-10 & 18% Crafco	TFA AC-20	TFA AC-20 & 3% Exxon	TFA AC-20 & 5% Dow
Penetration @ 39.2 F (25 C)		15	15	17	13	16	9	10	9
100g, 5 Sec.		14	13	15	13	14	9	10	11
	Avg.	14.5	14	16	13	15	9	10	10
Penetration @ 77 F (4 C)		101	99	101	92	78	69	69	67
100g, 5 Sec.		103	101	101	94	80	71	70	65
	Avg.	102	100	101	93	79	70	69.5	66
Viscosity @ 140 F (60 C)		1124	1300	3347	1320	-	2091	3300	5235
Poises		1138	1321	3317	1316	-	2083	3291	5161
	Avg.	1131	1310.5	3332	1318	-	2087	3295.5	5198
Viscosity @ 275 F (135 C)		298	500	750	490	-	414	927	1194
Centistokes		296	506	757	500	-	418	911	1209
	Avg.	297	503	753.5	495	-	416	919	1201.5
Softening Point, F		117	123	132	121	139	126	131	140
		117	121	131	123	137	126	134	138
	Avg.	117	122	131.5	122	138	126	132.5	139

Table A-6 (Continued)

Parameter		TFA AC-10	TFA AC-10 & 3% Goodyear	TFA AC-10 & 3% Styrelf	TFA AC-10 & 3% Polysar	TFA AC-10 & 18% Crafco	TFA AC-20	TFA AC-20 & 3% Exxon	TFA AC-20 & 5% Dow
Maximum True Stress, psi		63.2	85.8	382.8	127.2	135.3	102.8	286.5	172.2
		55.2	81.4	391.1	121.6	124.5	99.1	291.2	175.1
	Avg.	59.2	83.6	386.95	124.4	129.9	100.95	288.85	173.65
Maximum True Strain, in/in		2.97	3.5	2.76	3.54	1.39	2.39	2.47	2.26
		2.93	3.52	2.77	3.52	1.38	2.4	2.45	2.3
	Avg.	2.95	3.51	2.765	3.53	1.385	2.395	2.46	2.28
True Area , psi		117.8	156.4	392.8	245.4	125.1	124	363.3	194.7
		112.4	161.3	414.5	251.2	124.7	118.8	361.8	201.5
	Avg.	115.1	158.85	403.65	248.3	124.9	121.4	362.55	198.1
Asphalt Modulus, psi		132.2	210.8	238	304.9	222.6	339.8	320.5	405.3
		158.8	217.2	216	286.4	267.9	313	371.22	420.6
	Avg.	145.5	214	227	295.65	245.25	326.4	345.86	412.95
Asphalt-Polymer Modulus, psi		-	90.9	409	132.1	51.2	-	213.2	-
		-	87.6	374	129.3	48.7	-	196.3	-
	Avg.	-	89.25	391.5	130.7	49.95	-	204.75	-

Table A-6 (Continued)

Parameter	TFA AC-10	TFA AC-10 & 3% Goodyear	TFA AC-10 & 3% Styrelf	TFA AC-10 & 3% Polysar	TFA AC-10 & 18% Crafco	TFA AC-20	TFA AC-20 & 3% Exxon	TFA AC-20 & 5% Dow
Shear Susceptibility								
@ 39.2 F	6.024E-01	7.470E-01	1.135E+00	7.699E-01	5.349E-01	6.376E-01	5.070E-01	5.107E-01
@ 77 F	8.786E-01	8.159E-01	1.069E+00	8.576E-01	6.777E-01	7.778E-01	6.269E-01	5.189E-01
@ 140 F	9.378E-01	9.518E-01	1.019E+00	9.670E-01	6.990E-01	8.400E-01	7.133E-01	7.773E-01
Apparent Viscosity, pas-sec at Shear Rate = 1 1/sec								
@ 39.2 F	9.030E+06	1.766E+07	1.192E+08	2.905E+07	1.435E+07	2.182E+07	1.832E+07	1.216E+07
@ 77 F	1.115E+05	1.998E+05	6.213E+05	2.158E+05	3.543E+05	2.924E+05	2.834E+05	4.641E+05
@ 140 F	1.198E+02	1.476E+02	3.503E+02	1.381E+02	2.005E+03	2.879E+02	6.380E+02	6.875E+02
Constant Power Viscosity, pas-sec								
@ 39.2 F	2.760E+07	3.736E+07	7.610E+07	6.072E+07	6.464E+07	7.183E+07	1.007E+08	5.759E+07
@ 77 F	1.123E+05	2.143E+05	5.844E+05	2.289E+05	4.518E+05	3.343E+05	3.599E+05	7.548E+05
@ 140 F	9.651E+01	1.256E+02	3.691E+02	1.236E+02	1.003E+03	1.731E+02	2.738E+02	3.683E+02

Table A-6 (Continued)

Parameter	TFA AC-10	TFA AC-10 & 3% Goodyear	TFA AC-10 & 3% Styrelf	TFA AC-10 & 3% Polysar	TFA AC-10 & 18% Crafco	TFA AC-20	TFA AC-20 & 3% Exxon	TFA AC-20 & 5% Dow
Penetration Index PI(Pen/Pen)	-0.18	-0.11	0.33	-0.11	1.04	-0.39	-0.04	0.17
Penetration Index PI(Pen/SP)	-0.04	0.69	2.01	0.46	2.08	0.19	0.98	1.66
Penetration Viscosity Number, PVN	-0.72	0.14	0.79	0.02	-	-0.6	0.62	0.96
Stiffness Modulus @ 39.2 F, psi								
5 Sec. Loading	450	435	305	493	522	725	725	754
20 Sec. Loading	145	203	160	232	261	305	319	392
Stiffness Modulus @ 0.1 Sec								
39.2F	5075	3625	2030	4785	2900	6960	5800	4640
77F	160	145	189	218	247	290	319	363
104F	12	15	25	16	46	23	33	54
Stiffness/Temperature Slope	-0.073	-0.067	-0.053	-0.068	-0.050	-0.069	-0.062	-0.054
Apparent Viscosity/Temp. Slope								
before RTFOT	-0.087	-0.091	-0.098	-0.095	-0.068	-0.087	-0.079	-0.076
after RTFOT	-0.083	-0.085	-0.106	-0.087	-	-0.085	-0.069	-0.066
Constant Power Visco./Temp. Slope								
before RTFOT	-0.096	-0.097	-0.095	-0.101	-0.085	-0.100	-0.098	-0.093
after RTFOT	-0.097	-0.099	-0.105	-0.096	-	-0.101	-0.089	-0.084

Table A-6 (Continued)

Parameter	TFA AC-10	TFA AC-10 & 3% Goodyear	TFA AC-10 & 3% Styrelf	TFA AC-10 & 3% Polysar	TFA AC-10 & 18% Crafco	TFA AC-20	TFA AC-20 & 3% Exxon	TFA AC-20 & 5% Dow
Penetration Ratio, 77 F	0.63	0.67	0,72	0.75	-	0.65	0.70	0.64
Viscosity Ratio	2.65	3.00	1,90	2.87	-	3.55	7.97	6.08
Kinematic Viscosity Ratio	1.56	1.45	1,28	1.38	-	1.68	1.99	1.94
Shear Susceptibility Ratio								
@ 39.2 F	0.97	0.82	1,07	0.91	-	0.95	1.00	0.95
@ 77 F	0.91	0.88	1,08	0.89	-	0.92	0.98	0.94
@ 140 F	0.91	0.90	1,00	0.94	-	0.96	0.87	0.89
Apparent Viscosity Ratio								
@39.2 F	1.98	1.84	4,39	1.19	-	2.41	1.07	1.17
@ 77 F	3.14	2.61	2,95	2.63	-	3.50	2.58	1.75
@ 140 F	3.31	3.73	1,70	3.48	-	3.08	4.22	4.59
Constant Power Viscosity Ratio								
@ 39.2 F	2.53	3.50	3,02	1.62	-	3.40	1.10	1.37
@ 77 F	3.59	3.18	2,55	3.13	-	4.50	3.27	2.22
@ 140 F	2.62	2.93	1,68	3.05	-	3.06	4.24	4.54

Table A-7 Unmodified and Modified Asphalt Properties after RTFOT.

Parameter	TFA AC-10	TFA AC-10 & 3% Goodyear	TFA AC-10 & 3% Styrelf	TFA AC-10 & 3% Polysar	TFA AC-10 & 18% Crafco	TFA AC-20	TFA AC-20 & 3% Exxon	TFA AC-20 & 5% Dow
Penetration @ 77 F (4 C)	64	65	73	69	-	45	47	42
100g, 5 Sec.	65	68	72	70	-	46	50	43
Avg.	65	67	73	70	-	46	49	43
Viscosity @ 140 F (60 C)	2956	3960	6292	3765	-	7436	26109	31520
Poises	3044	3904	6370	3795	-	7365	26423	31663
Avg.	3000	3932	6331	3780	-	7401	26266	31592
Viscosity @ 275 F (135 C)	461	732	972	672	-	700	1849	2350
Centistokes	467	726	962	692	-	694	1810	2308
Avg.	464	729	967	682	-	697	1830	2329
Shear Susceptibility								
@ 39.2 F	5.836E-01	6.116E-01	1.213E+00	6.968E-01	-	6.067E-01	5.075E-01	4.853E-01
@ 77 F	7.957E-01	7.200E-01	1.156E+00	7.637E-01	-	7.154E-01	6.143E-01	4.863E-01
@ 140 F	8.498E-01	8.563E-01	1.016E+00	9.128E-01	-	8.034E-01	6.226E-01	6.899E-01
Apparent Viscosity, pas-sec								
Shear Rate = 1 1/sec								
@ 39.2 F	1.788E+07	3.247E+07	5.238E+08	3.468E+07	-	5.268E+07	1.966E+07	1.420E+07
@ 77 F	3.498E+05	5.216E+05	1.836E+06	5.680E+05	-	1.023E+06	7.307E+05	8.131E+05
@ 140 F	3.969E+02	5.509E+02	5.968E+02	4.809E+02	-	8.877E+02	2.690E+03	3.154E+03
Constant Power Viscosity, pas-sec								
@ 39.2 F	6.993E+07	1.309E+08	2.300E+08	9.859E+07	-	2.443E+08	1.104E+08	7.906E+07
@ 77 F	4.034E+05	6.826E+05	1.488E+06	7.168E+05	-	1.504E+06	1.175E+06	1.678E+06
@ 140 F	2.533E+02	3.683E+02	6.220E+02	3.771E+02	-	5.304E+02	1.160E+03	1.672E+03

Table A-8 Constant Stress Rheometer Results for Unmodified and Modified Binders.

Test Temp.	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosity Pascal-Sec	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosity Pascal-Sec
		TFA AC-10 Before RTFOT			TFA AC-10 After RTFOT	
T = 140 F	8.22E+04	1.04E+03	7.93E+01	6.95E+04	4.44E+02	1.56E+02
	4.17E+04	5.15E+02	8.09E+01	4.63E+04	2.67E+02	1.73E+02
	2.24E+04	2.72E+02	8.22E+01	2.85E+04	1.48E+02	1.93E+02
	1.36E+04	1.59E+02	8.55E+01	1.82E+04	9.31E+01	1.95E+02
	1.01E+04	1.12E+02	9.03E+01	1.25E+04	5.68E+01	2.19E+02
	8.55E+03	9.41E+01	9.09E+01	7.30E+03	3.20E+01	2.28E+02
	7.02E+03	7.55E+01	9.30E+01	4.99E+03	1.92E+01	2.60E+02
T = 77 F	8.81E+05	1.08E+01	8.15E+04	1.09E+06	3.98E+00	2.75E+05
	5.82E+05	6.24E+00	9.32E+04	7.41E+05	2.64E+00	2.80E+05
	2.45E+05	2.51E+00	9.76E+04	4.33E+05	1.39E+00	3.11E+05
	1.74E+05	1.67E+00	1.04E+05	2.27E+05	5.61E-01	4.05E+05
	8.70E+04	7.50E-01	1.16E+05	1.03E+05	2.13E-01	4.83E+05
	5.44E+04	4.41E-01	1.23E+05	6.06E+04	1.11E-01	5.48E+05
T = 39 F	4.19E+06	2.20E-01	1.90E+07	4.46E+06	8.90E-02	5.02E+07
	2.80E+06	1.57E-01	1.78E+07	3.32E+06	5.81E-02	5.72E+07
	1.74E+06	7.71E-02	2.25E+07	2.46E+06	3.48E-02	7.08E+07
	9.27E+05	2.88E-02	3.22E+07	1.42E+06	1.25E-02	1.14E+08
	5.48E+05	8.20E-03	6.68E+07	8.04E+05	4.97E-03	1.62E+08
	3.54E+05	3.85E-03	9.20E+07			
	2.24E+05	2.33E-03	9.62E+07			
		TFA AC-10 + 3% UP 70 Before RTFOT			TFA AC-10 + 3% UP 70 After RTFOT	
T = 140 F	2.18E+04	1.94E+02	1.12E+02	6.71E+04	2.74E+02	2.45E+02
	1.51E+04	1.29E+02	1.17E+02	4.02E+04	1.51E+02	2.67E+02
	1.09E+04	8.93E+01	1.22E+02	2.43E+04	8.24E+01	2.95E+02
	5.59E+03	4.54E+01	1.23E+02	1.63E+04	5.15E+01	3.16E+02
	2.69E+03	2.11E+01	1.28E+02	9.89E+03	2.93E+01	3.38E+02
	1.32E+03	1.01E+01	1.31E+02	5.45E+03	1.46E+01	3.73E+02
T = 77 F	8.45E+05	5.96E+00	1.42E+05	7.79E+05	1.71E+00	4.56E+05
	4.12E+05	2.51E+00	1.64E+05	4.35E+05	7.82E-01	5.57E+05
	2.17E+05	1.07E+00	2.02E+05	2.15E+05	3.07E-01	7.00E+05
	1.08E+05	4.42E-01	2.45E+05	1.07E+05	1.08E-01	9.98E+05
	5.47E+04	2.04E-01	2.68E+05			
	2.71E+04	9.03E-02	3.00E+05			
T = 39 F	3.23E+06	9.55E-02	3.38E+07	4.16E+06	3.50E-02	1.19E+08
	1.69E+06	4.49E-02	3.76E+07	3.15E+06	2.13E-02	1.48E+08
	8.66E+05	1.88E-02	4.61E+07	2.23E+06	1.24E-02	1.79E+08
	4.37E+05	7.19E-03	6.08E+07	1.17E+06	4.73E-03	2.47E+08
	2.22E+05	2.79E-03	7.96E+07	6.07E+05	1.43E-03	4.26E+08
	1.11E+05	1.10E-03	1.01E+08			

Table A-8 (Continued)

Test Temp.	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosity Pascal-Sec	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosity Pascal-Sec
	TFA AC-10 + 3% Styrelf Before RTFOT			TFA AC-10 + 3% Styrelf After RTFOT		
T = 140 F	4.56E+04	1.19E+02	3.82E+02	8.99E+04	1.39E+02	6.46E+02
	1.77E+04	4.68E+01	3.78E+02	6.36E+04	9.88E+01	6.44E+02
	9.12E+03	2.45E+01	3.72E+02	3.95E+04	6.19E+01	6.38E+02
	4.85E+03	1.32E+01	3.67E+02	2.06E+04	3.26E+01	6.32E+02
				1.07E+04	1.72E+01	6.25E+02
T = 77 F	1.01E+06	1.52E+00	6.63E+05	1.70E+06	8.92E-01	1.91E+06
	5.26E+05	8.74E-01	6.02E+05	1.26E+06	7.25E-01	1.74E+06
	2.63E+05	4.59E-01	5.72E+05	8.01E+05	5.01E-01	1.60E+06
	1.10E+05	1.99E-01	5.51E+05	4.72E+05	3.23E-01	1.46E+06
	5.91E+04	1.09E-01	5.42E+05	2.30E+05	1.67E-01	1.38E+06
	3.07E+04	5.96E-02	5.14E+05	1.04E+05	8.09E-02	1.29E+06
T = 39 F	2.77E+06	3.49E-02	7.93E+07	3.87E+06	1.72E-02	2.25E+08
	2.17E+06	3.03E-02	7.15E+07	2.83E+06	1.36E-02	2.08E+08
	8.51E+05	1.31E-02	6.47E+07	2.09E+06	1.06E-02	1.96E+08
	2.60E+05	4.47E-03	5.83E+07	1.57E+06	8.27E-03	1.89E+08
				9.15E+05	5.29E-03	1.73E+08
	TFA AC-10 + 3% NS 175 Before RTFOT			TFA AC-10 + 3% NS 175 After RTFOT		
T = 140 F	2.28E+04	1.96E+02	1.16E+02	8.66E+04	2.99E+02	2.89E+02
	1.14E+04	9.63E+01	1.18E+02	6.25E+04	2.09E+02	2.99E+02
	6.27E+03	5.18E+01	1.21E+02	3.51E+04	1.06E+02	3.31E+02
	4.28E+03	3.46E+01	1.23E+02	9.21E+03	2.56E+01	3.60E+02
	1.90E+03	1.51E+01	1.26E+02	6.14E+03	1.63E+01	3.76E+02
T = 77 F	3.10E+05	1.58E+00	1.96E+05	1.72E+06	4.11E+00	4.17E+05
	1.11E+05	4.32E-01	2.57E+05	1.29E+06	2.93E+00	4.42E+05
	6.52E+04	2.45E-01	2.65E+05	8.63E+05	1.79E+00	4.82E+05
	3.58E+04	1.28E-01	2.81E+05	5.39E+05	9.66E-01	5.58E+05
	2.28E+04	7.29E-02	3.13E+05	2.16E+05	2.72E-01	7.93E+05
				1.08E+05	1.14E-01	9.46E+05
T = 39 F	3.56E+06	5.98E-02	5.96E+07	3.07E+06	3.16E-02	9.73E+07
	1.71E+06	2.69E-02	6.37E+07	2.29E+06	1.97E-02	1.16E+08
	9.79E+05	1.30E-02	7.53E+07	1.63E+06	1.17E-02	1.39E+08
	5.01E+05	5.27E-03	9.51E+07	9.43E+05	6.13E-03	1.54E+08
	2.57E+05	2.11E-03	1.22E+08	4.77E+05	2.15E-03	2.22E+08
	1.38E+05	9.27E-04	1.49E+08	2.52E+05	8.35E-04	3.02E+08

Table A-8 (Continued)

Test Temp.	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosity Pascal-Sec	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosity Pascal-Sec
	TFA AC-10 + 18% C107 Before RTFOT					
T = 140 F	1.42E+05	4.49E+02	3.17E+02			
	9.97E+04	2.63E+02	3.79E+02			
	6.84E+04	1.57E+02	4.35E+02			
T = 77 F	1.07E+06	4.87E+00	2.20E+05			
	5.35E+05	1.88E+00	2.84E+05			
	2.73E+05	7.11E-01	3.84E+05			
	1.39E+05	2.61E-01	5.33E+05			
	7.54E+04	9.63E-02	7.83E+05			
T = 39 F	3.75E+06	7.24E-02	5.18E+07			
	2.02E+06	2.92E-02	6.91E+07			
	1.08E+06	8.65E-03	1.25E+08			
	5.97E+05	2.37E-03	2.52E+08			
	TFA AC-20 Before RTFOT			TFA AC-20 After RTFOT		
T = 140 F	1.63E+04	1.24E+02	1.31E+02	5.70E+04	1.79E+02	3.19E+02
	1.17E+04	8.19E+01	1.43E+02	3.99E+04	1.13E+02	3.55E+02
	8.38E+03	5.38E+01	1.56E+02	2.57E+04	6.78E+01	3.78E+02
	5.20E+03	3.19E+01	1.63E+02	1.01E+04	1.95E+01	5.19E+02
				5.70E+03	1.05E+01	5.43E+02
T = 77 F	9.51E+05	4.80E+00	1.98E+05	1.07E+06	1.04E+00	1.03E+06
	4.75E+05	1.83E+00	2.60E+05	6.44E+05	5.36E-01	1.20E+06
	2.59E+05	8.21E-01	3.16E+05	3.33E+05	2.16E-01	1.54E+06
	1.30E+05	3.56E-01	3.64E+05	1.72E+05	8.03E-02	2.14E+06
	6.70E+04	1.41E-01	4.75E+05			
	3.29E+04	6.44E-02	5.12E+05			
T = 39 F	3.86E+06	5.77E-02	6.70E+07	5.18E+06	2.46E-02	2.11E+08
	2.46E+06	3.38E-02	7.29E+07	3.60E+06	1.08E-02	3.33E+08
	1.55E+06	1.75E-02	8.83E+07	2.44E+06	5.82E-03	4.20E+08
	7.53E+05	6.21E-03	1.21E+08	1.26E+06	2.29E-03	5.51E+08
	4.36E+05	1.77E-03	2.46E+08			

Table A-8 (Continued)

Test Temp.	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosity Pascal-Sec	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosity Pascal-Sec
	TFA AC-10 + 3% Polybilt 103 Before RTFOT			TFA AC-10 + 3% Polybilt 103 After RTFOT		
T = 140 F	5.03E+04	3.70E+02	1.36E+02	7.12E+04	1.88E+02	3.79E+02
	2.01E+04	1.35E+02	1.49E+02	4.99E+04	1.11E+02	4.47E+02
	1.26E+04	6.13E+01	2.05E+02	2.85E+04	4.65E+01	6.12E+02
	5.36E+03	2.37E+01	2.26E+02	1.78E+04	1.95E+01	9.15E+02
	2.10E+03	7.94E+00	2.64E+02	1.28E+04	1.23E+01	1.04E+03
	9.22E+02	1.38E+00	6.68E+02	8.90E+03	6.94E+00	1.28E+03
	4.02E+02	4.36E-01	9.23E+02			
T = 77 F	1.23E+06	1.03E+01	1.20E+05	1.27E+06	2.39E+00	5.31E+05
	5.52E+05	3.01E+00	1.83E+05	7.32E+05	9.58E-01	7.64E+05
	2.02E+05	5.80E-01	3.48E+05	4.77E+05	5.88E-01	8.11E+05
	1.02E+05	1.80E-01	5.65E+05	2.76E+05	1.87E-01	1.48E+06
	5.95E+04	8.79E-02	6.76E+05	1.27E+05	5.82E-02	2.19E+06
T = 39 F	5.19E+06	7.80E-02	6.65E+07	5.93E+06	8.61E-02	6.88E+07
	3.49E+06	3.97E-02	8.80E+07	3.90E+06	4.40E-02	8.87E+07
	2.51E+06	2.10E-02	1.20E+08	2.71E+06	2.19E-02	1.24E+08
	1.26E+06	5.00E-03	2.53E+08	1.57E+06	6.66E-03	2.35E+08
	6.61E+05	1.41E-03	4.68E+08	8.85E+05	2.15E-03	4.11E+08
	TFA AC-10 + 5% Dow Before RTFOT			TFA AC-10 + 5% Dow After RTFOT		
T = 140 F	3.09E+04	1.37E+02	2.25E+02	7.87E+04	1.03E+02	7.67E+02
	1.71E+04	6.17E+01	2.77E+02	4.57E+04	5.13E+01	8.92E+02
	9.17E+03	2.71E+01	3.38E+02	2.17E+04	1.59E+01	1.37E+03
	4.51E+03	1.12E+01	4.02E+02	9.75E+03	5.15E+00	1.89E+03
	1.71E+03	3.29E+00	5.21E+02			
T = 77 F	1.04E+06	4.17E+00	2.50E+05	1.03E+06	1.59E+00	6.49E+05
	5.26E+05	1.53E+00	3.43E+05	7.64E+05	8.64E-01	8.85E+05
	2.81E+05	3.97E-01	7.08E+05	5.01E+05	3.95E-01	1.27E+06
	2.19E+05	2.20E-01	9.95E+05	2.69E+05	1.03E-01	2.60E+06
	1.05E+05	5.51E-02	1.91E+06	1.50E+05	3.01E-02	4.98E+06
T = 39 F	3.99E+06	1.02E-01	3.93E+07	3.04E+06	3.74E-02	8.12E+07
	1.99E+06	2.67E-02	7.46E+07	2.16E+06	2.29E-02	9.45E+07
	1.07E+06	1.08E-02	9.94E+07	1.30E+06	8.02E-03	1.62E+08
	5.42E+05	2.60E-03	2.09E+08	8.36E+05	2.66E-03	3.14E+08
	2.22E+05	3.28E-04	6.74E+08			

Table A-9 Marshall and Hveem Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES STABILITY lbs	MARSHALL VALUES FLOW .01 in
Control: TFA AC-10		7.6	39	7.1	509	8.5
		7.8	36	7.7	446	7.5
		7.5	37	7.0	545	8.5
		----	----	----	----	----
	AVG.	7.6	37	7.2	500	8.2
TFA AC-10 + 3% UP 70		6.0	33	5.5	898	11.5
		6.1	33	6.2	854	13.0
		5.8	33	5.9	882	11.5
		----	----	----	----	----
	AVG.	6.0	33	5.9	878	12.0
TFA AC-10 + 3% Styrelf		8.0	35	6.2	1071	13.0
		7.6	35	7.5	808	14.5
		8.0	36	7.6	655	13.0
		----	----	----	----	----
	AVG.	7.9	35	7.1	845	13.5
TFA AC-10 + 3% NS 175		7.0	44	7.0	1043	12.0
		7.2	40	7.0	1064	12.0
		6.9	37	7.1	1102	12.5
		----	----	----	----	----
	AVG.	7.1	40	7.0	1070	12.2
TFA AC-10 + 18% C107		12.1	38	11.6	751	25.0
		11.9	34	11.0	907	27.0
		10.9	39	10.3	1200	27.0
		----	----	----	----	----
	AVG.	11.6	37	10.9	953	26.3
Control: TFA AC-20		7.4	40	7.4	1105	10.5
		7.0	44	6.2	1000	12.5
		6.2	40	6.9	1112	10.5
		----	----	----	----	----
	AVG.	6.9	41	6.8	1072	11.2
TFA AC-20 + 3% Polybilt 103		7.3	37	6.6	1158	11.5
		7.2	38	7.2	981	11.0
		6.8	40	7.1	1061	10.0
		----	----	----	----	----
	AVG.	7.1	38	7.0	1067	10.8
TFA AC-20 + 5% Dow		7.6	39	6.7	1123	10.0
		7.5	39	7.4	1070	10.0
		6.9	38	7.5	1008	9.5
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		7.3	39	7.2	1067	9.8

Table A-10 Marshall and Hveem Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES STABILITY lbs	FLOW .01 in
Control: TFA AC-10		3.8	40	4.3	1114	9.5
		4.7	41	4.2	1045	9.5
		5.1	42	4.2	972	9.5
	AVG.	4.5	41	4.3	1044	9.5
TFA AC-10 + 3% UP 70		2.9	42	3.0	2443	13.0
		2.1	41	2.3	2256	13.0
		3.0	41	2.3	2217	12.0
	AVG.	2.6	41	2.6	2305	12.7
TFA AC-10 + 3% Styrelf		4.2	42	3.2	2127	14.0
		3.3	43	3.3	2025	12.5
		4.0	48	4.2	2017	12.5
	AVG.	3.8	44	3.5	2056	13.0
TFA AC-10 + 3% NS 175		4.0	41	4.9	1402	11.0
		4.2	41	4.4	1489	12.0
		3.4	40	3.4	1882	12.0
	AVG.	3.9	41	4.2	1591	11.7
TFA AC-10 + 18% C107		-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
	AVG.	-	-	-	-	-
Control: TFA AC-20		3.7	42	3.4	2129	12.0
		4.2	42	3.8	1995	12.0
		3.7	44	3.7	1830	12.0
	AVG.	3.9	43	3.6	1985	12.0
TFA AC-20 + 3% Polybilt 103		3.8	49	3.5	2920	12.0
		3.6	50	3.3	2675	12.0
		3.6	42	3.8	2656	12.0
	AVG.	3.7	47	3.5	2750	12.0
TFA AC-20 + 5% Dow		2.6	50	2.8	2423	10.0
		2.9	51	2.3	2364	9.5
		3.3	51	2.9	2451	10.0
	AVG.	2.9	51	2.6	2412	9.8

Table A-11 Marshall and Hveem Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES	
					STABILITY lbs	FLOW .01 in
TFA AC-10 + 3% UP 70		6.6	38	6.6	771	14.0
		6.6	36	6.5	664	15.0
		6.9	35	6.9	681	15.0
	AVG.	6.7	36	6.7	705	14.7
TFA AC-10 + 3% Styrelf		7.1	37	7.2	595	13.0
		6.9	40	7.2	596	12.0
		7.5	38	6.8	594	12.0
	AVG.	7.2	38	7.1	595	12.3
TFA AC-10 + 3% NS 175		6.7	35	6.8	553	14.0
		6.8	39	6.8	523	14.0
		6.7	37	6.6	520	12.5
	AVG.	6.7	37	6.7	532	13.5
TFA AC-10 + 18% C107		7.4	42	7.3	808	23.0
		7.5	38	7.1	811	23.5
		7.5	38	6.8	801	24.0
	AVG.	7.4	39	7.1	806	23.5
Control: TFA AC-20		6.9	34	6.9	709	21.0
		6.7	35	6.8	663	19.5
		7.0	36	6.7	667	19.0
	AVG.	6.8	35	6.8	680	19.8
TFA AC-20 + 3% Polybilt 103		7.0	40	7.0	707	14.0
		7.7	41	7.1	655	13.0
		7.3	42	7.3	668	14.0
	AVG.	7.3	41	7.2	677	13.7
TFA AC-20 + 5% Dow		8.2	44	7.7	846	9.0
		7.1	44	8.0	871	8.5
		7.6	45	7.9	874	9.5
	AVG.	7.7	44	7.9	864	9.0

Table A-12 Marshall and Hveem Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES	
					STABILITY lbs	FLOW .01 in
TFA AC-10 + 3% UP 70		4.3	43	4.4	1117	13.5
		4.3	39	4.0	1199	14.0
		4.3	42	4.3	1159	14.0
	AVG.	4.3	41	4.3	1159	13.8
TFA AC-10 + 3% Styrelf		4.2	41	4.0	1025	12.0
		3.9	43	4.0	921	12.0
		3.7	47	3.8	1043	12.0
	AVG.	3.9	44	3.9	996	12.0
TFA AC-10 + 3% NS 175		2.2	41	1.9	1300	12.0
		2.0	46	1.9	1179	11.5
		2.4	47	2.3	1240	13.0
	AVG.	2.2	45	2.0	1240	12.2
TFA AC-10 + 18% C107		4.7	40	3.8	1072	22.0
		3.8	42	4.0	1057	22.0
		4.0	41	4.2	1112	22.0
	AVG.	4.1	41	4.0	1080	22.0
Control: TFA AC-20		3.1	43	2.9	1405	14.0
		3.2	44	3.2	1549	14.0
		3.4	45	2.9	1358	13.0
	AVG.	3.2	44	3.0	1437	13.7
TFA AC-20 + 3% Polybilt 103		3.3	45	3.2	1402	12.0
		3.3	47	2.8	1409	11.5
		3.2	43			
	AVG.	3.3	45	3.0	1406	11.8
TFA AC-20 + 5% Dow		2.7	48	3.2	1630	12.0
		2.8	47	2.6	1656	12.0
		2.7	52	2.9	1665	12.0
	AVG.	2.7	49	2.9	1650	12.0

Table A-13 Indirect Tensile Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: TFA AC-10	39	7.6	319	0.44	146	1394	-
		7.0	328	0.32	203	1334	-
		7.7	306	0.34	181	981	-
	AVG.	7.4	318	0.37	177	1236	-
TFA AC-10 + 3% UP 70	39	5.6	299	0.29	205	960	-
		6.1	285	0.30	189	1556	-
		6.2	271	0.30	179	879	-
	AVG.	6.0	285	0.30	191	1132	-
TFA AC-10 + 3% Styrelf	39	7.7	327	0.48	135	1510	-
		7.8	306	0.51	120	1102	-
		7.9	323	0.51	127	1629	-
	AVG.	7.8	319	0.50	127	1414	-
TFA AC-10 + 3% NS 175	39	6.6	279	0.31	179	937	-
		7.0	272	0.35	156	879	-
		6.9	306	0.29	214	905	-
	AVG.	6.8	286	0.32	183	907	-
TFA AC-10 + 18% C107	39	10.9	116	0.57	40	467	-
		11.3	114	0.58	39	407	-
		11.4	105	0.52	40	409	-
	AVG.	11.2	112	0.56	40	428	-
Control: TFA AC-20	39	6.9	318	0.17	370	951	-
		7.5	304	0.17	354	1504	-
		6.5	339	0.21	325	1198	-
	AVG.	7.0	320	0.18	350	1217	-
TFA AC-20 + 3% Polybilt	39	6.7	284	0.19	295	1528	-
		7.5	275	0.21	258	1461	-
		7.3	294	0.17	353	1502	-
	AVG.	7.2	284	0.19	302	1497	-
TFA AC-10 + 5% Dow	39	6.4	323	0.20	318	987	-
		6.0	325	0.19	347	821	-
		6.9	268	0.23	229	901	-
		6.4	305	0.21	298	903	-

Table A-13 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: TFA AC-10	77	7.6	49	1.01	9.8	288	-
		7.3	50	1.14	8.7	200	-
		7.0	58	1.07	10.8	147	-
		----	----	-----	----	----	-----
		7.3	52	1.07	9.8	212	-
TFA AC-10 + 3% UP 70	77	6.2	66	0.95	13.8	397	-
		5.6	69	0.98	13.9	282	-
		5.9	67	0.89	15.0	301	-
		----	----	-----	----	----	-----
		5.9	67	0.94	14.3	327	-
TFA AC-10 + 3% Styrelf	77	7.5	77	1.39	11.0	270	-
		8.3	69	1.39	10.0	290	-
		7.5	83	1.36	12.2	291	-
		----	----	-----	----	----	-----
		7.8	76	1.38	11.0	284	-
TFA AC-10 + 3% NS 175	77	6.8	72	0.83	17.4	322	-
		7.0	64	0.97	13.2	363	-
		6.8	74	0.89	16.7	371	-
		----	----	-----	----	----	-----
		6.9	70	0.90	15.7	352	-
TFA AC-10 + 18% C107	77	11.9	37	1.85	4.0	102	-
		12.5	32	1.79	3.5	145	-
		12.4	40	1.77	4.6	148	-
		----	----	-----	----	----	-----
		12.3	36	1.80	4.0	131	-
Control: TFA AC-20	77	7.2	84	0.51	33.0	415	-
		8.4	76	0.54	28.5	297	-
		7.8	78	0.59	26.2	343	-
		----	----	-----	----	----	-----
		7.8	79	0.55	29.2	352	-
TFA AC-20 + 3% Polybilt	77	6.7	78	0.55	28.2	379	-
		7.3	79	0.60	26.1	411	-
		7.0	84	0.49	34.1	453	-
		----	----	-----	----	----	-----
		7.0	80	0.55	29.5	414	-
TFA AC-20 + 5% Dow	77	6.6	72	0.36	39.7	433	-
		7.7	72	0.36	39.4	361	-
		6.7	78	0.35	44.6	631	-
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		7.0	74	0.36	41.2	475	-

Table A-13 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: TFA AC-10	104	7.2	13	1.07	2.4	86	-
		7.2	13	0.98	2.7	75	-
		7.6	13	1.00	2.7	105	-
		----	----	-----	----	----	-----
		7.3	13	1.01	2.6	89	-
TFA AC-10 + 3% UP 70	104	6.0	21	1.40	3.0	178	-
		5.8	23	1.40	3.3	159	-
		5.1	28	1.22	4.6	143	-
		----	----	-----	----	----	-----
		5.6	24	1.34	3.6	160	-
TFA AC-10 + 3% Styrelf	104	7.0	27	1.98	2.7	94	-
		8.0	23	2.08	2.2	99	-
		7.5	25	1.72	2.9	120	-
		----	----	-----	----	----	-----
		7.5	25	1.92	2.6	104	-
TFA AC-10 + 3% NS 175	104	6.5	30	1.07	5.5	197	-
		6.9	25	1.09	4.7	137	-
		6.8	28	0.99	5.7	115	-
		----	----	-----	----	----	-----
		6.7	28	1.05	5.3	150	-
TFA AC-10 + 18% C10Z	104	11.0	15	2.58	1.1	70	-
		11.3	17	2.56	1.3	72	-
		10.5	13	3.04	0.9	71	-
		----	----	-----	----	----	-----
		10.9	15	2.73	1.1	71	-
Control: TFA AC-20	104	7.1	32	0.78	8.3	238	-
		7.8	32	0.77	8.4	135	-
		7.2	32	0.83	7.6	196	-
		----	----	-----	----	----	-----
		7.4	32	0.79	8.1	190	-
TFA AC-20 + 3% Polybilt	104	7.3	32	0.83	7.7	140	-
		6.9	35	0.79	8.9	136	-
		7.0	27	0.73	7.4	172	-
		----	----	-----	----	----	-----
		7.1	31	0.78	8.0	149	-
TFA AC-20 + 5% Dow	104	7.4	34	0.41	16.9	242	-
		7.5	38	0.42	18.3	219	-
		7.6	36	0.47	15.2	160	-
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		7.5	36	0.43	16.8	207	-

Table A-14 Indirect Tensile Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: TFA AC-10	39		5.0	368	-	-	1647	-
			5.3	388	0.38	204	1663	-
			5.3	378	0.35	214	1225	-
		AVG.	5.2	378	0.37	209	1512	-
TFA AC-10 + 3% UP 70	39		2.9	412	0.29	283	1826	-
			3.2	395	0.27	297	1346	-
			2.9	365	0.20	369	980	-
		AVG.	3.0	391	0.25	316	1384	-
TFA AC-10 + 3% Styrelf	39		3.3	469	0.35	265	1848	-
			3.6	527	0.36	289	2439	-
			3.3	452	0.35	256	2406	-
		AVG.	3.4	483	0.36	270	2231	-
TFA AC-10 + 3% NS 175	39		3.8	385	0.26	295	1292	-
			4.6	369	0.28	263	1456	-
			3.7	409	0.29	285	1433	-
		AVG.	4.0	388	0.28	281	1394	-
TFA AC-10 + 18% C107	39		-	-	-	-	-	-
			-	-	-	-	-	-
			-	-	-	-	-	-
		AVG.	-	-	-	-	-	-
Control: TFA AC-20	39		4.0	461	0.12	770	1925	-
			4.0	472	0.09	1007	2625	-
			3.9	459	0.10	928	1812	-
		AVG.	4.0	464	0.10	902	2121	-
TFA AC-20 + 3% Polybilt	39		3.7	436	0.23	380	2080	-
			3.9	447	0.20	440	1606	-
			3.5	435	0.19	464	1267	-
		AVG.	3.7	439	0.21	428	1651	-
TFA AC-20 + 5% Dow	39		3.0	480	0.18	542	1225	-
			2.8	482	0.21	463	711	-
			2.5	499	0.18	564	1293	-
			2.8	487	0.19	523	1076	-

Table A-14 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: TFA AC-10	77	4.7	62	0.73	17.1	318	-
		5.1	66	1.18	11.3	322	-
		5.1	64	1.00	12.7	372	-
		5.0	64	0.97	13.7	337	-
TFA AC-10 + 3% UP 70	77	2.8	98	0.86	22.7	394	-
		3.3	103	0.83	24.8	494	-
		2.9	111	0.84	26.3	374	-
		3.0	104	0.85	24.6	420	-
TFA AC-10 + 3% Styrelf	77	3.4	130	1.29	20.2	453	-
		4.0	128	1.21	21.1	430	-
		3.4	138	1.01	27.2	418	-
		3.6	132	1.17	22.9	434	-
TFA AC-10 + 3% NS 175	77	4.4	94	0.91	20.6	411	-
		4.4	97	0.90	21.4	530	-
		3.7	98	0.87	22.5	460	-
		4.2	96	0.90	21.5	467	-
TFA AC-10 + 18% C107	77	-	-	-	-	-	-
		-	-	-	-	-	-
		-	-	-	-	-	-
		-	-	-	-	-	-
Control: TFA AC-20	77	3.8	126	0.62	40.2	495	-
		3.7	125	0.65	38.4	580	-
		4.1	132	0.63	41.6	576	-
		3.9	128	0.64	40.1	550	-
TFA AC-20 + 3% Polybilt	77	3.7	136	0.51	52.9	490	-
		4.2	123	0.47	52.6	576	-
		3.7	138	0.48	57.7	575	-
		3.8	133	0.49	54.4	547	-
TFA AC-20 + 5% Dow	77	4.8	140	0.36	76.6	733	-
		2.9	135	0.42	64.6	566	-
		2.9	138	0.39	70.7	638	-
		3.5	137	0.39	70.6	646	-

Table A-14 (Continued)

MIXTURE	TEST TEMP.- F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: TFA AC-10	104	4.8	20	1.09	3.7	110	-
		4.9	15	0.88	3.5	124	-
		4.6	21	1.14	3.6	87	-
		----	----	-----	----	----	-----
		4.8	19	1.04	3.6	107	-
TFA AC-10 + 3% UP 70	104	3.1	43	1.06	8.2	206	-
		2.1	51	1.05	9.8	150	-
		3.1	42	1.04	8.2	147	-
		----	----	-----	----	----	-----
		2.8	46	1.05	8.7	168	-
TFA AC-10 + 3% Styrelf	104	3.1	52	1.46	7.1	269	-
		3.2	51	1.40	7.2	131	-
		3.6	44	1.52	5.8	178	-
		----	----	-----	----	----	-----
		3.3	49	1.46	6.7	193	-
TFA AC-10 + 3% NS 175	104	4.0	37	1.13	6.6	161	-
		4.6	37	1.12	6.5	151	-
		4.8	34	1.15	5.9	183	-
		----	----	-----	----	----	-----
		4.5	36	1.13	6.3	165	-
TFA AC-10 + 18% C107	104	-	-	-	-	-	-
		-	-	-	-	-	-
		-	-	-	-	-	-
		-----	-----	-----	-----	-----	-----
		-	-	-	-	-	-
Control: TFA AC-20	104	3.7	53	-	-	266	-
		4.0	50	0.86	11.6	233	-
		3.9	51	0.86	12.0	217	-
		----	----	-----	----	----	-----
		3.8	52	0.86	11.8	239	-
TFA AC-20 + 3% Polybilt	104	3.8	61	0.73	16.7	184	-
		3.9	60	0.72	16.5	412	-
		3.5	62	0.69	18.0	269	-
		----	----	-----	----	----	-----
		3.7	61	0.71	17.1	289	-
TFA AC-20 + 5% Dow	104	2.5	70	0.39	36.1	241	-
		3.3	60	0.47	25.6	233	-
		3.1	61	0.49	24.9	244	-
		----	----	-----	----	----	-----
		3.0	64	0.45	28.9	239	-

TTable A-15 Indirect Tensile Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
TFA AC-10 + 3% UP 70	39	6.8	303	0.37	164	1418	-
		6.9	297	0.37	158	1624	-
		7.0	304	0.36	167	1437	-
	AVG.	6.9	301	0.37	163	1493	-
TFA AC-10 + 3% Styrelf	39	7.1	415	0.48	173	1528	-
		7.0	386	0.45	170	1688	-
		7.1	401	0.49	164	1678	-
	AVG.	7.1	400	0.47	169	1632	-
TFA AC-10 + 3% NS 175	39	6.4	307	0.39	157	1566	-
		6.5	299	0.38	157	1601	-
		6.8	273	0.35	154	1823	-
	AVG.	6.6	293	0.37	156	1664	-
TFA AC-10 + 18% C107	39	7.2	172	0.37	77	1320	-
		7.6	166	0.37	73	1236	-
		7.6	170	0.36	76	879	-
	AVG.	7.5	169	0.37	75	1145	-
Control: TFA AC-20	39	7.2	257	0.23	224	1480	-
		7.0	265	0.22	237	1463	-
		6.9	260	0.22	238	1287	-
	AVG.	7.0	261	0.22	233	1410	-
TFA AC-20 + 3% Polybilt	39	7.0	313	0.26	240	1663	-
		7.2	304	0.29	212	1625	-
		7.6	288	0.32	182	1669	-
	AVG.	7.3	302	0.29	211	1652	-
TFA AC-20 + 5% Dow	39	7.9	274	0.19	284	1789	-
		7.9	283	0.20	286	1774	-
		7.8	295	0.21	284	1523	-
		7.9	284	0.20	285	1695	-

Table A-15 (Continued)

MIXTURE	TEST. TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
TFA AC-10 + 3% UP 70	77	7.1	97	0.75	25.8	415	-
		6.7	100	0.94	21.4	420	-
		6.9	95	0.85	22.4	409	-
		-----	-----	-----	-----	-----	-----
		6.9	98	0.85	23.2	415	-
TFA AC-10 + 3% Styrelf	77	7.0	119	1.14	20.9	422	-
		7.2	119	1.08	22.1	490	-
		7.6	110	1.17	18.8	394	-
		-----	-----	-----	-----	-----	-----
		7.3	116	1.13	20.6	435	-
TFA AC-10 + 3% NS 175	77	6.9	89	0.75	23.6	350	-
		6.9	91	0.85	21.5	405	-
		7.1	85	0.80	21.1	413	-
		-----	-----	-----	-----	-----	-----
		6.9	88	0.80	22.1	389	-
TFA AC-10 + 18% C107	77	6.5	71	0.37		199	-
		6.4	62	0.37	11.9	165	-
		6.6	67	0.36	11.9	182	-
		-----	-----	-----	-----	-----	-----
		6.5	67	0.37	11.9	182	-
Control: TFA AC-20	77	7.0	89	0.54	32.8	417	-
		6.6	86	0.59	29.1	422	-
		7.0	80	0.64	24.6	378	-
		-----	-----	-----	-----	-----	-----
		6.9	85	0.59	28.8	406	-
TFA AC-20 + 3% Polybilt	77	6.8	104	0.47	44.1	397	-
		7.5	100	0.47	42.5	407	-
		6.8	107	0.49	43.8	407	-
		-----	-----	-----	-----	-----	-----
		7.0	104	0.48	43.5	404	-
TFA AC-20 + 5% Dow	77	8.0	98	0.36	53.7	420	-
		7.5	113	0.33	69.1	446	-
		7.8	111	0.40	56.1	436	-
		-----	-----	-----	-----	-----	-----
		7.8	107	0.36	59.6	434	-

Table A-15 (Continued)

MIXTURE	TEST. TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
TFA AC-10 + 3% UP 70	104	7.0	43	1.17	7.4	127	-
		6.8	51	1.11	9.1	164	-
		6.8	47	1.09	8.6	115	-
		6.9	47	1.12	8.4	136	-
TFA AC-10 + 3% Styrelf	104	7.3	44	1.35	6.5	117	-
		7.1	46	1.25	7.3	155	-
		6.8	50	1.35	7.4	149	-
		7.0	47	1.32	7.1	140	-
TFA AC-10 + 3% NS 175	104	6.4	42	0.99	8.4	139	-
		6.4	41	1.01	8.1	142	-
		6.5	43	0.99	8.6	131	-
		6.5	42	0.99	8.4	137	-
TFA AC-10 + 18% C107	104	7.3	36	0.37	5.1	117	-
		7.3	35	0.37	5.4	116	-
		7.2	35	0.36	4.6	92	-
		7.3	35	0.37	5.1	108	-
Control: TFA AC-20	104	6.6	39	0.85	9.3	124	-
		7.4	42	0.84	9.9	143	-
		7.1	40	0.73	10.9	188	-
		7.0	40	0.81	10.0	152	-
TFA AC-20 + 3% Polybilt	104	6.8	52	0.72	14.6	123	-
		7.1	55	0.67	16.4	140	-
		7.2	50	0.73	13.7	122	-
		7.0	52	0.70	14.9	128	-
TFA AC-20 + 5% Dow	104	7.6	65	0.46	28.3	179	-
		7.6	62	0.42	29.3	174	-
		7.7	60	0.46	26.0	169	-
		7.6	62	0.45	27.9	174	-

Table A-16 Indirect Tensile Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
TFA AC-10 + 3% UP 70	39	4.2	408	0.31	261	1588	-
		4.0	420	0.31	274	1704	-
		4.2	401	0.29	275	1658	-
	AVG.	4.2	410	0.30	270	1650	-
TFA AC-10 + 3% Styrelf	39	4.3	554	0.30	373	1613	-
		3.7	572	0.31	366	1754	-
		4.1	542	0.31	347	1734	-
	AVG.	4.0	556	0.31	362	1700	-
TFA AC-10 + 3% NS 175	39	1.9	457	0.25	366	1762	-
		2.1	487	0.27	360	1640	-
		2.1	504	0.30	340	1765	-
	AVG.	2.1	483	0.27	355	1722	-
TFA AC-10 + 18% C107	39	4.5	259	0.37	172	1032	-
		4.4	272	0.37	180	1119	-
		3.9	274	0.36	170	1452	-
	AVG.	4.3	268	0.37	174	1201	-
Control: TFA AC-20	39	2.9	448	0.20	441	1797	-
		3.0	478	0.21	459	1935	-
		3.1	455	0.18	514	1790	-
	AVG.	3.0	460	0.20	471	1841	-
TFA AC-20 + 3% Polybilt	39	3.3	485	0.21	455	1600	-
		3.3	484	0.24	395	1856	-
		3.3	488	0.25	383	1511	-
	AVG.	3.3	486	0.24	411	1655	-
TFA AC-20 + 5% Dow	39	2.9	506	0.20	499	1707	-
		2.9	516	0.21	484	1864	-
		3.0	500	0.21	469	1655	-
		2.9	508	0.21	484	1742	-

Table A-16 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
TFA AC-10 + 3% UP 70	77	3.6	134	0.70	38.4	504	-
		4.1	140	0.71	39.4	506	-
		4.1	130	0.69	37.9	476	-
		-----	-----	-----	-----	-----	-----
		3.9	135	0.70	38.6	495	-
TFA AC-10 + 3% Styrelf	77	4.1	163	1.04	31.3	461	-
		4.2	162	1.04	31.1	459	-
		4.1	168	1.02	32.8	438	-
		-----	-----	-----	-----	-----	-----
		4.1	164	1.03	31.7	453	-
TFA AC-10 + 3% NS 175	77	2.2	160	0.70	45.4	470	-
		2.3	154	0.70	43.7	484	-
		2.0	156	0.75	41.5	501	-
		-----	-----	-----	-----	-----	-----
		2.2	157	0.72	43.5	485	-
TFA AC-10 + 18% C107	77	4.4	93	0.37	20.9	392	-
		5.1	103	0.37	21.9	401	-
		3.7	103	0.36	22.0	529	-
		-----	-----	-----	-----	-----	-----
		4.4	100	0.37	21.6	441	-
Control: TFA AC-20	77	3.2	149	0.54	55.1	457	-
		3.0	153	0.52	58.7	470	-
		3.1	162	0.55	58.6	445	-
		-----	-----	-----	-----	-----	-----
		3.1	155	0.54	57.5	457	-
TFA AC-20 + 3% Polybilt	77	3.1	165	0.46	71.3	498	-
		3.2	172	0.47	73.6	489	-
		3.4	178	0.47	75.8	478	-
		-----	-----	-----	-----	-----	-----
		3.2	172	0.47	73.6	488	-
TFA AC-20 + 5% Dow	77	2.8	190	0.40	94.8	539	-
		2.7	190	0.40	96.0	423	-
		2.6	191	0.41	93.9	436	-
		-----	-----	-----	-----	-----	-----
		2.7	190	0.40	94.9	466	-

Table A-16 (Continued)

MIXTURE	TEST. TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
TFA AC-10 + 3% UP 70	104	4.0	53	0.97	10.9	198	-
		4.2	53	0.99	10.6	185	-
		4.3	56	1.02	11.0	190	-
		-----	-----	-----	-----	-----	-----
		4.2	54	0.99	10.9	191	-
TFA AC-10 + 3% Styrelf	104	4.2	56	1.27	8.8	179	-
		3.7	59	1.19	9.9	209	-
		4.2	65	1.15	11.2	220	-
		-----	-----	-----	-----	-----	-----
		4.0	60	1.21	10.0	202	-
TFA AC-10 + 3% NS 175	104	2.2	69	0.94	14.8	176	-
		2.1	66	0.94	14.0	199	-
		2.0	71	0.94	15.1	209	-
		-----	-----	-----	-----	-----	-----
		2.1	69	0.94	14.6	195	-
TFA AC-10 + 18% C107	104	4.6	46	0.37	6.9	179	-
		4.2	47	0.37	8.0	148	-
		3.7	48	0.36	7.6	190	-
		-----	-----	-----	-----	-----	-----
		4.2	47	0.37	7.5	172	-
Control: TFA AC-20	104	2.8	68	0.62	21.8	222	-
		3.1	63	0.71	17.6	249	-
		3.2	70	0.75	18.7	215	-
		-----	-----	-----	-----	-----	-----
		3.0	67	0.70	19.4	229	-
TFA AC-20 + 3% Polybilt	104	3.1	76	0.63	24.0	213	-
		3.2	78	0.59	26.5	198	-
		3.7	81	0.69	23.5	252	-
		-----	-----	-----	-----	-----	-----
		3.3	78	0.64	24.7	221	-
TFA AC-20 + 5% Dow	104	2.8	95	0.57	33.5	298	-
		3.0	96	0.53	36.7	241	-
		3.0	96	0.52	37.0	201	-
		-----	-----	-----	-----	-----	-----
		2.9	96	0.54	35.7	247	-

Table A-17 Alpha and Gnu Parameters for Laboratory Mixed/Laboratory Compacted Mixtures

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	RESILIEN STRAIN IN/IN	ALPHA	GNU	Ea=IN^S		R-SQUR FOR Ea=IN^S
								S	LOG(I)	
Control: TFA AC-10	77	7.6	106	7.2	3.6E-05	0.0743	1.5062	0.9257	-4.2275	0.999
		7.1	106	7.0	3.4E-05	0.0742	2.6049	0.9258	-4.0218	0.994
	AVG.	7.4	106	7.1	3.5E-05	0.0743	2.0555	0.9258	-4.1247	
TFA AC-10 + 3% UP 70	77	6.2	138	9.5	5.7E-05	0.2574	0.6507	0.7426	-4.3000	0.998
		5.6	137	9.3	5.5E-05	0.2728	0.7682	0.7272	-4.2390	0.999
	AVG.	5.9	138	9.4	5.6E-05	0.2651	0.7094	0.7349	-4.2695	
TFA AC-10 + 3% Styrelf	77	7.1	161	10.9	7.8E-05	0.2747	0.6857	0.7253	-4.1323	0.999
		7.4	160	10.7	7.3E-05	0.2810	0.6393	0.7190	-4.1889	0.999
	AVG.	7.3	160	10.8	7.5E-05	0.2779	0.6625	0.7222	-4.1606	
TFA AC-10 + 3% NS 175	77	6.6	144	9.8	5.5E-05	0.2455	0.3986	0.7545	-4.5399	0.999
		7.4	144	9.9	5.7E-05	0.2662	0.4809	0.7338	-4.4261	0.999
	AVG.	7.0	144	9.8	5.6E-05	0.2559	0.4398	0.7442	-4.4830	
TFA AC-10 + 18% C107	77	13.4	74	4.8	7.3E-05	0.2495	0.2474	0.7505	-4.6198	0.996
		11.9	74	4.7	7.0E-05	0.2925	0.2750	0.7075	-4.5641	0.997
	AVG.	12.7	74	4.8	7.2E-05	0.2710	0.2612	0.7290	-4.5920	
Control: TFA AC-20	77	8.0	172	11.5	6.5E-05	0.2232	0.0432	0.7768	-5.4418	0.994
		7.7	171	11.5	6.5E-05	0.2024	0.1063	0.7976	-5.0622	0.999
	AVG.	7.8	171	11.5	6.5E-05	0.2128	0.0748	0.7872	-5.2520	
TFA AC-20 + 3% Polybilt	77	7.45	218	14.7	7.0E-05	0.2927	0.1055	0.7073	-4.9799	0.996
		6.95	221	14.9	7.0E-05	0.3606	0.0530	0.6394	-5.2354	0.998
	AVG.	7.2	220	14.8	7.0E-05	0.3267	0.0792	0.6734	-5.1077	
TFA AC-20 + 5% Dow	77	7.8	217	14.4	6.0E-05	0.3206	0.0188	0.6794	-5.7818	0.999
		7.6	216	14.4	6.0E-05	0.2874	0.0119	0.7126	-5.9990	0.999
		7.7	216	14.4	6.0E-05	0.3040	0.0154	0.6960	-5.8904	

Table A-18 Alpha and Gnu Parameters for Plant Mixed/Laboratory Compacted Mixtures

MIXTURE	TEST TEMP. F		AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	RESILIEN STRAIN IN/IN	ALPHA	GNU	Ea=IN^S S	Ea=IN^S LOG(I)	R-SQUR FOR Ea=IN^S
TFA AC-10 + 3% UP 70	77		7.4	194	13.7	4.9E-05	0.3042	0.2232	0.6958	-4.8000	0.998
			6.9	194	13.8	5.2E-05	0.4415	0.3523	0.5585	-4.4841	0.997
		AVG.	7.2	194	13.7	5.1E-05	0.3729	0.2878	0.6272	-4.6421	
TFA AC-10 + 3% Styrelf	77		7.3	228	16.1	6.8E-05	0.3584	0.4790	0.6416	-4.2970	0.992
			6.7	232	16.5	7.2E-05	0.3017	0.3595	0.6983	-4.4340	0.993
		AVG.	7.0	230	16.3	7.0E-05	0.3301	0.4193	0.6700	-4.3655	
TFA AC-10 + 3% NS 175	77		6.5	175	12.2	3.3E-05	0.2023	0.1445	0.7977	-5.2302	0.999
			6.6	176	12.3	4.2E-05	0.2562	0.2717	0.7438	-4.8182	0.998
		AVG.	6.5	176	12.3	3.7E-05	0.2293	0.2081	0.7708	-5.0242	
TFA AC-10 + 18% C107	77		7.6	131	9.1	3.1E-05	0.4508	0.4063	0.5492	-4.6367	0.999
			7.4	133	9.3	4.7E-05	0.3496	0.1161	0.6504	-5.0780	0.998
		AVG.	7.5	132	9.2	3.9E-05	0.4002	0.2612	0.5998	-4.8574	
Control: TFA AC-20	77		7.4	172	11.9	3.6E-05	0.3375	0.1109	0.6625	-5.2213	0.998
			7.0	171	11.9	3.5E-05	0.3173	0.0768	0.6827	-5.4034	0.987
		AVG.	7.2	171	11.9	3.5E-05	0.3274	0.0939	0.6726	-5.3124	
TFA AC-20 + 3% Polybilt	77		7.32	218	14.6	3.4E-05	0.7661	0.5669	0.2339	-4.0866	0.992
			7.33	221	14.7	4.4E-05	0.5413	0.1603	0.4587	-4.8112	0.993
		AVG.	7.3	220	14.7	3.9E-05	0.6537	0.3636	0.3463	-4.4489	
TFA AC-20 + 5% Dow	77		7.8	217	15.2	4.9E-05	0.6000	0.0259	0.4000	-5.4958	0.990
			7.6	216	15.1	4.8E-05	0.6767	0.0526	0.3233	-5.1067	0.993
			7.7	216	15.1	4.9E-05	0.6384	0.0392	0.3617	-5.3013	

Table A-19 Fatigue Parameter Values for Laboratory Mixed/Laboratory Compacted Mixtures

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	STATIC MODULUS KSI	INITIAL STRAIN IN/IN	LOAD CYCLES	FATIGUE CONSTANT K1	FATIGUE CONSTANT K2	R-SQUR FOR Nf=K1(1/Emix)^K
Control: TFA AC-10	77	7.6	106	7.2	28	2.6E-04	575	4.74E-02	1.11	0.84
		7.1	106	7.0	28	2.5E-04	288			
		7.4	184	12.6	28	4.5E-04	304			
		7.3	182	12.4	28	4.4E-04	283			
		7.7	376	25.5	28	9.1E-04	93			
		7.3	373	25.5	28	9.1E-04	109			
TFA AC-10 + 3% UP 70	77	6.2	138	9.5	42	2.3E-04	3245	4.96E-05	2.14	0.99
		5.6	137	9.3	42	2.2E-04	3400			
		6.0	235	16.1	42	3.8E-04	945			
		6.3	235	16.0	42	3.8E-04	982			
		6.4	478	32.6	42	7.8E-04	185			
		5.5	482	33.0	42	7.9E-04	277			
TFA AC-10 + 3% Styrelf	77	7.1	161	10.9	31	3.5E-04	2450	9.68E-04	1.82	0.96
		7.4	160	10.7	31	3.4E-04	1500			
		7.7	275	18.2	31	5.9E-04	720			
		7.3	275	18.6	31	6.0E-04	826			
		6.8	508	33.8	31	1.1E-03	221			
		7.2	509	34.0	31	1.1E-03	252			
TFA AC-10 + 3% NS 175	77	6.6	144	9.8	35	2.8E-04	4825	4.36E-06	2.54	0.96
		7.4	144	9.9	35	2.8E-04	4035			
		7.2	246	16.6	35	4.8E-04	1344			
		6.8	247	16.8	35	4.8E-04	1510			
		6.9	505	27.8	35	7.9E-04	205			
		6.9	506	34.8	35	1.0E-03	242			
TFA AC-10 + 18% C107	77	13.4	74	4.8	11	4.4E-04	8700	7.75E-05	2.43	0.97
		11.3	74	4.7	11	4.3E-04	11755			
		11.4	131	8.5	11	7.7E-04	4340			
		11.6	131	8.6	11	7.8E-04	2540			
		12.2	271	17.3	11	1.6E-03	377			
		11.9	267	17.5	11	1.6E-03	521			
Control: TFA AC-20	77	8.0	144	9.6	102	9.4E-05	13680	4.02E-06	2.35	0.98
		7.7	143	9.6	102	9.4E-05	9470			
		7.1	286	19.2	102	1.9E-04	2847			
		7.6	286	19.2	102	1.9E-04	2646			
		6.9	581	38.8	102	3.8E-04	353			
		6.8	581	38.9	102	3.8E-04	503			
TFA AC-20 + 3% Polybilt	77	7.4	167	11.3	103	1.1E-04	15120	1.54E-09	3.30	0.98
		6.9	168	11.3	103	1.1E-04	26100			
		7.6	286	19.3	103	1.9E-04	2392			
		7.7	286	19.2	103	1.9E-04	2410			
		6.9	584	39.5	103	3.8E-04	364			
		6.7	584	39.6	103	3.8E-04	260			
TFA AC-20 + 5% Dow	77	7.8	156	10.3	152	6.8E-05	81340	4.31E-14	4.40	0.98
		7.6	158	10.5	152	6.9E-05	73620			
		6.4	267	18.0	152	1.2E-04	16900			
		6.7	268	17.9	152	1.2E-04	8345			
		7.2	545	36.1	152	2.4E-04	316			
		7.6	545	36.1	152	2.4E-04	359			

Table A-20 Fatigue Parameter Values for Plant Mixed/Laboratory Compacted Mixtures

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	STATIC MODULUS KSI	INITIAL STRAIN IN/IN	LOAD CYCLES	FATIGUE CONSTANT		R-SQUR FOR Nf=K1(1/Emix)^K
								K1	K2	
TFA AC-10 + 3% UP 70	77	7.4	194	13.7	66	2.1E-04	17800	5.75E-06	2.57	0.993
		6.9	194	13.8	66	2.1E-04	14900			
		6.7	332	23.7	66	3.6E-04	4145			
		6.8	332	23.6	66	3.6E-04	4057			
		7.0	677	48.0	66	7.3E-04	552			
		6.7	674	48.1	66	7.3E-04	778			
TFA AC-10 + 3% Styrelf	77	7.3	228	16.1	57	2.8E-04	5623	8.52E-05	2.20	0.992
		6.7	232	16.5	57	2.9E-04	4948			
		6.86	395	28.1	57	4.9E-04	1489			
		7.38	398	28.1	57	4.9E-04	1622			
		7.32	799	56.4	57	9.9E-04	292			
		6.92	802	57.1	57	1.0E-03	392			
TFA AC-10 + 3% NS 175	77	6.5	175	12.2	61	2.0E-04	13700	3.54E-06	2.59	0.983
		6.6	176	12.3	61	2.0E-04	10300			
		6.71	303	21.3	61	3.5E-04	4051			
		6.66	302	21.2	61	3.5E-04	3492			
		6.91	625	43.6	61	7.1E-04	396			
		6.55	606	42.6	61	7.0E-04	566			
TFA AC-10 + 18% C107	77	7.6	131	9.1	39	2.3E-04	112300	1.07E-08	3.58	0.999
		7.4	133	9.3	39	2.4E-04	108400			
		7.00	229	15.9	39	4.1E-04	15985			
		7.30	230	15.9	39	4.1E-04	13825			
		7.55	465	32.4	39	8.3E-04	1156			
		7.16	467	32.4	39	8.3E-04	1235			
Control: TFA AC-20	77	7.4	172	11.9	88	1.3E-04	76500	4.99E-08	3.16	0.990
		7.0	171	11.9	88	1.4E-04	70650			
		7.10	294	20.4	88	2.3E-04	21130			
		6.85	294	20.2	88	2.3E-04	15750			
		7.53	607	41.7	88	4.7E-04	1427			
		7.05	601	41.8	88	4.7E-04	1440			
TFA AC-20 + 3% Polybilt	77	7.32	218	14.6	138	1.1E-04	260300	1.66E-12	4.30	0.995
		7.33	221	14.7	138	1.1E-04	181350			
		7.23	375	25.0	138	1.8E-04	16250			
		7.04	376	25.3	138	1.8E-04	20980			
		7.10	762	51.0	138	3.7E-04	920			
		7.42	764	51.1	138	3.7E-04	1105			
TFA AC-20 + 5% Dow	77	7.8	217	15.2	194	7.8E-05	191250	1.38E-13	4.43	0.986
		7.6	216	15.1	194	7.8E-05	198400			
		7.62	363	25.4	194	1.3E-04	22250			
		7.86	377	26.2	194	1.3E-04	34100			
		7.83	755	52.8	194	2.7E-04	970			
		7.94	759	52.8	194	2.7E-04	640			

Table A-21 Creep Compliance Properties for Laboratory Mixed/ Laboratory Compacted Mixture Using Modified Compaction.

MIXTURE	TEMP. F	D1	m	Log(SHIFT FACTOR)	BETA
Control: TFA AC-10	60	1.86E-06	0.84	0.77	0.033
	77	8.01E-06	0.84		
	90	2.70E-05	0.71	-0.27	
TFA AC-10 + 3% UP 70	60	2.61E-06	0.56	0.79	0.063
	77	5.18E-06	0.63		
	90	2.21E-05	0.64	-1.04	
TFA AC-10 + 3% Styrelf	60	2.97E-06	0.70	0.58	0.040
	77	1.24E-05	0.62		
	90	3.28E-05	0.59	-0.60	
TFA AC-10 + 3% NS 175	60	2.90E-06	0.54	0.83	0.042
	77	5.18E-06	0.63		
	90	1.06E-05	0.62	-0.44	
TFA AC-10 + 18% C107	60	6.56E-07	0.70	1.03	0.059
	77	3.80E-06	0.67		
	90	1.14E-05	0.69	-0.75	
Control: TFA AC-20	60	9.93E-07	0.58	1.05	0.073
	77	4.28E-06	0.57		
	90	1.55E-05	0.62	-1.10	
TFA AC-20 + 3% Polybilt	60	1.97E-06	0.41	1.19	0.089
	77	5.24E-06	0.45		
	90	2.42E-05	0.41	-1.41	
TFA AC-20 + 5% Dow	60	1.38E-06	0.31	1.26	0.083
	77	2.11E-06	0.42		
	90	6.12E-06	0.44	-1.20	

Table A-22 Creep Compliance Properties for Plant Mixed/ Laboratory Compacted Mixture Using Modified Compaction.

MIXTURE	TEMP. F	D1	m	Log(SHIFT FACTOR)	BETA
TFA AC-10 + 3% UP 70	60	2.30E-06	0.46	0.97	0.090
	77	3.46E-06	0.59		
	90	3.21E-05	0.58	-1.61	
TFA AC-10 + 3% Styrelf	60	3.90E-06	0.47	0.96	0.055
	77	9.24E-06	0.50		
	90	1.50E-05	0.58	-0.71	
TFA AC-10 + 3% NS 175	60	2.27E-06	0.44	1.15	0.064
	77	4.04E-06	0.56		
	90	1.68E-05	0.46	-0.78	
TFA AC-10 + 18% C107	60	5.50E-07	0.63	1.29	0.079
	77	3.58E-06	0.63		
	90	1.43E-05	0.66	-1.07	
Control: TFA AC-20	60	7.02E-07	0.49	1.21	0.077
	77	2.51E-06	0.51		
	90	1.17E-05	0.45	-1.07	
TFA AC-20 + 3% Polybilt	60	1.91E-06	0.30	0.81	0.074
	77	1.98E-06	0.42		
	90	5.90E-06	0.45	-1.30	
TFA AC-20 + 5% Dow	60	2.10E-06	0.14	1.01	0.053
	77	1.53E-06	0.29		
	90	1.82E-06	0.34	-0.60	

Table A-23 Creep Compliance of Laboratory Mixed / Laboratory Compacted Mixtures Using Modified Compaction.

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-20 TEST TEMP = 60 , ZIGMA = 7.648 PSI				TFA AC-20 TEST TEMP = 60 , ZIGMA = 7.648 PSI			
31.6	2.85E-04	1.48E-04	9.69E-06	31.6	3.20E-04	1.66E-04	5.66E-06
56.2	3.90E-04	2.03E-04	1.33E-05	56.2	4.50E-04	2.34E-04	7.96E-06
100.0	5.35E-04	2.78E-04	1.82E-05	100.0	6.10E-04	3.17E-04	1.08E-05
177.8	7.35E-04	3.82E-04	2.50E-05	177.8	8.40E-04	4.37E-04	1.49E-05
316.2	1.03E-03	5.33E-04	3.49E-05	316.2	1.15E-03	5.98E-04	2.03E-05
562.3	1.43E-03	7.41E-04	4.85E-05	562.3	1.60E-03	8.32E-04	2.83E-05
1000.0	2.09E-03	1.08E-03	7.09E-05	1000.0	2.24E-03	1.17E-03	3.96E-05
1778.3	2.99E-03	1.55E-03	1.01E-04	1778.3	3.13E-03	1.63E-03	5.53E-05
3162.3	4.30E-03	2.24E-03	1.46E-04	3162.3	4.40E-03	2.29E-03	7.78E-05
3600.0	4.60E-03	2.39E-03	1.56E-04	3600.0	4.72E-03	2.45E-03	8.35E-05
7200.0	4.13E-03	2.15E-03		7200.0	4.19E-03	2.18E-03	
TFA AC-20 TEST TEMP = 77 , ZIGMA=5.570 PSI				TFA AC-20 TEST TEMP = 77 , ZIGMA=3.917 PSI			
31.6	4.50E-04	2.34E-04	2.10E-05	31.6	6.50E-04	3.38E-04	4.32E-05
56.2	6.25E-04	3.25E-04	2.92E-05	56.2	9.00E-04	4.68E-04	5.98E-05
100.0	8.50E-04	4.42E-04	3.97E-05	100.0	1.20E-03	6.24E-04	7.97E-05
177.8	1.18E-03	6.11E-04	5.49E-05	177.8	1.65E-03	8.58E-04	1.10E-04
316.2	1.63E-03	8.45E-04	7.59E-05	316.2	2.15E-03	1.12E-03	1.43E-04
562.3	2.25E-03	1.17E-03	1.05E-04	562.3	2.88E-03	1.50E-03	1.91E-04
1000.0	3.30E-03	1.72E-03	1.54E-04	1000.0	3.95E-03	2.05E-03	2.62E-04
1778.3	4.95E-03	2.57E-03	2.31E-04	1778.3	5.63E-03	2.93E-03	3.73E-04
3162.3	7.80E-03	4.06E-03	3.64E-04	3162.3	8.13E-03	4.23E-03	5.39E-04
3600.0	8.63E-03	4.49E-03	4.03E-04	3600.0	8.90E-03	4.63E-03	5.91E-04
7200.0	8.25E-03	4.29E-03		7200.0	8.83E-03	4.59E-03	
TFA AC-20 TEST TEMP = 90 , ZIGMA=2.797 PSI				TFA AC-20 TEST TEMP = 90 , ZIGMA=1.405 PSI			
3.2	3.00E-04	1.56E-04	2.79E-05	3.2	1.40E-04	7.28E-05	2.59E-05
5.6	4.75E-04	2.47E-04	4.42E-05	5.6	1.95E-04	1.01E-04	3.61E-05
10.0	6.50E-04	3.38E-04	6.04E-05	10.0	2.65E-04	1.38E-04	4.90E-05
17.8	1.03E-03	5.33E-04	9.53E-05	17.8	3.70E-04	1.92E-04	6.85E-05
31.6	1.43E-03	7.41E-04	1.32E-04	31.6	5.10E-04	2.65E-04	9.44E-05
56.2	1.98E-03	1.03E-03	1.84E-04	56.2	7.00E-04	3.64E-04	1.30E-04
100.0	2.60E-03	1.35E-03	2.42E-04	100.0	9.50E-04	4.94E-04	1.76E-04
177.8	3.85E-03	2.00E-03	3.58E-04	177.8	1.35E-03	7.00E-04	2.49E-04
316.2	5.45E-03	2.83E-03	5.07E-04	316.2	1.95E-03	1.01E-03	3.60E-04
562.3	8.50E-03	4.42E-03	7.90E-04	562.3	2.82E-03	1.47E-03	5.22E-04
1000.0	1.55E-02	8.06E-03	1.44E-03	1000.0	4.26E-03	2.22E-03	7.88E-04

Table A-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-20 + 3% POLYBILT 103 TEST TEMP = 60 , ZIGMA = 7.700 PSI				TFA AC-20 + 3% POLYBILT 103 TEST TEMP = 60 , ZIGMA = 7.750 PSI			
31.6	2.75E-04	1.43E-04	9.29E-06	31.6	4.30E-04	2.24E-04	7.50E-06
56.2	3.50E-04	1.82E-04	1.18E-05	56.2	5.15E-04	2.68E-04	8.99E-06
100.0	4.60E-04	2.39E-04	1.55E-05	100.0	6.15E-04	3.20E-04	1.07E-05
177.8	6.15E-04	3.20E-04	2.08E-05	177.8	7.20E-04	3.74E-04	1.26E-05
316.2	8.00E-04	4.16E-04	2.70E-05	316.2	8.30E-04	4.32E-04	1.45E-05
562.3	1.03E-03	5.33E-04	3.46E-05	562.3	1.08E-03	5.62E-04	1.88E-05
1000.0	1.30E-03	6.76E-04	4.39E-05	1000.0	1.38E-03	7.18E-04	2.41E-05
1778.3	1.67E-03	8.66E-04	5.62E-05	1778.3	1.78E-03	9.26E-04	3.11E-05
3162.3	2.08E-03	1.08E-03	7.01E-05	3162.3	2.34E-03	1.22E-03	4.08E-05
3600.0	2.18E-03	1.13E-03	7.35E-05	3600.0	2.48E-03	1.29E-03	4.32E-05
7200.0	1.50E-03	7.80E-04		7200.0	1.77E-03	9.19E-04	
TFA AC-20 + 3% POLYBILT 103 TEST TEMP = 77 , ZIGMA=6.103 PSI				TFA AC-20 + 3% POLYBILT 103 TEST TEMP = 77 , ZIGMA=6.061 PSI			
31.6	6.00E-04	3.12E-04	2.56E-05	31.6	5.50E-04	2.86E-04	2.36E-05
56.2	7.85E-04	4.08E-04	3.34E-05	56.2	7.25E-04	3.77E-04	3.11E-05
100.0	1.00E-03	5.20E-04	4.26E-05	100.0	8.90E-04	4.63E-04	3.82E-05
177.8	1.30E-03	6.76E-04	5.54E-05	177.8	1.19E-03	6.19E-04	5.11E-05
316.2	1.69E-03	8.76E-04	7.18E-05	316.2	1.53E-03	7.93E-04	6.54E-05
562.3	2.25E-03	1.17E-03	9.59E-05	562.3	1.95E-03	1.01E-03	8.37E-05
1000.0	3.04E-03	1.58E-03	1.29E-04				
1778.3	4.20E-03	2.18E-03	1.79E-04				
3162.3	5.90E-03	3.07E-03	2.51E-04				
3600.0	6.40E-03	3.33E-03	2.73E-04				
7200.0	5.70E-03	2.96E-03					
TFA AC-20 + 3% POLYBILT 103 TEST TEMP = 90 , ZIGMA=3.300 PSI							
3.2	5.05E-04	2.63E-04	3.98E-05				
5.6	6.30E-04	3.28E-04	4.96E-05				
10.0	7.70E-04	4.00E-04	6.07E-05				
17.8	1.00E-03	5.20E-04	7.88E-05				
31.6	1.28E-03	6.63E-04	1.00E-04				
56.2	1.59E-03	8.27E-04	1.25E-04				
100.0	2.05E-03	1.07E-03	1.62E-04				
177.8	2.62E-03	1.36E-03	2.06E-04				
316.2	3.34E-03	1.73E-03	2.63E-04				
562.3	4.14E-03	2.15E-03	3.26E-04				

Table A-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
	TFA AC-20 + 5% DOW TEST TEMP = 60 , ZIGMA = 7.333 PSI				TFA AC-20 + 5% DOW TEST TEMP = 60 , ZIGMA = 7.395 PSI		
31.6	1.75E-04	9.10E-05	6.21E-06	31.6	1.20E-04	6.24E-05	2.19E-06
56.2	2.05E-04	1.07E-04	7.27E-06	56.2	1.30E-04	6.76E-05	2.38E-06
100.0	2.40E-04	1.25E-04	8.51E-06	100.0	1.53E-04	7.93E-05	2.79E-06
177.8	2.93E-04	1.52E-04	1.04E-05	177.8	1.73E-04	8.97E-05	3.15E-06
316.2	3.50E-04	1.82E-04	1.24E-05	316.2	2.08E-04	1.08E-04	3.80E-06
562.3	4.20E-04	2.18E-04	1.49E-05	562.3	2.33E-04	1.21E-04	4.25E-06
1000.0	5.15E-04	2.68E-04	1.83E-05	1000.0	2.60E-04	1.35E-04	4.76E-06
1778.3	6.35E-04	3.30E-04	2.25E-05	1778.3	2.98E-04	1.55E-04	5.44E-06
3162.3	7.85E-04	4.08E-04	2.78E-05	3162.3	3.45E-04	1.79E-04	6.31E-06
3600.0	8.28E-04	4.30E-04	2.93E-05	3600.0	3.57E-04	1.86E-04	6.53E-06
7200.0	3.70E-04	1.92E-04		7200.0			
	TFA AC-20 + 5% DOW TEST TEMP = 77 , ZIGMA=4.690 PSI				TFA AC-20 + 5% DOW TEST TEMP = 77 , ZIGMA=6.058 PSI		
31.6	1.50E-04	7.80E-05	8.32E-06	31.6	2.25E-04	1.17E-04	9.66E-06
56.2	2.10E-04	1.09E-04	1.16E-05	56.2	2.70E-04	1.40E-04	1.16E-05
100.0	2.75E-04	1.43E-04	1.52E-05	100.0	3.20E-04	1.66E-04	1.37E-05
177.8	3.70E-04	1.92E-04	2.05E-05	177.8	4.10E-04	2.13E-04	1.76E-05
316.2	4.75E-04	2.47E-04	2.63E-05	316.2	5.10E-04	2.65E-04	2.19E-05
562.3	5.90E-04	3.07E-04	3.27E-05	562.3	6.30E-04	3.28E-04	2.70E-05
1000.0	7.65E-04	3.98E-04	4.24E-05	1000.0	8.15E-04	4.24E-04	3.50E-05
1778.3	9.60E-04	4.99E-04	5.32E-05	1778.3	1.05E-03	5.46E-04	4.51E-05
3162.3	1.21E-03	6.27E-04	6.68E-05	3162.3	1.38E-03	7.15E-04	5.90E-05
3600.0	1.28E-03	6.63E-04	7.07E-05	3600.0	1.48E-03	7.67E-04	6.33E-05
7200.0	9.15E-04	4.76E-04		7200.0	1.03E-03	5.33E-04	
	TFA AC-20 + 5% DOW TEST TEMP = 90 , ZIGMA=3.363 PSI						
31.6	3.60E-04	1.87E-04	2.78E-05				
56.2	4.90E-04	2.55E-04	3.79E-05				
100.0	6.40E-04	3.33E-04	4.95E-05				
177.8	8.00E-04	4.16E-04	6.19E-05				
316.2	1.00E-03	5.20E-04	7.73E-05				
562.3	1.26E-03	6.55E-04	9.74E-05				
1000.0	1.65E-03	8.58E-04	1.28E-04				
1778.3	2.16E-03	1.12E-03	1.67E-04				
3162.3	2.90E-03	1.51E-03	2.24E-04				
3600.0	3.18E-03	1.65E-03	2.46E-04				
7200.0	2.83E-03	1.47E-03					

Table A-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-10 TEST TEMP = 60 , ZIGMA = 4.830 PSI				TFA AC-10 TEST TEMP = 60 , ZIGMA = 4.769 PSI			
31.6	1.50E-03	7.80E-04	8.08E-05	31.6	1.25E-03	6.50E-04	3.55E-05
56.2	2.10E-03	1.09E-03	1.13E-04	56.2	1.85E-03	9.62E-04	5.25E-05
100.0	2.80E-03	1.46E-03	1.51E-04	100.0	3.00E-03	1.56E-03	8.51E-05
177.8	4.20E-03	2.18E-03	2.26E-04	177.8	5.00E-03	2.60E-03	1.42E-04
316.2	6.00E-03	3.12E-03	3.23E-04	316.2	8.50E-03	4.42E-03	2.41E-04
				562.3	1.55E-02	8.06E-03	4.40E-04
				1000.0	2.50E-02	1.30E-02	7.09E-04
				1778.3	4.25E-02	2.21E-02	1.21E-03
				3162.3	7.15E-02	3.72E-02	2.03E-03
				3600.0	8.30E-02	4.32E-02	2.35E-03
				7200.0	8.30E-02	4.32E-02	
TFA AC-10 TEST TEMP = 77 , ZIGMA=0.774 PSI				TFA AC-10 TEST TEMP = 77 , ZIGMA=0.821 PSI			
31.6	4.00E-04	2.08E-04	1.34E-04	31.6	5.50E-04	2.86E-04	1.74E-04
56.2	6.50E-04	3.38E-04	2.18E-04	56.2	8.50E-04	4.42E-04	2.69E-04
100.0	1.10E-03	5.72E-04	3.70E-04	100.0	1.25E-03	6.50E-04	3.96E-04
177.8	1.80E-03	9.36E-04	6.05E-04	177.8	2.00E-03	1.04E-03	6.34E-04
316.2	2.90E-03	1.51E-03	9.74E-04	316.2	3.00E-03	1.56E-03	9.50E-04
562.3	5.00E-03	2.60E-03	1.68E-03	562.3	5.00E-03	2.60E-03	1.58E-03
1000.0	1.00E-02	5.20E-03	3.36E-03	1000.0	8.20E-03	4.26E-03	2.60E-03
TFA AC-10 TEST TEMP = 90 , ZIGMA=0.734 PSI				TFA AC-10 TEST TEMP = 90 , ZIGMA=0.585 PSI			
				3.2	2.50E-04	1.30E-04	1.11E-04
				5.6	3.50E-04	1.82E-04	1.56E-04
				10.0	4.50E-04	2.34E-04	2.00E-04
				17.8	6.25E-04	3.25E-04	2.78E-04
31.6	6.50E-04	3.38E-04	2.30E-04	31.6	8.70E-04	4.52E-04	3.87E-04
56.2	1.00E-03	5.20E-04	3.54E-04	56.2	1.30E-03	6.76E-04	5.78E-04
100.0	1.40E-03	7.28E-04	4.96E-04	100.0	2.00E-03	1.04E-03	8.89E-04
177.8	2.05E-03	1.07E-03	7.26E-04	177.8	3.08E-03	1.60E-03	1.37E-03

Table A-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-10 + 3% UP 70 TEST TEMP = 60 , ZIGMA = 6.505 PSI				TFA AC-10 + 3% UP 70 TEST TEMP = 60 , ZIGMA = 6.581 PSI			
31.6	6.00E-04	3.12E-04	2.40E-05	31.6	8.00E-04	4.16E-04	1.64E-05
56.2	7.50E-04	3.90E-04	3.00E-05	56.2	1.05E-03	5.46E-04	2.16E-05
100.0	9.50E-04	4.94E-04	3.80E-05	100.0	1.38E-03	7.15E-04	2.83E-05
177.8	1.30E-03	6.76E-04	5.20E-05	177.8	1.95E-03	1.01E-03	4.01E-05
316.2	1.80E-03	9.36E-04	7.19E-05	316.2	2.60E-03	1.35E-03	5.34E-05
562.3	2.45E-03	1.27E-03	9.79E-05	562.3	3.50E-03	1.82E-03	7.19E-05
1000.0	3.53E-03	1.83E-03	1.41E-04	1000.0	4.78E-03	2.48E-03	9.81E-05
1778.3	5.15E-03	2.68E-03	2.06E-04	1778.3	6.70E-03	3.48E-03	1.38E-04
3162.3	7.75E-03	4.03E-03	3.10E-04	3162.3	9.90E-03	5.15E-03	2.03E-04
3600.0	8.55E-03	4.45E-03	3.42E-04	3600.0	1.09E-02	5.64E-03	2.23E-04
7200.0	7.90E-03						
TFA AC-10 + 3% UP 70 TEST TEMP = 77 , ZIGMA=2.616 PSI				TFA AC-10 + 3% UP 70 TEST TEMP = 77 , ZIGMA=1.080 PSI			
31.6	5.50E-04	2.86E-04	5.47E-05	31.6	2.50E-04	1.30E-04	4.05E-05
56.2	8.00E-04	4.16E-04	7.95E-05	56.2	3.50E-04	1.82E-04	5.66E-05
100.0	1.10E-03	5.72E-04	1.09E-04	100.0	4.65E-04	2.42E-04	7.52E-05
177.8	1.65E-03	8.58E-04	1.64E-04	177.8	6.25E-04	3.25E-04	1.01E-04
316.2	2.30E-03	1.20E-03	2.29E-04	316.2	8.90E-04	4.63E-04	1.44E-04
562.3	3.10E-03	1.61E-03	3.08E-04	562.3	1.28E-03	6.63E-04	2.06E-04
1000.0	4.90E-03	2.55E-03	4.87E-04	1000.0	1.83E-03	9.52E-04	2.96E-04
1778.3	7.25E-03	3.77E-03	7.21E-04	1778.3	2.48E-03	1.29E-03	4.01E-04
3162.3	1.16E-02	6.03E-03	1.15E-03	3162.3	3.43E-03	1.78E-03	5.55E-04
3600.0	1.32E-02	6.87E-03	1.31E-03	3600.0	3.75E-03	1.95E-03	6.07E-04
7200.0	1.28E-02	6.66E-03		7200.0	3.70E-03	1.92E-03	
TFA AC-10 + 3% UP 70 TEST TEMP = 90 , ZIGMA=1.054 PSI				TFA AC-10 + 3% UP 70 TEST TEMP = 90 , ZIGMA=1.080 PSI			
31.6	6.50E-04	3.38E-04	1.60E-04	31.6	1.05E-03	5.46E-04	2.53E-04
56.2	1.00E-03	5.20E-04	2.47E-04	56.2	1.50E-03	7.80E-04	3.61E-04
100.0	1.40E-03	7.28E-04	3.45E-04	100.0	2.00E-03	1.04E-03	4.82E-04
177.8	2.05E-03	1.07E-03	5.06E-04	177.8	2.80E-03	1.46E-03	6.74E-04
316.2	3.10E-03	1.61E-03	7.65E-04	316.2	3.90E-03	2.03E-03	9.39E-04
562.3	4.35E-03	2.26E-03	1.07E-03	562.3	5.90E-03	3.07E-03	1.42E-03
1000.0	6.55E-03	3.41E-03	1.62E-03	1000.0	9.80E-03	5.10E-03	2.36E-03

Table A-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 7.375 PSI				TFA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 7.355 PSI			
31.6	2.00E-03	1.04E-03	7.05E-05				
56.2	2.65E-03	1.38E-03	9.34E-05				
100.0	3.45E-03	1.79E-03	1.22E-04	100.0	2.40E-03	1.25E-03	4.41E-05
177.8	4.75E-03	2.47E-03	1.67E-04	177.8	3.90E-03	2.03E-03	7.17E-05
316.2	6.30E-03	3.28E-03	2.22E-04	316.2	5.50E-03	2.86E-03	1.01E-04
562.3	8.90E-03	4.63E-03	3.14E-04	562.3	8.30E-03	4.32E-03	1.53E-04
1000.0	1.33E-02	6.89E-03	4.67E-04	1000.0	1.26E-02	6.53E-03	2.31E-04
1778.3	2.10E-02	1.09E-02	7.40E-04	1778.3	2.05E-02	1.07E-02	3.77E-04
3162.3	3.84E-02	2.00E-02	1.35E-03	3162.3	3.60E-02	1.87E-02	6.62E-04
3600.0	4.56E-02	2.37E-02	1.61E-03				
7200.0	4.17E-02						
TFA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA=1.356 PSI				TFA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA=.595 PSI			
31.6	5.50E-04	6.00E-04	1.05E-04	31.6	8.00E-04	4.16E-04	3.50E-04
56.2	8.00E-04	8.50E-04	1.53E-04	56.2	1.20E-03	6.24E-04	5.24E-04
100.0	1.10E-03	1.20E-03	2.11E-04	100.0	1.75E-03	9.10E-04	7.65E-04
177.8	1.65E-03	1.73E-03	3.16E-04	177.8	2.70E-03	1.40E-03	1.18E-03
316.2	2.30E-03	2.35E-03	4.41E-04	316.2	3.90E-03	2.03E-03	1.70E-03
562.3	3.10E-03	3.33E-03	5.95E-04	562.3	5.80E-03	3.02E-03	2.53E-03
1000.0	4.90E-03	4.85E-03	9.40E-04	1000.0	9.10E-03	4.73E-03	3.98E-03
1778.3	7.25E-03	7.10E-03	1.39E-03				
3162.3	1.16E-02	1.11E-02	2.22E-03				
3600.0	1.32E-02	1.24E-02	2.53E-03				
7200.0	1.28E-02	1.23E-02					
TFA AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA=0.848 PSI				TFA AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA=0.595 PSI			
3.2	2.50E-04	1.30E-04	7.67E-05	3.2	1.50E-04	7.80E-05	6.56E-05
5.6	3.25E-04	1.69E-04	9.97E-05	5.6	1.90E-04	9.88E-05	8.30E-05
10.0	4.50E-04	2.34E-04	1.38E-04	10.0	2.55E-04	1.33E-04	1.11E-04
17.8	6.50E-04	3.38E-04	1.99E-04	17.8	3.65E-04	1.90E-04	1.60E-04
31.6	9.00E-04	4.68E-04	2.76E-04	31.6	4.90E-04	2.55E-04	2.14E-04
56.2	1.28E-03	6.63E-04	3.91E-04	56.2	6.50E-04	3.38E-04	2.84E-04
100.0	1.85E-03	9.62E-04	5.67E-04	100.0	8.80E-04	4.58E-04	3.85E-04
177.8	2.73E-03	1.42E-03	8.36E-04	177.8	1.20E-03	6.24E-04	5.24E-04
316.2	4.20E-03	2.18E-03	1.29E-03	316.2	1.63E-03	8.45E-04	7.10E-04
562.3	6.70E-03	3.48E-03	2.05E-03	562.3	2.45E-03	1.27E-03	1.07E-03
				1000.0	3.43E-03	1.78E-03	1.50E-03
				1778.3	5.35E-03	2.78E-03	2.34E-03
				3162.3	9.10E-03	4.73E-03	3.98E-03
				3600.0	1.09E-02	5.67E-03	4.76E-03

Table A-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
	TFA AC-10 + 3% NS 175 TEST TEMP = 60 , ZIGMA = 6.890 PSI				TFA AC-10 + 3% NS 175 TEST TEMP = 60 , ZIGMA = 6.843 PSI		
31.6	6.50E-04	3.38E-04	2.45E-05	31.6	6.00E-04	3.12E-04	1.19E-05
56.2	9.25E-04	4.81E-04	3.49E-05	56.2	8.25E-04	4.29E-04	1.63E-05
100.0	1.30E-03	6.76E-04	4.91E-05	100.0	1.10E-03	5.72E-04	2.17E-05
177.8	1.78E-03	9.23E-04	6.70E-05	177.8	1.45E-03	7.54E-04	2.87E-05
316.2	2.35E-03	1.22E-03	8.87E-05	316.2	1.93E-03	1.00E-03	3.80E-05
562.3	3.15E-03	1.64E-03	1.19E-04	562.3	2.58E-03	1.34E-03	5.09E-05
1000.0	4.23E-03	2.20E-03	1.59E-04	1000.0	3.56E-03	1.85E-03	7.04E-05
1778.3	5.80E-03	3.02E-03	2.19E-04	1778.3	5.00E-03	2.60E-03	9.88E-05
3162.3	8.15E-03	4.24E-03	3.08E-04	3162.3	7.05E-03	3.67E-03	1.39E-04
3600.0	8.90E-03	4.63E-03	3.36E-04	3600.0	7.70E-03	4.00E-03	1.52E-04
7200.0	7.97E-03				6.73E-03		
	TFA AC-10 + 3% NS 175 TEST TEMP = 77 , ZIGMA=1.684 PSI				TFA AC-10 + 3% NS 175 TEST TEMP = 77 , ZIGMA=2.124 PSI		
31.6	3.50E-04	1.82E-04	5.40E-05	31.6	3.40E-04	1.77E-04	4.16E-05
56.2	5.10E-04	2.65E-04	7.88E-05	56.2	4.70E-04	2.44E-04	5.75E-05
100.0	7.00E-04	3.64E-04	1.08E-04	100.0	6.10E-04	3.17E-04	7.47E-05
177.8	1.05E-03	5.46E-04	1.62E-04	177.8	8.30E-04	4.32E-04	1.02E-04
316.2	1.50E-03	7.80E-04	2.32E-04	316.2	1.18E-03	6.14E-04	1.44E-04
562.3	2.05E-03	1.07E-03	3.17E-04	562.3	1.87E-03	9.73E-04	2.29E-04
1000.0	2.88E-03	1.50E-03	4.45E-04	1000.0	3.00E-03	1.56E-03	3.67E-04
1778.3	3.95E-03	2.05E-03	6.10E-04	1778.3	4.65E-03	2.42E-03	5.69E-04
3162.3	5.40E-03	2.81E-03	8.34E-04	3162.3	7.10E-03	3.69E-03	8.69E-04
3600.0	5.80E-03	3.02E-03	8.96E-04	3600.0	7.80E-03	4.06E-03	9.55E-04
7200.0	5.85E-03	3.04E-03		7200.0	7.55E-03	3.93E-03	
	TFA AC-10 + 3% NS 175 TEST TEMP = 90 , ZIGMA=1.104 PSI				TFA AC-10 + 3% NS 175 TEST TEMP = 90 , ZIGMA=.811 PSI		
				3.2	6.00E-05	3.12E-05	1.92E-05
				5.6	9.50E-05	4.94E-05	3.05E-05
				10.0	1.35E-04	7.02E-05	4.33E-05
				17.8	1.80E-04	9.36E-05	5.77E-05
31.6	4.00E-04	2.08E-04	9.42E-05	31.6	2.60E-04	1.35E-04	8.34E-05
56.2	5.75E-04	2.99E-04	1.35E-04	56.2	3.90E-04	2.03E-04	1.25E-04
100.0	7.60E-04	3.95E-04	1.79E-04	100.0	5.80E-04	3.02E-04	1.86E-04
177.8	1.05E-03	5.46E-04	2.47E-04	177.8	8.55E-04	4.45E-04	2.74E-04
316.2	1.40E-03	7.28E-04	3.30E-04	316.2	1.23E-03	6.37E-04	3.93E-04
562.3	1.93E-03	1.00E-03	4.53E-04	562.3	1.78E-03	9.23E-04	5.69E-04
1000.0	3.05E-03	1.59E-03	7.18E-04	1000.0	2.63E-03	1.37E-03	8.42E-04
				1778.3	4.05E-03	2.11E-03	1.30E-03
				3162.3	6.45E-03	3.35E-03	2.07E-03
				3600.0	6.75E-03	3.51E-03	2.16E-03
				7200.0	6.75E-03		

Table A-23 (Continued)

TFA AC-10 + 18% C107
TEST TEMP = 60 , ZIGMA = 9.889 PSI

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
31.6	2.50E-03	1.30E-03	6.57E-05
56.2	3.75E-03	1.95E-03	9.86E-05
100.0	5.25E-03	2.73E-03	1.38E-04
177.8	7.15E-03	3.72E-03	1.88E-04
316.2	9.80E-03	5.10E-03	2.58E-04

TFA AC-10 + 18% C107
TEST TEMP = 60 , ZIGMA = 5.920 PSI

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
31.6	3.50E-04	1.82E-04	8.00E-06
56.2	4.50E-04	2.34E-04	1.03E-05
100.0	6.50E-04	3.38E-04	1.49E-05
177.8	1.00E-03	5.20E-04	2.28E-05
316.2	1.60E-03	8.32E-04	3.66E-05
562.3	2.45E-03	1.27E-03	5.60E-05
1000.0	3.75E-03	1.95E-03	8.57E-05
1778.3	5.40E-03	2.81E-03	1.23E-04
3162.3	7.60E-03	3.95E-03	1.74E-04
3600.0	8.28E-03	4.30E-03	1.89E-04
7200.0	6.20E-03		

TFA AC-10 + 18% C107
TEST TEMP = 77 , ZIGMA=2.854 PSI

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
31.6	4.00E-04	2.08E-04	3.64E-05
56.2	7.00E-04	3.64E-04	6.38E-05
100.0	9.00E-04	4.68E-04	8.20E-05
177.8	1.40E-03	7.28E-04	1.28E-04
316.2	2.00E-03	1.04E-03	1.82E-04
562.3	2.90E-03	1.51E-03	2.64E-04
1000.0	4.45E-03	2.31E-03	4.05E-04
1778.3	6.00E-03	3.12E-03	5.47E-04
3162.3	7.78E-03	4.04E-03	7.08E-04
3600.0	8.13E-03	4.23E-03	7.40E-04
7200.0	6.00E-03		

TFA AC-10 + 18% C107
TEST TEMP = 90 , ZIGMA=1.283 PSI

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
3.2	1.50E-04	7.80E-05	3.04E-05
5.6	2.10E-04	1.09E-04	4.26E-05
10.0	3.00E-04	1.56E-04	6.08E-05
17.8	4.70E-04	2.44E-04	9.53E-05
31.6	7.25E-04	3.77E-04	1.47E-04
56.2	1.08E-03	5.59E-04	2.18E-04
100.0	1.55E-03	8.06E-04	3.14E-04
177.8	2.25E-03	1.17E-03	4.56E-04
316.2	3.15E-03	1.64E-03	6.38E-04
562.3	4.45E-03	2.31E-03	9.02E-04
1000.0	7.03E-03	3.65E-03	1.42E-03
1778.3	1.13E-02	5.85E-03	2.28E-03
3162.3	1.75E-02	9.08E-03	3.54E-03
3600.0	1.90E-02	9.88E-03	3.85E-03
7200.0	1.86E-02	9.67E-03	3.77E-03

TFA AC-10 + 18% C107
TEST TEMP = 90 , ZIGMA=1.274 PSI

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
5.6	1.60E-04	8.32E-05	3.27E-05
10.0	2.05E-04	1.07E-04	4.18E-05
17.8	3.85E-04	2.00E-04	7.86E-05
31.6	5.50E-04	2.86E-04	1.12E-04
56.2	8.75E-04	4.55E-04	1.79E-04
100.0	1.23E-03	6.37E-04	2.50E-04
177.8	1.71E-03	8.89E-04	3.49E-04
316.2	2.50E-03	1.30E-03	5.10E-04
562.3	3.63E-03	1.89E-03	7.40E-04
1000.0	5.55E-03	2.89E-03	1.13E-03
1778.3	8.60E-03	4.47E-03	1.76E-03
3162.3	1.27E-02	6.61E-03	2.59E-03
3600.0	~~1.~~39E-02	7.23E-03	2.84E-03
7200.0	1.33E-02		

Table A-24 Creep Compliance of Plant Mixed / Laboratory Compacted Mixtures Using Modified Compaction.

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
	TFA AC-20 TEST TEMP = 60 , ZIGMA = 8.271 PSI						
31.6	1.25E-04	6.50E-05	3.93E-06				
56.2	1.60E-04	8.32E-05	5.03E-06				
100.0	2.05E-04	1.07E-04	6.45E-06				
177.8	2.85E-04	1.48E-04	8.96E-06				
316.2	3.75E-04	1.95E-04	1.18E-05				
562.3	4.90E-04	2.55E-04	1.54E-05				
1000.0	6.40E-04	3.33E-04	2.01E-05				
1778.3	8.70E-04	4.52E-04	2.74E-05				
3162.3	1.17E-03	6.06E-04	3.66E-05				
3600.0	1.25E-03	6.50E-04	3.93E-05				
7200.0	7.00E-04	3.64E-04					
	TFA AC-20 TEST TEMP = 77 , ZIGMA=8.935 PSI				TFA AC-20 TEST TEMP = 77 , ZIGMA=8.733 PSI		
31.6	4.25E-04	2.21E-04	1.24E-05	31.6	5.50E-04	2.86E-04	1.64E-05
56.2	5.65E-04	2.94E-04	1.64E-05	56.2	8.00E-04	4.16E-04	2.38E-05
100.0	7.10E-04	3.69E-04	2.07E-05	100.0	1.10E-03	5.72E-04	3.28E-05
177.8	9.40E-04	4.89E-04	2.74E-05	177.8	1.48E-03	7.72E-04	4.42E-05
316.2	1.23E-03	6.37E-04	3.57E-05	316.2	1.95E-03	1.01E-03	5.81E-05
562.3	1.65E-03	8.58E-04	4.80E-05	562.3	2.57E-03	1.33E-03	7.64E-05
1000.0	2.24E-03	1.16E-03	6.50E-05	1000.0	3.39E-03	1.76E-03	1.01E-04
1778.3	3.13E-03	1.63E-03	9.10E-05	1778.3	4.51E-03	2.35E-03	1.34E-04
3162.3	4.50E-03	2.34E-03	1.31E-04	3162.3	6.10E-03	3.17E-03	1.82E-04
3600.0	4.87E-03	2.54E-03	1.42E-04	3600.0	6.55E-03	3.41E-03	1.95E-04
7200.0	4.33E-03	2.25E-03		7200.0	6.20E-03	3.22E-03	
	TFA AC-20 TEST TEMP = 90 , ZIGMA=2.060 PSI						
31.6	4.00E-04	2.08E-04	5.05E-05				
56.2	5.50E-04	2.86E-04	6.94E-05				
100.0	7.50E-04	3.90E-04	9.47E-05				
177.8	1.00E-03	5.20E-04	1.26E-04				
316.2	1.31E-03	6.81E-04	1.65E-04				
562.3	1.68E-03	8.71E-04	2.11E-04				
1000.0	2.12E-03	1.10E-03	2.67E-04				
1778.3	2.65E-03	1.38E-03	3.35E-04				
3162.3	3.28E-03	1.70E-03	4.13E-04				
3600.0	3.45E-03	1.79E-03	4.36E-04				
7200.0	3.28E-03	1.70E-03					

Table A-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-20 + 3% POLYBILT 103 TEST TEMP = 60 , ZIGMA = 10.416 PSI							
31.6	2.25E-04	1.17E-04	5.62E-06				
56.2	2.65E-04	1.38E-04	6.62E-06				
100.0	3.10E-04	1.61E-04	7.74E-06				
177.8	3.62E-04	1.89E-04	9.05E-06				
316.2	4.20E-04	2.18E-04	1.05E-05				
562.3	5.05E-04	2.63E-04	1.26E-05				
1000.0	6.10E-04	3.17E-04	1.52E-05				
1778.3	7.45E-04	3.87E-04	1.86E-05				
3162.3	9.05E-04	4.71E-04	2.26E-05				
3600.0	9.40E-04	4.89E-04	2.35E-05				
7200.0	5.25E-04	2.73E-04					
TFA AC-20 + 3% POLYBILT 103 TEST TEMP = 77 , ZIGMA=6.764 PSI				TFA AC-20 + 3% POLYBILT 103 TEST TEMP = 77 , ZIGMA=9.729 PSI			
31.6	2.00E-04	1.04E-04	7.69E-06	31.6	3.00E-04	1.56E-04	8.41E-06
56.2	2.70E-04	1.40E-04	1.04E-05	56.2	3.75E-04	1.95E-04	1.05E-05
100.0	3.50E-04	1.82E-04	1.35E-05	100.0	5.00E-04	2.60E-04	1.40E-05
177.8	4.40E-04	2.29E-04	1.69E-05	177.8	6.50E-04	3.38E-04	1.82E-05
316.2	5.50E-04	2.86E-04	2.11E-05	316.2	8.30E-04	4.32E-04	2.33E-05
562.3	6.75E-04	3.51E-04	2.60E-05	562.3	1.08E-03	5.62E-04	3.03E-05
1000.0	8.30E-04	4.32E-04	3.19E-05	1000.0	1.41E-03	7.33E-04	3.95E-05
1778.3	1.00E-03	5.20E-04	3.84E-05	1778.3	1.84E-03	9.57E-04	5.16E-05
3162.3	1.21E-03	6.29E-04	4.65E-05	3162.3	2.31E-03	1.20E-03	6.47E-05
3600.0	1.28E-03	6.63E-04	4.90E-05	3600.0	2.44E-03	1.27E-03	6.82E-05
7200.0	7.90E-04	4.11E-04		7200.0	1.80E-03	9.36E-04	
TFA AC-20 + 3% POLYBILT 103 TEST TEMP = 90 , ZIGMA=2.01 PSI							
31.6	2.00E-04	1.04E-04	2.59E-05				
56.2	2.75E-04	1.43E-04	3.56E-05				
100.0	3.75E-04	1.95E-04	4.85E-05				
177.8	5.00E-04	2.60E-04	6.47E-05				
316.2	6.75E-04	3.51E-04	8.73E-05				
562.3	8.50E-04	4.42E-04	1.10E-04				
1000.0	1.10E-03	5.72E-04	1.42E-04				
1778.3	1.35E-03	7.02E-04	1.75E-04				
3162.3	1.65E-03	8.58E-04	2.13E-04				
3600.0	1.78E-03	9.23E-04	2.30E-04				
7200.0	3.38E-03	1.76E-03					

Table A-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-20 + 5% DOW TEST TEMP = 60 , ZIGMA = 10.775 PSI							
31.6	1.37E-04	7.15E-05	3.32E-06				
56.2	1.52E-04	7.93E-05	3.68E-06				
100.0	1.68E-04	8.71E-05	4.04E-06				
177.8	1.82E-04	9.49E-05	4.40E-06				
316.2	2.01E-04	1.05E-04	4.86E-06				
562.3	2.22E-04	1.16E-04	5.37E-06				
1000.0	2.40E-04	1.25E-04	5.79E-06				
1778.3	2.45E-04	1.27E-04	5.91E-06				
3162.3	2.65E-04	1.38E-04	6.40E-06				
3600.0	2.73E-04	1.42E-04	6.58E-06				
7200.0	6.25E-05	3.25E-05					
TFA AC-20 + 5% DOW TEST TEMP = 77 , ZIGMA=6.764 PSI				TFA AC-20 + 5% DOW TEST TEMP = 77 , ZIGMA=7.695 PSI			
31.6	1.60E-04	8.32E-05	3.80E-06	31.6	1.45E-04	7.54E-05	4.90E-06
56.2	1.90E-04	9.88E-05	4.51E-06	56.2	1.65E-04	8.58E-05	5.58E-06
100.0	2.35E-04	1.22E-04	5.58E-06	100.0	1.88E-04	9.75E-05	6.34E-06
177.8	2.90E-04	1.51E-04	6.88E-06	177.8	2.08E-04	1.08E-04	7.01E-06
316.2	3.55E-04	1.85E-04	8.43E-06	316.2	2.25E-04	1.17E-04	7.60E-06
562.3	4.35E-04	2.26E-04	1.03E-05	562.3	2.36E-04	1.23E-04	7.98E-06
1000.0	5.35E-04	2.78E-04	1.27E-05	1000.0	2.67E-04	1.39E-04	9.01E-06
1778.3	6.85E-04	3.56E-04	1.63E-05	1778.3	3.08E-04	1.60E-04	1.04E-05
3162.3	8.80E-04	4.58E-04	2.09E-05	3162.3	3.85E-04	2.00E-04	1.30E-05
3600.0	9.25E-04	4.81E-04	2.20E-05	3600.0	4.05E-04	2.11E-04	1.37E-05
7200.0	3.15E-04	1.64E-04					
TFA AC-20 + 5% DOW TEST TEMP = 90 , ZIGMA=4.250 PSI							
31.6	1.00E-04	5.20E-05	6.12E-06				
56.2	1.15E-04	5.98E-05	7.04E-06				
100.0	1.40E-04	7.28E-05	8.57E-06				
177.8	1.70E-04	8.84E-05	1.04E-05				
316.2	2.00E-04	1.04E-04	1.22E-05				
562.3	2.35E-04	1.22E-04	1.44E-05				
1000.0	3.00E-04	1.56E-04	1.84E-05				
1778.3	4.00E-04	2.08E-04	2.45E-05				
3162.3	4.55E-04	2.37E-04	2.78E-05				
3600.0	4.70E-04	2.44E-04	2.88E-05				
7200.0	1.55E-04	8.06E-05					

Table A-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
	TFA AC-10 + 3% UP 70						
	TEST TEMP = 60 , ZIGMA = 9.723 PSI						
31.6	4.25E-04	2.21E-04	1.14E-05				
56.2	5.40E-04	2.81E-04	1.44E-05				
100.0	6.95E-04	3.61E-04	1.86E-05				
177.8	9.25E-04	4.81E-04	2.47E-05				
316.2	1.20E-03	6.24E-04	3.21E-05				
562.3	1.55E-03	8.06E-04	4.15E-05				
1000.0	2.06E-03	1.07E-03	5.52E-05				
1778.3	2.73E-03	1.42E-03	7.29E-05				
3162.3	3.42E-03	1.78E-03	9.13E-05				
3600.0	3.60E-03	1.87E-03	9.63E-05				
7200.0	2.91E-03	1.51E-03					
	TFA AC-10 + 3% UP 70				TFA AC-10 + 3% UP 70		
	TEST TEMP = 77 , ZIGMA=9.251 PSI				TEST TEMP = 77 , ZIGMA=9.480 PSI		
31.6	1.05E-03	5.46E-04	2.95E-05	31.6	1.00E-03	5.20E-04	2.74E-05
56.2	1.40E-03	7.28E-04	3.94E-05	56.2	1.40E-03	7.28E-04	3.84E-05
100.0	1.85E-03	9.62E-04	5.20E-05	100.0	1.90E-03	9.88E-04	5.21E-05
177.8	2.50E-03	1.30E-03	7.03E-05	177.8	2.75E-03	1.43E-03	7.54E-05
316.2	3.45E-03	1.79E-03	9.70E-05	316.2	3.75E-03	1.95E-03	1.03E-04
562.3	4.75E-03	2.47E-03	1.34E-04	562.3	5.00E-03	2.60E-03	1.37E-04
1000.0	6.70E-03	3.48E-03	1.88E-04	1000.0	6.85E-03	3.56E-03	1.88E-04
1778.3	1.00E-02	5.20E-03	2.81E-04	1778.3	1.00E-02	5.20E-03	2.74E-04
3162.3	1.63E-02	8.45E-03	4.57E-04	3162.3	1.49E-02	7.72E-03	4.07E-04
3600.0	1.86E-02	9.65E-03	5.21E-04	3600.0	1.65E-02	8.58E-03	4.53E-04
7200.0	1.78E-02	9.23E-03		7200.0	1.58E-02	8.22E-03	
	TFA AC-10 + 3% UP 70						
	TEST TEMP = 90 , ZIGMA=1.094 PSI						
31.6	1.10E-03	5.72E-04	2.61E-04				
56.2	1.50E-03	7.80E-04	3.57E-04				
100.0	1.95E-03	1.01E-03	4.64E-04				
177.8	2.60E-03	1.35E-03	6.18E-04				
316.2	3.55E-03	1.85E-03	8.44E-04				
562.3	4.85E-03	2.52E-03	1.15E-03				
1000.0	7.65E-03	3.98E-03	1.82E-03				
1778.3	1.07E-02	5.54E-03	2.53E-03				
3162.3	1.57E-02	8.17E-03	3.73E-03				
3600.0	1.71E-02	8.89E-03	4.06E-03				
7200.0	1.62E-02						

Table A-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 11.188 PSI							
31.6	9.00E-04	4.68E-04	2.09E-05				
56.2	1.15E-03	5.98E-04	2.67E-05				
100.0	1.42E-03	7.41E-04	3.31E-05				
177.8	1.83E-03	9.49E-04	4.24E-05				
316.2	2.30E-03	1.20E-03	5.35E-05				
562.3	3.05E-03	1.59E-03	7.09E-05				
1000.0	4.05E-03	2.11E-03	9.41E-05				
1778.3	5.47E-03	2.85E-03	1.27E-04				
3162.3	7.65E-03	3.98E-03	1.78E-04				
3600.0	8.24E-03	4.29E-03	1.92E-04				
7200.0	7.62E-03	3.97E-03					
TFA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA=4.392 PSI				TFA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA=4.402 PSI			
31.6	1.50E-03	7.80E-04	8.88E-05	31.6	9.00E-04	4.68E-04	5.32E-05
56.2	2.25E-03	1.17E-03	1.33E-04	56.2	1.20E-03	6.24E-04	7.09E-05
100.0	3.00E-03	1.56E-03	1.78E-04	100.0	1.55E-03	8.06E-04	9.16E-05
177.8	4.50E-03	2.34E-03	2.66E-04	177.8	2.05E-03	1.07E-03	1.21E-04
316.2	6.25E-03	3.25E-03	3.70E-04	316.2	2.80E-03	1.46E-03	1.65E-04
562.3	1.08E-02	5.59E-03	6.37E-04	562.3	3.85E-03	2.00E-03	2.27E-04
1000.0	2.00E-02	1.04E-02	1.18E-03	1000.0	5.05E-03	2.63E-03	2.98E-04
TFA AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA=1.091 PSI							
31.6	4.50E-04	2.34E-04	1.07E-04				
56.2	6.75E-04	3.51E-04	1.61E-04				
100.0	9.25E-04	4.81E-04	2.20E-04				
177.8	1.28E-03	6.63E-04	3.04E-04				
316.2	1.75E-03	9.10E-04	4.17E-04				
562.3	2.40E-03	1.25E-03	5.72E-04				
1000.0	3.53E-03	1.83E-03	8.40E-04				

Table A-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-10 + 3% NS 175 TEST TEMP = 60 , ZIGMA = 8.813 PSI							
31.6	3.25E-04	1.69E-04	9.59E-06				
56.2	4.45E-04	2.31E-04	1.31E-05				
100.0	5.75E-04	2.99E-04	1.70E-05				
177.8	8.00E-04	4.16E-04	2.36E-05				
316.2	1.08E-03	5.62E-04	3.19E-05				
562.3	1.38E-03	7.18E-04	4.07E-05				
1000.0	1.70E-03	8.84E-04	5.02E-05				
1778.3	2.10E-03	1.09E-03	6.20E-05				
3162.3	2.55E-03	1.33E-03	7.52E-05				
3600.0	2.65E-03	1.38E-03	7.82E-05				
7200.0	1.83E-03	9.49E-04					
TFA AC-10 + 3% NS 175 TEST TEMP = 77 , ZIGMA=9.177 PSI				TFA AC-10 + 3% NS 175 TEST TEMP = 77 , ZIGMA=5.637 PSI			
31.6	1.25E-03	6.50E-04	3.54E-05				
56.2	1.75E-03	9.10E-04	4.96E-05				
100.0	2.25E-03	1.17E-03	6.38E-05	100.0	9.50E-04	4.94E-04	4.38E-05
177.8	3.25E-03	1.69E-03	9.21E-05	177.8	1.30E-03	6.76E-04	6.00E-05
316.2	4.35E-03	2.26E-03	1.23E-04	316.2	1.70E-03	8.84E-04	7.84E-05
562.3	6.35E-03	3.30E-03	1.80E-04	562.3	2.35E-03	1.22E-03	1.08E-04
				1000.0	3.25E-03	1.69E-03	1.50E-04
				1778.3	4.50E-03	2.34E-03	2.08E-04
				3162.3	6.65E-03	3.46E-03	3.07E-04
				3600.0	7.35E-03	3.82E-03	3.39E-04
				7200.0	7.00E-03	3.64E-03	
TFA AC-10 + 3% NS 175 TEST TEMP = 90 , ZIGMA=1.070 PSI							
31.6	3.25E-04	1.69E-04	7.90E-05				
56.2	4.50E-04	2.34E-04	1.09E-04				
100.0	5.90E-04	3.07E-04	1.43E-04				
177.8	7.70E-04	4.00E-04	1.87E-04				
316.2	9.90E-04	5.15E-04	2.41E-04				
562.3	1.28E-03	6.63E-04	3.10E-04				
1000.0	1.64E-03	8.56E-04	4.00E-04				
1778.3	2.15E-03	1.12E-03	5.21E-04				
3162.3	2.84E-03	1.47E-03	6.89E-04				
3600.0	3.02E-03	1.57E-03	7.34E-04				
7200.0	2.96E-03						

Table A-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TFA AC-10 + 3% C107 TEST TEMP = 60 , ZIGMA = 10.477 PSI							
31.6	2.40E-04	1.25E-04	5.96E-06				
56.2	3.05E-04	1.59E-04	7.57E-06				
100.0	3.85E-04	2.00E-04	9.56E-06				
177.8	5.35E-04	2.78E-04	1.33E-05				
316.2	7.10E-04	3.69E-04	1.76E-05				
562.3	9.75E-04	5.07E-04	2.42E-05				
1000.0	1.53E-03	7.98E-04	3.81E-05				
1778.3	2.60E-03	1.35E-03	6.45E-05				
3162.3	4.10E-03	2.13E-03	1.02E-04				
3600.0	4.50E-03	2.34E-03	1.12E-04				
7200.0	1.83E-03	9.49E-04					
TFA AC-10 + 3% C107 TEST TEMP = 77 , ZIGMA= 10.338 PSI				TFA AC-10 + 3% C107 TEST TEMP = 77 , ZIGMA=9.103 PSI			
31.6	1.65E-03	8.58E-04	4.15E-05	31.6	1.00E-03	5.20E-04	2.86E-05
56.2	2.20E-03	1.14E-03	5.53E-05	56.2	1.40E-03	7.28E-04	4.00E-05
100.0	2.85E-03	1.48E-03	7.17E-05	100.0	2.00E-03	1.04E-03	5.71E-05
177.8	4.00E-03	2.08E-03	1.01E-04	177.8	2.80E-03	1.46E-03	8.00E-05
316.2	5.60E-03	2.91E-03	1.41E-04	316.2	3.75E-03	1.95E-03	1.07E-04
562.3	8.60E-03	4.47E-03	2.16E-04	562.3	5.20E-03	2.70E-03	1.49E-04
1000.0	1.19E-02	6.19E-03	2.99E-04	1000.0	7.25E-03	3.77E-03	2.07E-04
1778.3	1.82E-02	9.47E-03	4.58E-04	1778.3	1.00E-02	5.20E-03	2.86E-04
3162.3	3.39E-02	1.76E-02	8.51E-04	3162.3	1.38E-02	7.15E-03	3.93E-04
3600.0	4.19E-02	2.18E-02	1.05E-03	3600.0	1.48E-02	7.67E-03	4.21E-04
7200.0	3.83E-02			7200.0	1.35E-02	7.02E-03	
TFA AC-10 + 3% C107 TEST TEMP = 90 , ZIGMA=2.084 PSI							
177.8	4.00E-03	2.08E-03	4.99E-04				
316.2	5.00E-03	2.60E-03	6.24E-04				
562.3	7.00E-03	3.64E-03	8.73E-04				
1000.0	1.05E-02	5.46E-03	1.31E-03				
1778.3	1.45E-02	7.54E-03	1.81E-03				
3162.3	2.54E-02	1.32E-02	3.17E-03				
3600.0	2.84E-02	1.48E-02	3.54E-03				
7200.0	2.60E-02	1.35E-02					

Table A-25 Moisture Sensitivity Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

		Dry Condition		Wet Condition		
MIXTURE	TEST TEMP. F	AIR VOIDS %	TENSILE STRENGTH PSI	AIR VOIDS %	TENSILE STRENGTH PSI	TSR
Control: TFA AC-10	77	7.6	49	7.2	20	
		7.3	50	7.5	14	
		7.0	58	7.4	18	
		----	----	----	----	
		7.3	52	7.4	17	0.33
TFA AC-10 + 3% UP 70	77	6.2	66	5.7	38	
		5.6	69	5.9	51	
		5.9	67	6.1	39	
		----	----	----	----	
		5.9	67	5.9	42	0.63
TFA AC-10 + 3% Styrelf	77	7.5	77	8.1	52	
		8.3	69	7.0	47	
		7.5	83	7.5	52	
		----	----	----	----	
		7.8	76	7.5	50	0.66
TFA AC-10 + 3% NS 175	77	6.8	72	7.2	38	
		7.0	64	6.7	51	
		6.8	74	6.8	39	
		----	----	----	----	
		6.9	70	6.9	43	0.61
TFA AC-10 + 18% C107	77	11.9	37	11.3	21	
		12.5	32	11.2	20	
		12.4	40	11.1	20	
		----	----	----	----	
		12.3	36	11.2	21	0.57
Control: TFA AC-20	77	7.2	84	6.9	40	
		8.4	76	7.5	37	
		7.8	78	7.5	37	
		----	----	----	----	
		7.8	79	7.3	38	0.48
TFA AC-20 + 3% Polybilt	77	6.7	78	7.6	40	
		7.3	79	7.0	43	
		7.0	84	6.2	59	
		----	----	----	----	
		7.0	80	6.9	47	0.59
TFA AC-20 + 5% Dow	77	6.6	72	7.2	62	
		7.7	72	7.3	59	
		6.7	78	7.4	52	
		----	----	----	----	
		7.0	74	7.3	58	0.78

Table A-26 Moisture Sensitivity Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

		Dry Condition		Wet Condition		
MIXTURE	TEST TEMP. F	AIR VOIDS %	TENSILE STRENGTH PSI	AIR VOIDS %	TENSILE STRENGTH PSI	TSR
TFA AC-10 + 3% UP 70	77	7.1	97	7.0	94	
		6.7	100	7.3	78	
		6.9	95	6.7	91	
		-----	-----	-----	----	
		6.9	98	7.0	88	0.90
TFA AC-10 + 3% Styrelf	77	7.0	119	6.8	122	
		7.2	119	7.2	112	
		7.6	110	7.2	121	
		-----	-----	-----	----	
		7.3	116	7.1	118	1.02
TFA AC-10 + 3% NS 175	77	6.9	89	6.7	78	
		6.9	91	6.5	76	
		7.1	85	6.6	71	
		-----	-----	-----	----	
		6.9	88	6.6	75	0.85
TFA AC-10 + 18% C107	77	6.5	71	7.3	49	
		6.4	62	7.3	53	
		6.6	67	7.3	49	
		-----	-----	-----	----	
		6.5	67	7.3	50	0.76
Control: TFA AC-20	77	7.0	89	7.5	61	
		6.6	86	7.2	64	
		7.0	80	7.0	66	
		-----	-----	-----	----	
		6.9	85	7.2	64	0.75
TFA AC-20 + 3% Polybilt	77	6.8	104	6.9	93	
		7.5	100	7.5	77	
		6.8	107	7.4	94	
		-----	-----	-----	----	
		7.0	104	7.3	88	0.85
TFA AC-20 + 5% Dow	77	8.0	98	7.6	85	
		7.5	113	7.6	79	
		7.8	111	7.6	86	
		-----	-----	-----	----	
		7.8	107	7.6	83	0.78

Table A-27 AGGREGATE GRADATION OF EXTRACTED CORES (DISTRICT 15)

Combined Design Gradation AC Content	SDHPT Specification	Polysar	Exxon	TFA	Goodyear	Styrelf	DOW	Rubber
		4.63	4.47	4.52	4.57	4.52	4.45	
0.0	0							
10.2	0-15	11.5	10.4	8.8	6.1	9.4	12.5	We Could
31.3	21-53	31.5	37	36.2	32.1	36.7	34.6	Not Separate
18.5	11-32	18.8	16.5	24.1	21.4	19.7	17.5	The Rubber
60.1	54-74	61.8	63.9	69.1	59.6	65.8	64.6	From Agg & AC
13.6	6-32	14.4	13.9	13	18.2	15	17.9	Some of The Fine
17.6	4-27	13.8	13.6	10.7	14.1	12.3	118	Agg's Might
6.6	3-27	6.9	6.5	4.8	5.9	5.4	4.4	Have Been Counted
2.1	1-8	3.1	2.1	2.4	2.2	1.5	1.3	As AC
100.0		100.0	100.0	100.0	100.0	100.0	206.2	

Aggregate produced by Vulcan Whites Mines, using delta grade 4 sandstone, limestone (grade 5), limestone screenings from Vulcan Materials, and field sand.

District 15 Field Test Sections
US281 – Comal County, Beginning North Of Cibolo River
Date Placed: April 1987

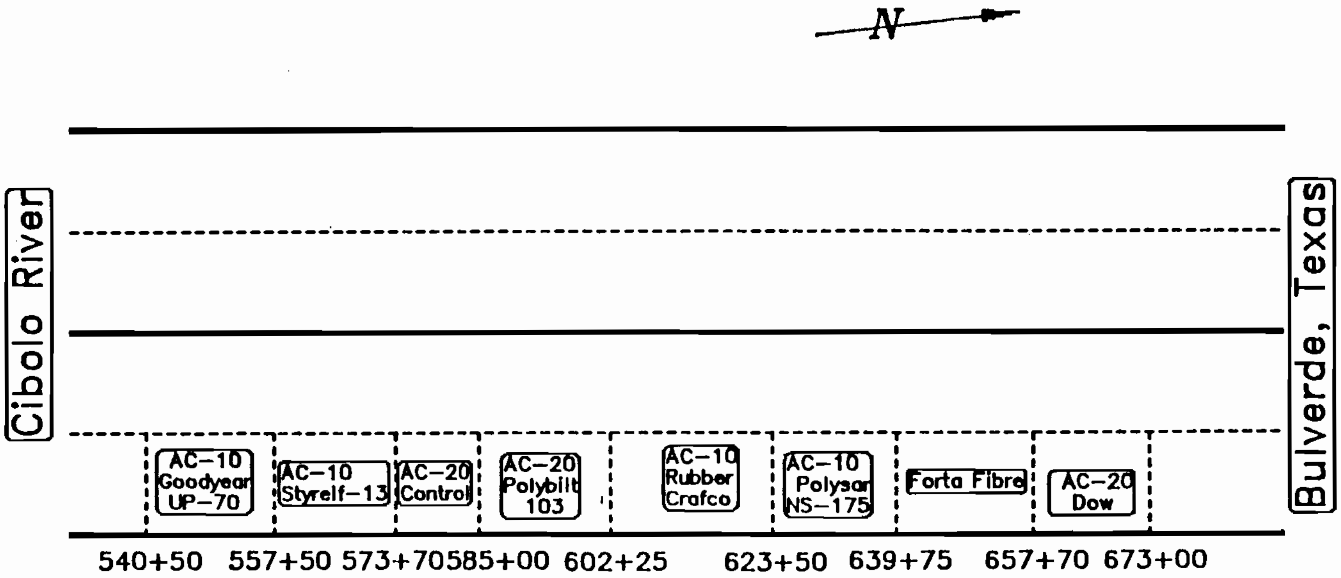

Fig A-1 Schematic Illustration of Field Test Sections.

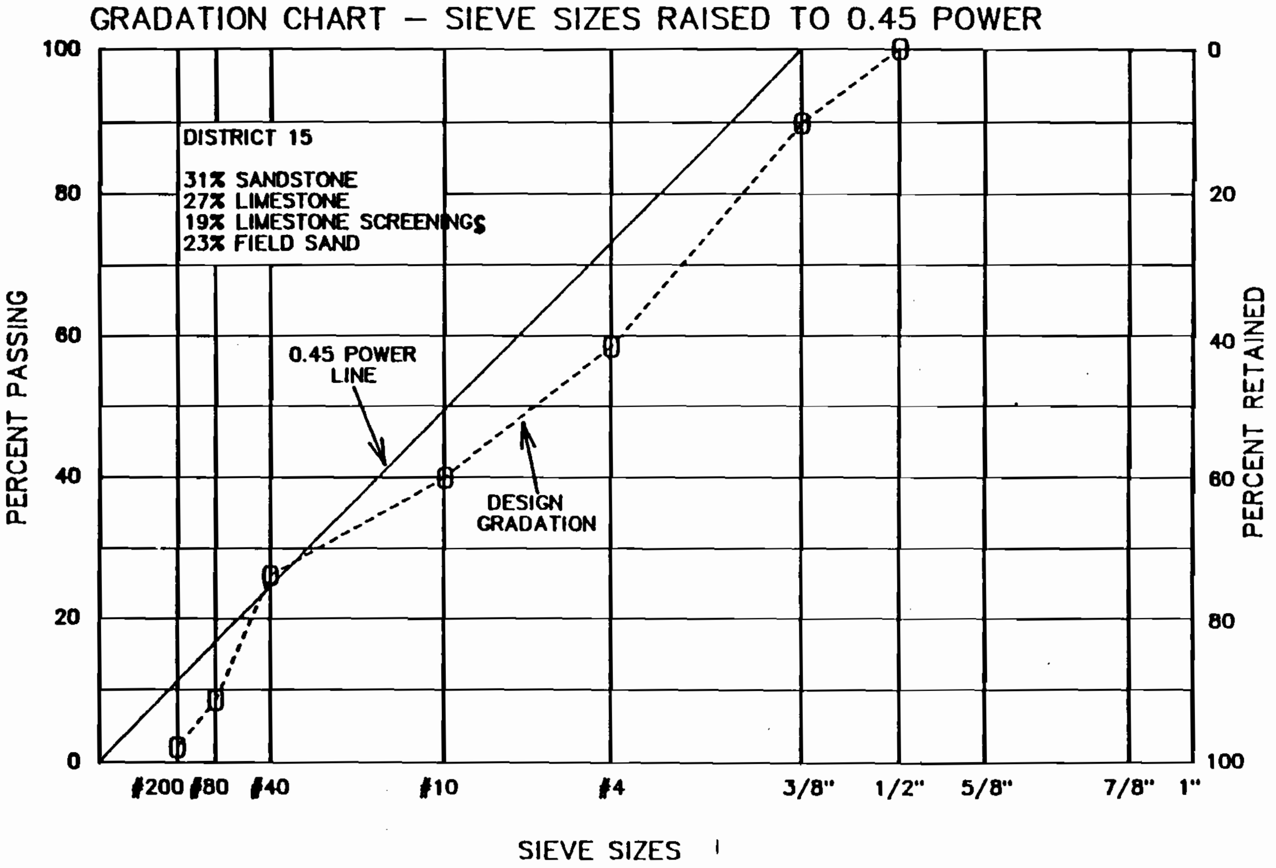

Fig A-2 Aggregate gradation Chart.

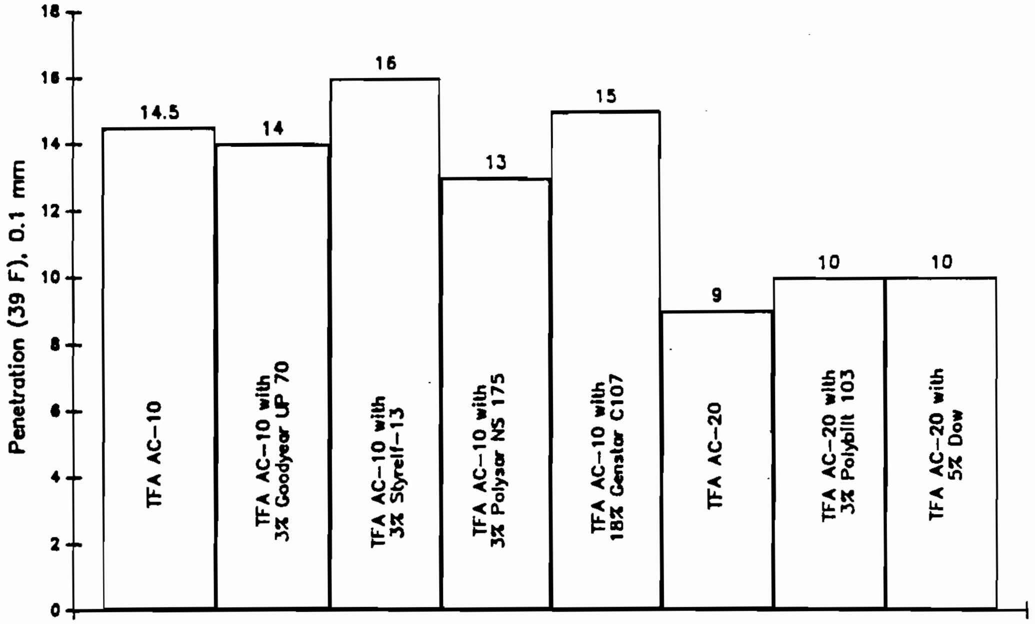

Fig A-3 Penetration at 39 F for Unmodified and Modified TFA Binders

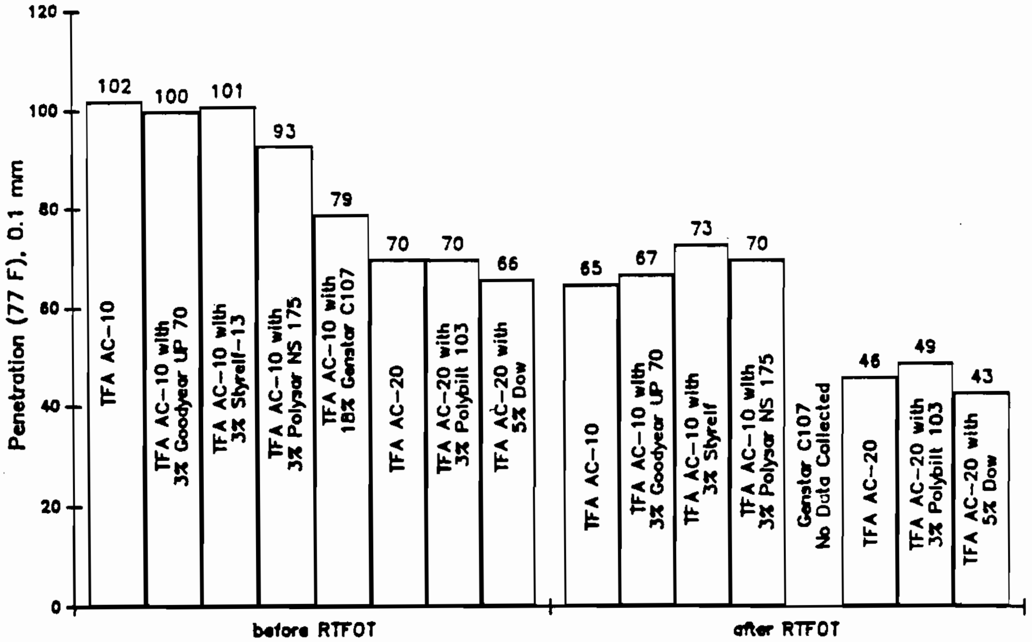

Fig A-4 Penetration at 77 F for Unmodified and Modified TFA Binders

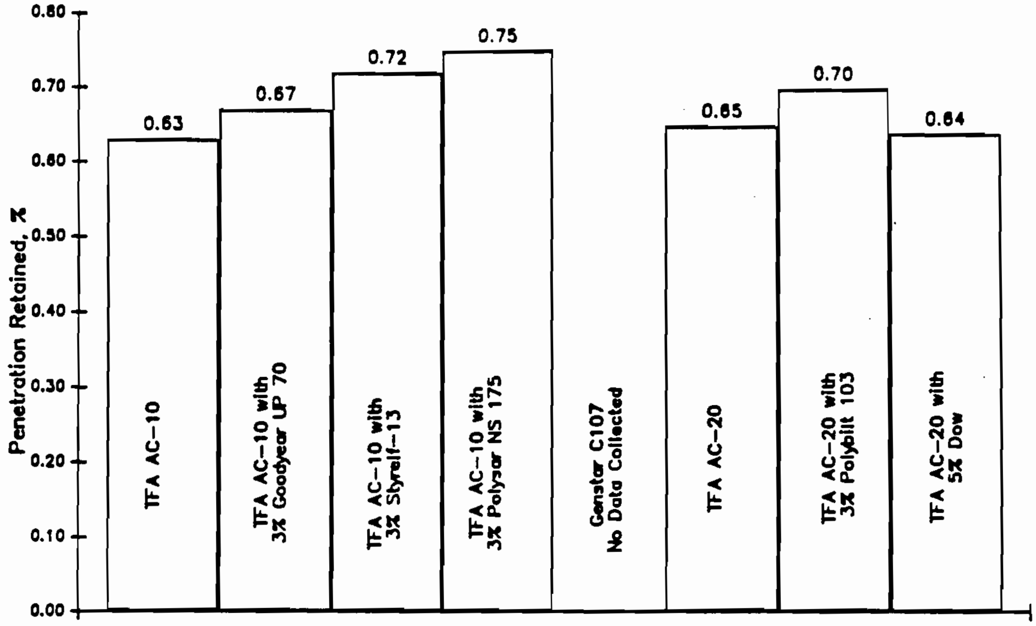

Fig A-5 Retained Penetration at 77 F for Unmodified and Modified TFA Binders

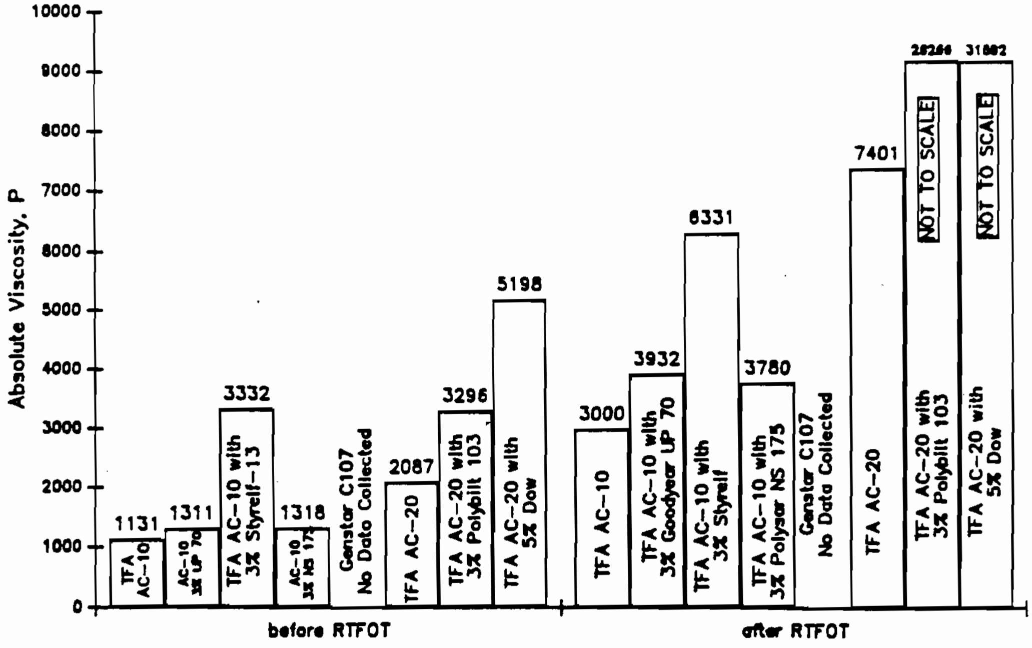

Fig A-6 Viscosity at 140 F for Unmodified and Modified TFA Binders

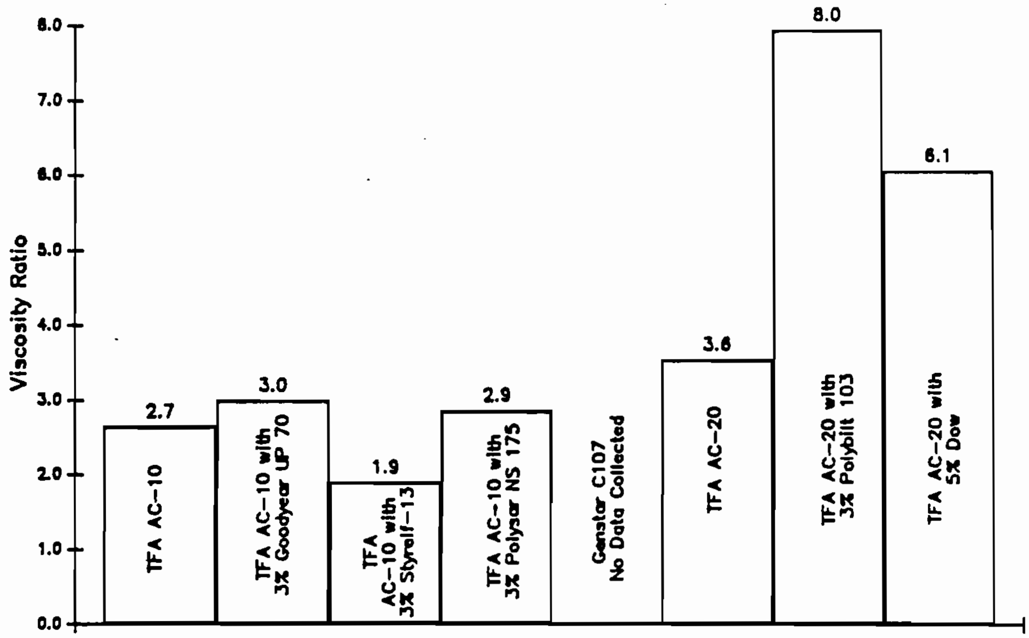

Fig A-7 Viscosity Ratio at 140 F for Unmodified and Modified TFA Binders

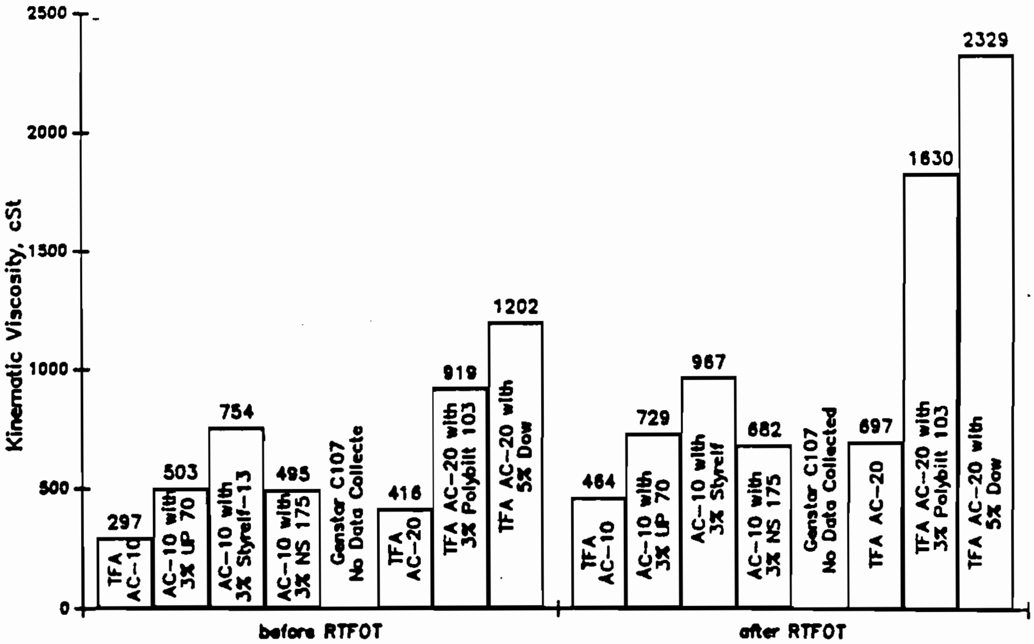

Fig A-8 Viscosity at 275 F for Unmodified and Modified TFA Binders

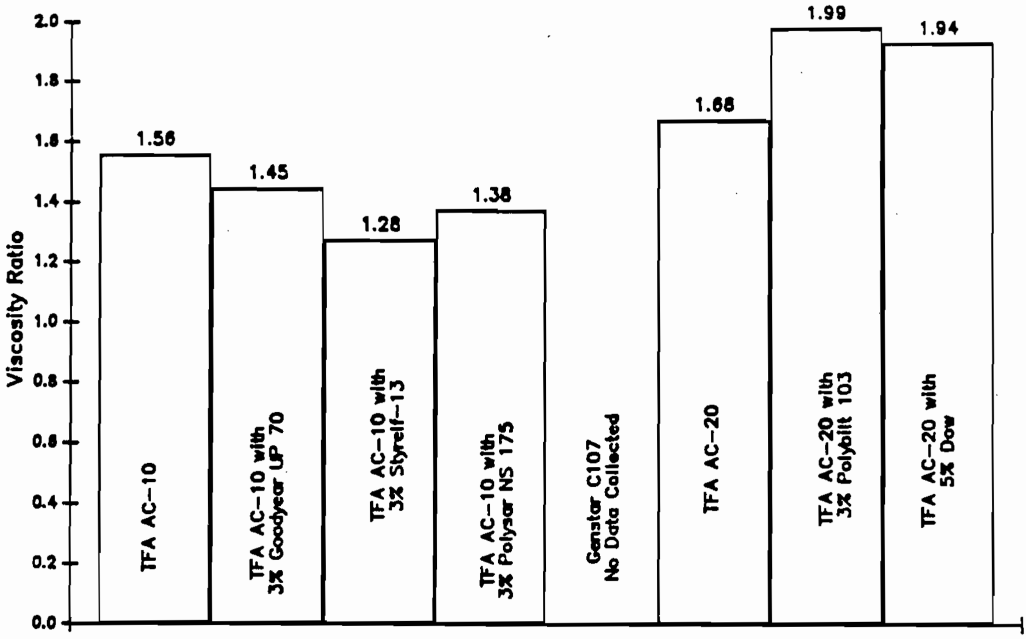

Fig A-9 Viscosity Ratio at 275 F for Unmodified and Modified TFA Binders

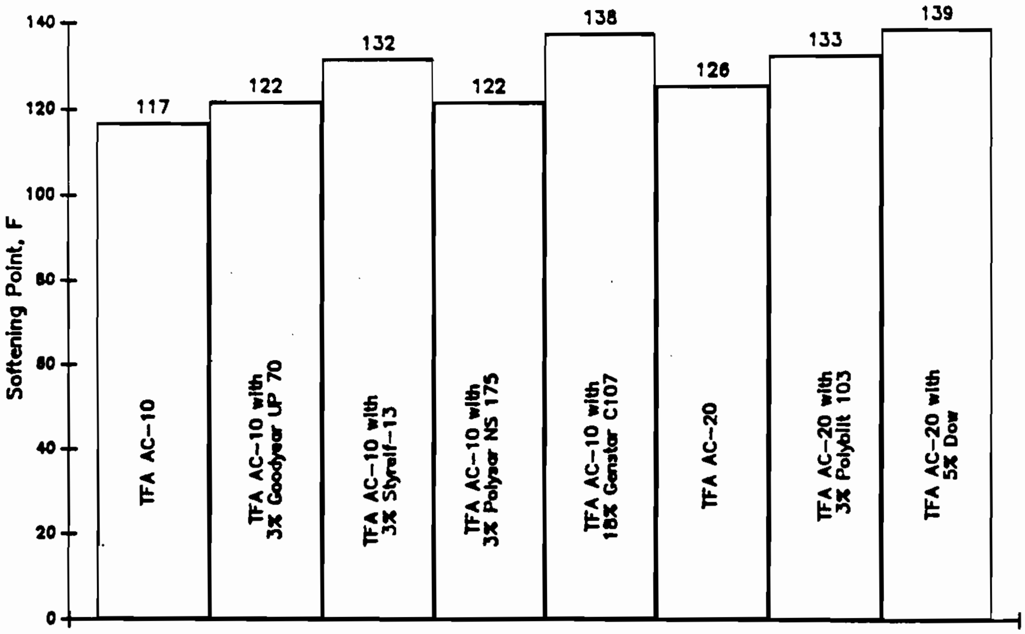

Fig A-10 Softening Point for Unmodified and Modified TFA Binders

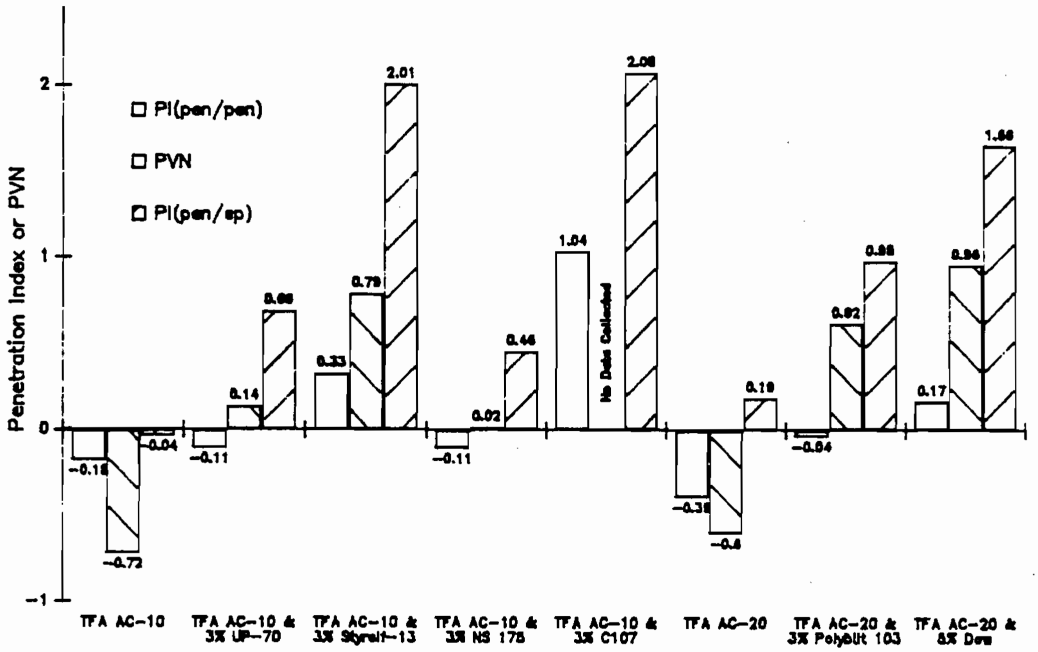

Fig A-11 Penetration Index and PVN for Unmidified and Modified TFA Binders

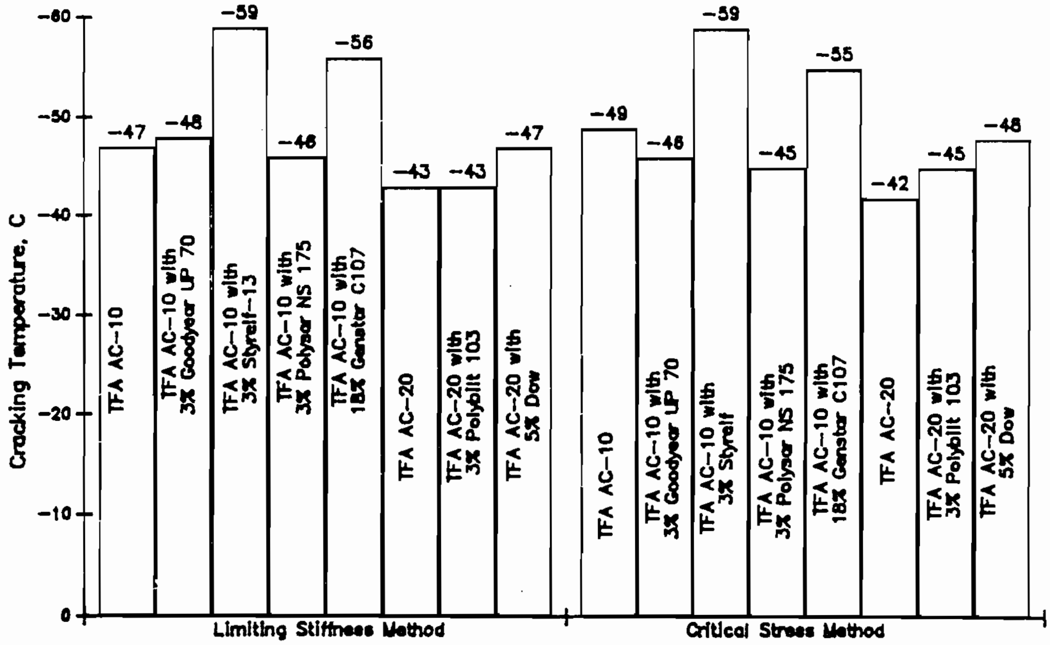

Fig A-12 Cracking Temperature for Unmodified and Modified TFA Binders

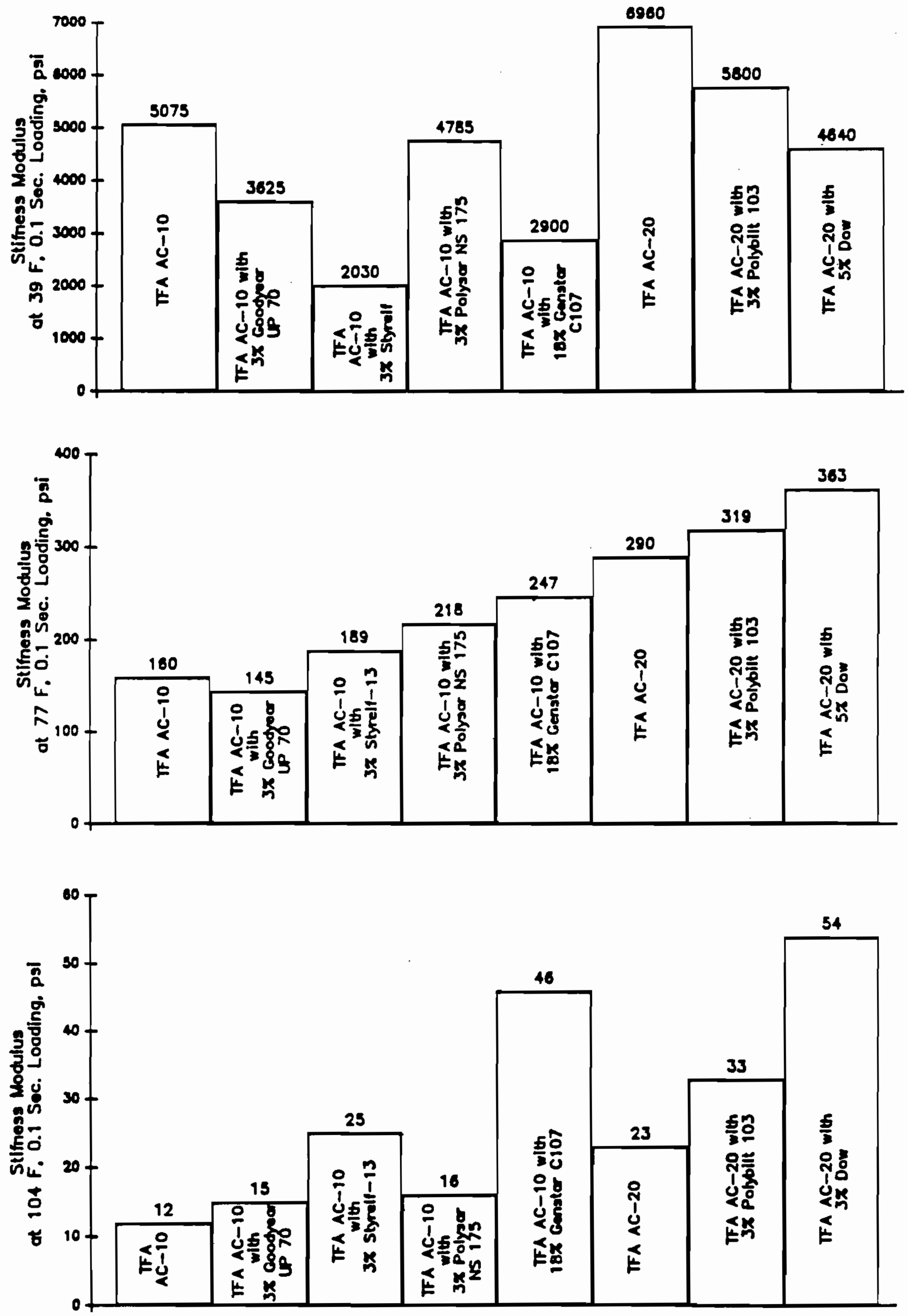

Fig A-13 Stiffness Modulus for Modified and Unmodified TFA Binders.

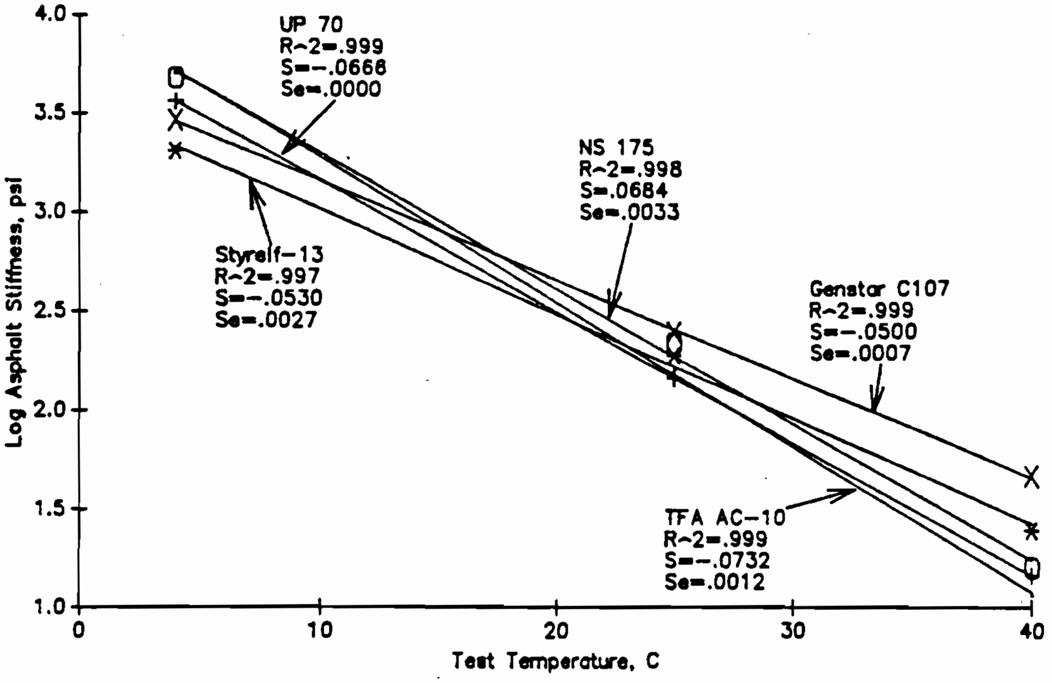

Fig. A-14 Asphalt Stiffness vs. Test Temperature for TFA AC-10 Binders

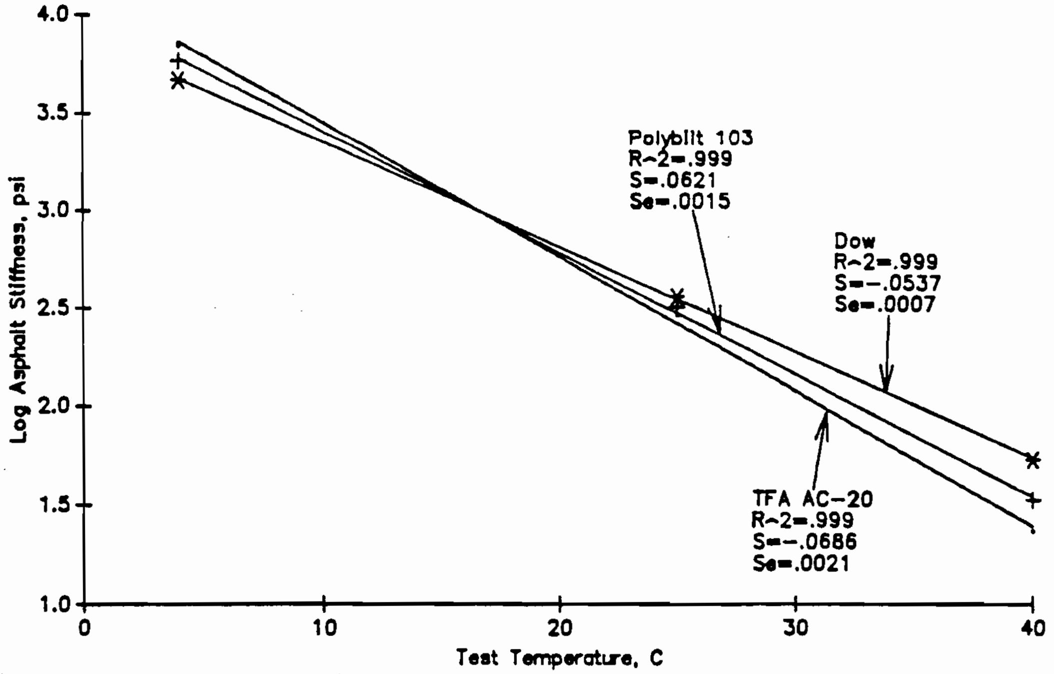

Fig A-15 Asphalt Stiffness vs. Test Temperature for TFA AC-20 Binders.

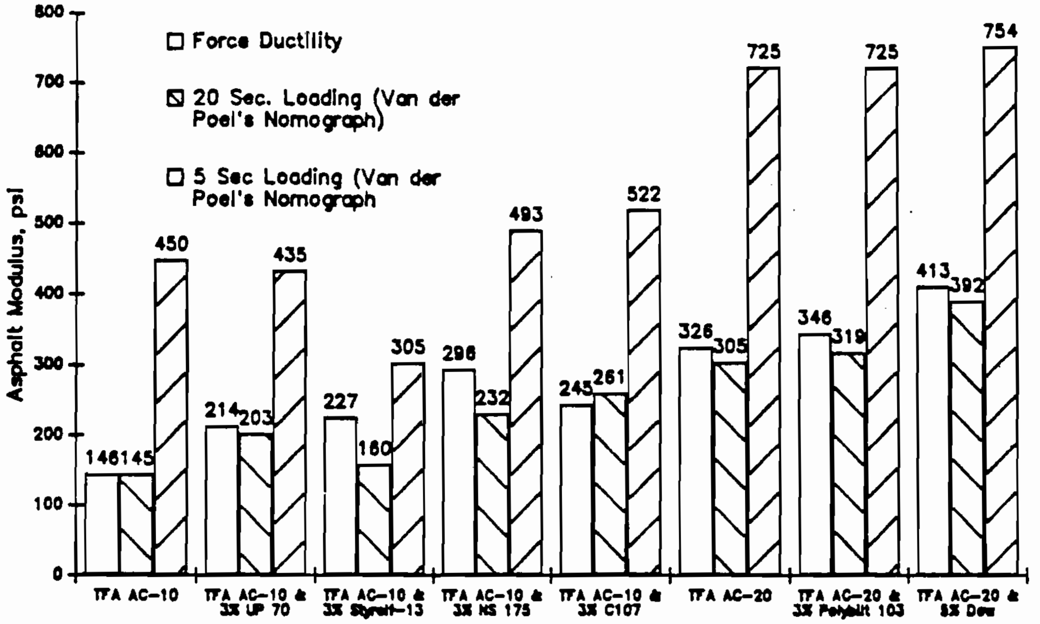

Fig A-16 Asphalt Modulus of Modified TFA Asphalt At 39.2 F

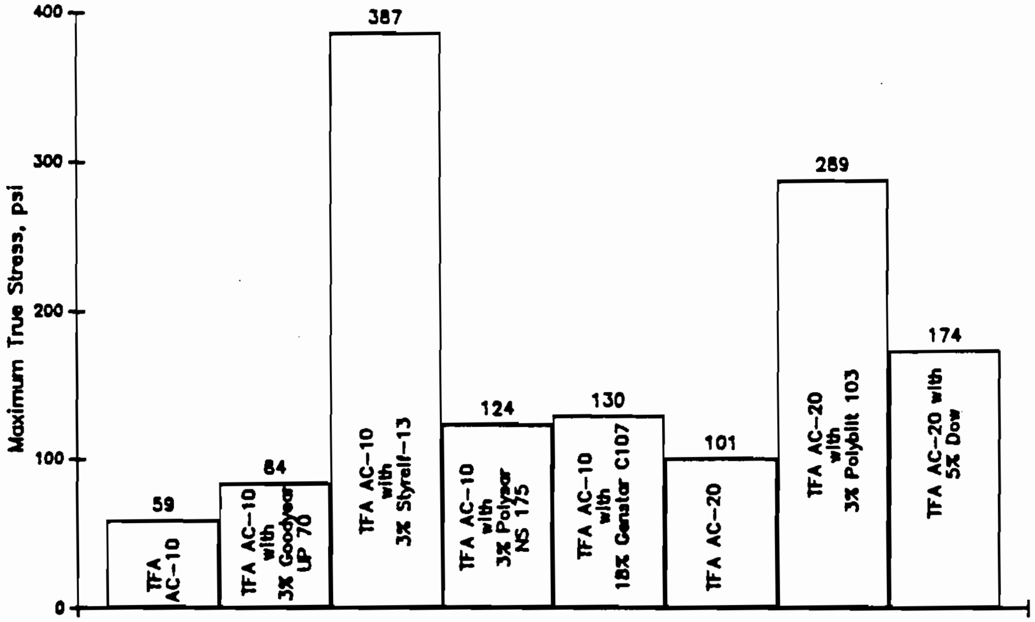

Fig A-17 Maximum True Stress at 39 F for Unmodified and Modified TFA Binders

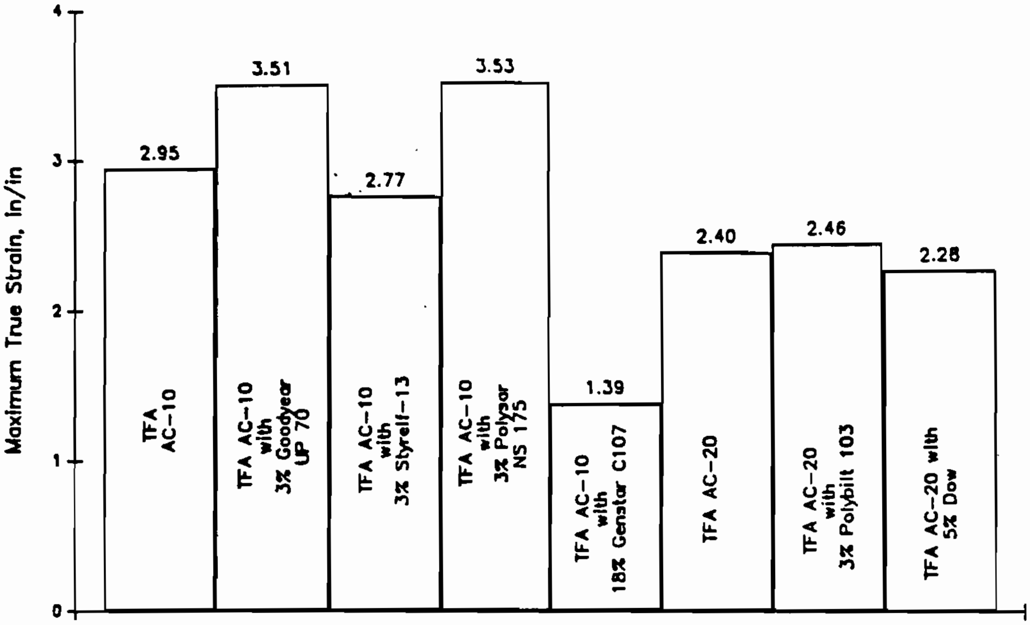

Fig A-18 Maximum True Strain at 39 F for Unmodified and Modified TFA Binders

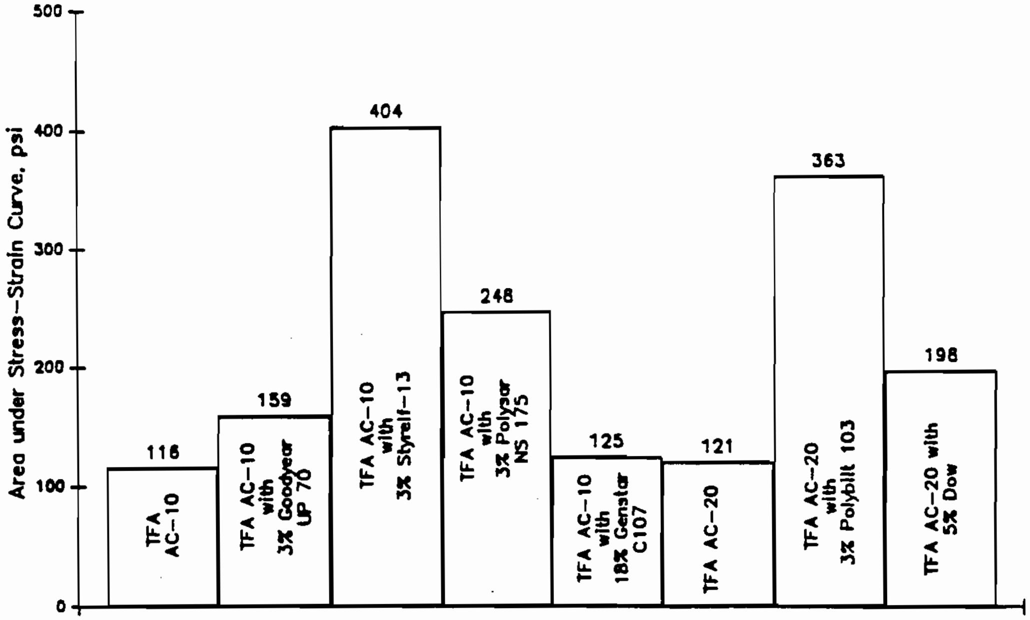

Fig A-19 Curve Area at 39 F for Unmodified and Modified TFA Binders

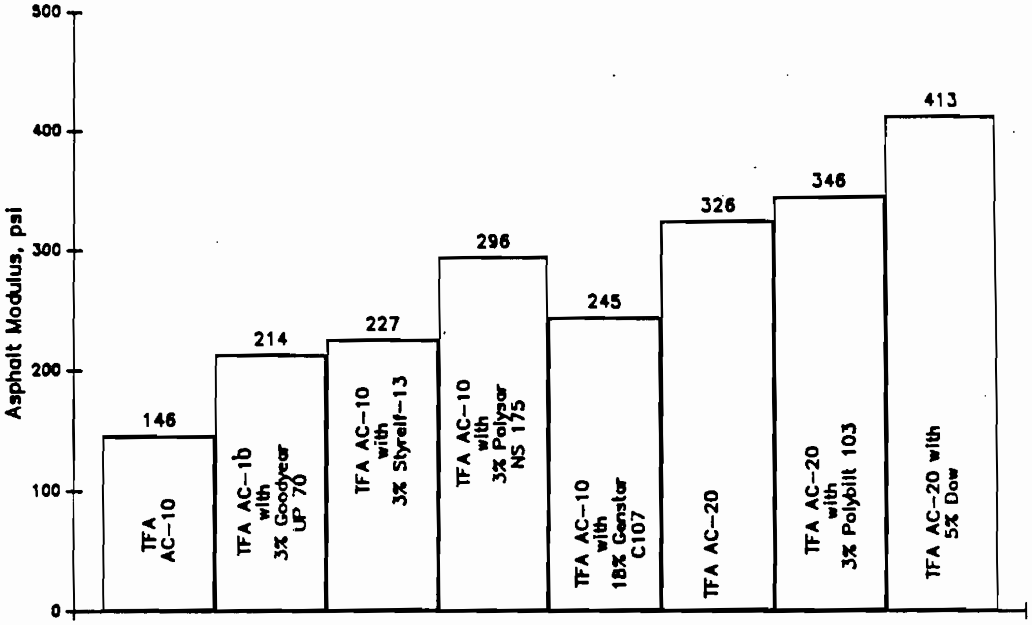

Fig A-20 Asphalt Modulus at 39 F for Unmodified and Modified TFA Binders

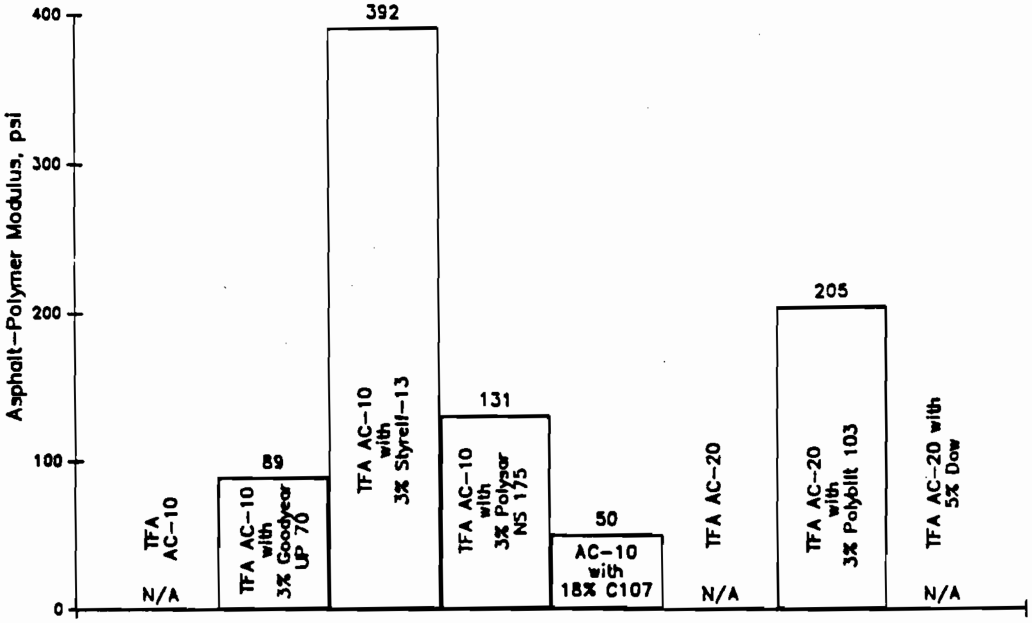

Fig A-21 Asphalt-Polymer Modulus at 39 F for Unmodified and Modified TFA Binders

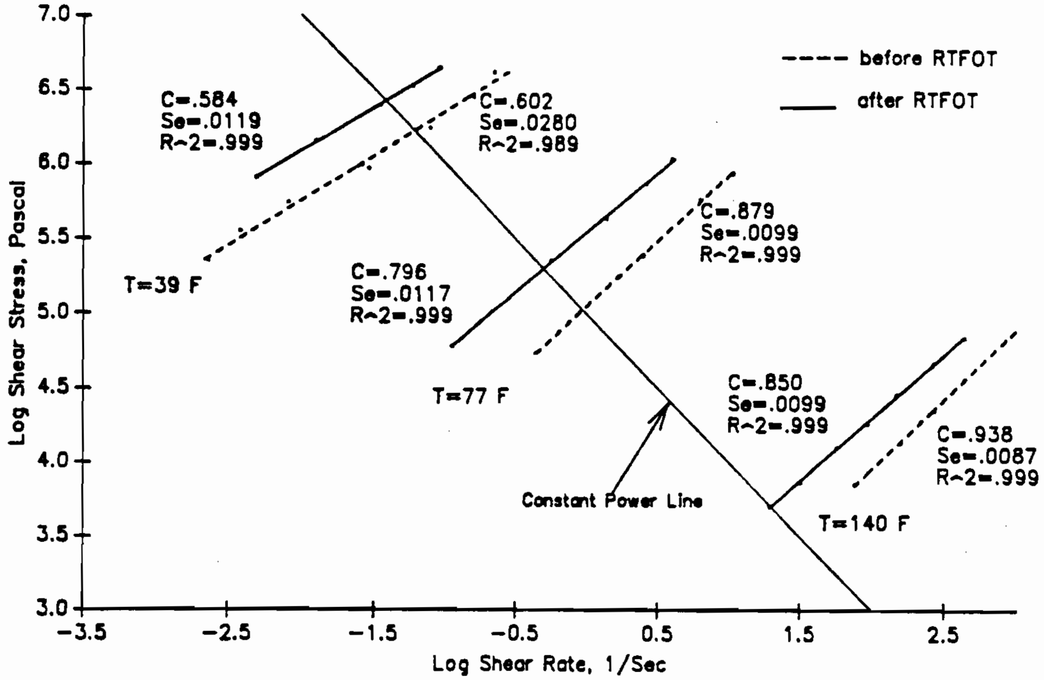

Fig A-22 Shear Stress vs. Shear Rate for TFA AC-10 at Different Test Temperature.

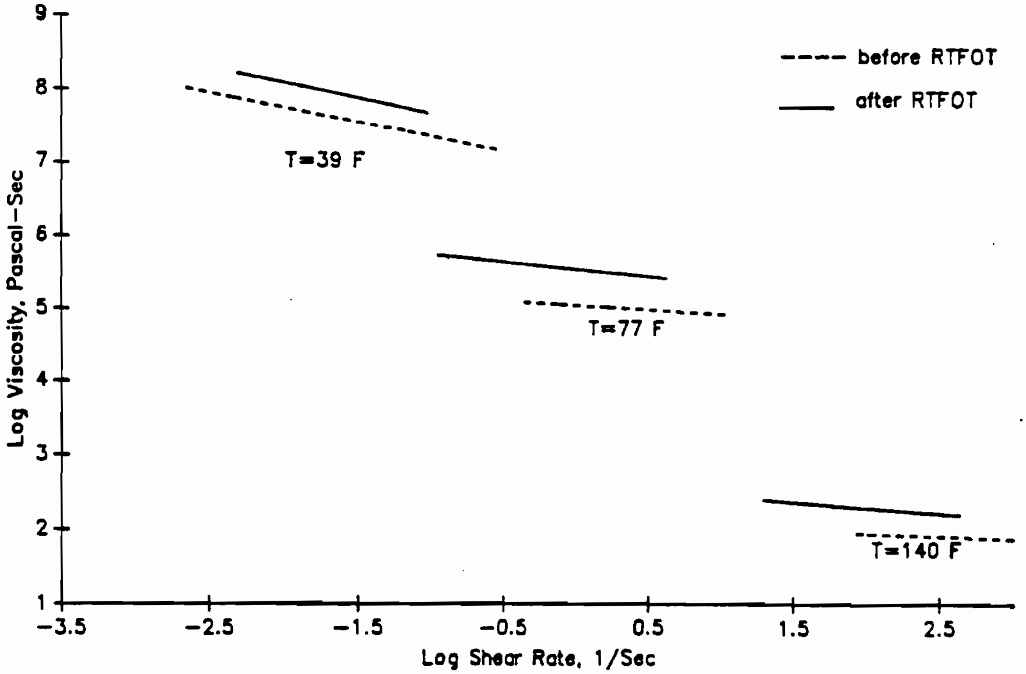

Fig A-23 Viscosity vs. Shear Rate for TFA AC-10 at Different Test Temperatures.

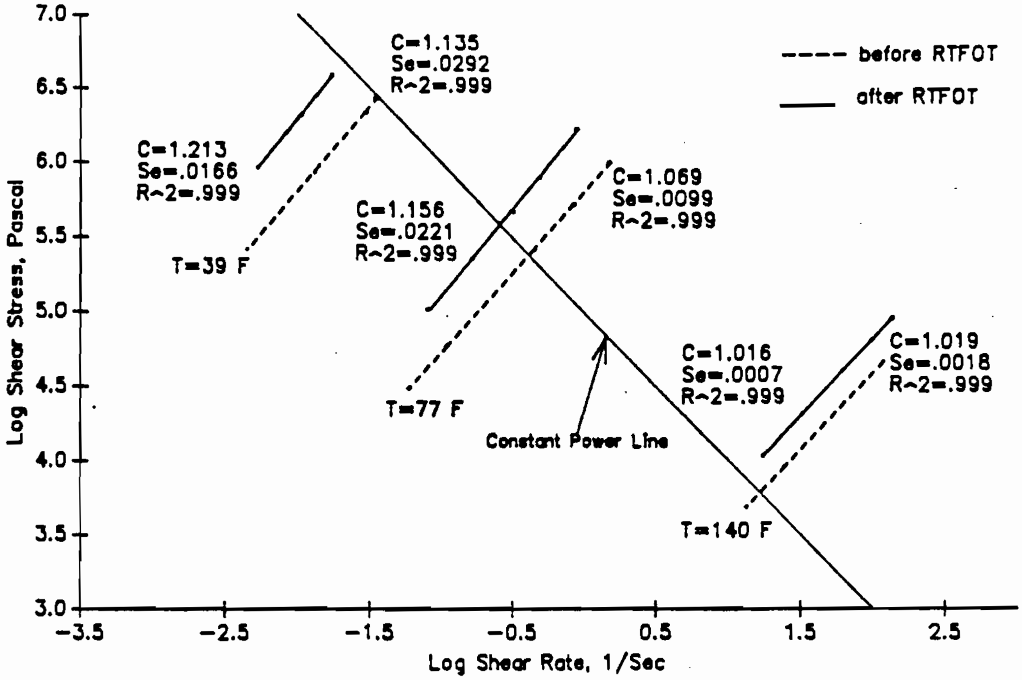

Fig A-26 Shear STress vs. Shear Rate for Styrelf Modified Binder at Different Test Temperatures.

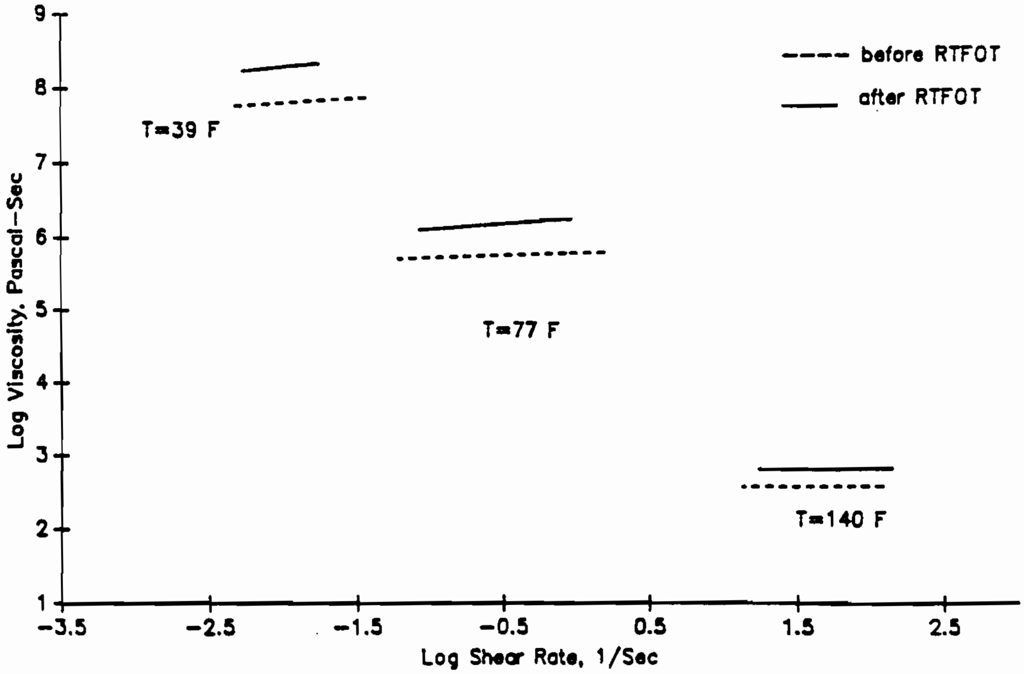

Fig A-27 Viscosity vs. Shear Rate for Styrelf Modified Binder at Different Test Temperatures.

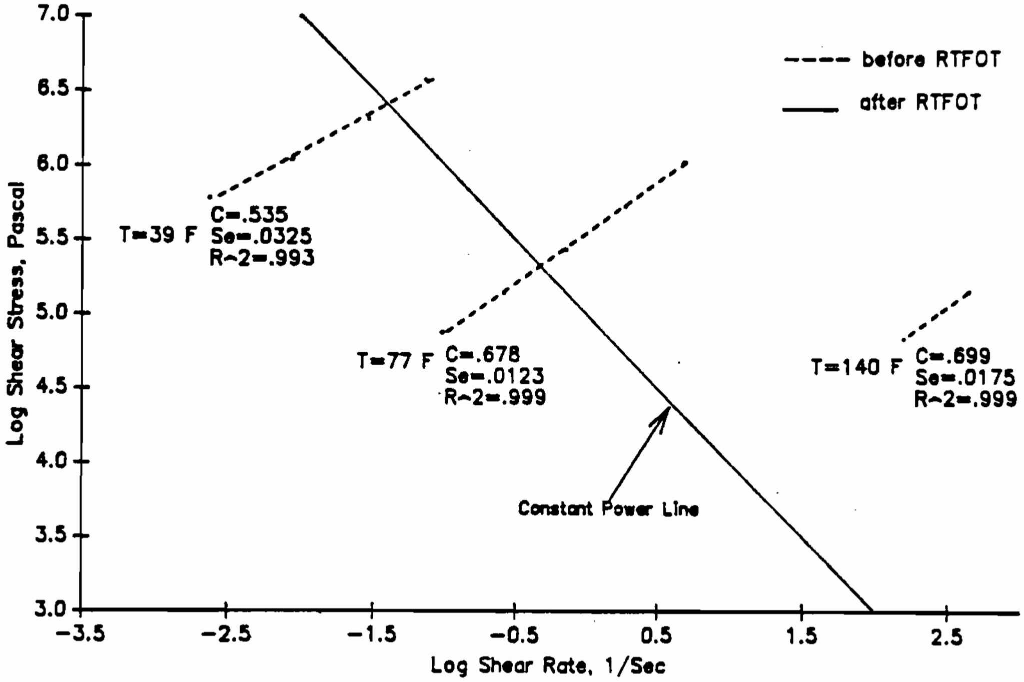

Fig A-30 Shear Stress vs. Shear Rate for C107 Modified Binder at Different Test Temperatures.

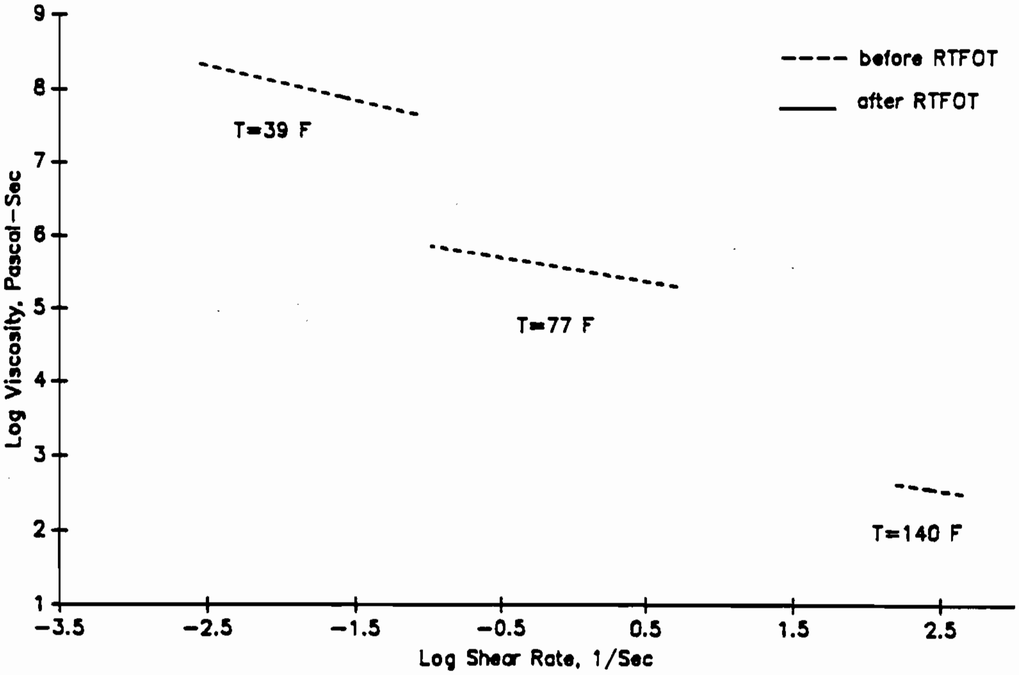

Fig-A-31 Viscosity vs. Shear Rate for C107 Modified Binder at Different Test Temperatures.

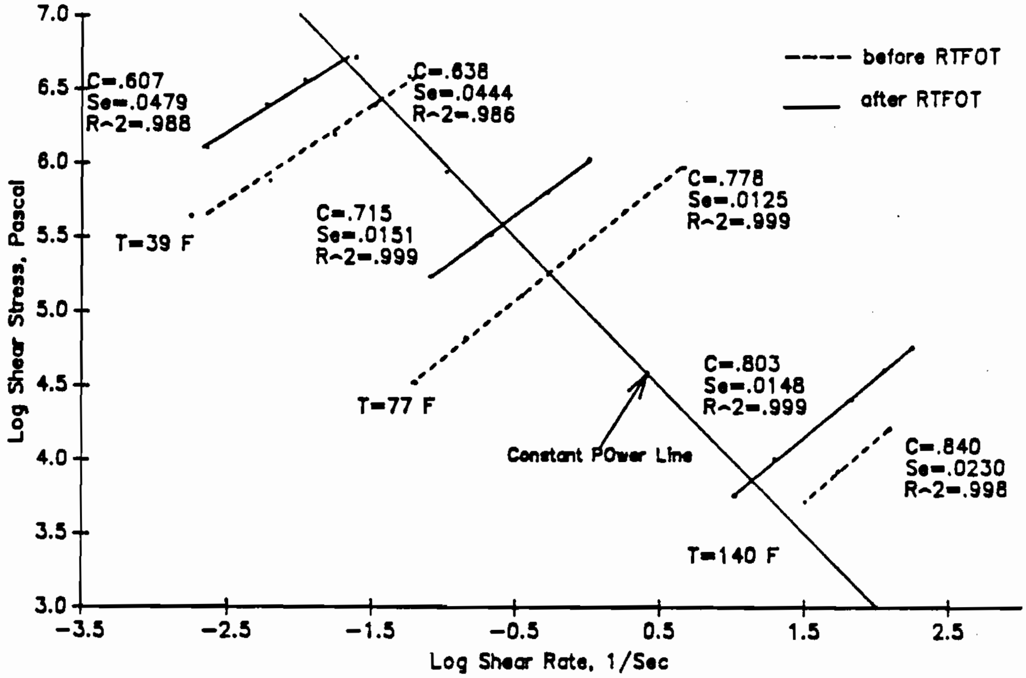

Fig A-32 Shear Stress vs. Shear Rate for TFA AC-20 at Different Test Temperatures.

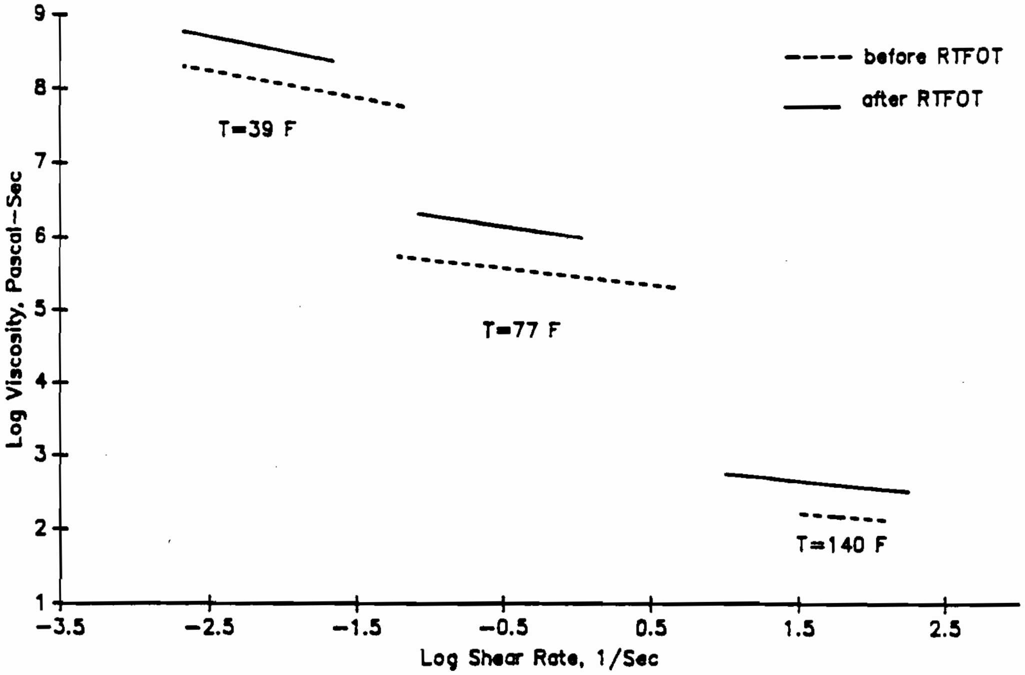

Fig A-33 Viscosity vs. Shear Rate for TFA AC-20 at Different Test Temperatures.

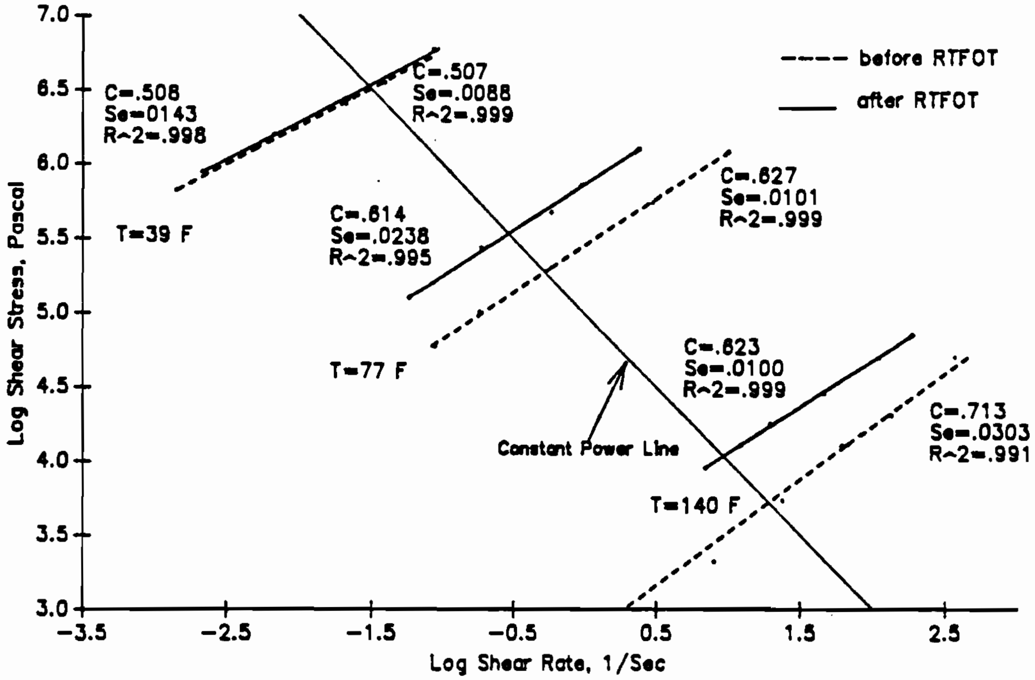

Fig A-34 Shear Stress vs. Shear Rate for Polybilt Modified Binder at Different Test Temperatures.

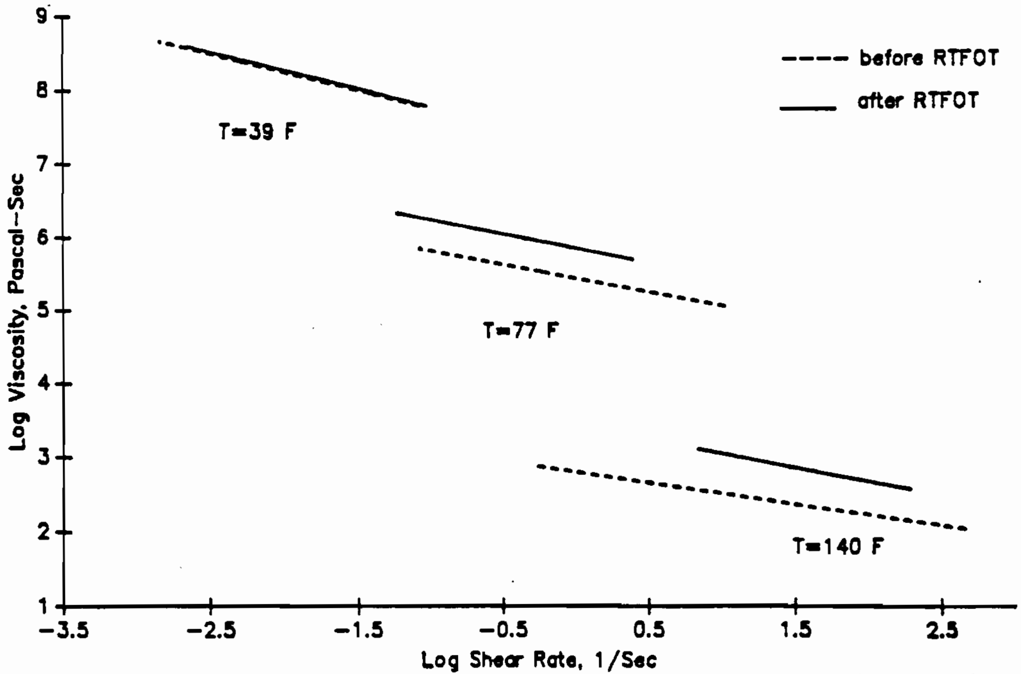

Fig A-35 Viscosity vs. Shear Rate for Polybilt Modified Binder at Different Test Temperatures.

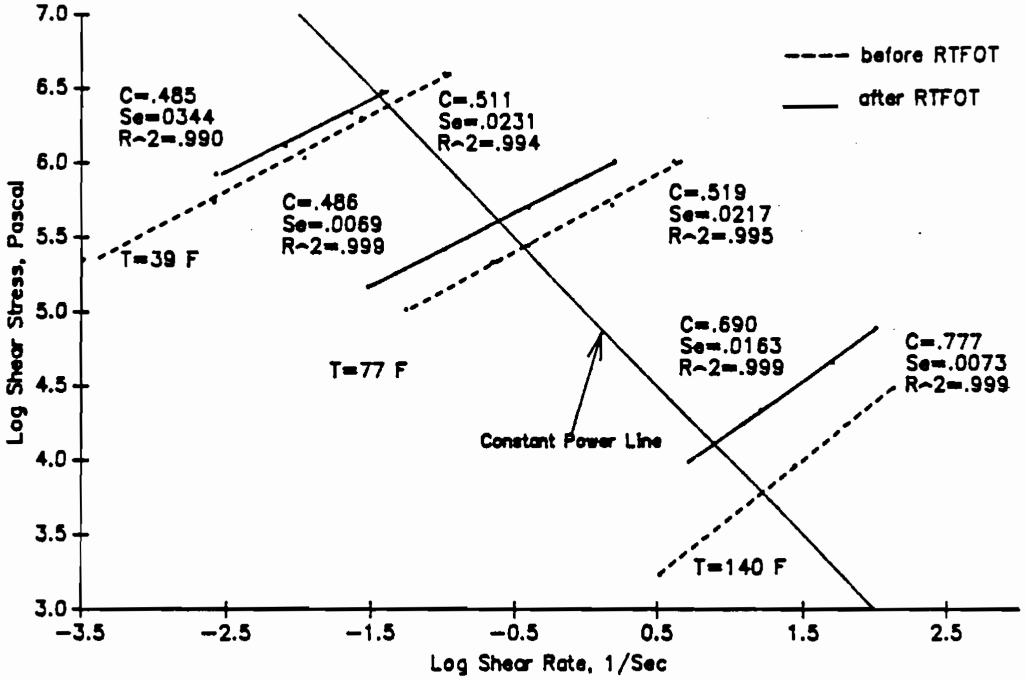

Fig A-36 Shear Stress vs. Shear Rate for Dow Modified Binder at Different Test Temperatures.

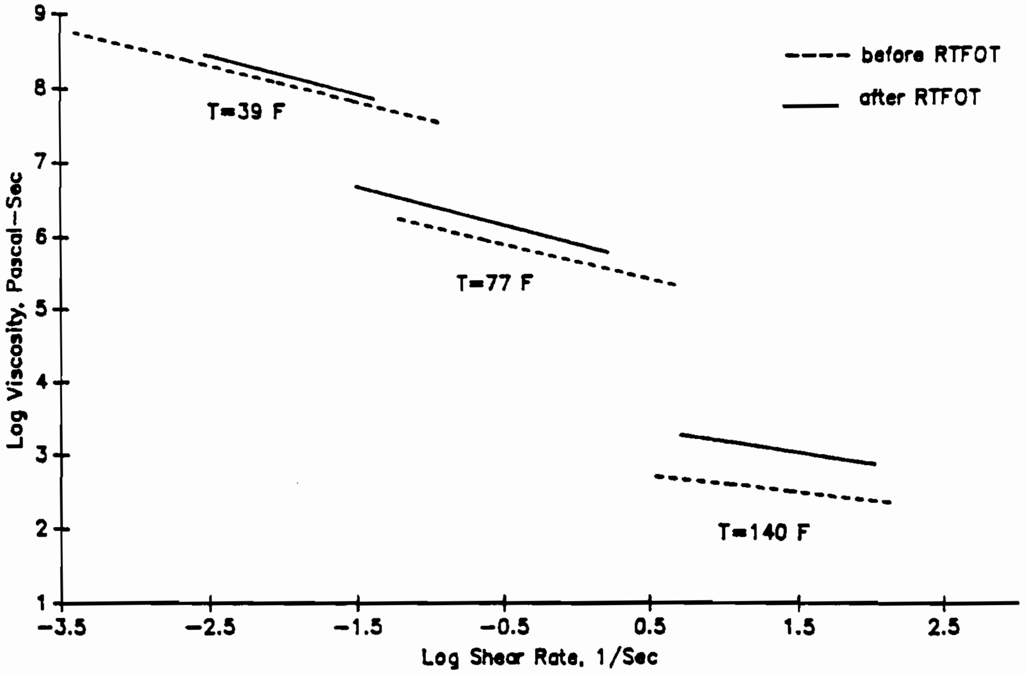

Fig A-37 Viscosity vs. Shear Rate for Dow Modified Binder at Different Test Temperatures.

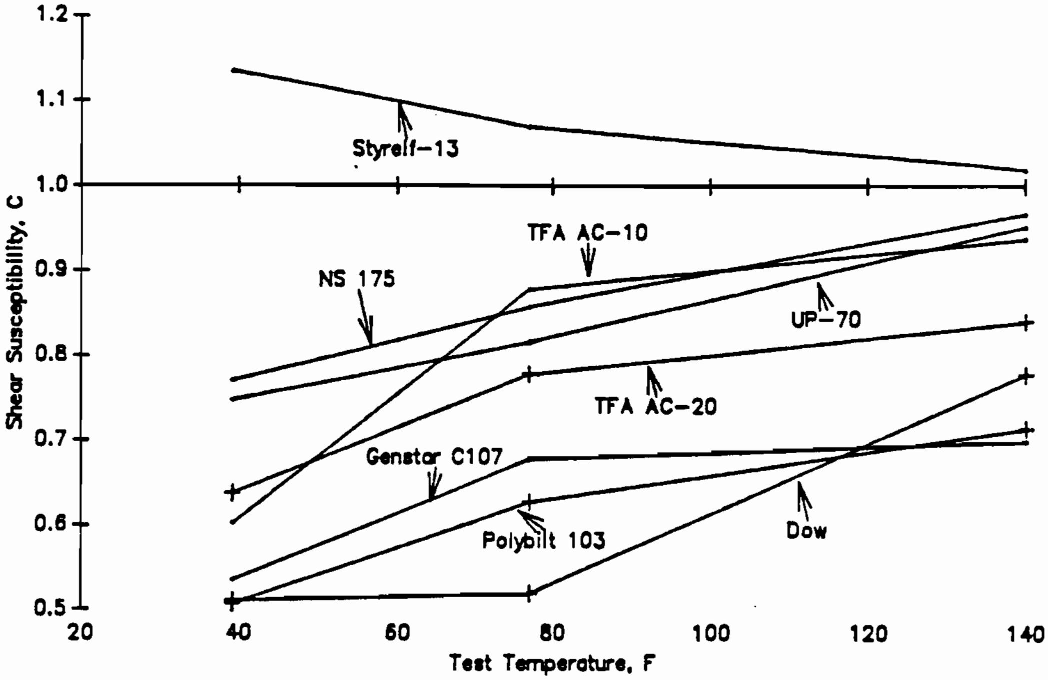

Fig A-38 Shear Susceptibility vs. Test Temperature for Modified and Unmodified Binders before RTFOT.

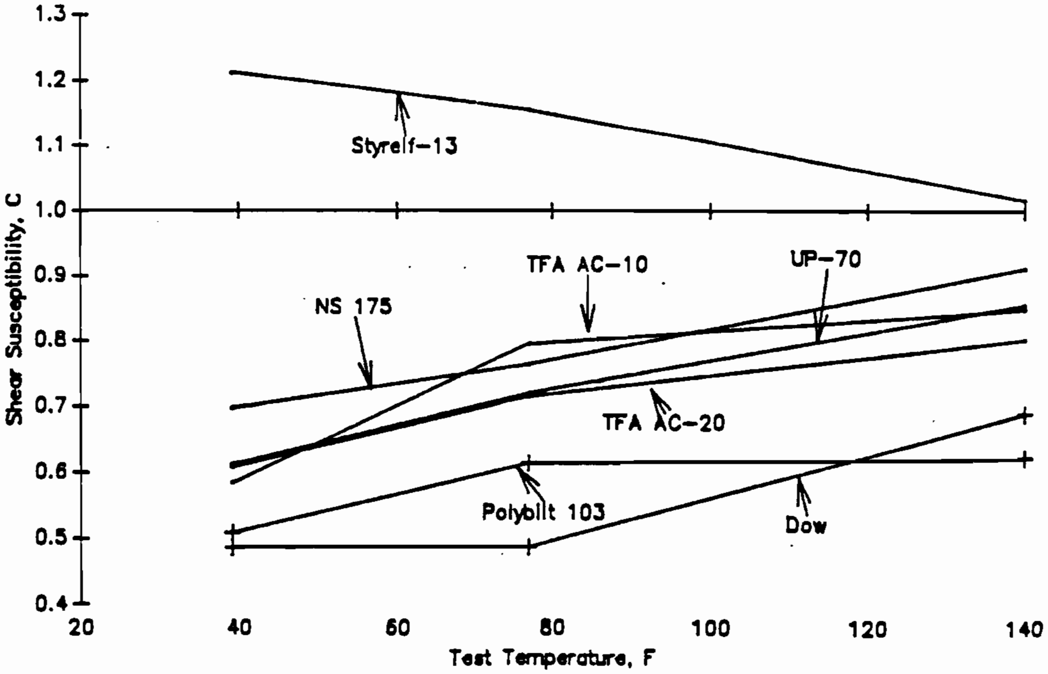

Fig A-39 Shear Susceptibility vs. Test Temperature for Modified and Unmodified Binders after RTFOT.

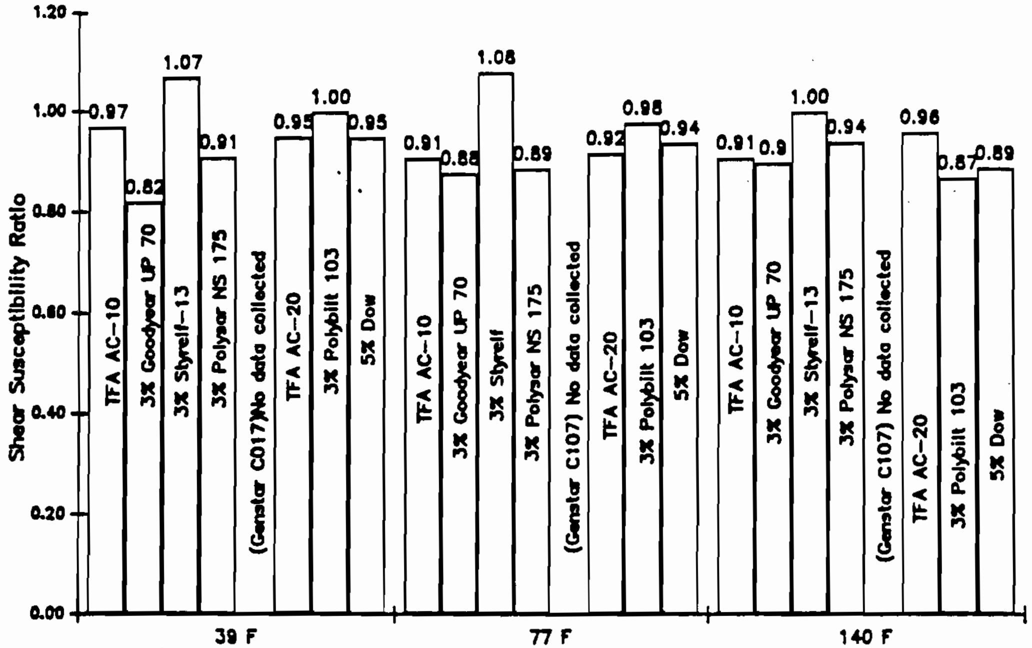

Fig A-40 Shear Susceptibility Ratio for Unmodified and Modified TFA Binders

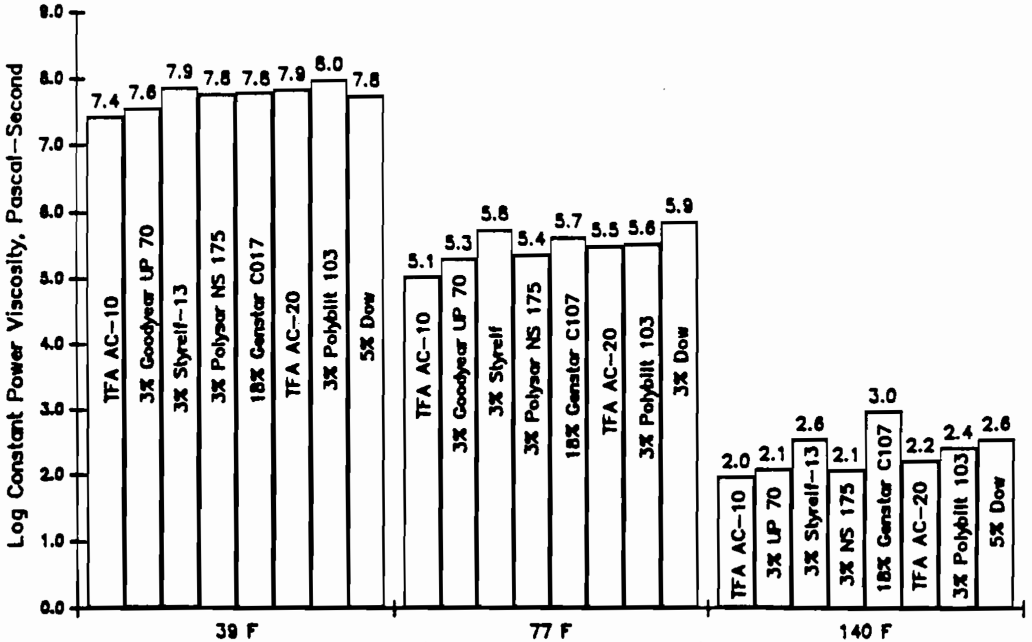

Fig A-41 Constant Power Viscosity for Unmodified and Modified TFA Binders before RTOT

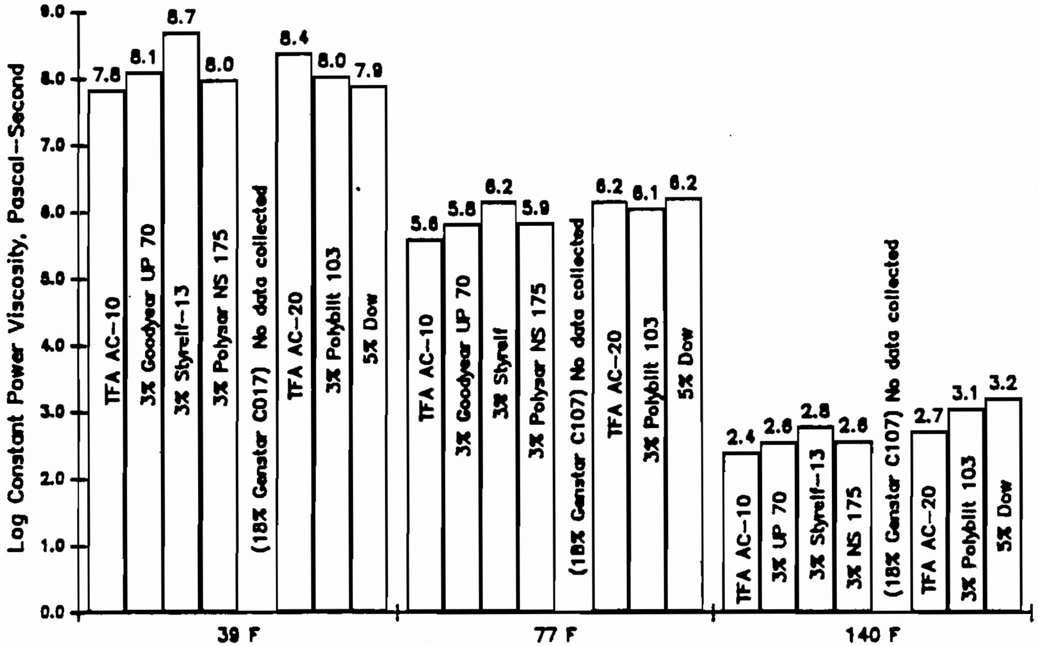

Fig A-42 Constant Power Viscosity for Unmodified and Modified TFA Binders after RTOT

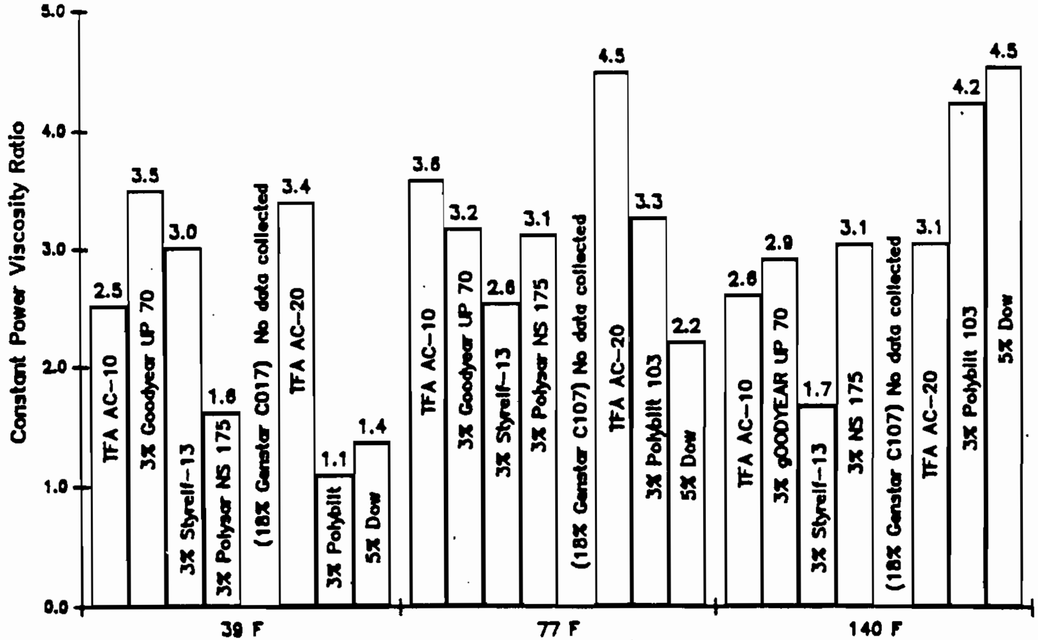

Fig A-43 Constant Power Viscosity Ratio for Unmodified and Modified TFA Binders.

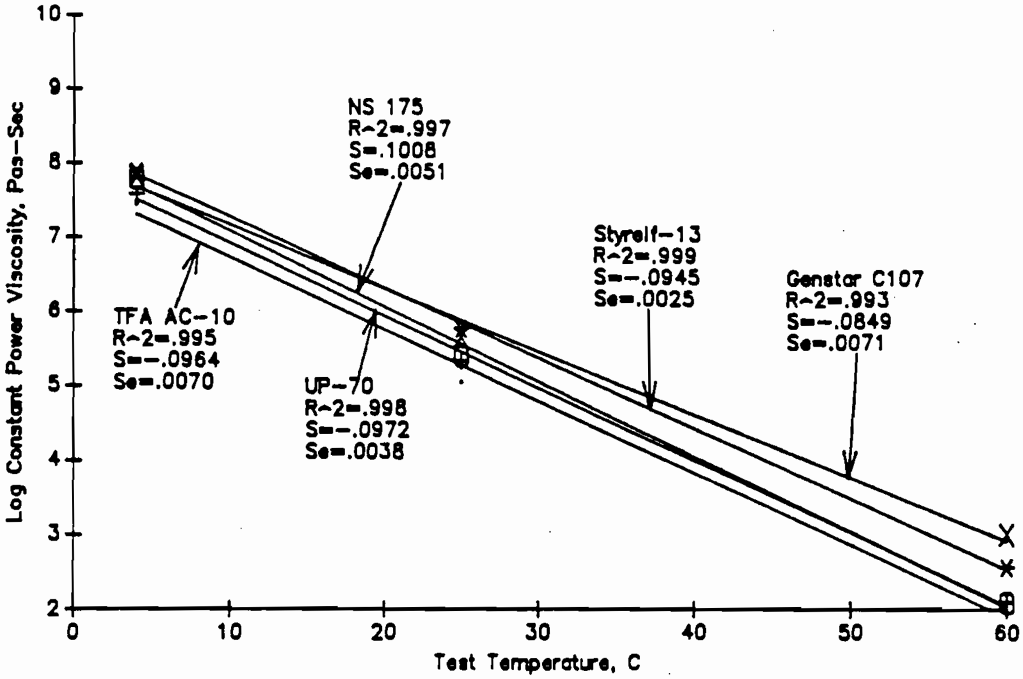

Fig A-44 Constant Power Viscosity vs. Test Temperature for TFA AC-10 Binders before RTFOT.

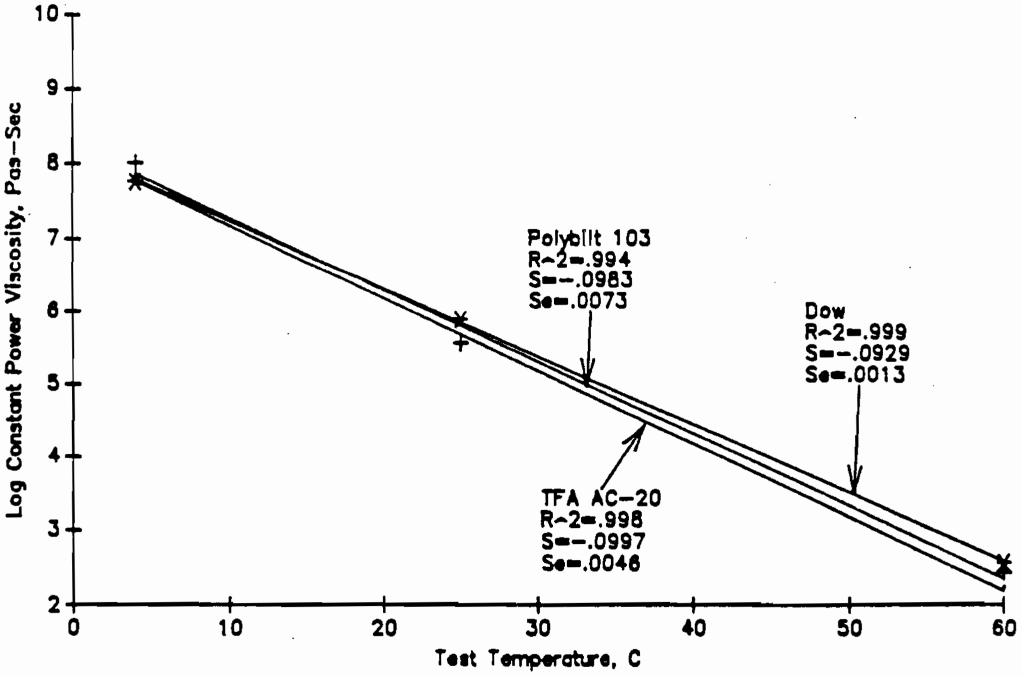

Fig A-45 Constant Power Viscosity vs. Test Temperature for TFA AC-20 Binders before RTFOT.

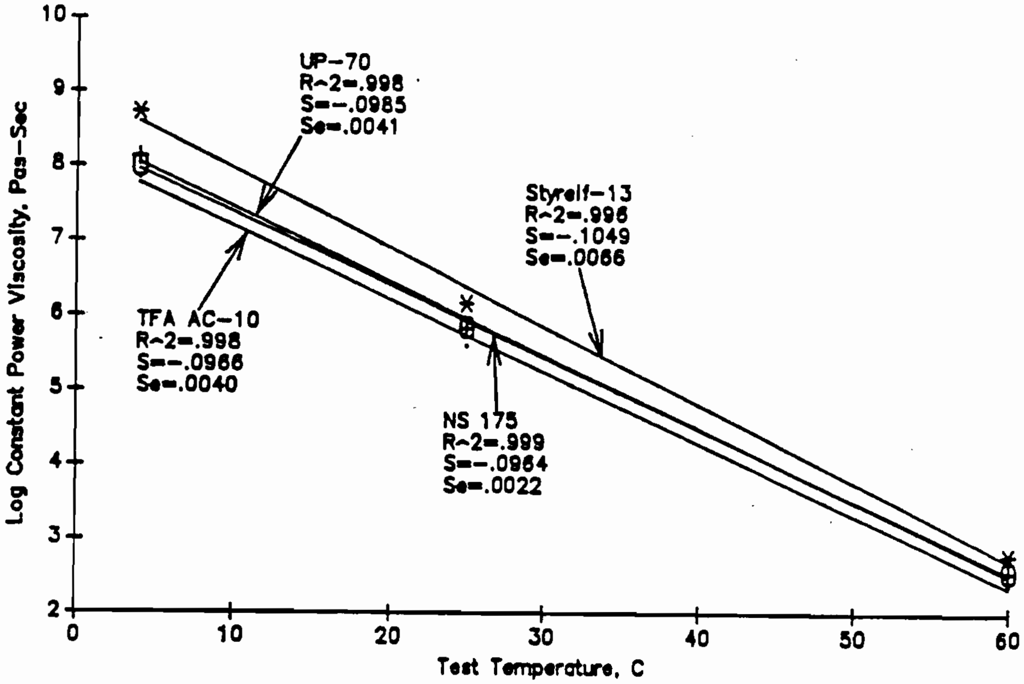

Fig A-46 Constant Power Viscosity vs. Test Temperature for TFA AC-10 Binders after RTFOT.

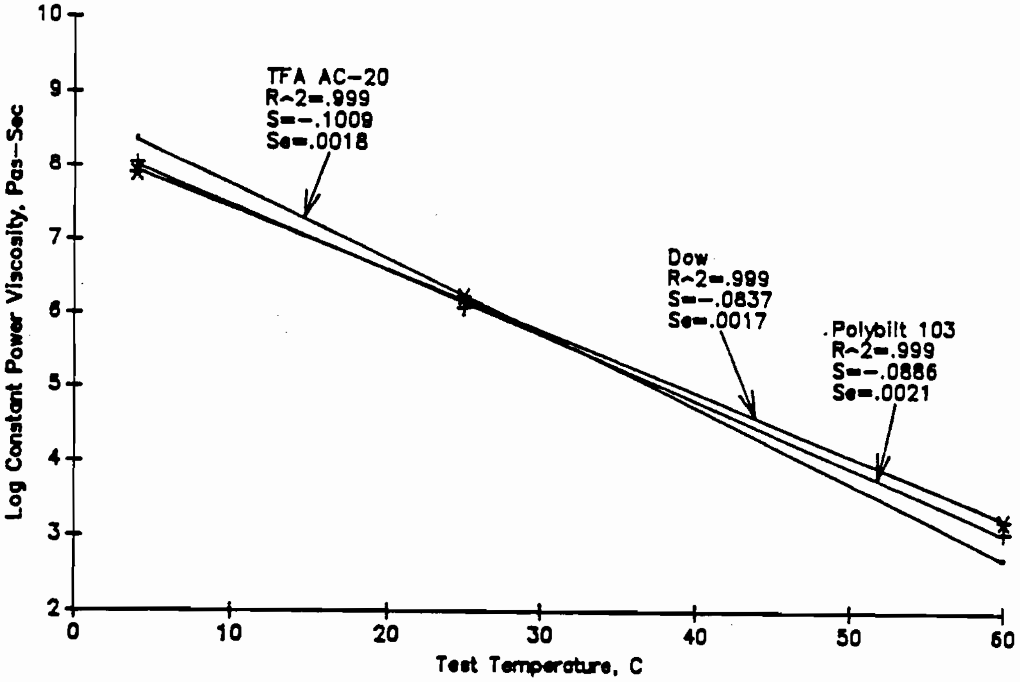

Fig A-47 Constant Power Viscosity vs. Test Temperature for TFA AC-10 Binders after RTFOT.

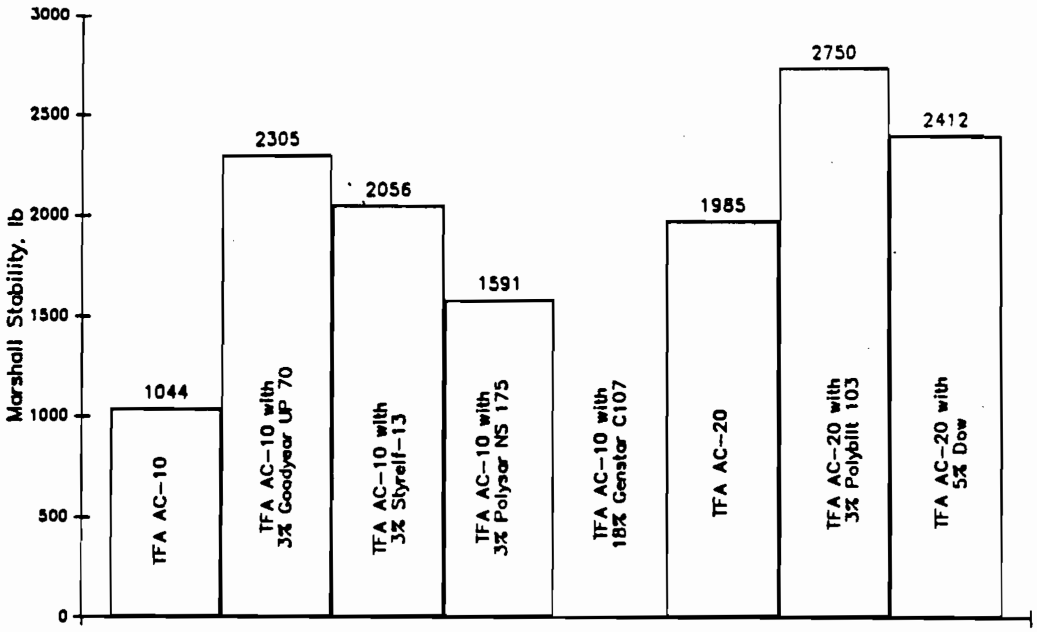

Fig A-48 Marshall Stability for Laboratory Mixtures Using Standard Compaction.

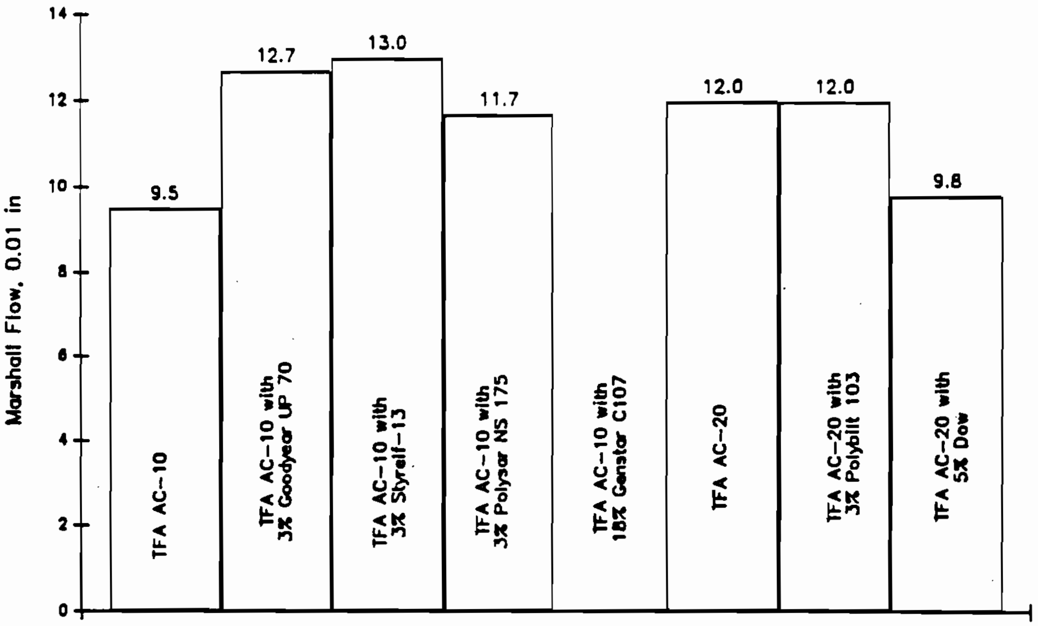

Fig A-49 Marshall Flow for Laboratory Mixtures Using Standard Compaction.

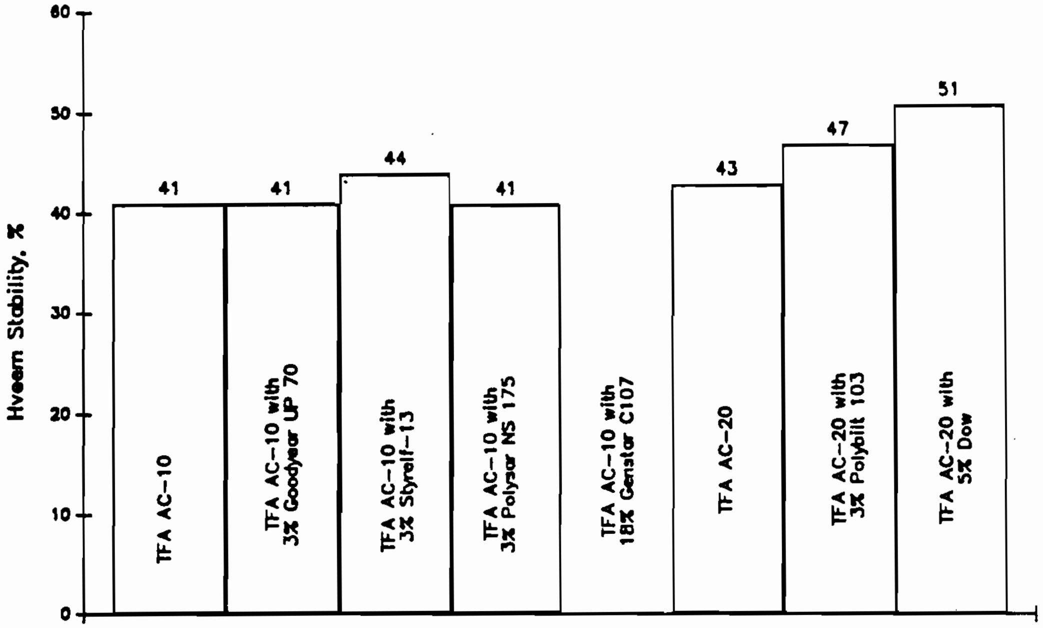

Fig A-50 Hveem Stability for Laboratory Mixtures Using Standard Compaction.

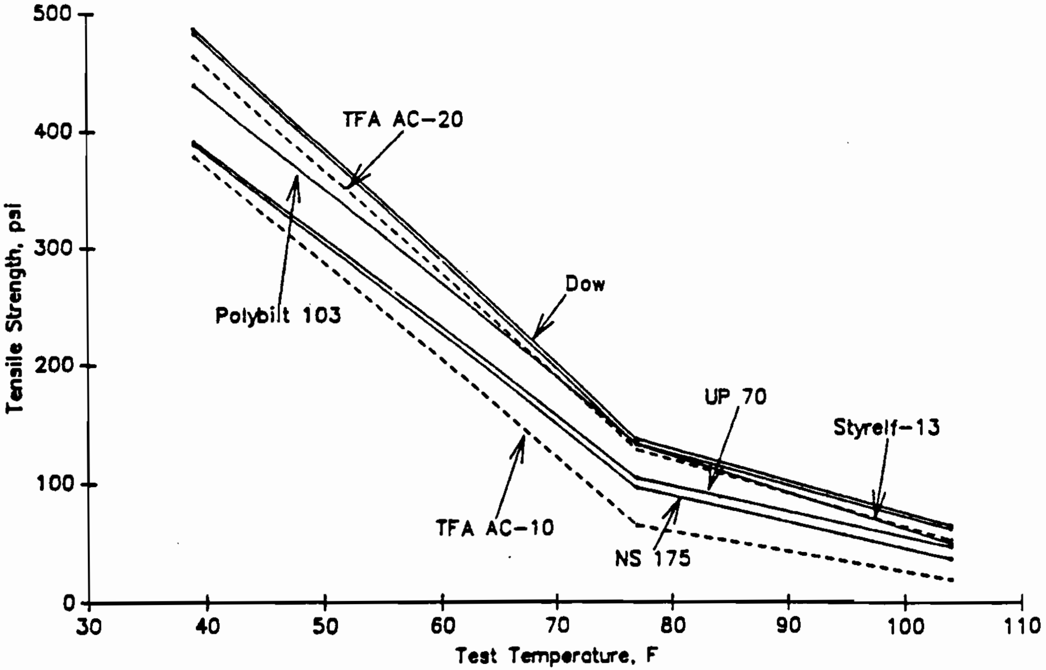

Fig A-51 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

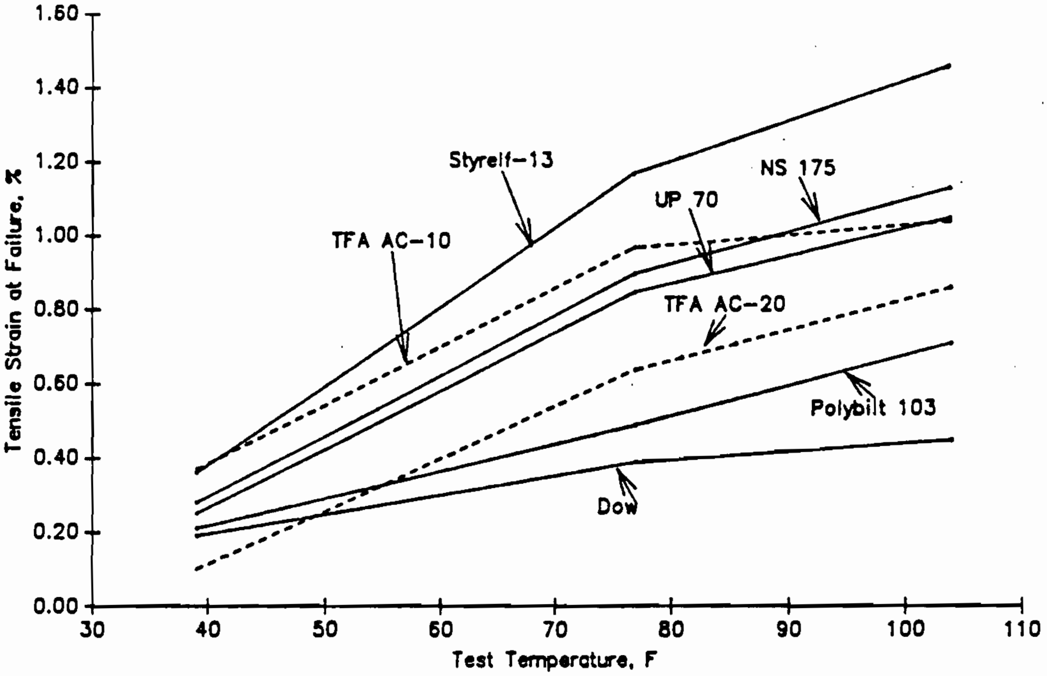

Fig A-52 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

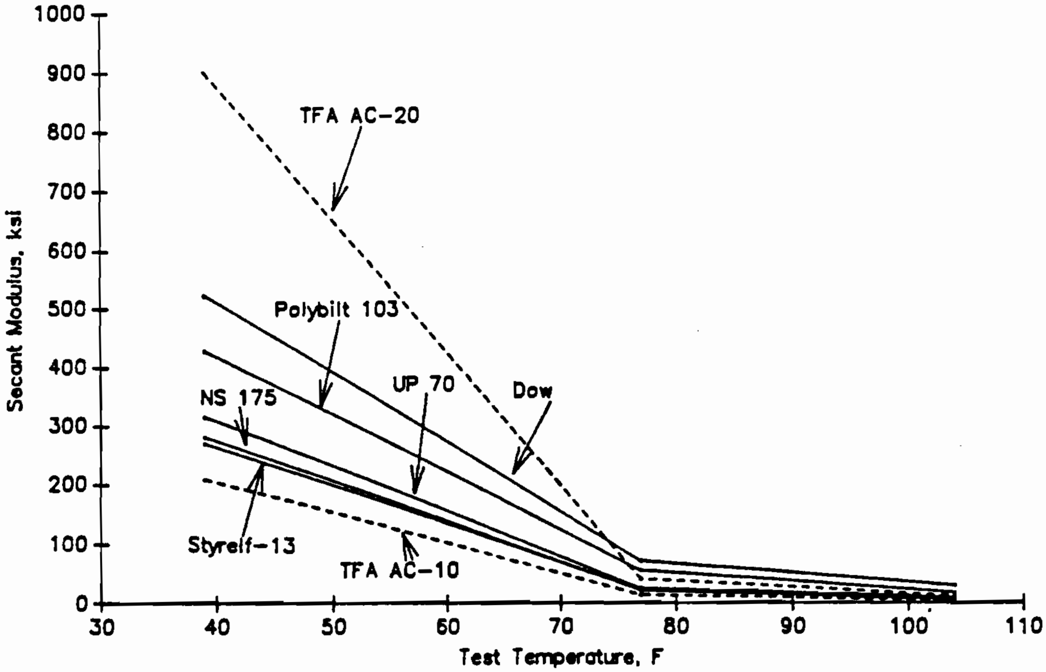

Fig. A-53 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

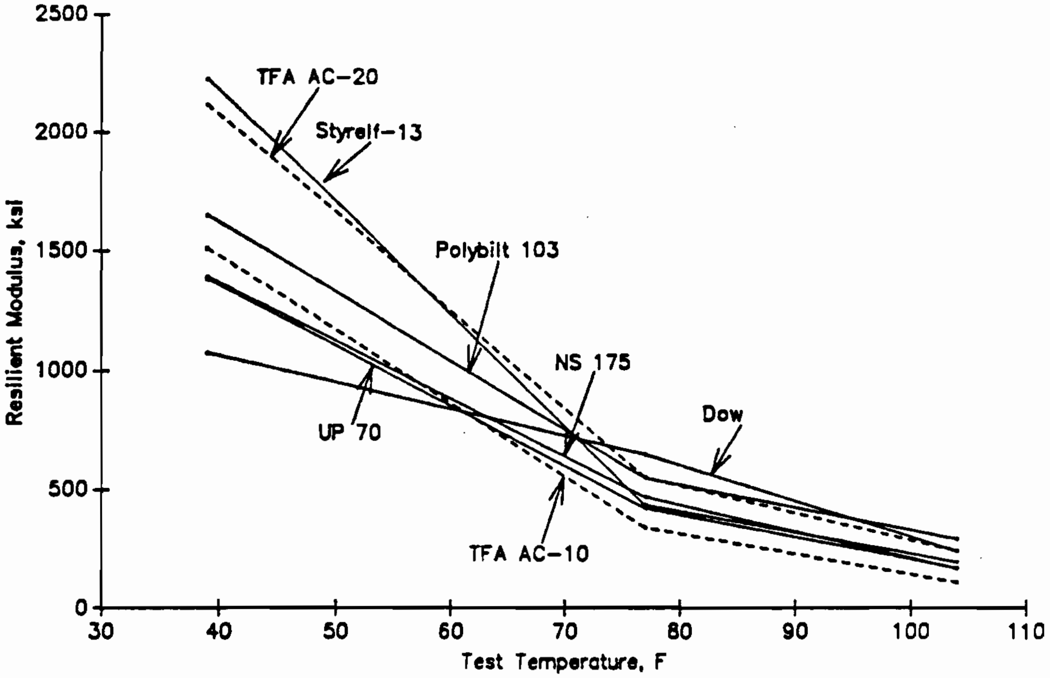

Fig A-54 Resilient Modulus vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

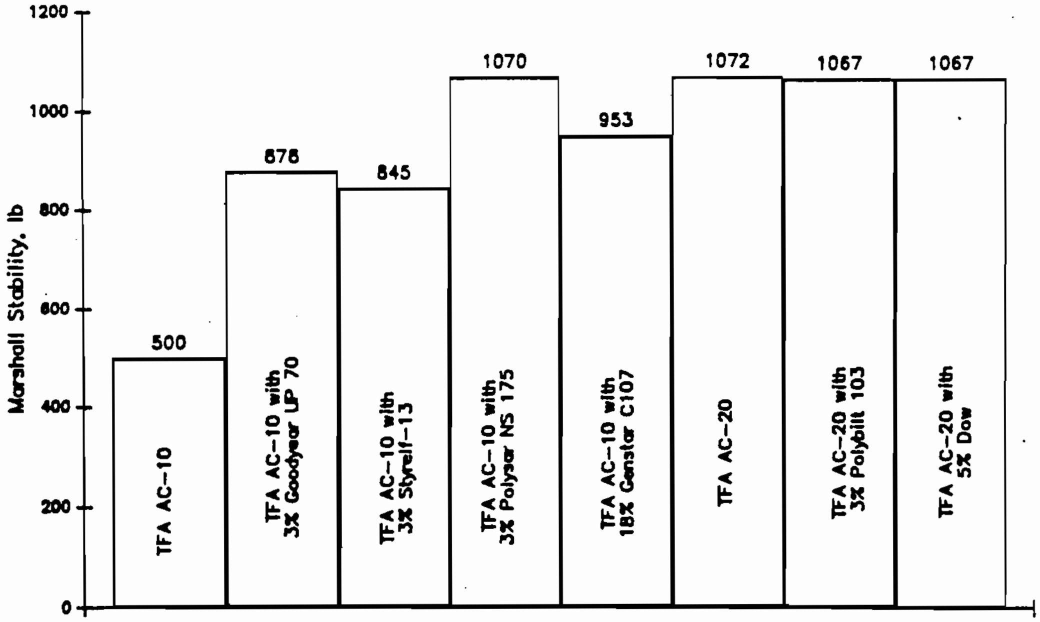

Fig A-55 Marshall Stability for Laboratory Mixtures Using Modified Compaction.

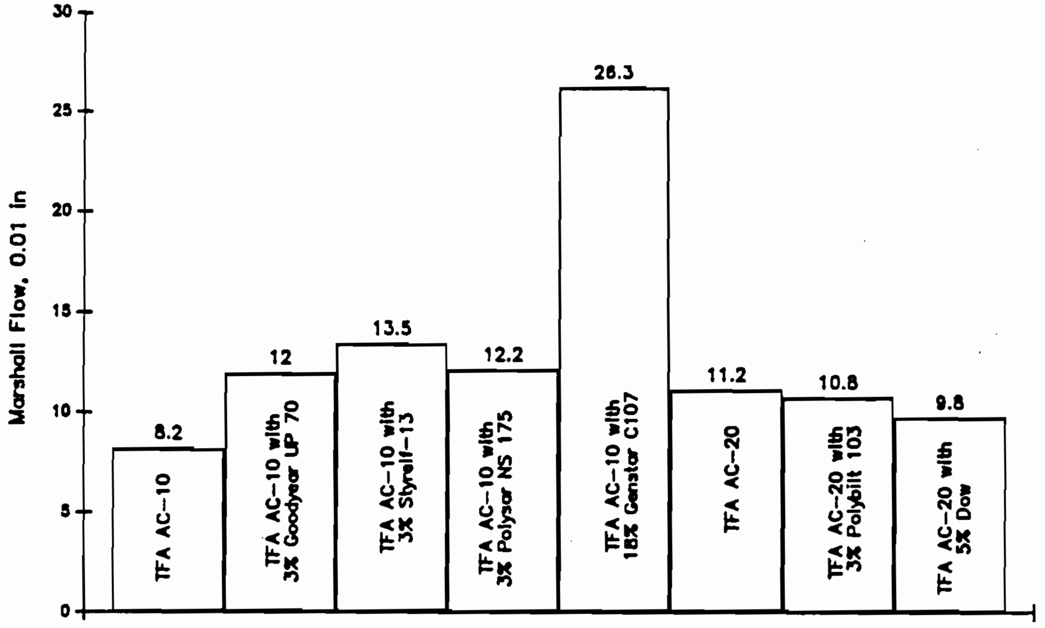

Fig A-56 Marshall Flow for Laboratory Mixtures Using Modified Compaction.

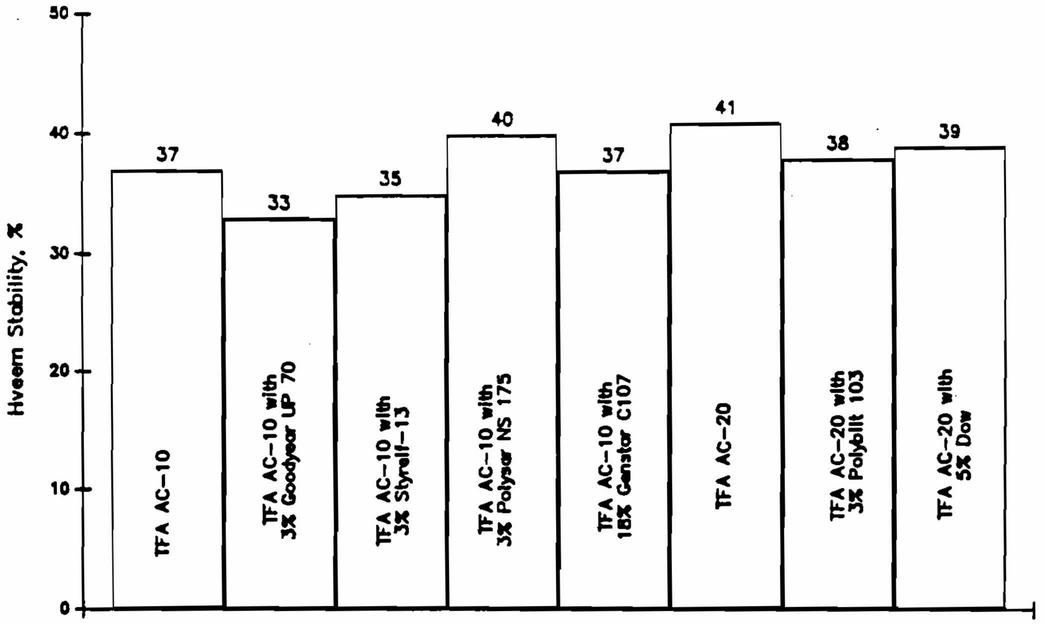

Fig A-57 Hveem Stability for Laboratory Mixtures Using Modified Compaction.

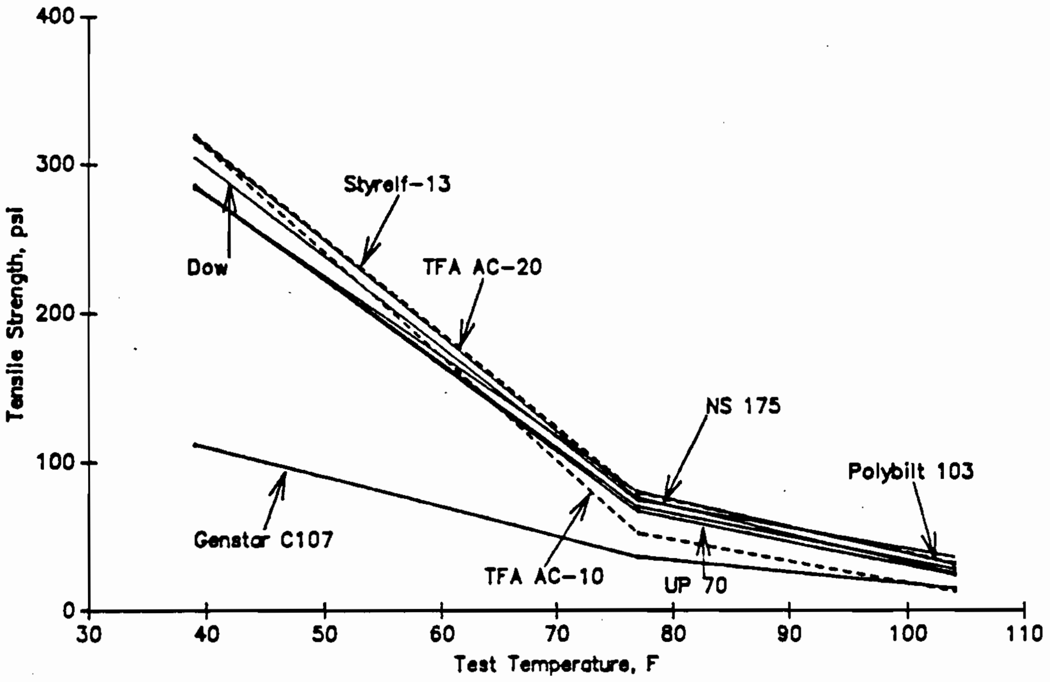

Fig A-58 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

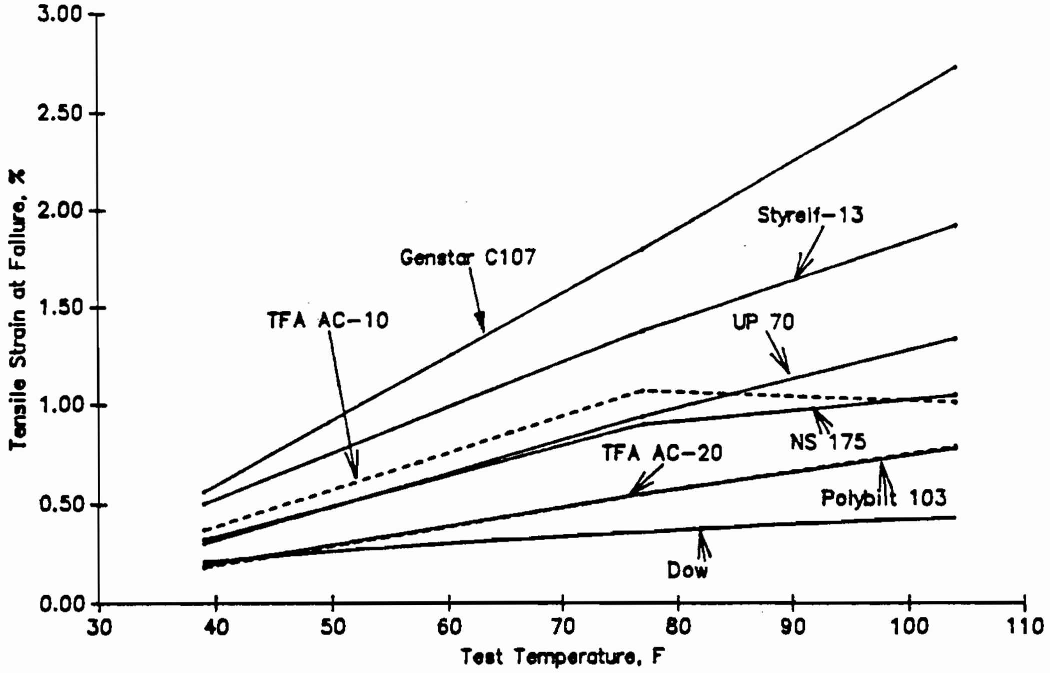

Fig A-59 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

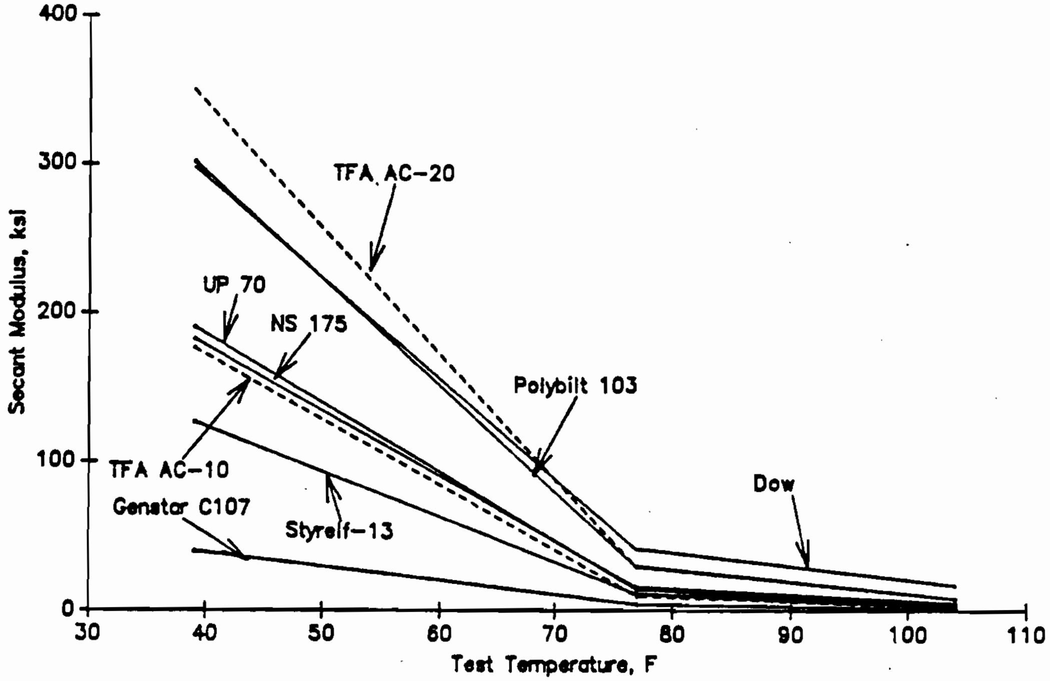

Fig A-60 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

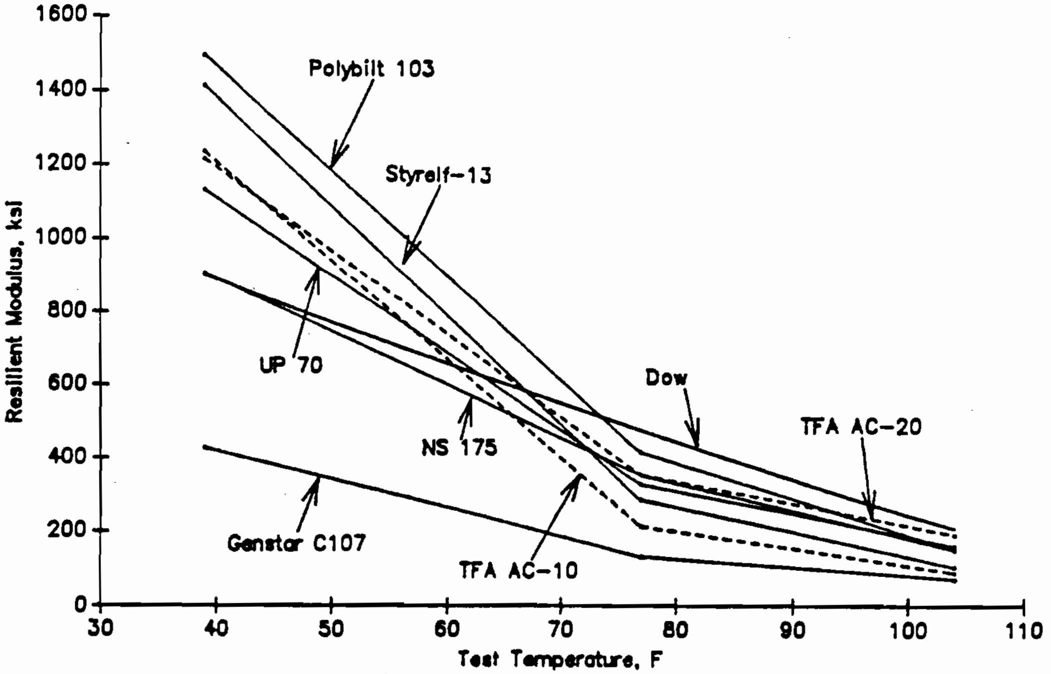

Fig A-61 Resilient Modulus vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

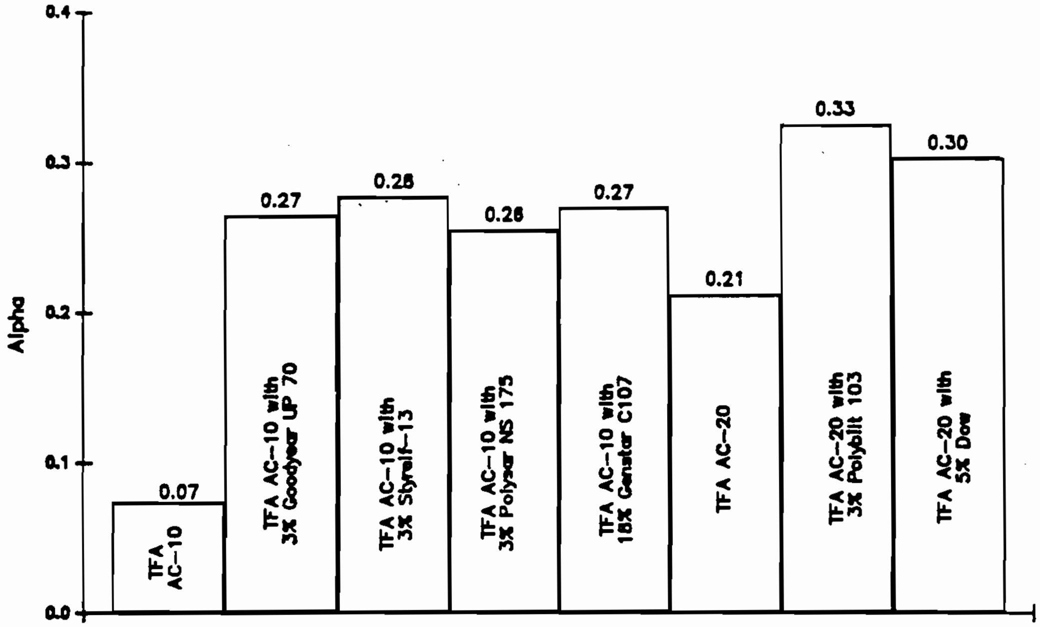

Fig A-62 Alpha Values for Laboratory Mixtures Using Modified Compaction.

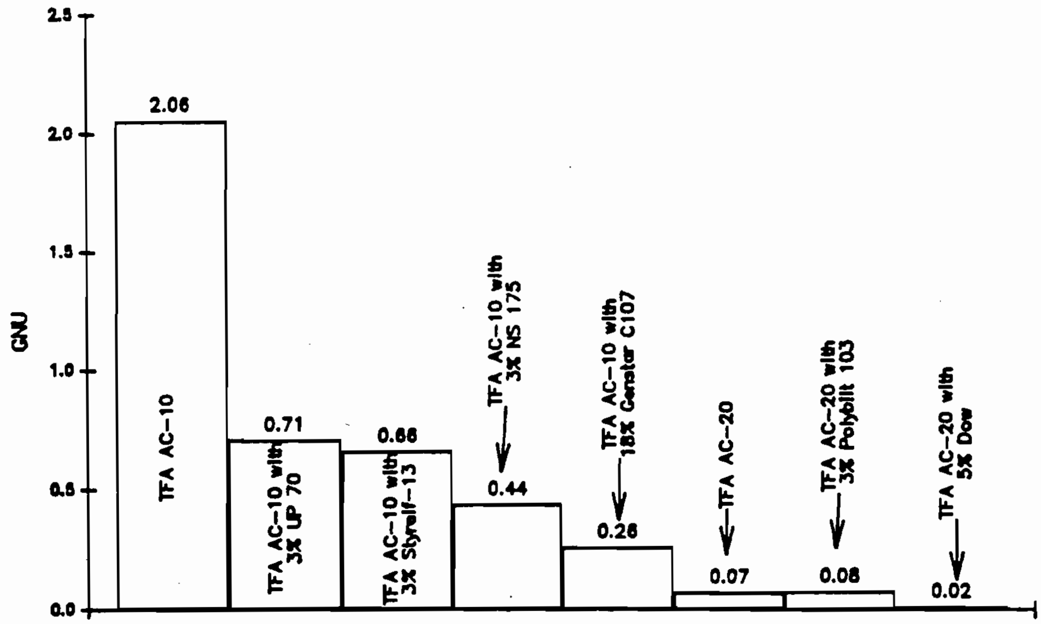

Fig A-63 GNU Values for Laboratory Mixtures Using Modified Compaction.

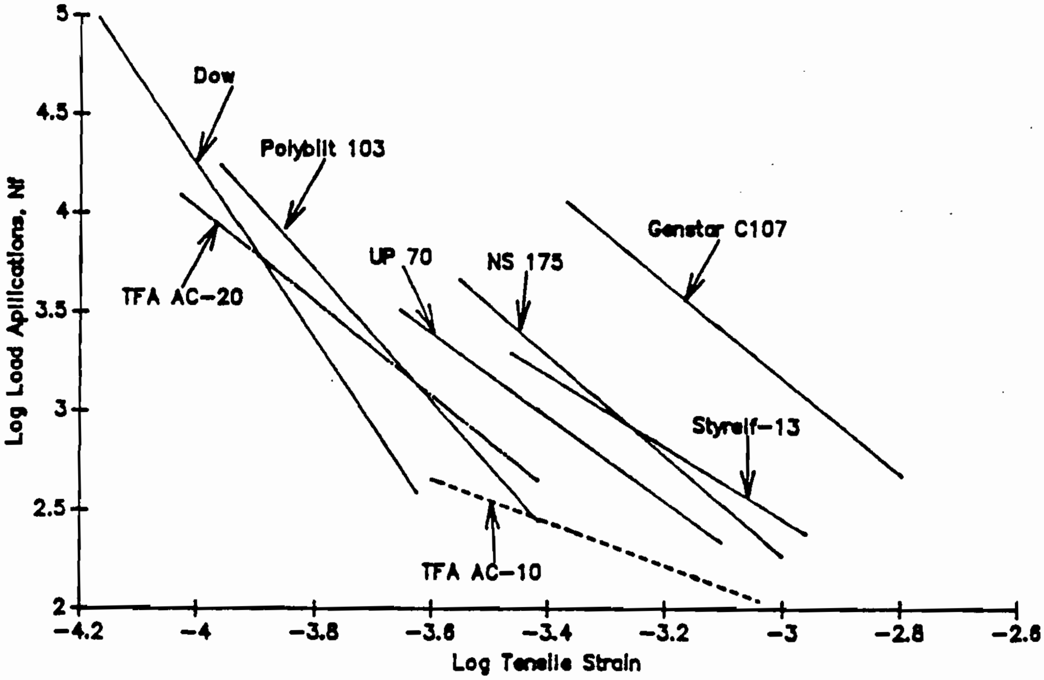

Fig A-64 Relationship between Fatigue Life and Applied Strain for Laboratory Mixtures Using Modified Compaction.

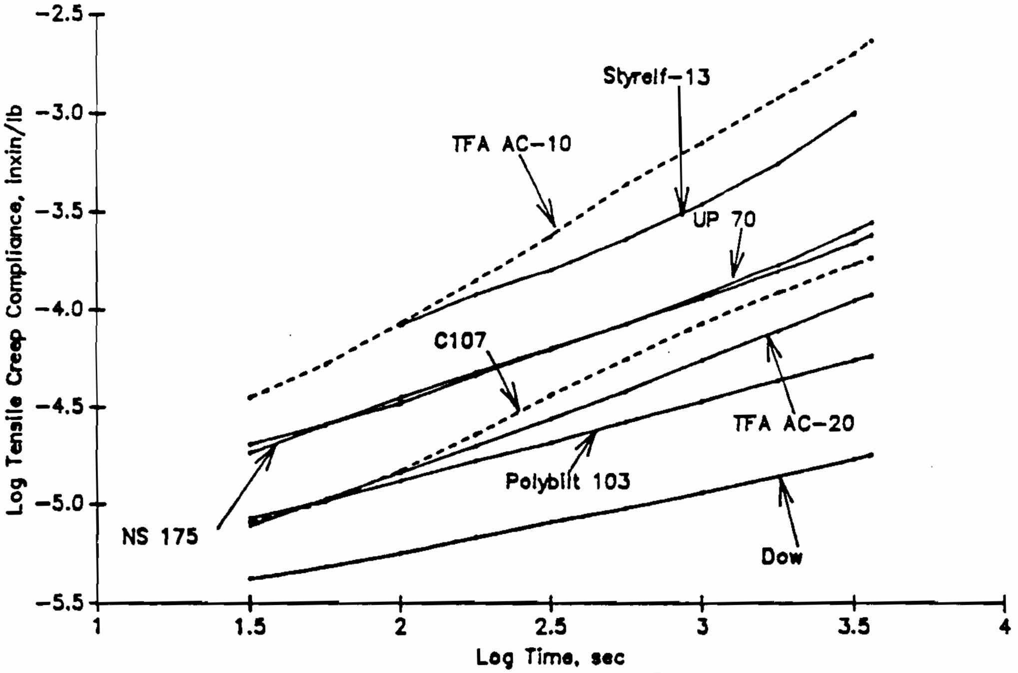

Fig A-65 Creep Compliance Curves at 60 F for Laboratory Mixtures Using Modified Compaction.

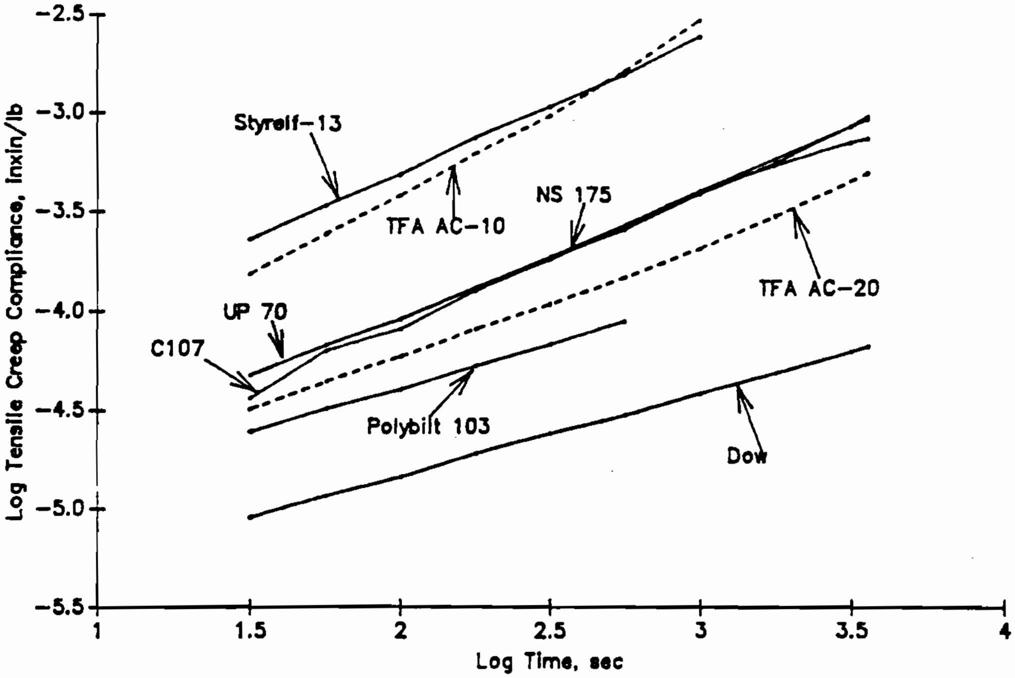

Fig A-66 Creep Compliance Curves at 77 F for Laboratory Mixtures. Using Modififed Compaction.

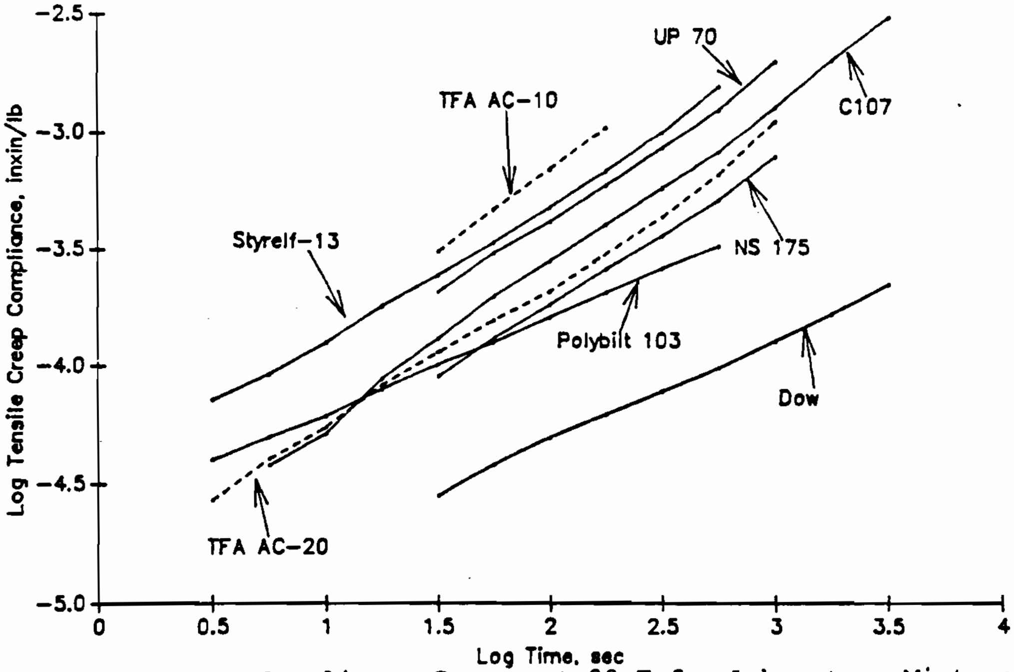

Fig A-67 Creep Compliance Curves at 90 F for Laboratory Mixtures Using Modified Compaction.

APPENDIX B

PRESENTATION OF TEST RESULTS - DISTRICT 11

APPENDIX B

PRESENTATION OF TEST RESULTS - DISTRICT 11

The objectives of Appendix B are twofold: (1) to describe the site-specific field operations of the test sections along with a description of the materials, polymers, and construction techniques used for this field project, and (2) to present the laboratory test results of the unmodified and modified binders and laboratory mixed and plant mixed mixtures for the experimental field study in District 11 of the Texas Department Transportation (TxDOT).

EXPERIMENTAL FIELD PROGRAM

The test pavements were constructed on US 190 in Polk County, Texas, in April 1989, and involved pavement overlay of four lanes of the highway. The test sections are shown schematically in Figure B-1. Each test section was approximately one to one and a half inches thick. A total of three test sections were constructed with two different polymers plus a control. Field construction was conducted by District 11 of the TxDOT and assisted by the Center for Transportation Research, the University of Texas at Austin.

MATERIALS

ASPHALT CEMENT. AC-10 and an AC-20 asphalt cements were supplied by Texaco of Port Neches, Texas, and used throughout this project.

AGGREGATE. Four aggregates, a red lightweight type D, a coarse sandstone screening, a fine sandstone screening, and a field sand, were combined to produce project gradation. Gradations of individual aggregates, the project gradation, percentage of each aggregate, and the gradation specifications are given in Table B-1. The project gradation is plotted on a 0.45 power graph in Figure B-2.

POLYMER. Two polymers included in this field project consisted of a Styrene Butadiene Rubber (SBR), and a Styrene block copolymer (SBS). Sources of these polymers and designations used for this study are shown below.

SOURCE	TYPE	DESIGNATION
Goodyear	SBR	UP 70
Elf	SBS	Styrelf-13

Blending of the asphalts and the polymers was performed by the polymer manufacturers or processors in the refinery or in a distributor truck. No polymer was introduced into the asphalt in-line injection system of the plant.

Styrene Butadiene Rubber. One type of Styrene Butadiene Rubber, Ultra Pave 70, was included in this field project. The latex UP 70 was supplied by Textile Rubber and Chemical Co. The total amount of the UP 70 used in the Texaco AC-10 was 3 percent.

Styrene Butadiene Styrene. The Styrelf-13 utilized was a triblock copolymer of styrene and butadiene. The Styrelf modified binder was blended by Elf Asphalt, Baytown, Texas, with Texaco AC-10 at 3% Styrelf-13 by weight of total binder.

FIELD OPERATION

Approximately 12,000 tons of each mix were produced using a drum mix plant. Identical aggregates were utilized throughout the experiment. Two grades , AC-10 and AC-20, of Texaco asphalt cement were utilized. The Ultra Pave 70 (3 percent) and the Styrelf-13 (3 percent) were preblended with Texaco AC-10. The AC-20 was used for the control test section.

Mixing temperature for the UP 70, and the styrelf-13 mixtures was about 320°F. The control asphalt, Texaco AC-20, was mixed at 305°F. The initial breakdown compaction occurred between 250°F and

270°F for all mixtures. The Styrelf mix on this project seemed to hold its heat for quite a long time. Mixing, production, and paving operation went well for all mixtures. Compaction of each test section was achieved using a vibratory roller, a pneumatic roller, and a steel wheel roller. Environmental conditions during construction were favorable with early morning temperatures of approximately 68°F and afternoon temperatures of 93°F.

Twelve field cores were obtained from each test section soon after the construction. These cores were approximately 4-inch in diameter and one to one and a half inches in thickness. The field cores were transported to the Center for Transportation Research immediately after sampling.

PRESENTATION OF TEST RESULTS

Summaries of test results for the unmodified and the modified binders are presented in Tables B-6 through B-8 and are plotted in Figures B-3 through B-30.

Summaries of test results for the unmodified and the modified mixtures and the cores are presented in Tables B-9 through B-26 and are plotted in Figures B-31 through B-50.

Table B-1 AGGREGATE GRADATION (DISTRICT 11)

	Red LtWt		Sandstone Coarse Screenings		Sandstone Fine Screenings		Field Sand			
	Sieve Analysis % By Volume	56%	Sieve Analysis % By Volume	10%	Sieve Analysis % By Volume	15%	Sieve Analysis % By Volume	19%	Combined Gradation	SDHPT Specification
Plus 1/2 in.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1/2 to 3/8 in	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0-15
3/8 to No. 4	68.8	38.5	4.1	0.4	0.0	0.0	0.0	0.0	38.9	21-53
No. 4 to No. 10	30.0	16.8	25.6	2.6	6.5	1.0	0.4	0.1	20.4	11-32
Plus No. 10									59.3	54-74
No. 10 to No.40	0.6	0.3	43.2	4.3	20.3	3.0	8.7	1.7	9.4	6-32
No. 40 to No. 80	0.0	0.0	8.0	0.8	27.7	4.2	57.1	10.8	15.8	4-27
No. 80 to No. 200	0.0	0.0	17.3	1.7	40.7	6.1	22.8	4.3	12.2	3-27
Minus No. 200	0.6	0.3	1.8	0.2	4.8	0.7	11.0	2.1	3.3	1-8
Total	100.0	56.0	100.0	10.0	100.0	15.0	100.0	19.0	100.0	

TABLE B-2 Experimental Testing Program for Unmodified and Polymer-Modified Asphalt Binders

District 11

Binder		Penetration			Viscosity				Softening Point	Focce Ductility		Schweyer Rheology				
		Before RTFOT		After RTFOT	Before RTFOT		After RTFOT		Before RTFOT	Before RTFOT	After RTFOT	Before RTFOT				
Asphalt	Polymer	39.2 F	77 F	77 F	140 F	275 F	140 F	275 F		39.2 F	39.2 F	39 F	60 F	77 F	90 F	140 F
Texaco AC-20	-	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1
Texaco AC-10	Styrelf-13	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1
Texaco AC-10	Goodyear UP 70	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1

TABLE B-3 Experimental Testing Program for Laboratory Compacted-Laboratory Mixed Mixtures
District 11

Binder		Modified Compaction												Standard Compaction				
		Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F	Creep @			Fatique Stress levels			Moisture Resistance	Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F
Asphalt	Polymer	39F	77F	104F			60F	77F	90F	15%	25%	50%		39F	77F	104F		
Texaco AC-20	-	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Texaco AC-10	Styrelf-13	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Texaco AC-10	Goodyear UP 70	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3

TABLE B-4 Experimental Testing Program for Laboratory Compacted-Plant Mixed Mixtures
District 11

		Modified Compaction												Standard Compaction				
Binder		Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F	Creep @			Fatique Stress levels			Moisture Resistance	Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F
Asphalt	Polymer	39F	77F	104F			60F	77F	90F	15%	25%	50%		39F	77F	104F		
Texaco AC-20	-	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Texaco AC-10	Styrelf-13	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Texaco AC-10	Goodyear UP 70	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3

TABLE B-5 Experimental Testing Program for Field Cores.
District 11

Binder		Resilient modulus & Indirect Tensile Strength			Marshall 140F
Asphalt	Polymer	39F	77F	104F	
Texaco AC-20	-	3	3	3	3
Texaco AC-10	Styrelf-13	3	3	3	3
Texaco AC-10	Goodyear UP 70	3	3	3	3

Table B-6 Unmodified and Modified Asphalt Properties before RTFOT.

Parameter		Texaco AC-20	Texaco AC-10 & 3% Goodyear	Texaco AC-10 & 3% Styrelf
Penetration @ 39.2 F (25 C)		9	12	15
100g, 5 Sec.		9	14	15
	Avg.	9	13	15
Penetration @ 77 F (4 C)		72	87	92
100g, 5 Sec.		70	86	94
	Avg.	71	87	93
Viscosity @ 140 F (60 C)		2380	2348	3025
Poises		2370	2312	3095
	Avg.	2375	2330	3060
Viscosity @ 275 F (135 C)		500	841	703
Centistokes		492	802	726
	Avg.	496	822	715
Softening Point, F		126	128	130
		126	126	130
	Avg.	126	127	130
Maximum True Stress, psi		58	73	204
		62	76	216
	Avg.	60	75	210
Maximum True Strain, in/in		2.48	3.74	3.35
		2.40	3.71	3.40
	Avg.	2.44	3.73	3.38
True Area , psi		80	149	266
		85	151	272
	Avg.	83	150	269

Table B-6 (Continued)

Parameter		Texaco AC-20	Texaco AC-10 & 3% Goodyear	Texaco AC-10 & 3% Styrelf
Asphalt Modulus, psi		249	225	151
		236	223	157
	Avg.	242	224	154
Asphalt-Polymer Modulus, psi		-	103	170
		-	108	168
	Avg.	-	105	169
Shear Susceptibility				
@ 39.2 F		6.459E-01	7.468E-01	1.277E+00
@ 60 F		8.043E-01	8.925E-01	1.167E+00
@ 77 F		8.040E-01	8.028E-01	1.152E+00
@ 90 F		8.301E-01	7.940E-01	1.131E+00
@ 140 F		8.321E-01	8.796E-01	9.713E-01
Apparent Viscosity, Pascal-Second Shear Rate = 1 1/sec,				
@ 39.2 F		1.699E+07	2.808E+07	9.222E+07
@ 60 F		2.056E+06	2.118E+06	1.046E+07
@ 77 F		3.254E+05	2.394E+05	4.380E+05
@ 90 F		8.017E+04	5.414E+04	5.488E+04
@ 140 F		3.291E+02	3.030E+02	3.144E+02
Constant Power Viscosity, Pascal-Second				
@ 39.2 F		5.126E+07	6.359E+07	4.014E+07
@ 60 F		2.854E+06	2.519E+06	7.308E+06
@ 77 F		3.699E+05	2.634E+05	3.945E+05
@ 90 F		7.854E+04	5.046E+04	5.694E+04
@ 140 F		1.949E+02	2.090E+02	2.891E+02

Table B-6 (Continued)

Parameter	Texaco AC-20	Texaco AC-10 & 3% Goodyear	Texaco AC-10 & 3% Styrelf
Penetration Index PI(Pen/Pen)	-0.43	0.12	0.39
Penetration Index PI(Pen/SP)	0.23	0.97	1.6
Penetration Viscosity Number PVN	-0.32	0.76	0.63
Stiffness Modulus @ 39.2 F, psi			
5 Sec. Loading	1015	508	363
20 Sec. Loading	348	246	174
Stiffness Modulus @ 0.1 Sec			
39.2F	7250	3190	2465
77F	334	232	174
104F	26	23	25
Stiffness/Temperature Slope	-0.068	-0.059	-0.056
Apparent Viscosity/Temp. Slope	-0.084	-0.088	-0.100
Constant Power Visco./Temp. Slope	-0.096	-0.097	-0.095
Penetration Ratio, 77 F	0.65	0.58	0.72
Viscosity Ratio	2.95	1.86	1.92
Kinematic Viscosity Ratio	1.51	1.28	1.26
Maximum True Stress Ratio	2.57	6.99	1.26
Maximum True Strain Ratio	0.94	0.99	0.82
True Area Ratio	2.19	4.60	1.20
Asphalt Modulus Ratio	1.87	1.83	1.62
Asphalt-Polymer Modulus Ratio	-	4.33	1.37

Table B-7 Unmodified and Modified Asphalt Properties after RTFOT.

Parameter		Texaco AC-20	Texaco AC-10 & 3% Goodyear	Texaco AC-10 & 3% Styrelf
Penetration @ 77 F (4 C)		46	50	66
100g, 5 Sec.		47	50	68
	Avg.	46	50	67
Viscosity @ 140 F (60 C)		6975	4351	5895
Poises		7029	4302	5868
	Avg.	7002	4327	5882
Viscosity @ 275 F (135 C)		741	1045	895
Centistokes		761	1052	899
	Avg.	751	1049	897
Maximum True Stress, psi		152	520	264
		155	524	266
	Avg.	154	522	265
Maximum True Strain, in/in		2.31	3.68	2.79
		2.27	3.70	2.74
	Avg.	2.29	3.69	2.77
True Area , psi		181	688	321
		182	690	322
	Avg.	181	689	322
Asphalt Modulus, psi		499	395	246
		406	425	251
	Avg.	453	410	248
Asphalt-Polymer Modulus, psi		-	465	228
		-	447	235
	Avg.	-	456	232

Table B-8 Constant Stress Rheometer Results for Unmodified and Modified Binders.

Test Temp.	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosoty Pascal-Sec	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosoty Pascal-Sec
		Texaco AC-20			Texaco AC-10 + 3% UP 70	
T = 140 F	8.18E+04	7.06E+02	1.16E+02	8.44E+04	6.16E+02	1.37E+02
	4.35E+04	3.56E+02	1.22E+02	4.17E+04	2.62E+02	1.59E+02
	2.40E+04	1.86E+02	1.29E+02	2.19E+04	1.33E+02	1.65E+02
	1.20E+04	8.08E+01	1.49E+02	1.27E+04	6.77E+01	1.88E+02
	9.00E+03	5.20E+01	1.73E+02	7.24E+03	3.73E+01	1.94E+02
	3.60E+03	1.68E+01	2.14E+02	4.39E+03	2.11E+01	2.08E+02
T = 90 F	7.22E+05	1.30E+01	5.54E+04	5.93E+05	1.84E+01	3.21E+04
	4.29E+05	7.82E+00	5.48E+04	4.00E+05	1.25E+01	3.20E+04
	2.43E+05	3.98E+00	6.11E+04	2.32E+05	6.74E+00	3.44E+04
	1.39E+05	2.03E+00	6.86E+04	1.36E+05	3.41E+00	3.98E+04
	7.29E+04	8.99E-01	8.11E+04	7.50E+04	1.58E+00	4.75E+04
	3.86E+04	3.93E-01	9.83E+04	3.86E+04	5.90E-01	6.53E+04
T = 77 F	1.04E+06	4.20E+00	2.48E+05	1.23E+06	7.19E+00	1.72E+05
	6.49E+05	2.37E+00	2.74E+05	7.90E+05	4.20E+00	1.88E+05
	4.33E+05	1.42E+00	3.05E+05	4.27E+05	2.20E+00	1.95E+05
	2.44E+05	7.05E-01	3.45E+05	2.06E+05	9.75E-01	2.11E+05
	9.96E+04	2.36E-01	4.22E+05	1.08E+05	3.69E-01	2.93E+05
	6.93E+04	1.42E-01	4.89E+05	4.98E+04	1.28E-01	3.89E+05
T = 60 F	5.88E+05	2.10E-01	2.81E+06	1.65E+06	7.61E-01	2.17E+06
	3.81E+05	1.25E-01	3.05E+06	1.06E+06	4.57E-01	2.31E+06
	2.21E+05	6.16E-02	3.60E+06	6.02E+05	2.46E-01	2.45E+06
	1.32E+05	3.34E-02	3.94E+06	2.87E+05	1.06E-01	2.70E+06
	9.69E+04	2.22E-02	4.37E+06	1.47E+05	4.89E-02	3.01E+06
				7.69E+04	2.49E-02	3.09E+06
T = 39 F	4.12E+06	9.49E-02	4.34E+07	2.87E+06	4.71E-02	6.09E+07
	2.92E+06	6.84E-02	4.26E+07	1.90E+06	2.92E-02	6.52E+07
	1.82E+06	3.52E-02	5.16E+07	1.10E+06	1.03E-02	1.07E+08
	1.00E+06	1.39E-02	7.21E+07	5.95E+05	6.84E-03	8.69E+07
	6.06E+05	5.72E-03	1.06E+08	2.77E+05	2.30E-03	1.21E+08
	3.34E+05	2.08E-03	1.61E+08	1.64E+05	9.07E-04	1.81E+08
	1.77E+05	8.54E-04	2.08E+08			

Table B-8 (Continued)

Test Temp.	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosoty Pascal-Sec
	Texaco AC-10 + 3% Styrelf		
T = 140 F	9.98E+04	3.76E+02	2.65E+02
	5.23E+04	1.93E+02	2.70E+02
	2.02E+04	7.24E+01	2.79E+02
	1.12E+04	3.95E+01	2.83E+02
	6.53E+03	2.27E+01	2.87E+02
T = 90 F	4.73E+05	6.61E+00	7.15E+04
	2.51E+05	3.92E+00	6.40E+04
	1.29E+05	2.14E+00	6.04E+04
	6.59E+04	1.17E+00	5.64E+04
	4.30E+04	7.96E-01	5.40E+04
	2.19E+04	4.46E-01	4.89E+04
T = 77 F	1.43E+06	2.61E+00	5.46E+05
	8.67E+05	1.75E+00	4.94E+05
	4.39E+05	1.10E+00	4.00E+05
	2.63E+05	6.86E-01	3.84E+05
	9.32E+04	2.59E-01	3.59E+05
	6.14E+04	1.76E-01	3.49E+05
	3.18E+04	1.00E-01	3.17E+05
T = 60 F	2.07E+06	2.36E-01	8.76E+06
	1.35E+06	1.77E-01	7.66E+06
	8.77E+05	1.25E-01	7.02E+06
	4.99E+05	7.49E-02	6.66E+06
	2.85E+05	4.58E-02	6.23E+06
	1.21E+05	2.14E-02	5.66E+06
T = 39 F	3.78E+06	8.18E-02	4.62E+07
	1.89E+06	4.77E-02	3.96E+07
	1.00E+06	2.93E-02	3.43E+07
	4.72E+05	1.60E-02	2.94E+07

Table B-9 Marshall and Hveem Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES	
					STABILITY lbs	FLOW .01 in
Control: Texaco AC-20		6.0	38	7.0	858	13.5
		6.8	39	6.4	976	13.5
		6.2	37	6.6	890	14.0
	AVG.	6.3	38	6.7	908	13.7
Texaco AC-10 + 3% UP 70		6.9	36	6.9	957	15.0
		7.2	35	7.1	968	17.0
		6.8	34	7.0	928	15.0
	AVG.	7.0	35	7.0	951	15.7
Texaco AC-10 + 3% Styrelf		6.7	32	6.6	676	16.0
		6.3	34	6.4	692	16.0
		6.2	34	6.8	-	16.0
	AVG.	6.4	33	6.6	684	16.0

Table B-10 Marshall and Hveem Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES	
					STABILITY lbs	FLOW .01 in
Control: Texaco AC-20		2.1	43	2.0	2207	12.0
		2.4	44	2.2	2384	12.0
		2.9	42	2.1	2319	12.0
	AVG.	2.5	43	2.1	2303	12.0
Texaco AC-10 + 3% UP 70		2.8	41	2.6	2407	13.0
		3.2	42	3.6	2935	13.5
		2.9	41	3.1	2823	14.5
	AVG.	3.0	41	3.1	2722	13.7
Texaco AC-10 + 3% Styrelf		1.3	42	1.5	2206	13.0
		1.4	40	1.2	2350	12.5
		1.5	44	1.4	2462	13.0
	AVG.	1.4	42	1.4	2339	12.8

Table B-11 Marshall and Hveem Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES	
					STABILITY lbs	FLOW .01 in
Control: Texaco AC-20		7.4	38	6.1	944	11.5
		7.8	37	6.5	842	12.0
		7.5	34	8.9	861	12.5
	AVG.	7.6	36	7.2	882	12.0
Texaco AC-10 + 3% UP 70		7.1	37	6.5	943	14.0
		6.3	37	7.0	820	13.0
		7.0	36	6.7	800	13.5
	AVG.	6.8	37	6.7	854	13.5
Texaco AC-10 + 3% Styrelf		6.6	28	5.7	459	16.0
		7.2	29	6.3	-	-
		6.3	29	7.0	509	17.0
	AVG.	6.7	29	6.3	484	16.5

Table B-12 Marshall and Hveem Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES	
					STABILITY lbs	FLOW .01 in
Control: Texaco AC-20		3.8	40	3.3	1850	11.0
		3.0	40	3.8	1545	10.5
		3.6	42	4.6	1678	11.0
	AVG.	3.5	41	3.9	1691	10.8
Texaco AC-10 + 3% UP 70		3.2	42	2.8	1948	12.5
		3.6	42	2.9	1928	11.5
		3.4	42	3.3	1743	12.5
	AVG.	3.4	42	3.0	1873	12.2
Texaco AC-10 + 3% Styrelf		0.6	40	0.9	2197	13.0
		1.0	40	0.8	2002	12.5
		0.6	38	0.3	2214	13.0
	AVG.	0.7	39	0.7	2138	12.8

Table B-13 Indirect Tensile Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Texaco AC-20	39		6.5	315	0.42	151	491	0.24
			6.4	295	0.35	167	644	0.02
			7.0	300	0.30	198	733	-0.08
		AVG.	6.6	303	0.36	172	623	0.06
Texaco AC-10 + 3% UP 70	39		6.9	349	0.34	206	922	-0.04
			7.2	356	0.38	185	452	0.24
			6.6	384	0.34	227	471	0.23
		AVG.	6.9	363	0.35	206	615	0.14
Texaco AC-10 + 3% Styrelf	39		6.4	318	0.73	87	678	0.01
			6.6	316	0.74	85	508	0.11
			6.4	277	0.73	76	505	0.09
		AVG.	6.5	304	0.73	83	564	0.07
Control: Texaco AC-20	77		6.8	69	1.23	11.2	129	0.38
			6.1	74	1.21	12.2	162	0.21
			6.9	68	1.40	9.7	123	0.35
		AVG.	6.6	70	1.28	11.0	138	0.31
Texaco AC-10 + 3% UP 70	77		7.1	81	1.56	10.3	186	0.24
			7.1	85	1.52	11.2	294	0.08
			7.0	87	1.46	11.9	148	0.36
		AVG.	7.1	84	1.51	11.1	209	0.22
Texaco AC-10 + 3% Styrelf	77		6.4	62	2.13	5.8	77	0.49
			6.3	65	2.13	6.0	123	0.24
			6.0	65	2.18	5.9	146	0.14
		AVG.	6.2	64	2.15	5.9	115	0.29
Control: Texaco AC-20	104		6.5	19	1.29	3.0	95	0.04
			6.5	20	1.29	3.1	68	0.25
			6.4	21	1.34	3.1	79	0.16
		AVG.	6.5	20	1.31	3.0	81	0.15
Texaco AC-10 + 3% UP 70	104		7.6	20	1.61	2.4	47	0.54
			6.7	20	1.56	2.6	106	0.10
			6.7	21	1.56	2.7	58	0.44
		AVG.	7.0	20	1.58	2.6	70	0.36
Texaco AC-10 + 3% Styrelf	104		6.3	18	2.60	1.4	30	0.63
			6.8	14	2.34	1.2	43	0.34
			6.3	14	2.34	1.2	85	0.21
		AVG.	6.5	15	2.43	1.2	53	0.40

Table B-14 Indirect Tensile Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Texaco AC-20	39		1.7	460	0.28	333	764	0.17
			2.2	430	0.24	359	626	0.12
			2.4	467	0.25	374	612	0.22
		AVG.	2.1	452	0.25	355	667	0.17
Texaco AC-10 + 3% UP 70	39		3.0	488	0.19	521	1042	-0.01
			3.0	492	0.22	450	1043	-0.03
			3.4	477	0.22	436	769	0.06
		AVG.	3.1	486	0.21	469	952	0.01
Texaco AC-10 + 3% Styrelf	39		1.4	517	0.44	237	462	0.24
			1.5	554	0.52	213	617	0.17
			1.4	520	0.62	167	872	0.05
		AVG.	1.4	530	0.53	205	651	0.16
Control: Texaco AC-20	77		2.3	118	1.04	22.7	264	0.20
			2.2	119	1.12		246	0.20
			2.6	115	1.04	22.1	187	0.39
		AVG.	2.4	117	1.07	22.4	232	0.26
Texaco AC-10 + 3% UP 70	77		3.2	159	1.25	25.5	355	0.21
			3.5	150	1.08	27.8	323	0.22
			2.7	148	1.26	23.4	381	0.17
		AVG.	3.1	152	1.20	25.6	353	0.20
Texaco AC-10 + 3% Styrelf	77		2.0	125	1.56	16.0	202	0.26
			1.3	124	1.51	16.4	220	0.23
			1.8	129	1.51	17.1	217	0.27
		AVG.	1.7	126	1.53	16.5	213	0.25
Control: Texaco AC-20	104		2.1	42	0.99	8.5	123	0.19
			2.3	41	1.07	7.6	58	0.67
			2.7	39	1.06	7.3	78	0.45
		AVG.	2.4	40	1.04	7.8	86	0.44
Texaco AC-10 + 3% UP 70	104		2.9	48	1.25	7.7	113	0.33
			3.5	53	1.20	8.9	112	0.37
			2.4	45	1.25	7.2	81	0.51
		AVG.	2.9	49	1.23	8.0	102	0.40
Texaco AC-10 + 3% Styrelf	104		1.8	37	1.56	4.7	53	0.43
			1.3	39	1.53	5.1	86	0.16
			1.3	36	1.49	4.8	67	0.37
		AVG.	1.5	37	1.53	4.9	69	0.32

Table B-15 Indirect Tensile Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Texaco AC-20	39	7.0	347	0.31	222	334	-
		6.7	349	0.35	200	466	-
		8.3	352	0.26	270	457	-
		----	-----	-----	-----	-----	-----
	AVG.	7.3	349	0.31	231	419	-
Texaco AC-10 + 3% UP 70	39	6.6	337	0.33	202	502	-
		7.1	343	0.43	159	450	-
		6.7	353	0.30	238	466	-
		----	-----	-----	-----	-----	-----
	AVG.	6.8	344	0.35	200	473	-
Texaco AC-10 + 3% Styrelf	39	7.7	314	0.69	91	507	-
		6.5	329	0.79	83	450	-
		6.3	315	0.41	155	382	-
		----	-----	-----	-----	-----	-----
	AVG.	6.8	319	0.63	110	446	-
Control: Texaco AC-20	77	7.6	107	1.20	17.8	221	-
		7.3	108	1.26	17.2	235	-
		6.4	101	1.20	16.9	219	-
		----	-----	-----	-----	-----	-----
	AVG.	7.1	106	1.22	17.3	225	-
Texaco AC-10 + 3% UP 70	77	6.8	102	1.35	15.0	218	-
		7.1	107	1.38	15.5	191	-
		7.1	103	1.37	15.0	254	-
		----	-----	-----	-----	-----	-----
	AVG.	7.0	104	1.37	15.2	221	-
Texaco AC-10 + 3% Styrelf	77	7.8	68	2.02	6.8	192	-
		6.1	69	1.82	7.6	106	-
		6.5	80	1.72	9.3	113	-
		----	-----	-----	-----	-----	-----
	AVG.	6.8	73	1.85	7.9	137	-
Control: Texaco AC-20	104	7.2	31	1.45	4.3	96	0.28
		7.0	31	1.31	4.8	80	0.28
		6.6	33	1.43	4.6	88	0.36
		----	-----	-----	-----	-----	-----
	AVG.	6.9	32	1.40	4.6	88	0.31
Texaco AC-10 + 3% UP 70	104	7.1	26	1.74	3.0	72	0.38
		6.9	25	1.57	3.2	182	0.09
		6.9	29	1.61	3.6	99	0.17
		----	-----	-----	-----	-----	-----
	AVG.	7.0	27	1.64	3.3	118	0.21
Texaco AC-10 + 3% Styrelf	104	6.1	19	2.37	1.6	180	-0.10
		7.2	22	2.12	2.1	271	-0.12
		6.1	19	2.28	1.7	65	0.23
		----	-----	-----	-----	-----	-----
	AVG.	6.5	20	2.26	1.8	172	0.00

Table B-16 Indirect Tensile Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Texaco AC-20	39		3.0	446	0.23	381	562	-
			4.2	429	0.20	434	780	-
			3.5	464	0.22	425	443	-
		AVG.	3.6	446	0.22	413	595	-
Texaco AC-10 + 3% UP 70	39		3.4	467	0.26	359	457	-
			3.8	467	0.26	358	374	-
			2.8	473	0.26	364	736	-
		AVG.	3.3	469	0.26	360	522	-
Texaco AC-10 + 3% Styrelf	39		1.9	515	0.00		513	-
			0.9	512	0.33	312	525	-
			1.3	504	0.35	289	698	-
		AVG.	1.4	510	0.23	300	579	-
Control: Texaco AC-20	77		4.1	161	0.88	36.4	283	-
			3.3	154	1.04	29.6	310	-
			3.1	159	1.11	28.7	287	-
		AVG.	3.5	158	1.01	31.5	293	-
Texaco AC-10 + 3% UP 70	77		3.2	162	1.30	24.9	290	-
			2.8	164	1.20	27.3	581	-
			2.4	159	1.20	26.6	290	-
		AVG.	2.8	162	1.23	26.3	387	-
Texaco AC-10 + 3% Styrelf	77		0.9	155	1.39	22.3	257	-
			1.4	156	1.36	22.9	180	-
			0.9	150	1.51	19.8	254	-
		AVG.	1.1	153	1.42	21.7	230	-
Control: Texaco AC-20	104		5.1	58	1.21	9.5	202	0.15
			3.5	53	1.30	8.1	102	0.36
			3.6	57	1.23	9.3	131	0.33
		AVG.	4.1	56	1.25	9.0	145	0.28
Texaco AC-10 + 3% UP 70	104		3.2	50	1.59	6.4	114	0.27
			2.6	49	1.62	6.1	116	0.30
			2.8	50	1.62	6.2	118	0.35
		AVG.	2.9	50	1.61	6.2	116	0.31
Texaco AC-10 + 3% Styrelf	104		1.0	51	1.87	5.4	103	0.22
			0.4	48	1.68	5.8	84	0.38
			0.8	50	1.61	6.2	102	0.21
		AVG.	0.7	50	1.72	5.8	96	0.27

Table B-17 Alpha and Gnu Parameters for Laboratory Mixed/Laboratory Compacted Mixtures

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	RESILIEN STRAIN IN/IN	ALPHA	GNU	Ea=IN^S		R-SQUR FOR Ea=IN^S
								S	LOG(I)	
Control: Texaco AC-20	77	6.9	155	9.7	3.8E-05	0.2362	0.3670	0.7638	-4.7420	0.989
		6.8	155	9.5	3.8E-05	0.1196	0.2333	0.8804	-5.0005	0.988
	AVG.	6.9	155	9.6	3.8E-05	0.1779	0.3001	0.8221	-4.8713	
Texaco AC-10 + 3% UP 70	77	7.0	185	11.3	6.2E-05	0.1508	0.1536	0.8492	-4.9473	0.996
		7.1	185	11.4	6.2E-05	0.1640	0.1665	0.8360	-4.9055	0.991
	AVG.	7.1	185	11.4	6.2E-05	0.1574	0.1601	0.8426	-4.9264	
Texaco AC-10 + 3% Styrelf	77	6.3	140	8.6	5.2E-05	0.2046	0.6955	0.7954	-4.3423	0.994
		6.0	140	8.6	5.2E-05	0.2192	0.7118	0.7808	-4.3242	0.993
	AVG.	6.2	140	8.6	5.2E-05	0.2119	0.7036	0.7881	-4.3333	

Table B-18 Alpha and Gnu Parameters for Plant Mixed/Laboratory Compacted Mixtures

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	RESILIEN STRAIN IN/IN	ALPHA	GNU	Ea=IN^S		R-SQUR FOR Ea=IN^S
								S	LOG(I)	
Control: Texaco AC-20	77	6.6	219	15.0	7.8E-05	0.3439	0.4454	0.6561	-4.2761	0.998
		7.0	221	14.9	7.8E-05	0.2708	0.2354	0.7292	-4.5990	0.993
	AVG.	6.8	220	15.0	7.8E-05	0.3074	0.3404	0.6927	-4.4376	
Texaco AC-10 + 3% UP 70	77	6.5	230	15.2	7.3E-05	0.1705	0.1901	0.8295	-4.7777	0.999
		7.0	230	15.0	7.3E-05	0.2178	0.2383	0.7822	-4.6540	0.998
	AVG.	6.8	230	15.1	7.3E-05	0.1942	0.2142	0.8059	-4.7159	
Texaco AC-10 + 3% Styrelf	77	6.2	160	10.3	1.2E-04	0.2703	0.1845	0.7297	-4.5290	0.983
		6.8	162	10.4	1.0E-04	0.1326	0.3131	0.8674	-4.4255	0.994
	AVG.	6.5	161	10.4	1.1E-04	0.2015	0.2488	0.7986	-4.4773	

Table B-19 Fatigue Parameter Values for Laboratory Mixed/Laboratory Compacted Mixtures

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	STATIC MODULUS KSI	INITIAL STRAIN IN/IN	LOAD CYCLES	FATIGUE CONSTANT		R-SQUR FOR Nf=K1(1/Emix)^K
								K1	K2	
Control: Texaco AC-20	77	6.9	155	9.7	29	3.3E-04	5220	7.18E-04	2.01	0.983
		9.8	155	9.5	29	3.3E-04	6750			
		6.2	260	16.2	29	5.6E-04	2890			
		6.6	260	16.0	29	5.5E-04	3150			
		6.2	775	47.4	29	1.6E-03	282			
		6.8	775	47.5	29	1.6E-03	240			
Texaco AC-10 + 3% UP 70	77	7.0	185	11.3	30	3.8E-04	7434	2.21E-04	2.17	0.890
		7.1	185	11.4	30	3.8E-04	8115			
		7.1	310	19.2	30	6.4E-04	1225			
		7.2	310	19.1	30	6.4E-04	1020			
		7.2	600	37.4	30	1.2E-03	575			
		6.9	600	37.2	30	1.2E-03	535			
Texaco AC-10 + 3% Styrelf	77	6.3	140	8.6	14	6.1E-04	3120	4.65E-03	1.82	0.991
		6.0	140	8.6	14	6.1E-04	3458			
		6.4	230	14.0	14	1.0E-03	1320			
		6.5	235	14.6	14	1.0E-03	1410			
		6.9	470	28.9	14	2.1E-03	320			
		6.3	470	28.8	14	2.1E-03	406			

Table 8-20 Fatigue Parameter Values for Plant Mixed/Laboratory Compacted Mixtures

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	STATIC MODULUS KSI	INITIAL STRAIN IN/IN	LOAD CYCLES	FATIGUE CONSTANT		R-SQUR FOR Nf=K1(1/Emix)^K
								K1	K2	
Control: Texaco AC-20	77	6.6	219	15.0	44	3.4E-04	6160	2.89E-05	2.40	0.993
		7.0	221	14.9	44	3.4E-04	5860			
		6.5	367	25.2	44	5.7E-04	1720			
		6.7	366	25.1	44	5.7E-04	2260			
		6.6	739	50.4	44	1.1E-03	320			
		6.5	742	50.3	44	1.1E-03	340			
Texaco AC-10 + 3% UP 70	77	6.5	230	15.2	45	3.4E-04	5620	6.31E-07	2.87	0.969
		7.0	230	15.0	45	3.3E-04	4750			
		6.70	390	25.9	45	5.8E-04	1860			
		7.30	390	25.5	45	5.7E-04	1500			
		6.60	762	50.2	45	1.1E-03	220			
		6.70	763	50.4	45	1.1E-03	130			
Texaco AC-10 + 3% Styrelf	77	6.2	160	10.3	19	5.4E-04	2560	1.57E-04	2.24	0.938
		6.8	162	10.4	19	5.5E-04	2560			
		6.30	265	17.3	19	9.1E-04	1300			
		6.00	266	17.5	19	9.2E-04	1650			
		6.20	535	35.1	19	1.8E-03	185			
		7.00	530	34.0	19	1.8E-03	180			

Table B-21 Creep Compliance Properties for Laboratory Mixed/ Laboratory Compacted Mixture Using Modified Compaction.

MIXTURE	TEMP. F	D1	m	Log(SHIFT FACTOR)	BETA
Control: Texaco AC-20	60	2.69E-06	0.58	1.14	0.072
	77	1.21E-05	0.58		
	90	4.55E-05	0.58	-1.00	
Texaco AC-10 + 3% UP 70	60	1.05E-06	0.62	1.03	0.062
	77	3.63E-06	0.70		
	90	4.11E-05	0.41	-0.82	
Texaco AC-10 + 3% Styrelf	60	9.43E-06	0.53	1.06	0.051
	77	3.29E-05	0.55		
	90	6.50E-05	0.55	-0.52	

Table B-22 Creep Compliance Properties for Plant Mixed/ Laboratory Compacted Mixture Using Modified Compaction.

MIXTURE	TEMP. F	D1	m	Log(SHIFT FACTOR)	BETA
Control: Texaco AC-20	60	5.00E-06	0.40	1.13	0.063
	77	1.09E-05	0.49		
	90	2.32E-05	0.54	-0.78	
Texaco AC-10 + 3% UP 70	60	1.76E-06	0.49	1.60	0.074
	77	9.27E-06	0.55		
	90	1.72E-05	0.63	-0.70	
Texaco AC-10 + 3% Styrelf	60	1.09E-05	0.46	1.14	0.049
	77	3.22E-05	0.51		
	90	4.47E-05	0.56	-0.39	

Table B-23 Creep Compliance of Laboratory Mixed / Laboratory Compacted Mixtures Using Modified Compaction.

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-20 TEST TEMP = 60 , ZIGMA = 6.913 PSI				TEXACO AC-20 TEST TEMP = 60 , ZIGMA = 6.983 PSI			
1.0	5.50E-05	2.86E-05	2.07E-06	1.0	9.50E-05	4.94E-05	3.54E-06
1.8	9.00E-05	4.68E-05	3.39E-06	1.8	1.30E-04	6.76E-05	4.84E-06
3.2	1.20E-04	6.24E-05	4.51E-06	3.2	1.60E-04	8.32E-05	5.96E-06
5.6	2.00E-04	1.04E-04	7.52E-06	5.6	2.15E-04	1.12E-04	8.01E-06
10.0	2.75E-04	1.43E-04	1.03E-05	10.0	2.70E-04	1.40E-04	1.01E-05
18.0	3.98E-04	2.07E-04	1.50E-05	18.0	3.53E-04	1.83E-04	1.31E-05
31.6	5.38E-04	2.80E-04	2.02E-05	31.6	4.65E-04	2.42E-04	1.73E-05
56.2	7.18E-04	3.73E-04	2.70E-05	56.2	6.05E-04	3.15E-04	2.25E-05
100.0	1.08E-03	5.62E-04	4.06E-05	100.0	8.20E-04	4.26E-04	3.05E-05
177.8	1.53E-03	7.93E-04	5.74E-05	177.8	1.14E-03	5.90E-04	4.23E-05
316.2	2.11E-03	1.10E-03	7.94E-05	316.2	1.50E-03	7.80E-04	5.59E-05
562.3	3.00E-03	1.56E-03	1.13E-04	562.3	2.28E-03	1.18E-03	8.47E-05
1000.0	4.25E-03	2.21E-03	1.60E-04	1000.0	3.30E-03	1.72E-03	1.23E-04
1778.3	5.95E-03	3.09E-03	2.24E-04	1778.3	4.97E-03	2.58E-03	1.85E-04
3162.3	8.78E-03	4.56E-03	3.30E-04	3162.3	7.84E-03	4.08E-03	2.92E-04
3600.0	9.64E-03	5.01E-03	3.62E-04	3600.0	8.54E-03	4.44E-03	3.18E-04
7200.0	8.40E-03	4.37E-03		7200.0	7.50E-03	3.90E-03	
TEXACO AC-20 TEST TEMP = 77 , ZIGMA = 2.263 PSI				TEXACO AC-20 TEST TEMP = 77 , ZIGMA = 2.452 PSI			
1.0	9.50E-05	4.94E-05	1.09E-05	1.0	1.15E-04	5.98E-05	1.22E-05
1.8	1.40E-04	7.28E-05	1.61E-05	1.8	2.00E-04	1.04E-04	2.12E-05
3.2	1.80E-04	9.36E-05	2.07E-05	3.2	2.45E-04	1.27E-04	2.60E-05
5.6	2.50E-04	1.30E-04	2.87E-05	5.6	3.70E-04	1.92E-04	3.92E-05
10.0	3.35E-04	1.74E-04	3.85E-05	10.0	5.05E-04	2.63E-04	5.36E-05
18.0	4.60E-04	2.39E-04	5.29E-05	18.0	7.30E-04	3.80E-04	7.74E-05
31.6	6.20E-04	3.22E-04	7.12E-05	31.6	1.06E-03	5.51E-04	1.12E-04
56.2	8.10E-04	4.21E-04	9.31E-05	56.2	1.40E-03	7.28E-04	1.48E-04
100.0	1.08E-03	5.59E-04	1.24E-04	100.0	1.96E-03	1.02E-03	2.08E-04
177.8	1.45E-03	7.54E-04	1.67E-04	177.8	2.68E-03	1.39E-03	2.84E-04
316.2	2.13E-03	1.11E-03	2.44E-04	316.2	3.88E-03	2.02E-03	4.11E-04
562.3	3.07E-03	1.59E-03	3.52E-04	562.3	5.53E-03	2.87E-03	5.86E-04
1000.0	4.38E-03	2.28E-03	5.03E-04	1000.0	8.23E-03	4.28E-03	8.72E-04
1778.3	6.63E-03	3.45E-03	[illegible]	1778.3	1.26E-02	6.54E-03	1.33E-03
3162.3	1.04E-02	5.38E-03	[illegible]				
3600.0	1.16E-02	6.02E-03	1.33E-03				
7200.0	1.12E-02	5.81E-03					

Table 8-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-20 TEST TEMP = 90 , ZIGMA = 0.678 PSI				TEXACO AC-20 TEST TEMP = 90 , ZIGMA = 0.746 PSI			
1.0	1.10E-04	5.72E-05	4.22E-05	1.0	1.40E-04	7.28E-05	4.88E-05
1.8	1.55E-04	8.06E-05	5.95E-05	1.8	2.00E-04	1.04E-04	6.97E-05
3.2	2.00E-04	1.04E-04	7.67E-05	3.2	2.85E-04	1.48E-04	9.93E-05
5.6	2.85E-04	1.48E-04	1.09E-04	5.6	4.20E-04	2.18E-04	1.46E-04
10.0	3.75E-04	1.95E-04	1.44E-04	10.0	5.80E-04	3.02E-04	2.02E-04
18.0	5.30E-04	2.76E-04	2.03E-04	18.0	8.30E-04	4.32E-04	2.89E-04
31.6	7.80E-04	4.06E-04	2.99E-04	31.6	1.10E-03	5.72E-04	3.83E-04
56.2	1.17E-03	6.09E-04	4.49E-04	56.2	1.46E-03	7.59E-04	5.09E-04
100.0	1.67E-03	8.66E-04	6.39E-04	100.0	1.93E-03	1.00E-03	6.73E-04
177.8	2.56E-03	1.33E-03	9.82E-04	177.8	2.54E-03	1.32E-03	8.84E-04
316.2	3.26E-03	1.70E-03	1.25E-03	316.2	3.53E-03	1.83E-03	1.23E-03
562.3	4.91E-03	2.55E-03	1.88E-03	562.3	5.02E-03	2.61E-03	1.75E-03
1000.0	7.16E-03	3.72E-03	2.75E-03	1000.0	7.45E-03	3.87E-03	2.60E-03
1778.3	1.29E-02	6.71E-03	4.95E-03				
3162.3	2.74E-02	1.43E-02	1.05E-02				
3600.0	3.51E-02	1.82E-02	1.34E-02				
TEXACO AC-10 + 3% UP 70 TEST TEMP = 60 , ZIGMA = 8.128 PSI				TEXACO AC-10 + 3% UP 70 TEST TEMP = 60 , ZIGMA = 8.112 PSI			
1.0	5.50E-05	2.86E-05	1.76E-06	1.0	1.50E-05	7.80E-06	4.81E-07
1.8	8.00E-05	4.16E-05	2.56E-06	1.8	2.00E-05	1.04E-05	6.41E-07
3.2	1.05E-04	5.46E-05	3.36E-06	3.2	3.00E-05	1.56E-05	9.62E-07
5.6	1.60E-04	8.32E-05	5.12E-06	5.6	3.85E-05	2.00E-05	1.23E-06
10.0	2.10E-04	1.09E-04	6.72E-06	10.0	4.50E-05	2.34E-05	1.44E-06
18.0	3.05E-04	1.59E-04	9.76E-06	18.0	7.50E-05	3.90E-05	2.40E-06
31.6	4.20E-04	2.18E-04	1.34E-05	31.6	1.15E-04	5.98E-05	3.69E-06
56.2	5.64E-04	2.93E-04	1.80E-05	56.2	1.84E-04	9.54E-05	5.88E-06
100.0	7.88E-04	4.10E-04	2.52E-05	100.0	3.20E-04	1.66E-04	1.03E-05
177.8	1.10E-03	5.72E-04	3.52E-05	177.8	5.75E-04	2.99E-04	1.84E-05
316.2	1.49E-03	7.72E-04	4.75E-05	316.2	8.50E-04	4.42E-04	2.72E-05
562.3	2.02E-03	1.05E-03	6.45E-05	562.3	1.30E-03	6.76E-04	4.17E-05
1000.0	2.20E-03	1.14E-03	7.04E-05	1000.0	2.15E-03	1.12E-03	6.89E-05
1778.3	3.64E-03	1.89E-03	1.16E-04	1778.3	3.45E-03	1.79E-03	1.11E-04
3162.3	4.50E-03	2.34E-03	1.44E-04	3162.3	5.55E-03	2.89E-03	1.78E-04
3600.0	5.37E-03	2.79E-03	1.72E-04	3600.0	6.00E-03	3.12E-03	1.92E-04
7200.0	4.60E-03	2.39E-03		7200.0	4.98E-03	2.59E-03	

Table 8-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-10 + 3% UP 70 TEST TEMP = 77 , ZIGMA = 2.199 PSI				TEXACO AC-10 + 3% UP 70 TEST TEMP = 77 , ZIGMA = 1.869 PSI			
1.0	3.00E-05	1.56E-05	3.55E-06	1.0	3.00E-05	1.56E-05	4.17E-06
1.8	4.25E-05	2.21E-05	5.03E-06	1.8	4.50E-05	2.34E-05	6.26E-06
3.2	5.00E-05	2.60E-05	5.91E-06	3.2	6.00E-05	3.12E-05	8.35E-06
5.6	7.00E-05	3.64E-05	8.28E-06	5.6	1.15E-04	5.98E-05	1.60E-05
10.0	1.00E-04	5.20E-05	1.18E-05	10.0	1.75E-04	9.10E-05	2.43E-05
18.0	1.35E-04	7.02E-05	1.60E-05	18.0	2.75E-04	1.43E-04	3.83E-05
31.6	1.85E-04	9.62E-05	2.19E-05	31.6	4.40E-04	2.29E-04	6.12E-05
56.2	2.65E-04	1.38E-04	3.13E-05	56.2	6.50E-04	3.38E-04	9.04E-05
100.0	3.50E-04	1.82E-04	4.14E-05	100.0	1.04E-03	5.38E-04	1.44E-04
177.8	5.20E-04	2.70E-04	6.15E-05	177.8	1.60E-03	8.32E-04	2.23E-04
316.2	7.80E-04	4.06E-04	9.22E-05	316.2	2.45E-03	1.27E-03	3.41E-04
562.3	1.29E-03	6.68E-04	1.52E-04	562.3	3.50E-03	1.82E-03	4.87E-04
1000.0	2.09E-03	1.08E-03	2.47E-04	1000.0	4.80E-03	2.50E-03	6.68E-04
1778.3	3.19E-03	1.66E-03	3.77E-04	1778.3	6.70E-03	3.48E-03	9.32E-04
3162.3	5.19E-03	2.70E-03	6.14E-04	3162.3	9.85E-03	5.12E-03	1.37E-03
3600.0	5.80E-03	3.02E-03	6.86E-04				
7200.0	5.58E-03	2.90E-03					
TEXACO AC-10 + 3% UP 70 TEST TEMP = 90 , ZIGMA = 0.760 PSI				TEXACO AC-10 + 3% UP 70 TEST TEMP = 90 , ZIGMA = 0.754 PSI			
1.0	6.50E-05	3.38E-05	2.22E-05	1.0	1.50E-04	7.80E-05	5.17E-05
1.8	9.50E-05	4.94E-05	3.25E-05	1.8	2.00E-04	1.04E-04	6.90E-05
3.2	1.20E-04	6.24E-05	4.11E-05	3.2	2.40E-04	1.25E-04	8.28E-05
5.6	1.70E-04	8.84E-05	5.82E-05	5.6	3.20E-04	1.66E-04	1.10E-04
10.0	2.15E-04	1.12E-04	7.36E-05	10.0	4.00E-04	2.08E-04	1.38E-04
18.0	2.83E-04	1.47E-04	9.67E-05	18.0	5.05E-04	2.63E-04	1.74E-04
31.6	3.70E-04	1.92E-04	1.27E-04	31.6	6.65E-04	3.46E-04	2.29E-04
56.2	4.88E-04	2.54E-04	1.67E-04	56.2	8.80E-04	4.58E-04	3.04E-04
100.0	6.75E-04	3.51E-04	2.31E-04	100.0	1.09E-03	5.64E-04	3.74E-04
177.8	8.90E-04	4.63E-04	3.05E-04	177.8	1.30E-03	6.76E-04	4.48E-04
316.2	1.09E-03	5.64E-04	3.71E-04	316.2	1.53E-03	7.96E-04	5.28E-04
562.3	1.27E-03	6.58E-04	4.33E-04	562.3	1.88E-03	9.78E-04	6.48E-04
1000.0	1.64E-03	8.50E-04	5.59E-04	1000.0	2.25E-03	1.17E-03	7.76E-04
1778.3	2.16E-03	1.12E-03	7.39E-04	1778.3	2.57E-03	1.33E-03	8.85E-04
3162.3	2.87E-03	1.49E-03	9.80E-04	3162.3	3.15E-03	1.64E-03	1.09E-03
3600.0	3.20E-03	1.66E-03	1.09E-03	3600.0	3.28E-03	1.70E-03	1.13E-03
7200.0	2.99E-03	1.55E-03					

Table B-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 6.999 PSI				TEXACO AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 6.958 PSI			
1.0	2.50E-04	1.30E-04	9.29E-06	1.0	2.30E-04	1.20E-04	8.60E-06
1.8	3.75E-04	1.95E-04	1.39E-05	1.8	3.40E-04	1.77E-04	1.27E-05
3.2	5.00E-04	2.60E-04	1.86E-05	3.2	4.45E-04	2.31E-04	1.66E-05
5.6	7.10E-04	3.69E-04	2.64E-05	5.6	6.35E-04	3.30E-04	2.37E-05
10.0	9.35E-04	4.86E-04	3.47E-05	10.0	8.00E-04	4.16E-04	2.99E-05
18.0	1.31E-03	6.81E-04	4.87E-05	18.0	1.12E-03	5.80E-04	4.17E-05
31.6	1.79E-03	9.31E-04	6.65E-05	31.6	1.44E-03	7.49E-04	5.38E-05
56.2	2.38E-03	1.24E-03	8.82E-05	56.2	1.94E-03	1.01E-03	7.25E-05
100.0	3.14E-03	1.63E-03	1.16E-04	100.0	2.69E-03	1.40E-03	1.00E-04
177.8	3.87E-03	2.01E-03	1.44E-04	177.8	3.63E-03	1.89E-03	1.35E-04
316.2	5.37E-03	2.79E-03	1.99E-04	316.2	4.80E-03	2.50E-03	1.79E-04
562.3	7.47E-03	3.88E-03	2.77E-04	562.3	6.55E-03	3.41E-03	2.45E-04
1000.0	1.05E-02	5.47E-03	3.91E-04	1000.0	9.28E-03	4.82E-03	3.47E-04
1778.3	1.77E-02	9.21E-03	6.58E-04	1778.3	1.34E-02	6.96E-03	5.00E-04
3162.3	2.34E-02	1.22E-02	8.69E-04				
3600.0	2.64E-02	1.37E-02	9.80E-04				
7200.0	2.37E-02	1.23E-02					
TEXACO AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 1.240 PSI				TEXACO AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 1.845 PSI			
1.0	1.10E-04	5.72E-05	2.31E-05	1.0	2.50E-04	1.30E-04	3.52E-05
1.8	1.70E-04	8.84E-05	3.57E-05	1.8	4.00E-04	2.08E-04	5.64E-05
3.2	2.25E-04	1.17E-04	4.72E-05	3.2	5.75E-04	2.99E-04	8.10E-05
5.6	3.35E-04	1.74E-04	7.03E-05	5.6	8.50E-04	4.42E-04	1.20E-04
10.0	4.25E-04	2.21E-04	8.91E-05	10.0	1.15E-03	5.98E-04	1.62E-04
18.0	5.70E-04	2.96E-04	1.20E-04	18.0	1.45E-03	7.54E-04	2.04E-04
31.6	8.75E-04	4.55E-04	1.84E-04	31.6	1.88E-03	9.75E-04	2.64E-04
56.2	1.20E-03	6.24E-04	2.52E-04	56.2	2.47E-03	1.28E-03	3.47E-04
100.0	1.64E-03	8.50E-04	3.43E-04	100.0	3.32E-03	1.72E-03	4.67E-04
177.8	2.20E-03	1.14E-03	4.61E-04	177.8	4.48E-03	2.33E-03	6.31E-04
316.2	2.94E-03	1.53E-03	6.17E-04	316.2	6.35E-03	3.30E-03	8.95E-04
562.3	3.98E-03	2.07E-03	8.35E-04	562.3	9.35E-03	4.86E-03	1.32E-03
1000.0	5.39E-03	2.80E-03	1.13E-03	1000.0	1.45E-02	7.52E-03	2.04E-03
1778.3	7.92E-03	4.12E-03	1.66E-03				
3162.3	1.20E-02	6.22E-03	2.51E-03				
3600.0	1.44E-02	7.46E-03	3.01E-03				
7200.0	1.40E-02	7.28E-03					

Table B-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 0.413 PSI				TEXACO AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 0.688 PSI			
1.0	1.00E-04	5.20E-05	6.30E-05	1.0	1.75E-04	9.10E-05	6.61E-05
1.8	1.40E-04	7.28E-05	8.82E-05	1.8	2.50E-04	1.30E-04	9.45E-05
3.2	1.80E-04	9.36E-05	1.13E-04	3.2	3.10E-04	1.61E-04	1.17E-04
5.6	2.65E-04	1.38E-04	1.67E-04	5.6	4.50E-04	2.34E-04	1.70E-04
10.0	3.40E-04	1.77E-04	2.14E-04	10.0	6.35E-04	3.30E-04	2.40E-04
18.0	4.55E-04	2.37E-04	2.86E-04	18.0	9.20E-04	4.78E-04	3.48E-04
31.6	6.15E-04	3.20E-04	3.87E-04	31.6	1.25E-03	6.48E-04	4.71E-04
56.2	8.65E-04	4.50E-04	5.45E-04	56.2	1.92E-03	9.96E-04	7.24E-04
100.0	1.25E-03	6.50E-04	7.87E-04	100.0	2.49E-03	1.29E-03	9.39E-04
177.8	1.70E-03	8.84E-04	1.07E-03	177.8	3.15E-03	1.64E-03	1.19E-03
316.2	2.55E-03	1.33E-03	1.61E-03	316.2	3.15E-03	1.64E-03	1.19E-03
562.3	3.75E-03	1.95E-03	2.36E-03	562.3	4.45E-03	2.31E-03	1.68E-03
1000.0	5.40E-03	2.81E-03	3.40E-03				
1778.3	8.10E-03	4.21E-03	5.10E-03				
3162.3	1.29E-02	6.68E-03	8.09E-03				
3600.0	1.46E-02	7.59E-03	9.19E-03				
7200.0	1.41E-02	7.33E-03					

Table B-24 Creep Compliance of Plant Mixed / Laboratory Compacted Mixtures Using Modified Compaction.

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-20 TEST TEMP = 60 , ZIGMA = 5.547 PSI				TEXACO AC-20 TEST TEMP = 60 , ZIGMA = 7.112 PSI			
1.0	1.40E-04	7.28E-05	6.56E-06	1.0	1.00E-04	5.20E-05	3.66E-06
1.8	1.90E-04	9.88E-05	8.91E-06	1.8	1.60E-04	8.32E-05	5.85E-06
3.2	2.00E-04	1.04E-04	9.38E-06	3.2	1.95E-04	1.01E-04	7.13E-06
5.6	2.30E-04	1.20E-04	1.08E-05	5.6	2.55E-04	1.33E-04	9.32E-06
10.0	2.75E-04	1.43E-04	1.29E-05	10.0	3.20E-04	1.66E-04	1.17E-05
18.0	3.25E-04	1.69E-04	1.52E-05	18.0	4.00E-04	2.08E-04	1.46E-05
31.6	3.70E-04	1.92E-04	1.73E-05	31.6	4.90E-04	2.55E-04	1.79E-05
56.2	4.75E-04	2.47E-04	2.23E-05	56.2	6.15E-04	3.20E-04	2.25E-05
100.0	6.35E-04	3.30E-04	2.98E-05	100.0	7.70E-04	4.00E-04	2.82E-05
177.8	8.30E-04	4.32E-04	3.89E-05	177.8	9.65E-04	5.02E-04	3.53E-05
316.2	1.15E-03	5.96E-04	5.37E-05	316.2	1.17E-03	6.06E-04	4.26E-05
562.3	1.50E-03	7.80E-04	7.03E-05	562.3	1.39E-03	7.20E-04	5.06E-05
1000.0	2.04E-03	1.06E-03	9.56E-05	1000.0	1.71E-03	8.87E-04	6.23E-05
1778.3	2.82E-03	1.47E-03	1.32E-04	1778.3	2.11E-03	1.09E-03	7.70E-05
3162.3	3.54E-03	1.84E-03	1.66E-04	3162.3	2.64E-03	1.37E-03	9.63E-05
3600.0	3.72E-03	1.93E-03	1.74E-04	3600.0	2.79E-03	1.45E-03	1.02E-04
7200.0	2.77E-03	1.44E-03		7200.0	1.68E-03	8.74E-04	
TEXACO AC-20 TEST TEMP = 77 , ZIGMA = 5.629 PSI				TEXACO AC-20 TEST TEMP = 77 , ZIGMA = 5.597 PSI			
1.0	1.90E-04	9.88E-05	8.78E-06	1.0	3.10E-04	1.61E-04	1.44E-05
1.8	2.80E-04	1.46E-04	1.29E-05	1.8	4.25E-04	2.21E-04	1.97E-05
3.2	3.50E-04	1.82E-04	1.62E-05	3.2	5.25E-04	2.73E-04	2.44E-05
5.6	4.60E-04	2.39E-04	2.13E-05	5.6	6.60E-04	3.43E-04	3.07E-05
10.0	6.10E-04	3.17E-04	2.82E-05	10.0	8.25E-04	4.29E-04	3.83E-05
18.0	7.85E-04	4.08E-04	3.63E-05	18.0	1.04E-03	5.41E-04	4.83E-05
31.6	1.02E-03	5.28E-04	4.69E-05	31.6	1.41E-03	7.33E-04	6.55E-05
56.2	1.30E-03	6.76E-04	6.01E-05	56.2	1.85E-03	9.62E-04	8.60E-05
100.0	1.75E-03	9.10E-04	8.08E-05	100.0	2.36E-03	1.22E-03	1.09E-04
177.8	2.28E-03	1.18E-03	1.05E-04	177.8	3.21E-03	1.67E-03	1.49E-04
316.2	3.05E-03	1.59E-03	1.41E-04	316.2	4.45E-03	2.31E-03	2.07E-04
562.3	3.95E-03	2.05E-03	1.82E-04	562.3	6.10E-03	3.17E-03	2.83E-04
1000.0	6.10E-03	3.17E-03	2.82E-04	1000.0	9.25E-03	4.81E-03	4.30E-04
1778.3	9.35E-03	4.86E-03	4.32E-04	1778.3	1.57E-02	8.14E-03	7.27E-04
3162.3	1.52E-02	7.92E-03	7.03E-04				
3600.0	1.73E-02	9.00E-03	7.99E-04				
7200.0	1.49E-02	7.72E-03					

Table B-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-20 TEST TEMP = 90 , ZIGMA = 1.298 PSI				TEXACO AC-20 TEST TEMP = 90 , ZIGMA = 1.654 PSI			
1.0	1.20E-04	6.24E-05	2.40E-05	1.0	1.40E-04	7.28E-05	2.20E-05
1.8	1.55E-04	8.06E-05	3.11E-05	1.8	2.00E-04	1.04E-04	3.14E-05
3.2	2.00E-04	1.04E-04	4.01E-05	3.2	2.85E-04	1.48E-04	4.48E-05
5.6	2.75E-04	1.43E-04	5.51E-05	5.6	4.20E-04	2.18E-04	6.60E-05
10.0	3.60E-04	1.87E-04	7.21E-05	10.0	5.80E-04	3.02E-04	9.12E-05
18.0	4.80E-04	2.50E-04	9.62E-05	18.0	8.30E-04	4.32E-04	1.30E-04
31.6	6.65E-04	3.46E-04	1.33E-04	31.6	1.10E-03	5.72E-04	1.73E-04
56.2	9.05E-04	4.71E-04	1.81E-04	56.2	1.46E-03	7.59E-04	2.30E-04
100.0	1.20E-03	6.22E-04	2.39E-04	100.0	1.93E-03	1.00E-03	3.03E-04
177.8	1.59E-03	8.27E-04	3.19E-04	177.8	2.54E-03	1.32E-03	3.99E-04
316.2	2.18E-03	1.13E-03	4.36E-04	316.2	3.53E-03	1.83E-03	5.54E-04
562.3	2.99E-03	1.55E-03	5.98E-04	562.3	5.02E-03	2.61E-03	7.88E-04
1000.0	4.23E-03	2.20E-03	8.46E-04	1000.0	7.45E-03	3.87E-03	1.17E-03
1778.3	6.20E-03	3.22E-03	1.24E-03				
3162.3	9.80E-03	5.10E-03	1.96E-03				
3600.0	1.09E-02	5.68E-03	2.19E-03				
7200.0	1.05E-02	5.47E-03					
TEXACO AC-10 + 3% UP 70 TEST TEMP = 60 , ZIGMA = 8.726 PSI				TEXACO AC-10 + 3% UP 70 TEST TEMP = 60 , ZIGMA = 8.726 PSI			
1.0	8.00E-05	4.16E-05	2.38E-06	1.0	8.00E-05	4.16E-05	2.38E-06
1.8	9.50E-05	4.94E-05	2.83E-06	1.8	9.00E-05	4.68E-05	2.68E-06
3.2	1.10E-04	5.72E-05	3.28E-06	3.2	1.15E-04	5.98E-05	3.43E-06
5.6	1.30E-04	6.76E-05	3.87E-06	5.6	1.35E-04	7.02E-05	4.02E-06
10.0	1.60E-04	8.32E-05	4.77E-06	10.0	1.65E-04	8.58E-05	4.92E-06
18.0	2.00E-04	1.04E-04	5.96E-06	18.0	2.10E-04	1.09E-04	6.26E-06
31.6	2.60E-04	1.35E-04	7.75E-06	31.6	2.60E-04	1.35E-04	7.75E-06
56.2	3.45E-04	1.79E-04	1.03E-05	56.2	3.50E-04	1.82E-04	1.04E-05
100.0	4.70E-04	2.44E-04	1.40E-05	100.0	4.75E-04	2.47E-04	1.42E-05
177.8	7.30E-04	3.80E-04	2.18E-05	177.8	6.75E-04	3.51E-04	2.01E-05
316.2	1.04E-03	5.38E-04	3.08E-05	316.2	9.45E-04	4.91E-04	2.82E-05
562.3	1.42E-03	7.36E-04	4.22E-05	562.3	1.35E-03	7.02E-04	4.02E-05
1000.0	1.90E-03	9.88E-04	5.66E-05	1000.0	1.80E-03	9.36E-04	5.36E-05
1778.3	2.56E-03	1.33E-03	7.63E-05	1778.3	2.40E-03	1.25E-03	7.15E-05
3162.3	3.59E-03	1.86E-03	1.07E-04	3162.3	3.25E-03	1.69E-03	9.69E-05
3600.0	3.87E-03	2.01E-03	1.15E-04	3600.0	3.50E-03	1.82E-03	1.04E-04
7200.0	2.71E-03	1.41E-03		7200.0	2.40E-03	1.25E-03	

Table B-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-10 + 3% UP 70				TEXACO AC-10 + 3% UP 70			
TEST TEMP = 77 , ZIGMA = 4.318 PSI				TEST TEMP = 77 , ZIGMA = 3.615 PSI			
1.0	1.50E-04	7.80E-05	9.03E-06	1.0	2.00E-04	1.04E-04	1.44E-05
1.8	1.65E-04	8.58E-05	9.94E-06	1.8	3.25E-04	1.69E-04	2.34E-05
3.2	1.80E-04	9.36E-05	1.08E-05	3.2	4.10E-04	2.13E-04	2.95E-05
5.6	2.00E-04	1.04E-04	1.20E-05	5.6	5.15E-04	2.68E-04	3.70E-05
10.0	2.50E-04	1.30E-04	1.51E-05	10.0	6.10E-04	3.17E-04	4.39E-05
18.0	3.15E-04	1.64E-04	1.90E-05	18.0	8.25E-04	4.29E-04	5.93E-05
31.6	4.50E-04	2.34E-04	2.71E-05	31.6	1.07E-03	5.57E-04	7.70E-05
56.2	6.55E-04	3.41E-04	3.94E-05	56.2	1.40E-03	7.28E-04	1.01E-04
100.0	9.00E-04	4.68E-04	5.42E-05	100.0	1.90E-03	9.88E-04	1.37E-04
177.8	1.14E-03	5.93E-04	6.87E-05	177.8	2.58E-03	1.34E-03	1.85E-04
316.2	1.64E-03	8.53E-04	9.88E-05	316.2	3.53E-03	1.83E-03	2.54E-04
562.3	2.64E-03	1.37E-03	1.59E-04	562.3	4.95E-03	2.57E-03	3.56E-04
1000.0	4.43E-03	2.30E-03	2.66E-04	1000.0	7.39E-03	3.84E-03	5.31E-04
1778.3	7.85E-03	4.08E-03	4.73E-04	1778.3	1.06E-02	5.51E-03	7.63E-04
3162.3	1.48E-02	7.70E-03	8.91E-04	3162.3	1.67E-02	8.69E-03	1.20E-03
3600.0	1.72E-02	8.95E-03	1.04E-03	3600.0	1.88E-02	9.76E-03	1.35E-03
7200.0	1.56E-02	8.12E-03		7200.0	1.71E-02	8.90E-03	
TEXACO AC-10 + 3% UP 70				TEXACO AC-10 + 3% UP 70			
TEST TEMP = 90 , ZIGMA = 1.322 PSI				TEST TEMP = 90 , ZIGMA = 0.886 PSI			
1.0	1.10E-04	5.72E-05	2.16E-05	1.0	5.50E-05	2.86E-05	1.61E-05
1.8	1.55E-04	8.06E-05	3.05E-05	1.8	7.50E-05	3.90E-05	2.20E-05
3.2	2.15E-04	1.12E-04	4.23E-05	3.2	1.05E-04	5.46E-05	3.08E-05
5.6	3.00E-04	1.56E-04	5.90E-05	5.6	1.40E-04	7.28E-05	4.11E-05
10.0	4.25E-04	2.21E-04	8.36E-05	10.0	1.95E-04	1.01E-04	5.72E-05
18.0	6.20E-04	3.22E-04	1.22E-04	18.0	2.90E-04	1.51E-04	8.51E-05
31.6	8.35E-04	4.34E-04	1.64E-04	31.6	4.20E-04	2.18E-04	1.23E-04
56.2	1.16E-03	6.01E-04	2.27E-04	56.2	5.75E-04	2.99E-04	1.69E-04
100.0	1.60E-03	8.32E-04	3.15E-04	100.0	8.65E-04	4.50E-04	2.54E-04
177.8	2.22E-03	1.15E-03	4.36E-04	177.8	1.34E-03	6.94E-04	3.92E-04
316.2	3.10E-03	1.61E-03	6.10E-04	316.2	2.07E-03	1.07E-03	6.06E-04
562.3	4.45E-03	2.31E-03	8.75E-04	562.3	3.03E-03	1.57E-03	8.88E-04
1000.0	6.59E-03	3.42E-03	1.30E-03	1000.0	4.77E-03	2.48E-03	1.40E-03
1778.3	1.10E-02	5.72E-03	2.16E-03	1778.3	7.84E-03	4.07E-03	2.30E-03
				3162.3	1.27E-02	6.58E-03	3.71E-03
				3600.0	1.42E-02	7.40E-03	4.18E-03
				7200.0	1.37E-02	7.14E-03	

Table B-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 7.652 PSI				TEXACO AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 5.613 PSI			
1.0	2.75E-04	1.43E-04	9.35E-06	1.0	2.10E-04	1.09E-04	9.73E-06
1.8	4.55E-04	2.37E-04	1.55E-05	1.8	3.60E-04	1.87E-04	1.67E-05
3.2	5.60E-04	2.91E-04	1.90E-05	3.2	4.50E-04	2.34E-04	2.08E-05
5.6	7.50E-04	3.90E-04	2.55E-05	5.6	5.50E-04	2.86E-04	2.55E-05
10.0	9.65E-04	5.02E-04	3.28E-05	10.0	6.70E-04	3.48E-04	3.10E-05
18.0	1.28E-03	6.66E-04	4.35E-05	18.0	8.40E-04	4.37E-04	3.89E-05
31.6	1.69E-03	8.79E-04	5.74E-05	31.6	1.04E-03	5.38E-04	4.80E-05
56.2	2.21E-03	1.15E-03	7.49E-05	56.2	1.38E-03	7.18E-04	6.39E-05
100.0	2.93E-03	1.52E-03	9.94E-05	100.0	1.78E-03	9.26E-04	8.25E-05
177.8	3.68E-03	1.91E-03	1.25E-04	177.8	2.20E-03	1.14E-03	1.02E-04
316.2	4.83E-03	2.51E-03	1.64E-04	316.2	2.79E-03	1.45E-03	1.29E-04
562.3	6.29E-03	3.27E-03	2.14E-04	562.3	3.55E-03	1.85E-03	1.64E-04
1000.0	8.55E-03	4.45E-03	2.91E-04	1000.0	4.60E-03	2.39E-03	2.13E-04
1778.3	1.19E-02	6.19E-03	4.04E-04	1778.3	6.04E-03	3.14E-03	2.80E-04
3162.3	1.74E-02	9.05E-03	5.91E-04	3162.3	8.42E-03	4.38E-03	3.90E-04
3600.0	1.91E-02	9.91E-03	~~6.47E-04~~	3600.0	9.00E-03	4.68E-03	4.17E-04
7200.0	1.58E-02	8.20E-03		7200.0	7.24E-03	3.77E-03	
TEXACO AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 3.515 PSI				TEXACO AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 1.840 PSI			
1.0	5.25E-04	2.73E-04	3.88E-05	1.0	1.60E-04	8.32E-05	2.26E-05
1.8	7.75E-04	4.03E-04	5.73E-05	1.8	2.10E-04	1.09E-04	2.97E-05
3.2	1.03E-03	5.33E-04	7.58E-05	3.2	3.00E-04	1.56E-04	4.24E-05
5.6	1.38E-03	7.15E-04	1.02E-04	5.6	4.00E-04	2.08E-04	5.65E-05
10.0	1.85E-03	9.62E-04	1.37E-04	10.0	5.40E-04	2.81E-04	7.63E-05
18.0	2.40E-03	1.25E-03	1.78E-04	18.0	7.60E-04	3.95E-04	1.07E-04
31.6	3.16E-03	1.64E-03	2.34E-04	31.6	1.07E-03	5.57E-04	1.51E-04
56.2	4.16E-03	2.16E-03	3.07E-04	56.2	1.43E-03	7.44E-04	2.02E-04
100.0	5.53E-03	2.88E-03	4.09E-04	100.0	1.94E-03	1.01E-03	2.74E-04
177.8	7.25E-03	3.77E-03	5.36E-04	177.8	2.59E-03	1.35E-03	3.66E-04
316.2	9.80E-03	5.10E-03	7.25E-04	316.2	3.40E-03	1.77E-03	4.81E-04
562.3	1.29E-02	6.68E-03	9.51E-04	562.3	4.74E-03	2.47E-03	6.70E-04
				1000.0	6.65E-03	3.46E-03	9.40E-04
				1778.3	9.68E-03	5.03E-03	1.37E-03
				3162.3	1.47E-02	7.62E-03	2.07E-03
				3600.0	1.62E-02	8.43E-03	2.29E-03
				7200.0	1.50E-02	7.80E-03	

Table B-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TEXACO AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 1.148 PSI				TEXACO AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 1.250 PSI			
1.0	2.00E-04	1.04E-04	4.53E-05	1.0	2.50E-04	1.30E-04	5.20E-05
1.8	3.00E-04	1.56E-04	6.80E-05	1.8	3.50E-04	1.82E-04	7.28E-05
3.2	4.00E-04	2.08E-04	9.06E-05	3.2	4.50E-04	2.34E-04	9.36E-05
5.6	4.60E-04	2.39E-04	1.04E-04	5.6	5.50E-04	2.86E-04	1.14E-04
10.0	6.60E-04	3.43E-04	1.50E-04	10.0	7.50E-04	3.90E-04	1.56E-04
18.0	9.00E-04	4.68E-04	2.04E-04	18.0	1.05E-03	5.46E-04	2.18E-04
31.6	1.24E-03	6.42E-04	2.80E-04	31.6	1.45E-03	7.54E-04	3.02E-04
56.2	1.66E-03	8.63E-04	3.76E-04	56.2	1.95E-03	1.01E-03	4.06E-04
100.0	2.31E-03	1.20E-03	5.23E-04	100.0	2.70E-03	1.40E-03	5.62E-04
177.8	3.30E-03	1.72E-03	7.48E-04	177.8	3.65E-03	1.90E-03	7.59E-04
316.2	4.90E-03	2.55E-03	1.11E-03	316.2	5.50E-03	2.86E-03	1.14E-03
562.3	7.26E-03	3.78E-03	1.64E-03	562.3	8.25E-03	4.29E-03	1.72E-03
1000.0	1.15E-02	5.99E-03	2.61E-03	1000.0	1.27E-02	6.58E-03	2.63E-03

Table B-25 Moisture Sensitivity Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

MIXTURE	TEST TEMP. F		Dry Condition		Wet Condition		TSR
			AIR VOIDS %	TENSILE STRENGTH PSI	AIR VOIDS %	TENSILE STRENGTH PSI	
Control: Texaco AC-20	77		6.8	69	6.5	44	
			6.1	74	7.3	37	
			6.9	68	7.3	37	
		AVG.	6.6	70	7.0	39	0.56
Texaco AC-10 + 3% UP 70	77		7.1	81	7.4	50	
			7.1	85	6.8	65	
			7.0	87	6.9	62	
		AVG.	7.1	84	7.0	59	0.71
Texaco AC-10 + 3% Styrelf	77		6.4	62	6.1	55	
			6.3	65	6.2	57	
			6.0	65	6.6	56	
		AVG.	6.2	64	6.3	56	0.88

Table B-26 Moisture Sensitivity Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

MIXTURE	TEST TEMP. F		Dry Condition		Wet Condition		TSR
			AIR VOIDS %	TENSILE STRENGTH PSI	AIR VOIDS %	TENSILE STRENGTH PSI	
Control: Texaco AC-20	77		7.6	107	6.5	86	
			7.3	108	7.7	79	
			6.4	101	7.5	90	
		AVG.	7.1	106	7.2	85	0.81
Texaco AC-10 + 3% UP 70	77		6.8	102	6.9	86	
			7.1	107	6.8	86	
			7.1	103	6.7	96	
		AVG.	7.0	104	6.8	89	0.86
Texaco AC-10 + 3% Styrelf	77		7.8	68	6.6	74	
			6.1	69	6.7	75	
			6.5	80	6.8	71	
		AVG.	6.8	73	6.7	73	1.00

Table B-27 AGGREGATE GRADATION OF EXTRACTED CORES (DISTRICT 11)

Combined Gradation	SDHPT Specification	AC-20 AC=6.91	Latex AC=6.72	Styrelf AC=6.88
0.0	0	0	0	0
0.0	0-15	0	0	0
38.9	21-53	38.7	38.8	37.5
20.4	11-32	19.4	20.5	19.8
59.3	54-74	58.1	59.3	57.3
9.4	6-32	9.7	9.4	9.6
15.8	4-27	19.4	15.8	17.8
12.2	3-27	9.7	12.2	12.1
3.3	1-8	3.1	3.3	3.2
100.0		100.0	100.0	100.0

	Source
Red Light wt. Type D.	TXI-Clodine Pit
Coarse Sandstone Screenings	Lafarge, Oakwood Pit
Fine Sandstone Screenings	Lafarge, Oakwood Pit
Field Sand	Champion Pit

District 11 Field Test Sections
US59 – Polk County, Beginning South Of
Livingston, Texas At US190
Date Placed: April 1989

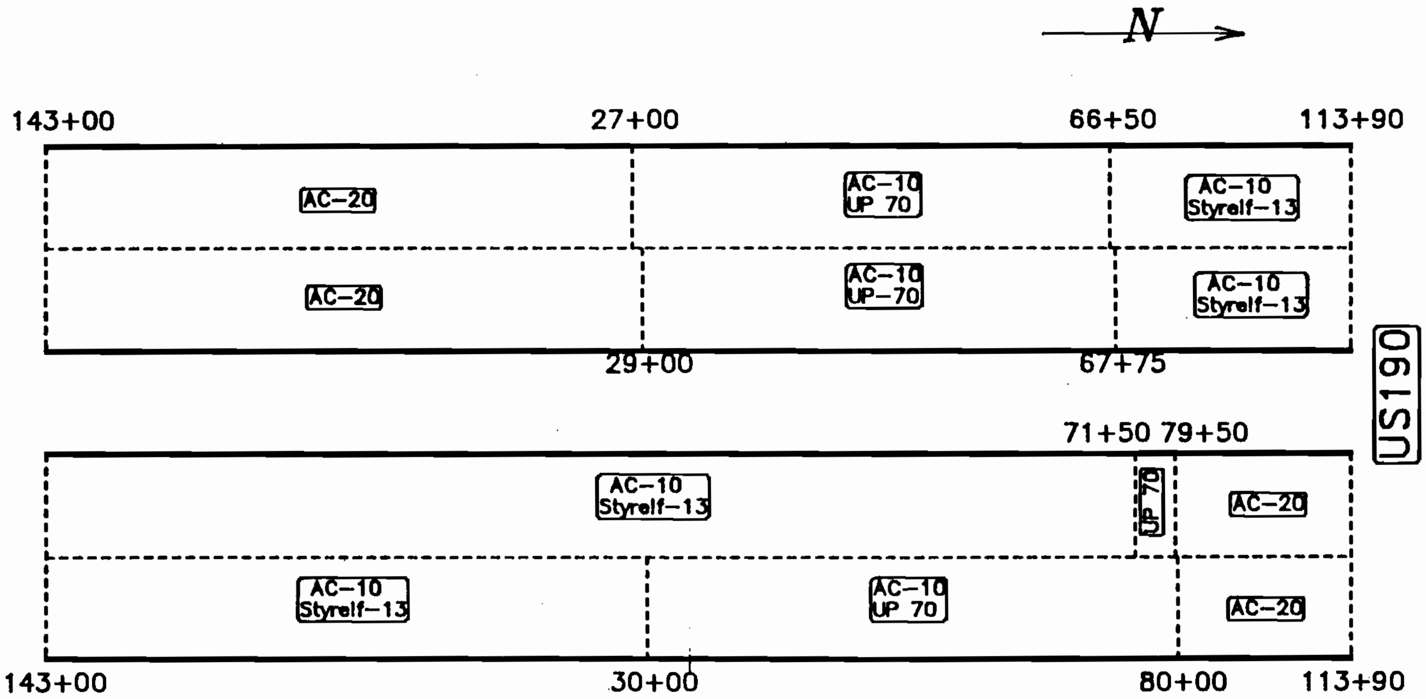

Fig B-1 Schematic Illustration of Field Test Sections.

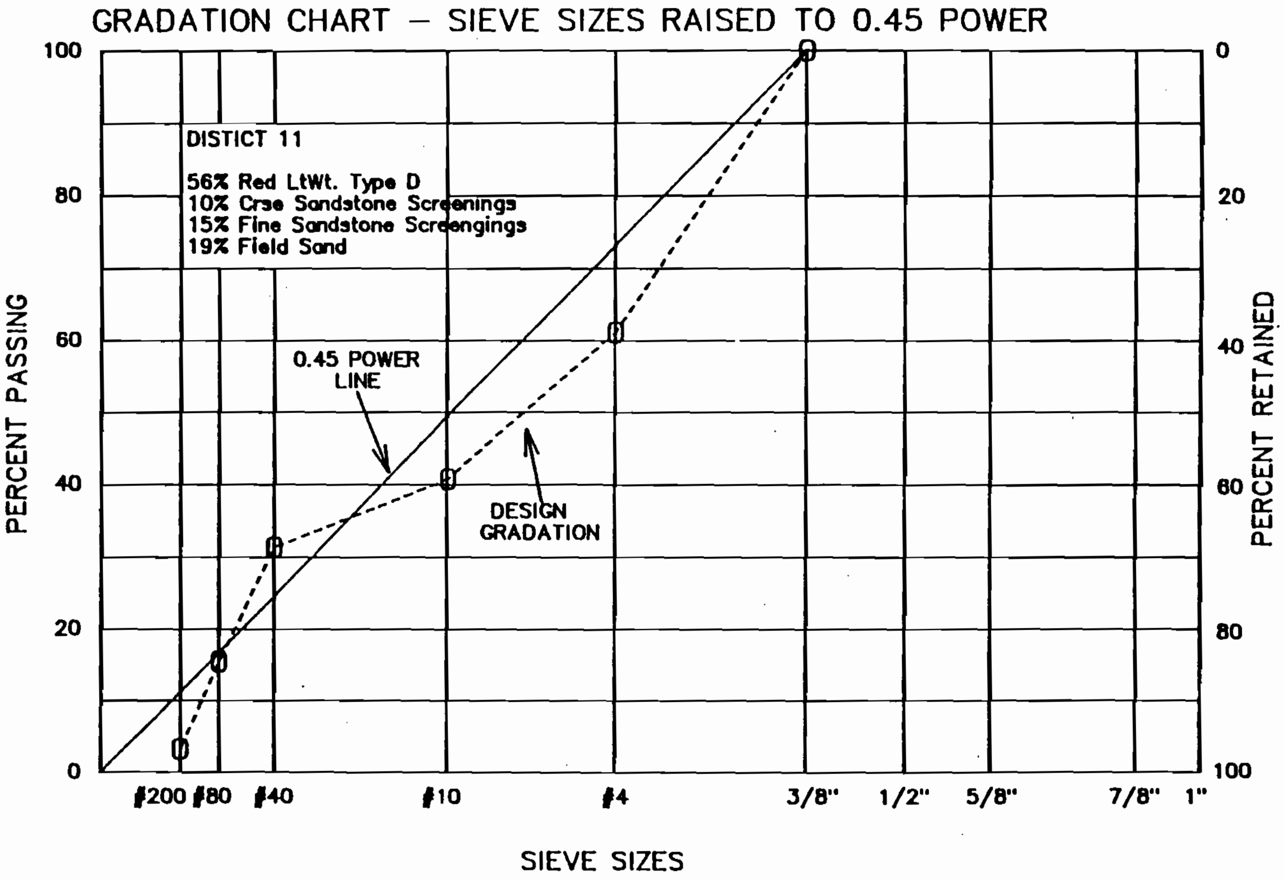

Fig B-2 Aggregate gradation Chart

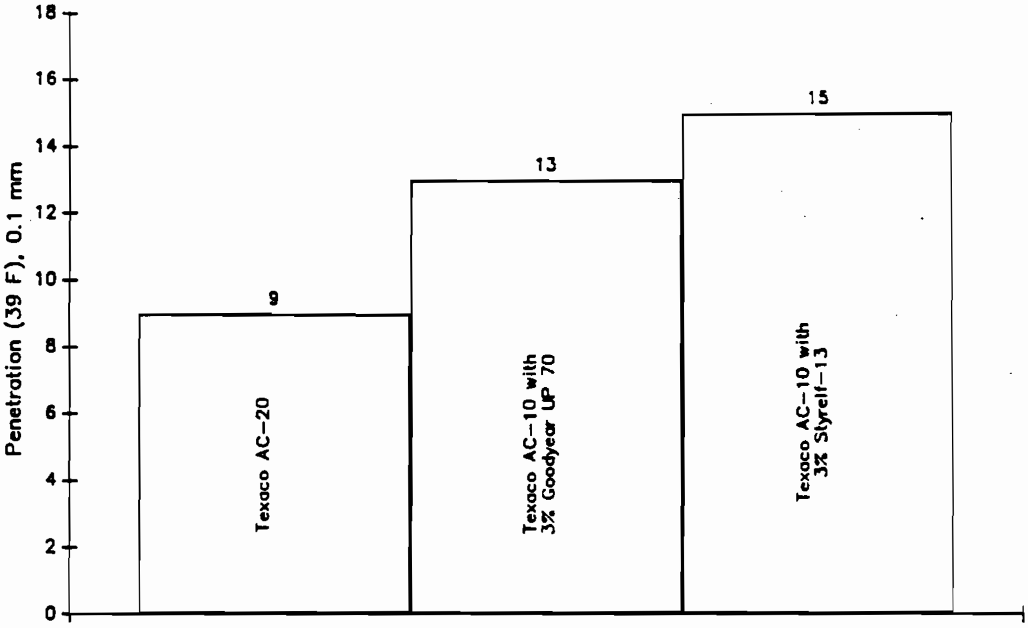

Fig B-3 Penetration at 39 F for Unmodified and Modified Texaco Binders

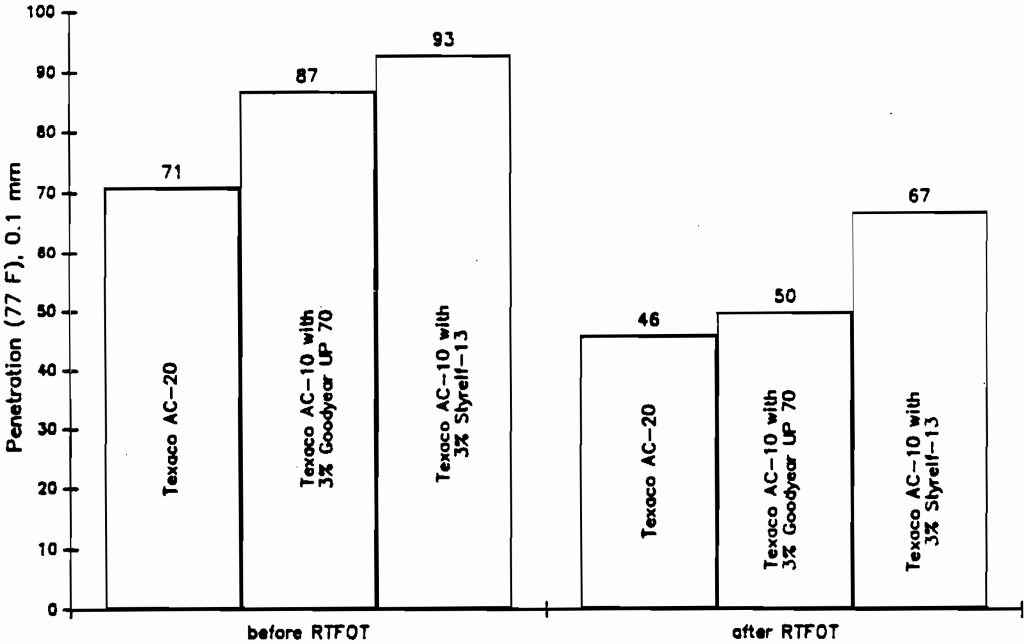

Fig B-4 Penetration at 77 F for Unmodified and Modified Texaco Binders

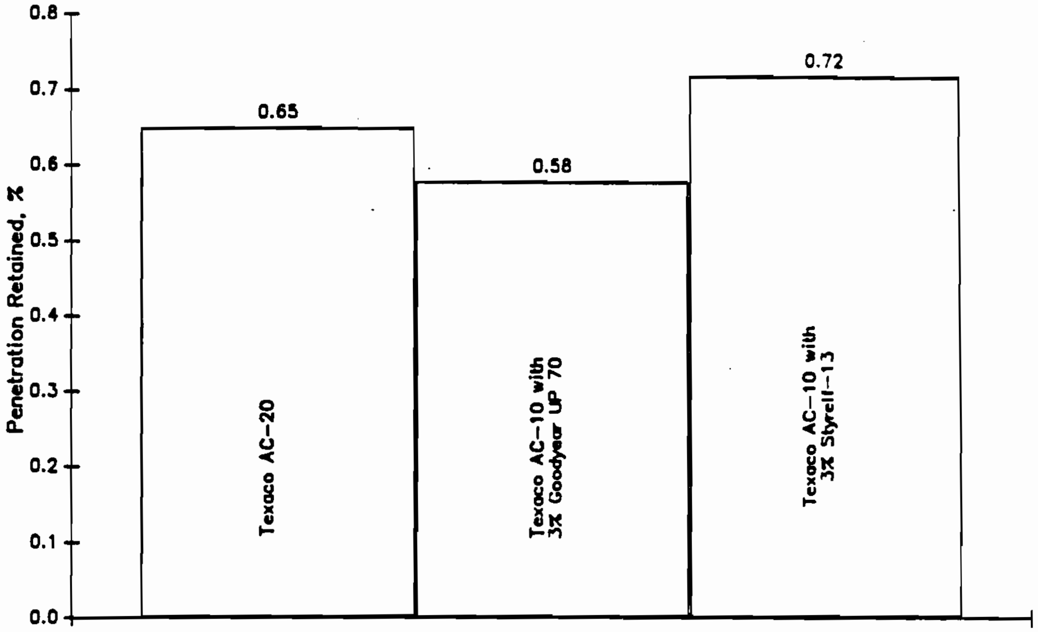

Fig B-5 Retained Penetration at 77 F for Unmodified and Modified Texaco Binders

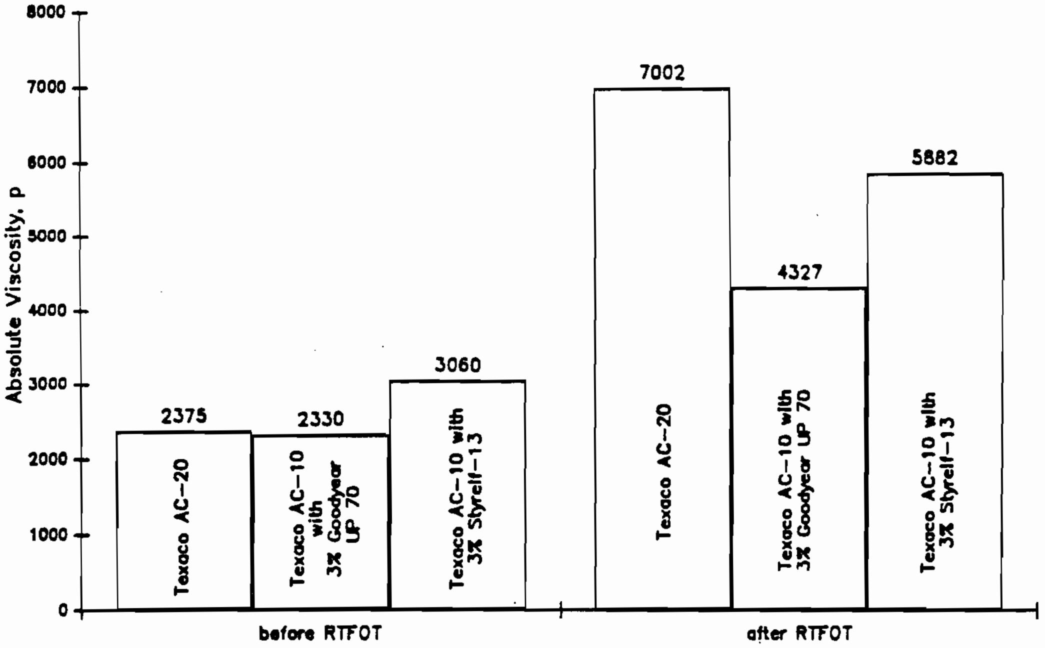

Fig B-6 Viscosity at 140 F for Unmodified and Modified Texaco Binders

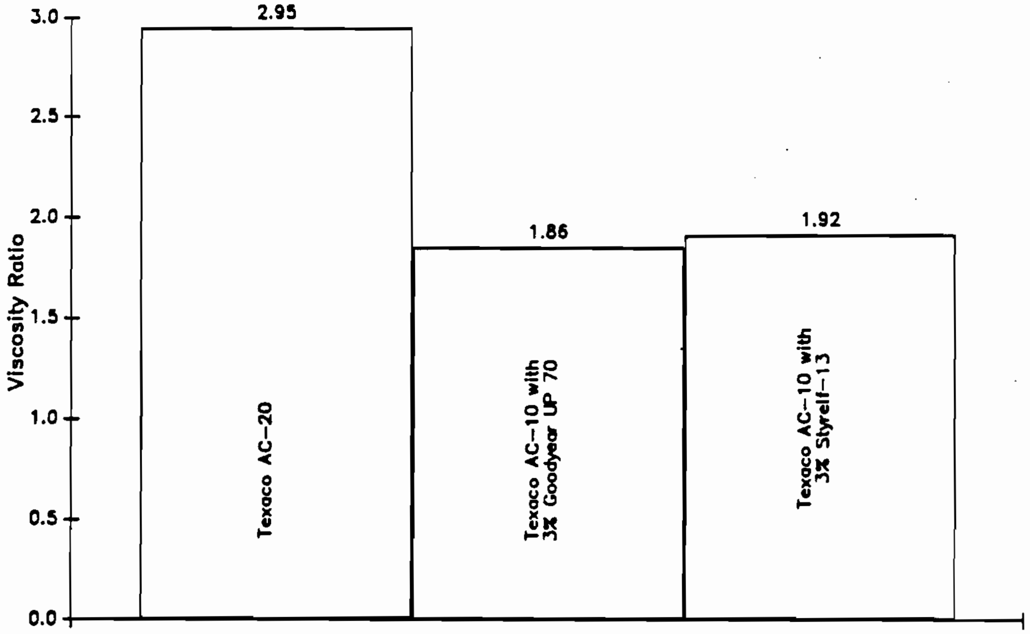

Fig B-7 Viscosity Ratio at 140 F for Unmodified and Modified Texaco Binders

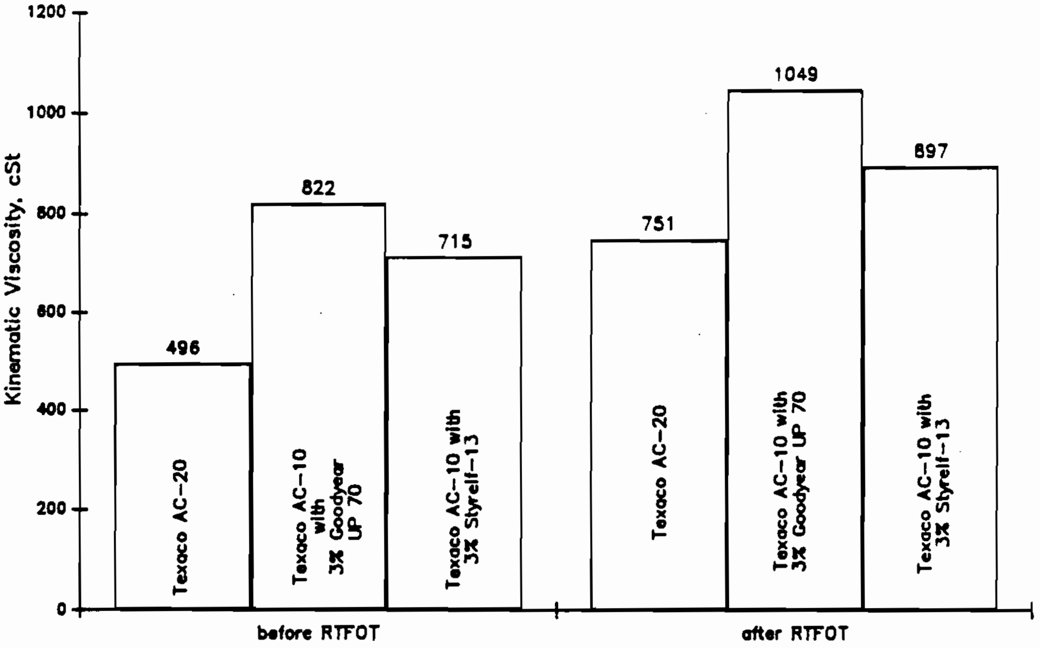

Fig B-8 Viscosity at 275 F for Unmodified and Modified Texaco Binders

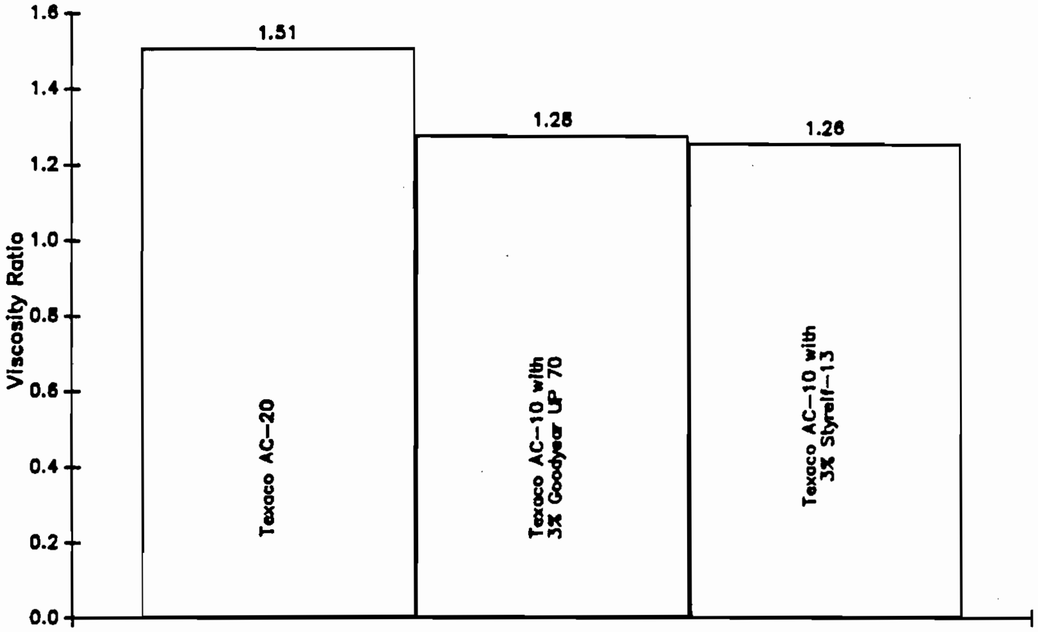

Fig B-9 Viscosity Ratio at 275 F for Unmodified and Modified Texaco Binders

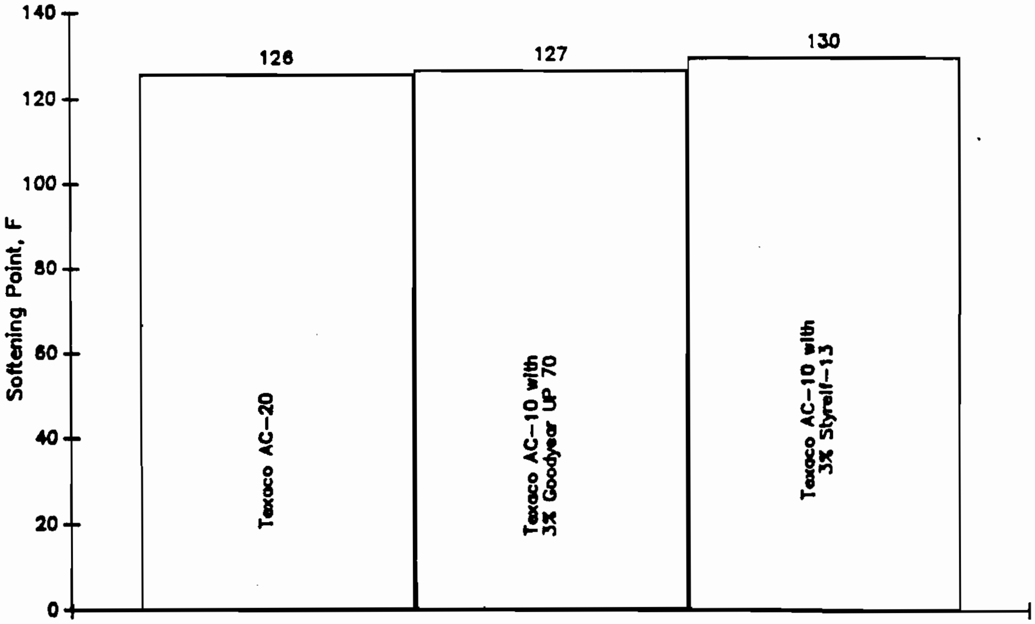

Fig B-10 Softening Point for Unmodified and Modified Texaco Binders

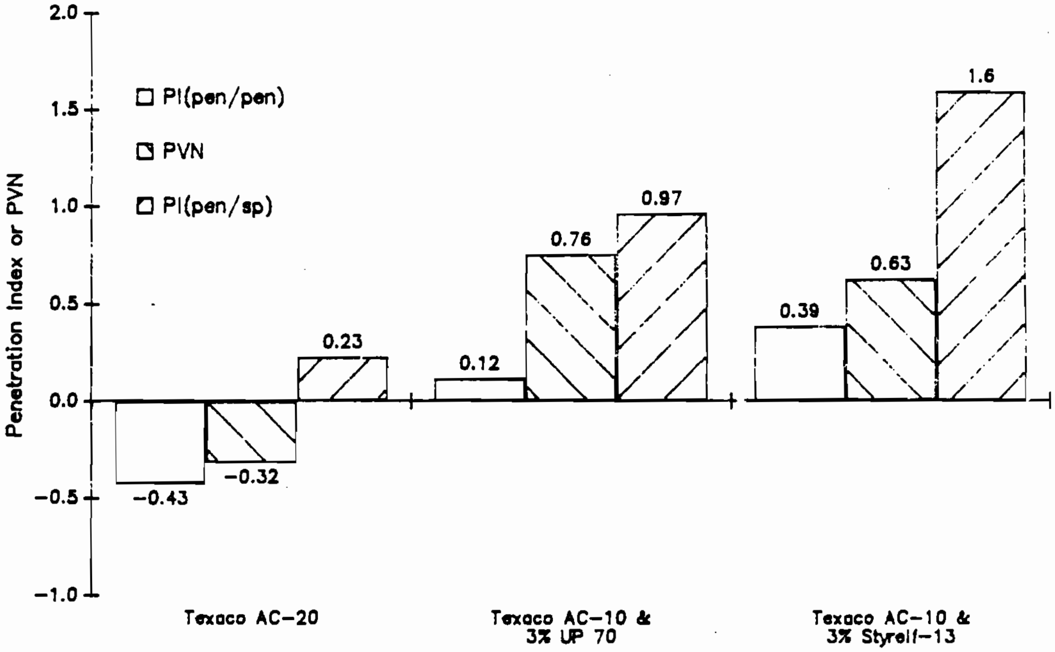

Fig B-11 Penetration Index and PVN for Unmodified and Modified Texaco Binders.

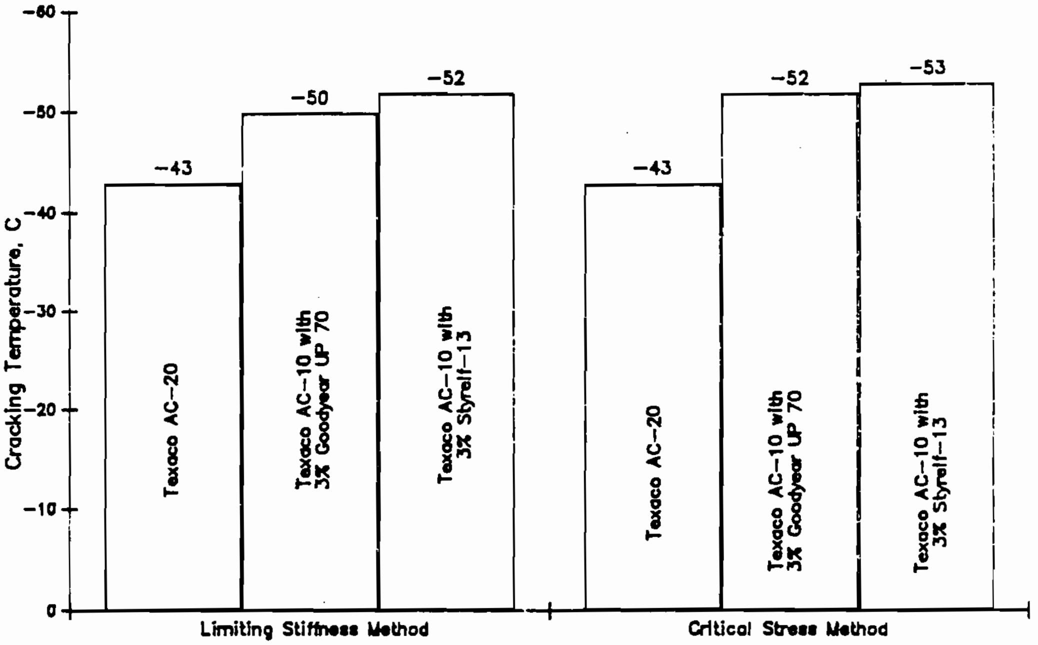

Fig B-12 Cracking Temperature for Unmodified and Modified Texaco Binders

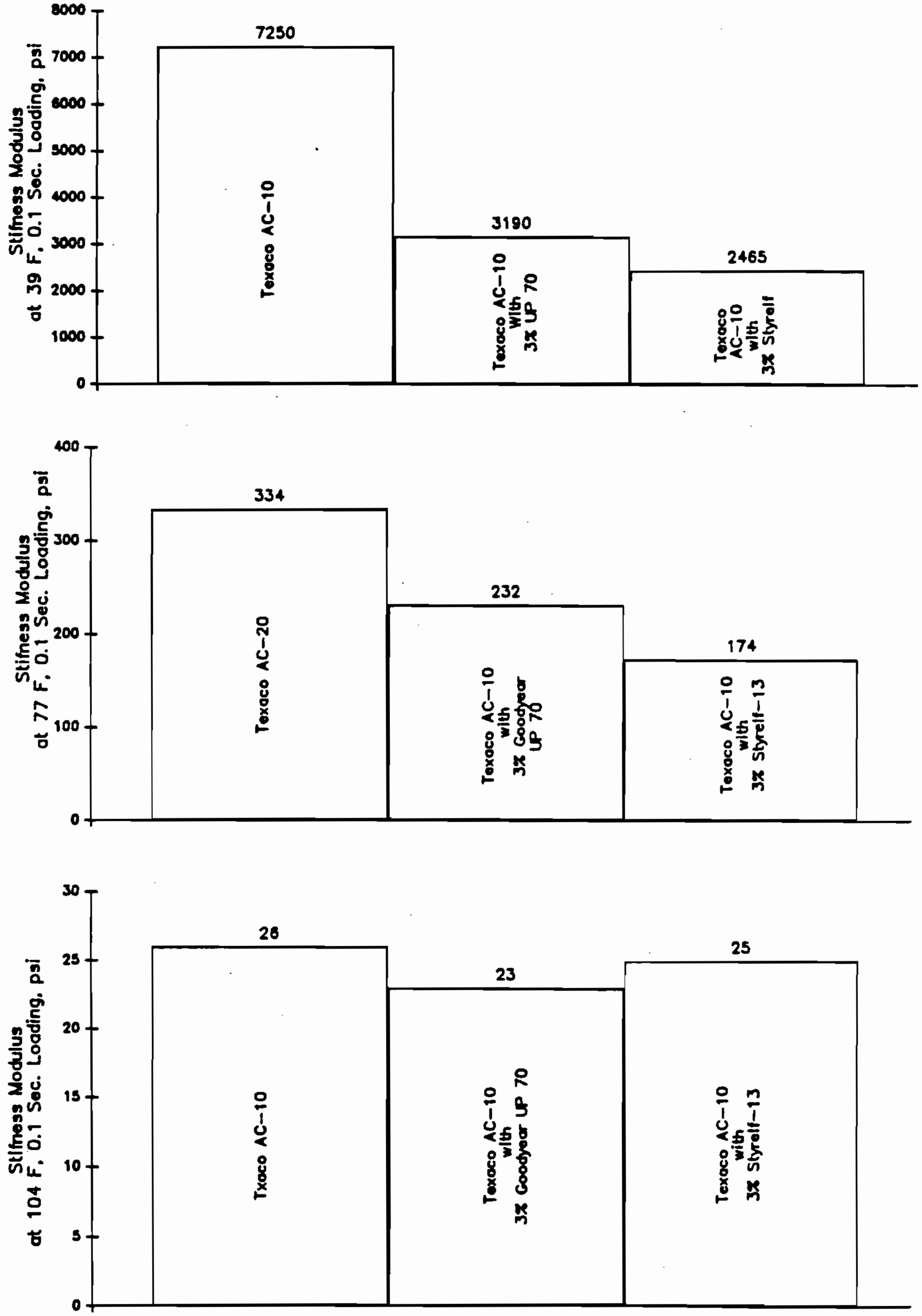

Fig B-13 Stiffness Modulus for Modified and Unmodified Texaco Binders.

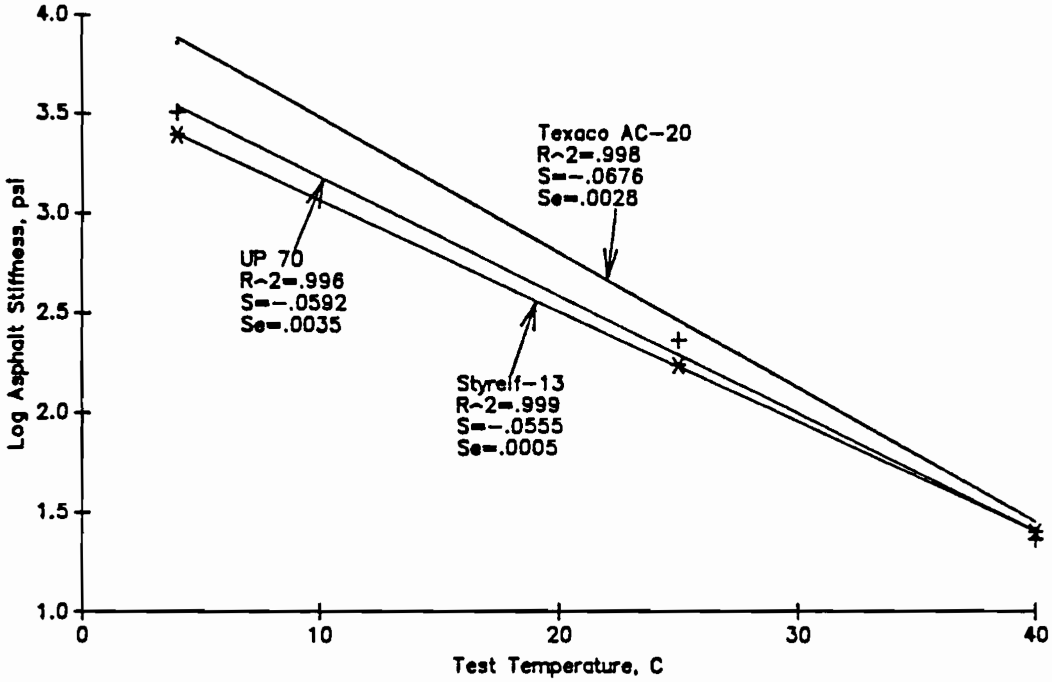

Fig B-14 Asphalt Stiffness vs. Test Temperature for Texaco Binders.

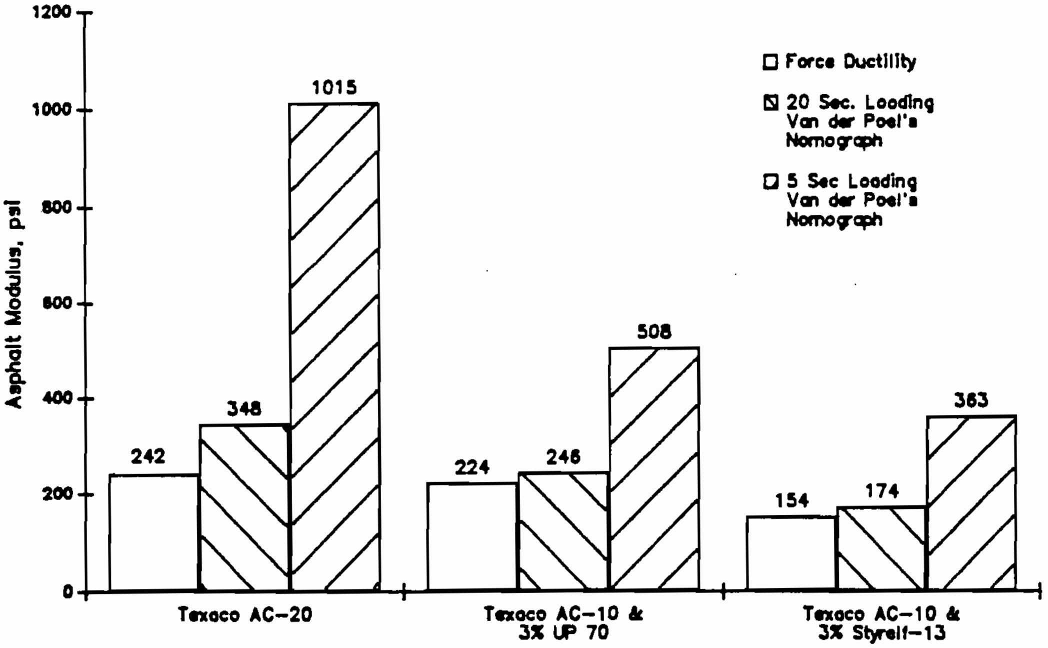

Fig B-15 Asphalt Modulus at 39 F for Unmodified and Modified Texaco Binders.

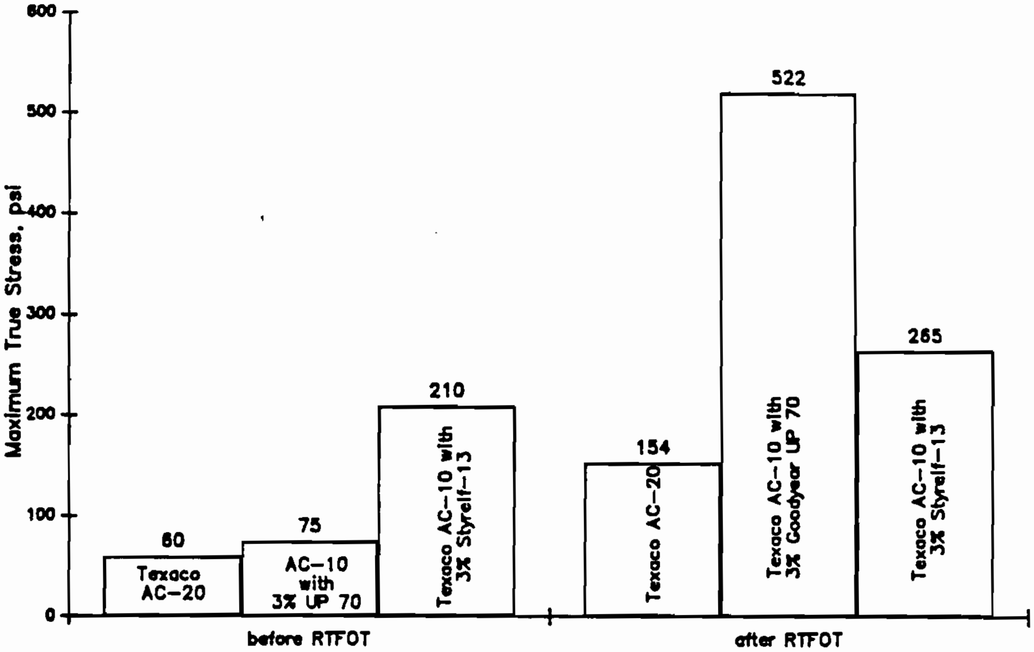

Fig B-16 Maximum True Stress at 39 F for Unmodified and Modified Texaco Binders

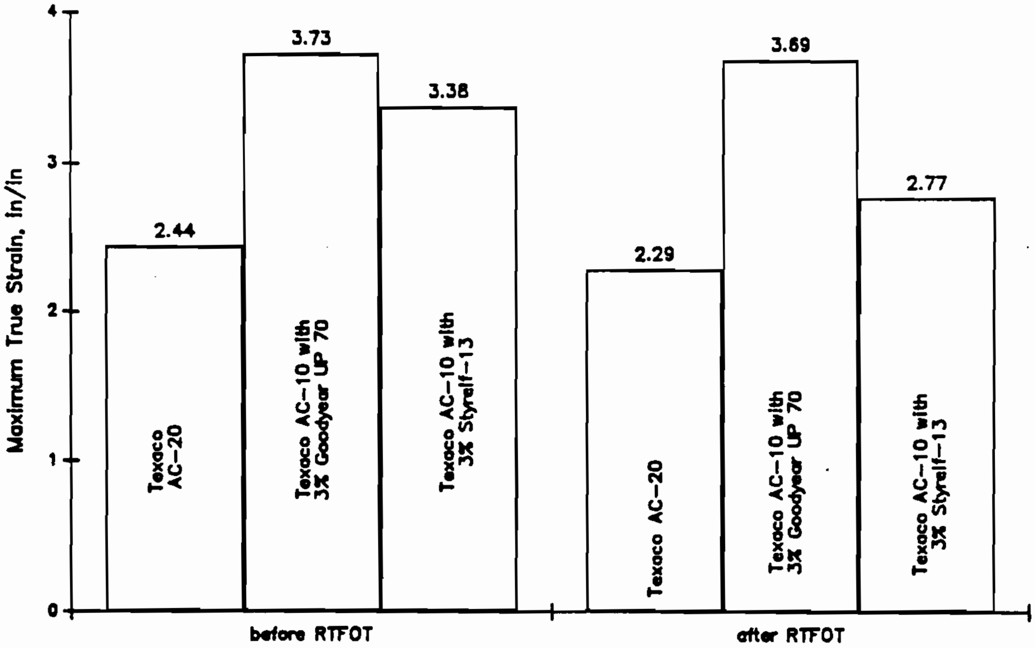

Fig B-17 Maximum True Strain at 39 F for Unmodified and Modified Texaco Binders

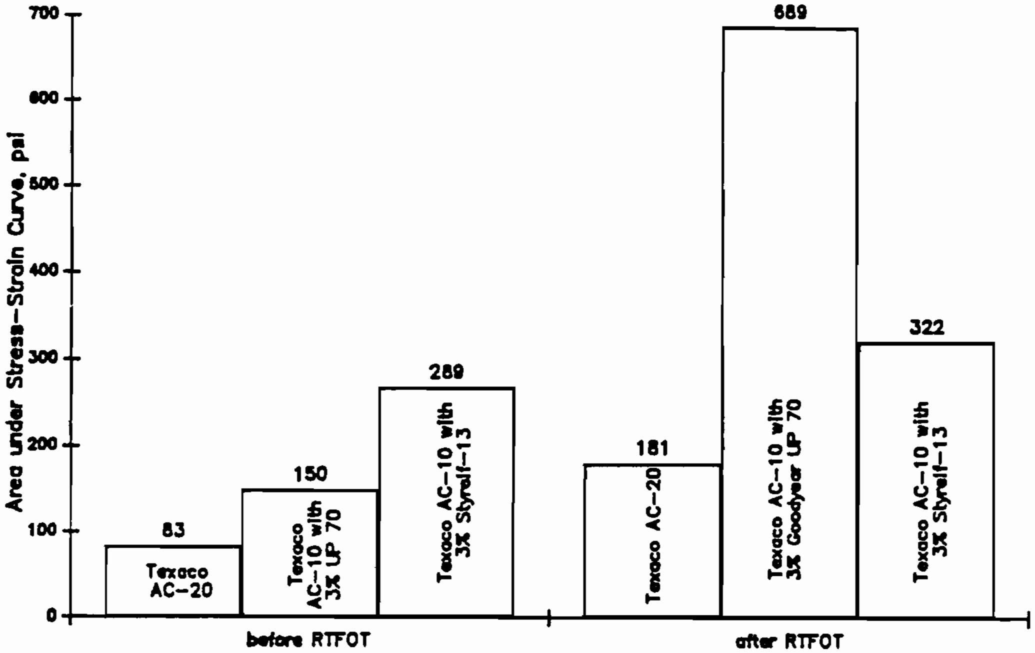

Fig B-18 Curve Area at 39 F for Unmodified and Modified Texaco Binders

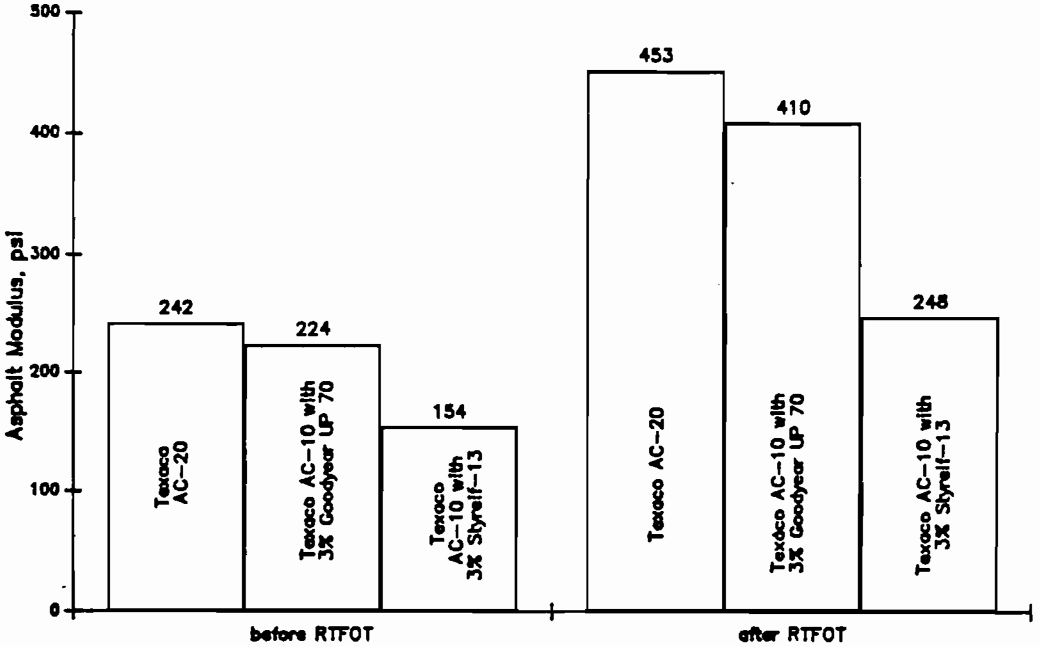

Fig B-19 Asphalt Modulus at 39 F for Unmodified and Modified Texaco Binders

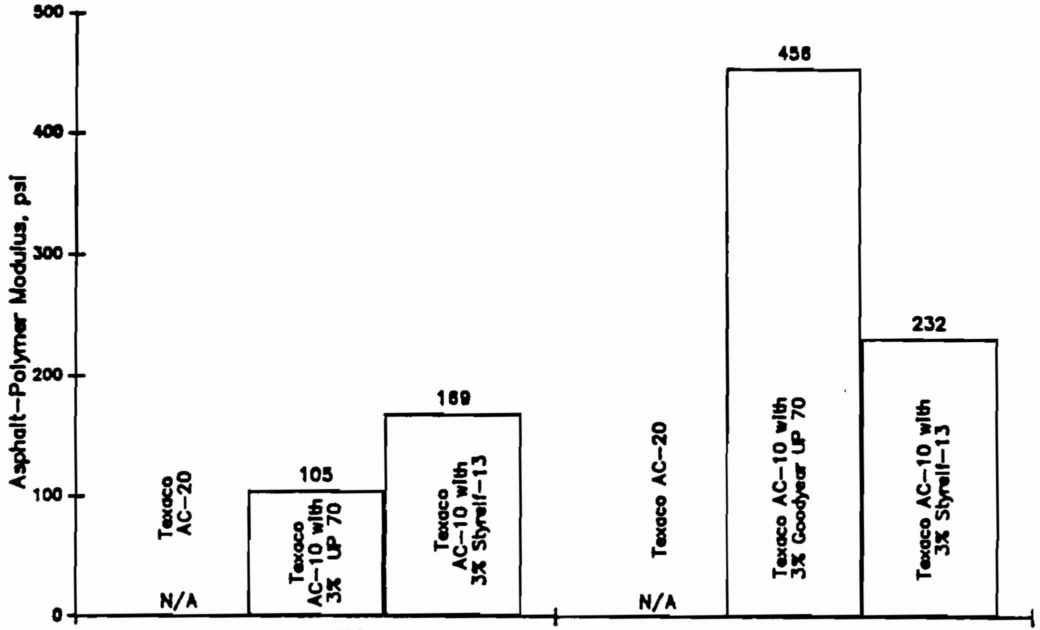

Fig B–20 Asphalt–Polymer Modulus at 39 F for Unmodified and Modified Texaco Binders

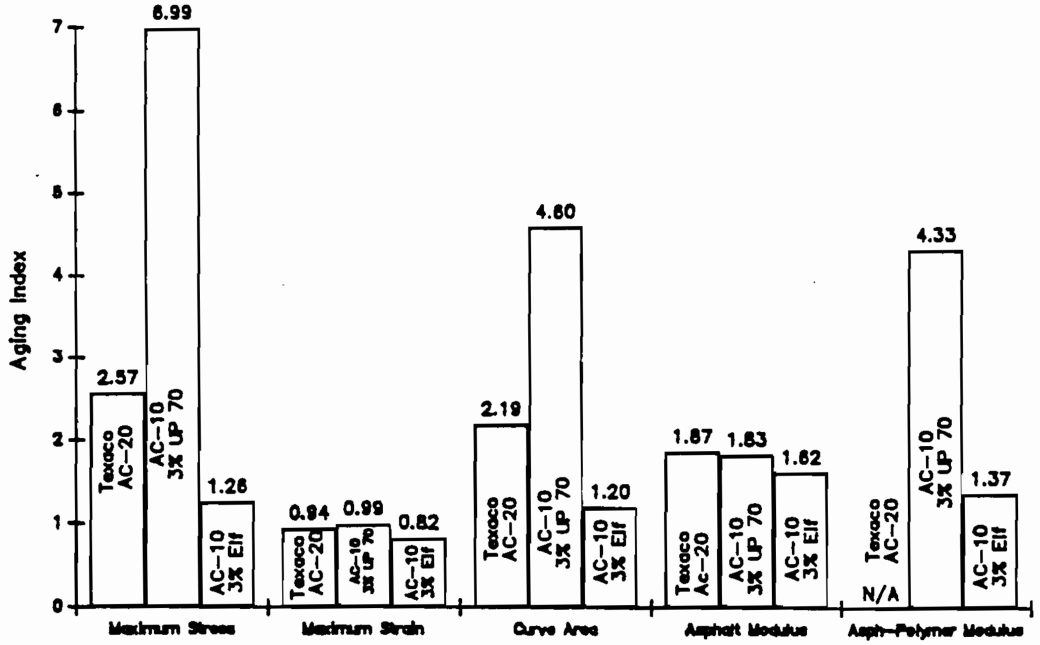

Fig B–21 Aging Index of Force Ductility Parameters for Unmodified and Modified Texaco Binders.

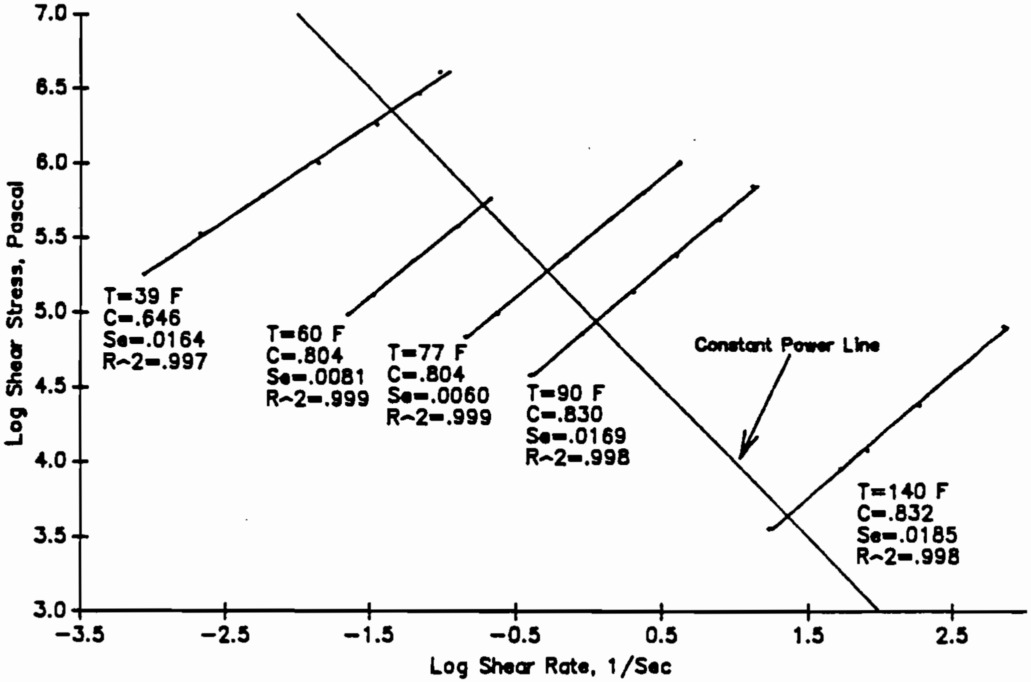

Fig B-22 Shear Stress vs. Shear Rate for Texaco AC-20 at Different Test Temperatures.

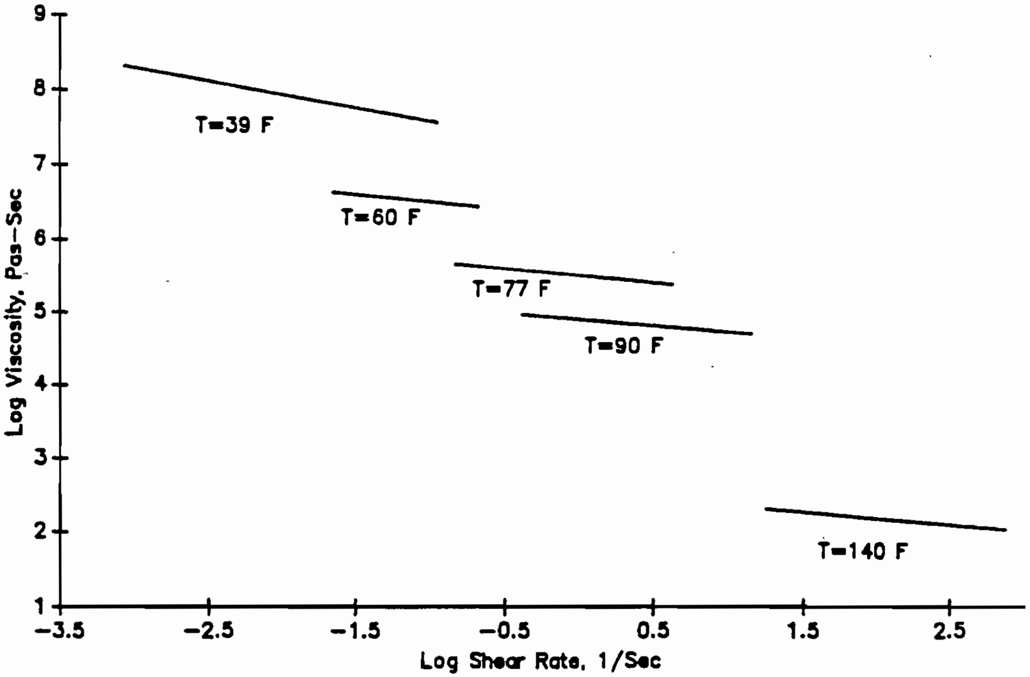

Fig B-23 Viscosity vs. Shear Rate for Texaco AC-20 at Different Test Temperatures.

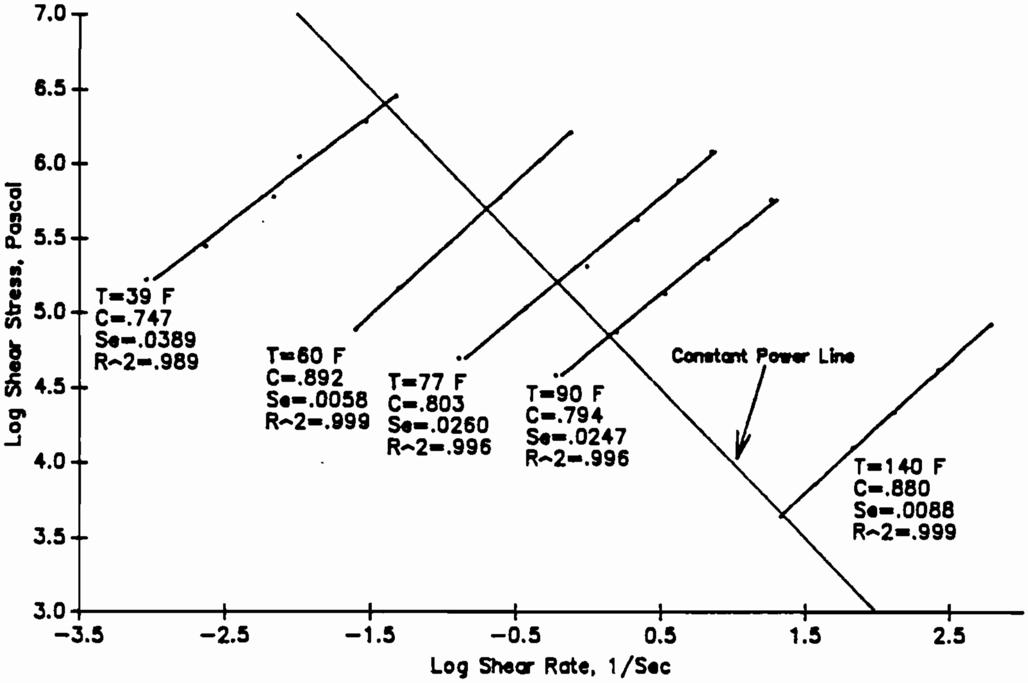

Fig B-24 Shear Stress vs. Shear Rate for UP-70 Modified Binder at Different Test Temperatures.

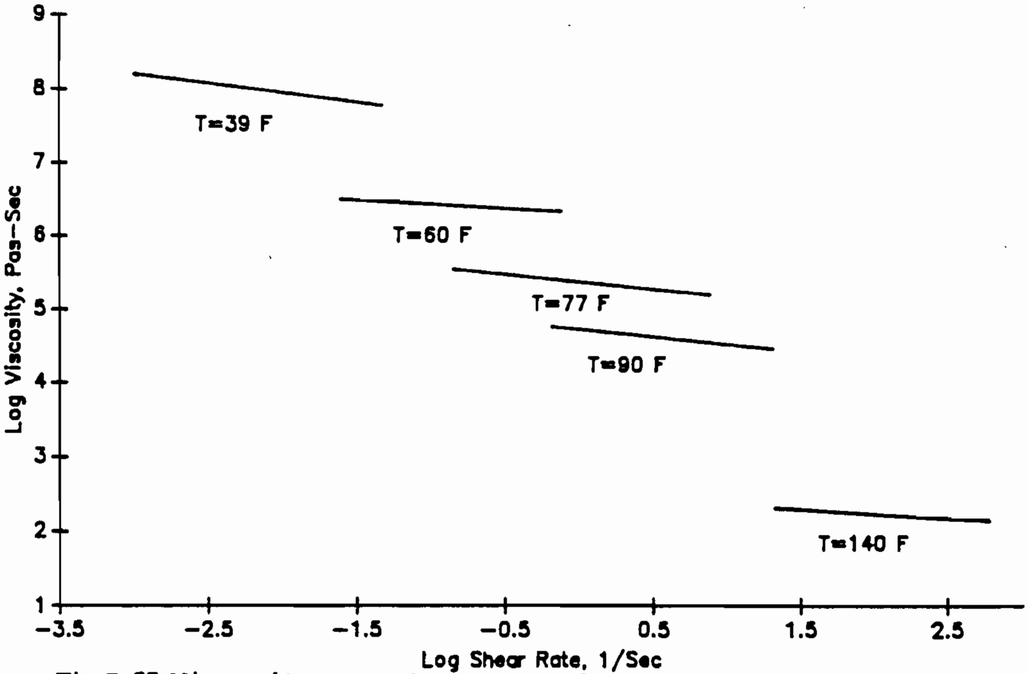

Fig B-25 Viscosity vs. Shear Rate for UP-70 Modified Binder at Different Test Temperatures.

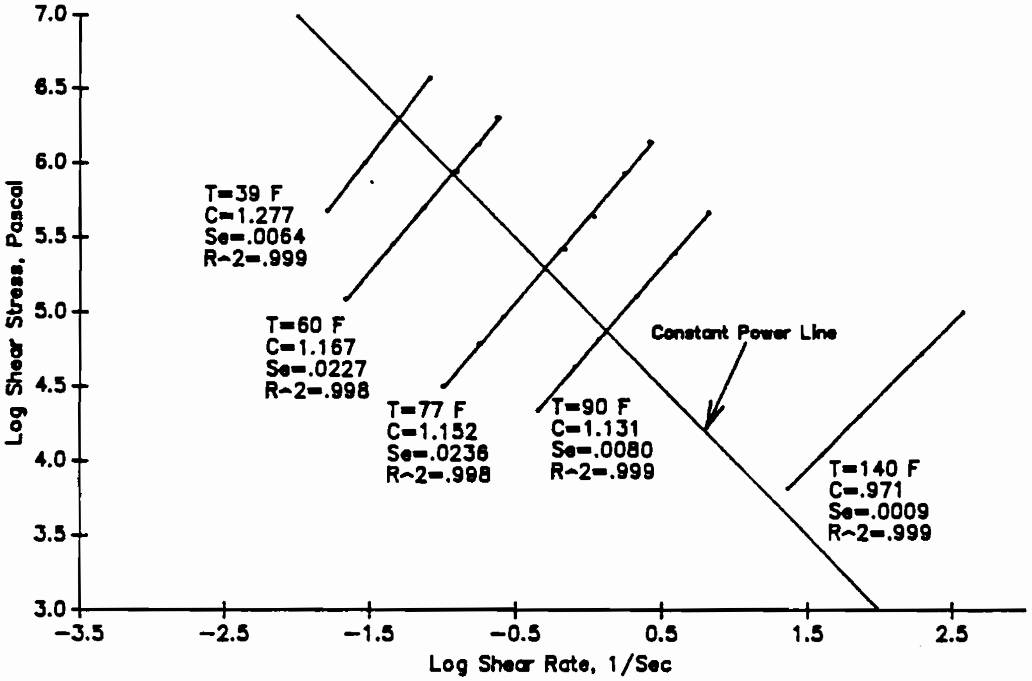

Fig B-26 Shear Stress vs. Shear Rate for Styrelf Modified Binder at Different Test Temperatures.

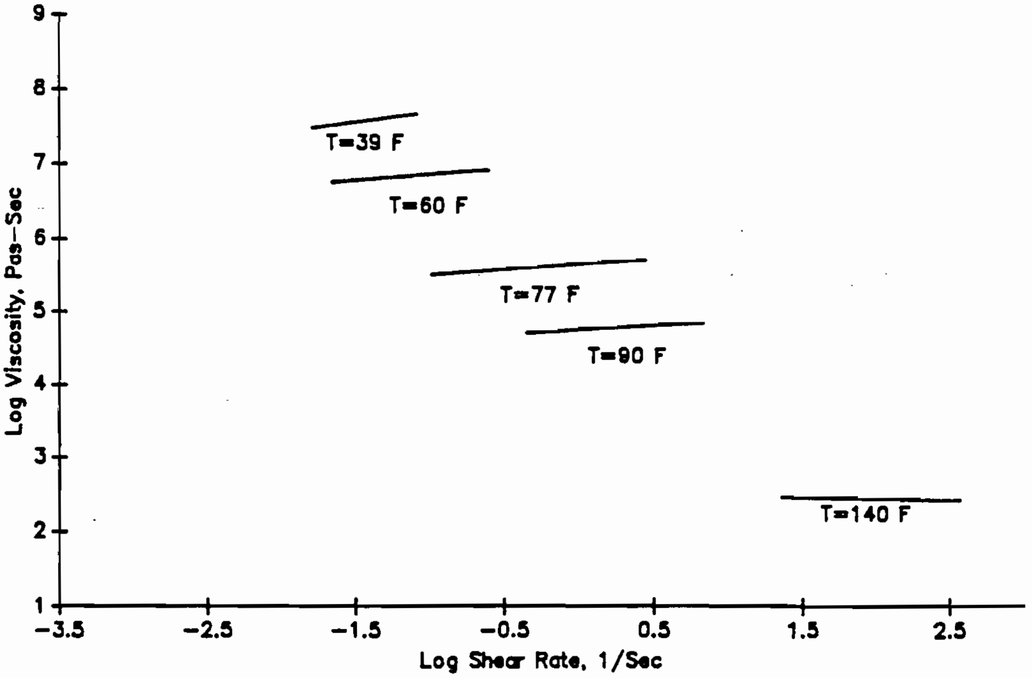

Fig B-27 Viscosity vs. Shear Rate for Styrelf Modified Binder at Different Test Temperatures.

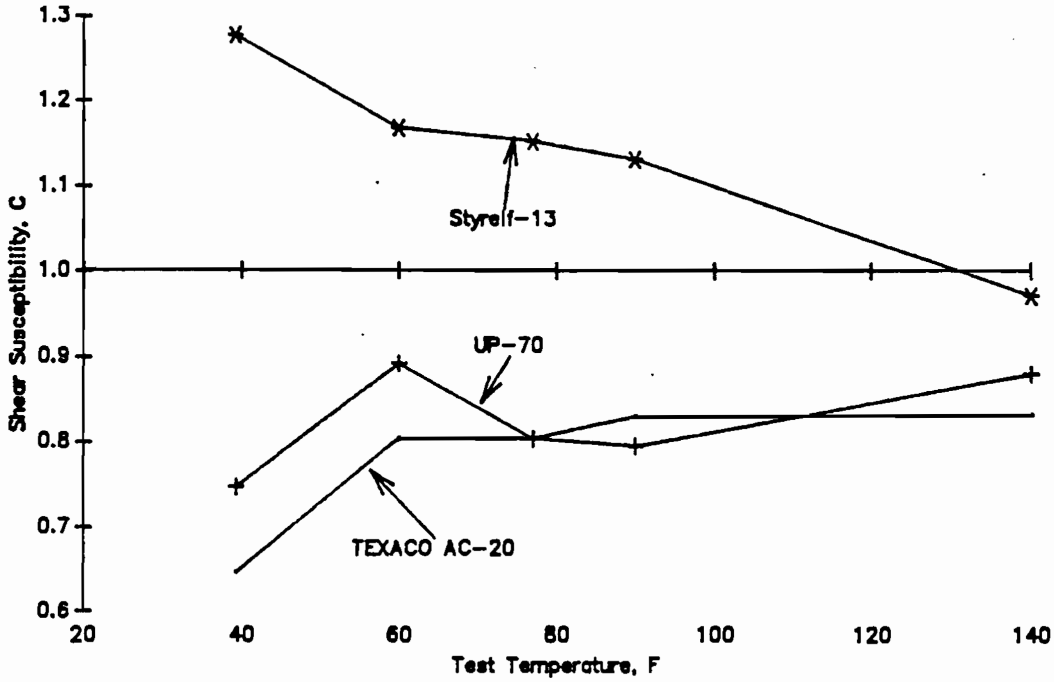

Fig B-28 Shear Susceptibility vs. Test Temperature for Modified and Unmodified Texaco Binders.

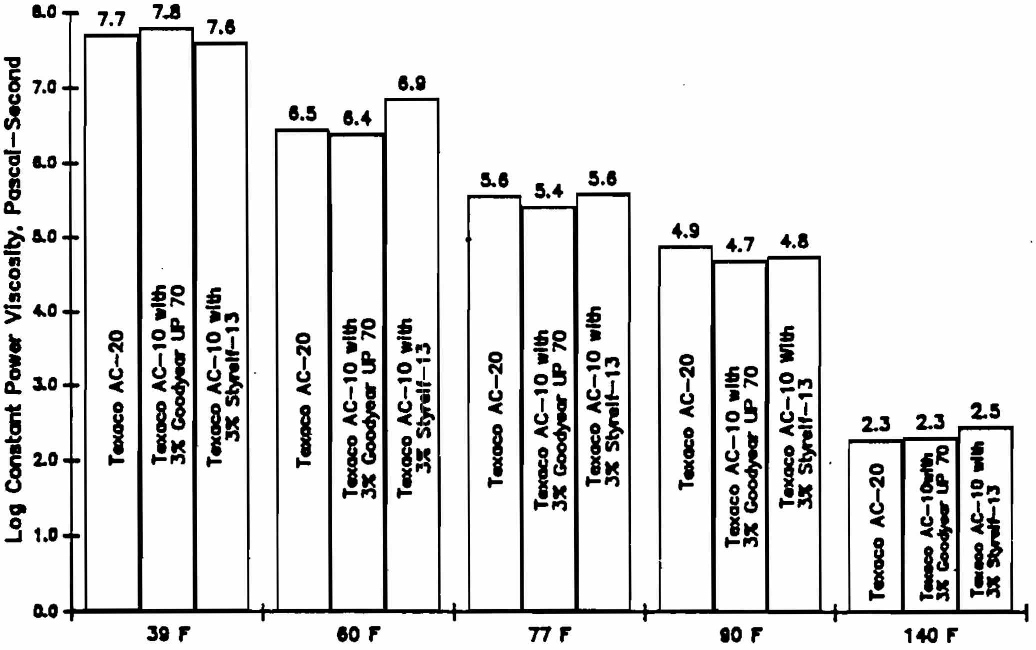

Fig B-29 Constant Power Viscosity for Unmodified and Modified Texaco Binders

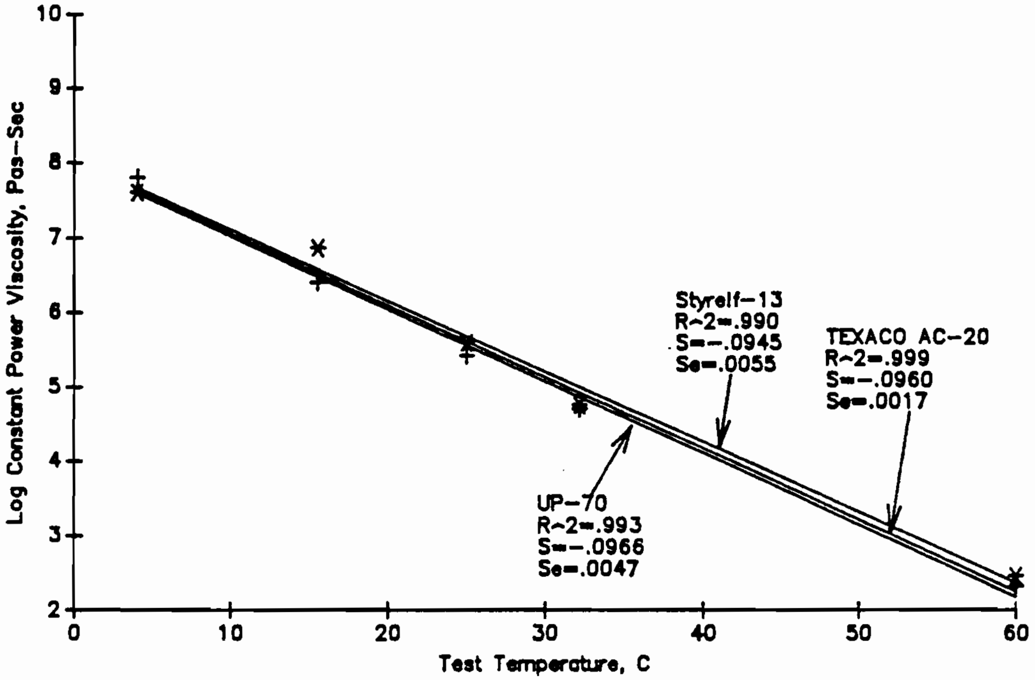

Fig B-30 Constant Power Viscosity vs. Test Temperature for Unmodified and Modified Texaco Binders.

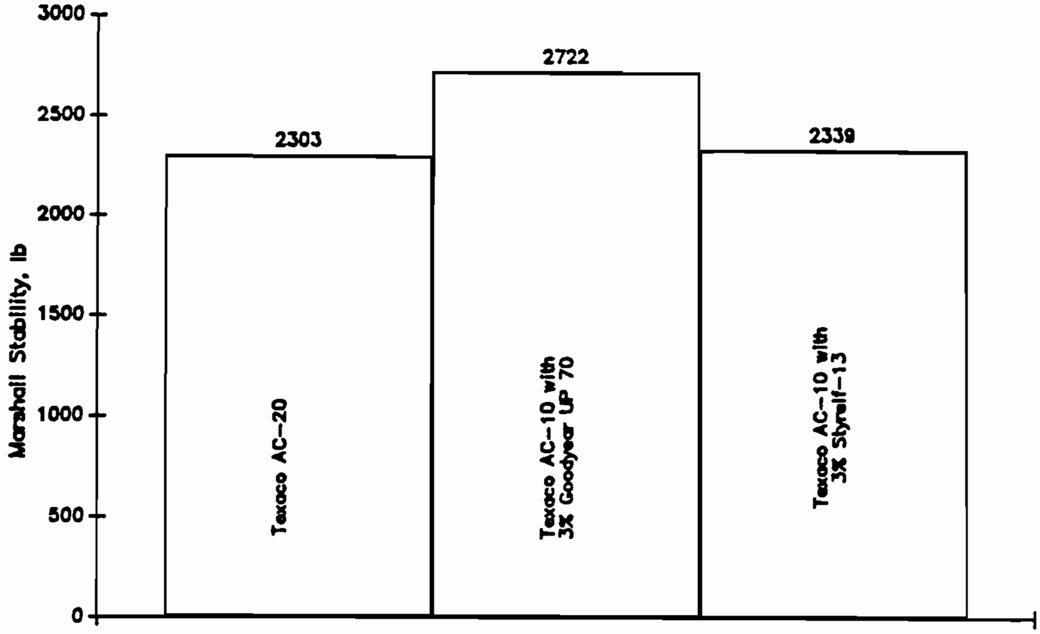

Fig B-31 Marshall Stability for Laboratory Mixtures Using Standard Compaction

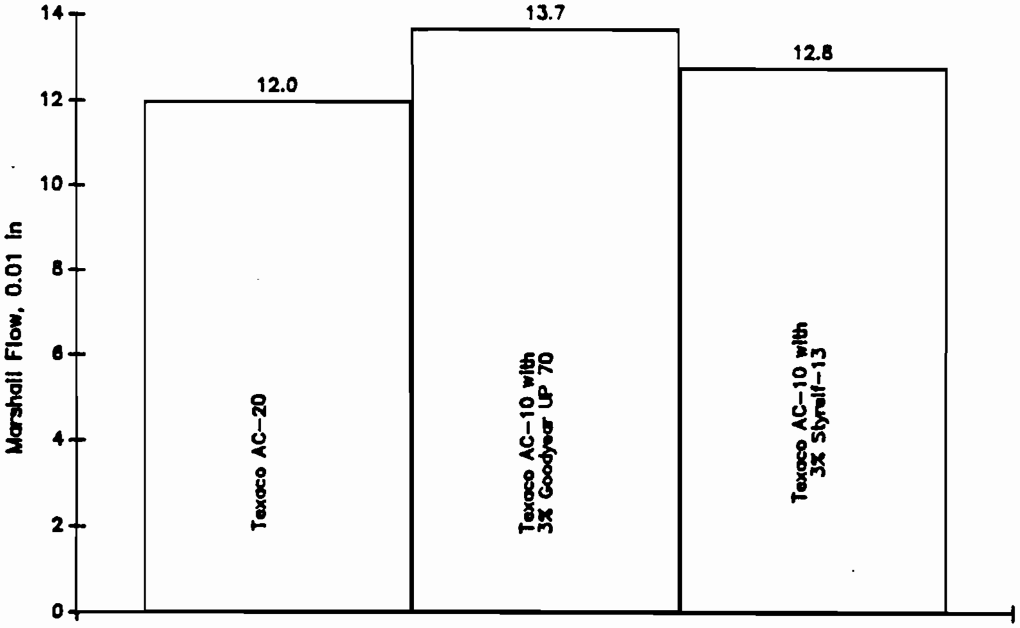

Fig B-32 Marshall Flow for Laboratory Mixtures Using Standard Compaction

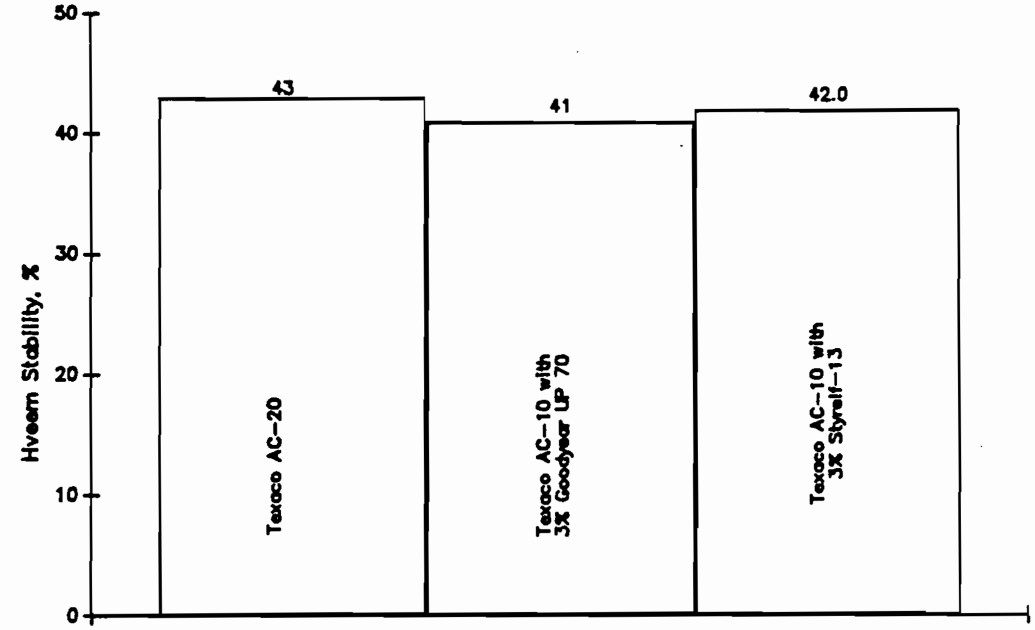

Fig B-33 Hveem Stability for Laboratory Mixtures Using Standard Compaction

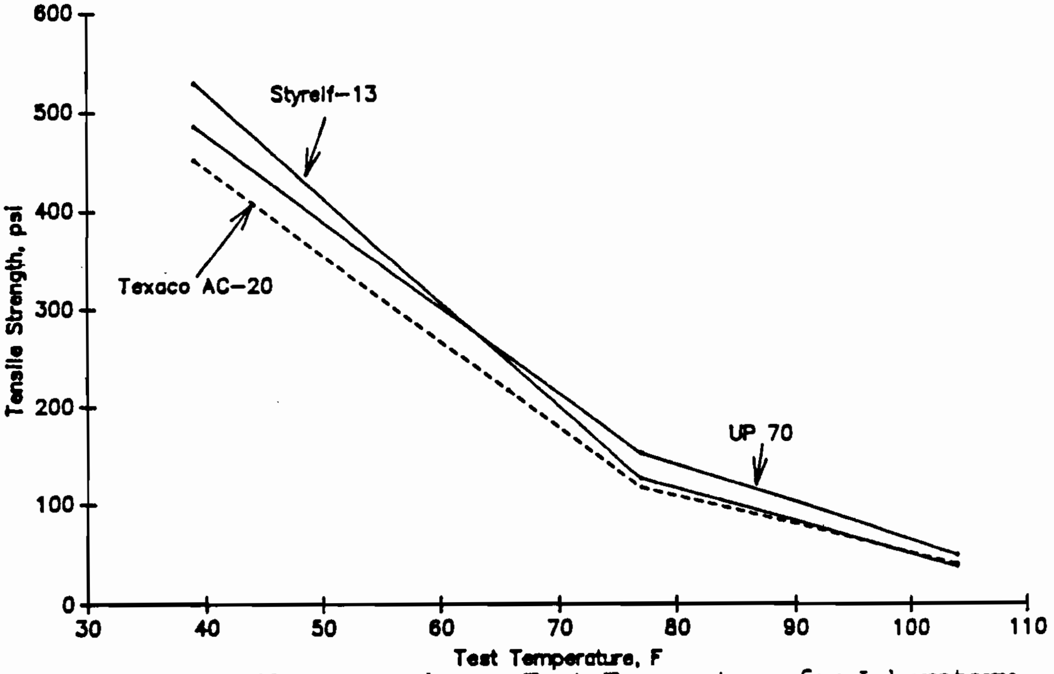

Fig B-34 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

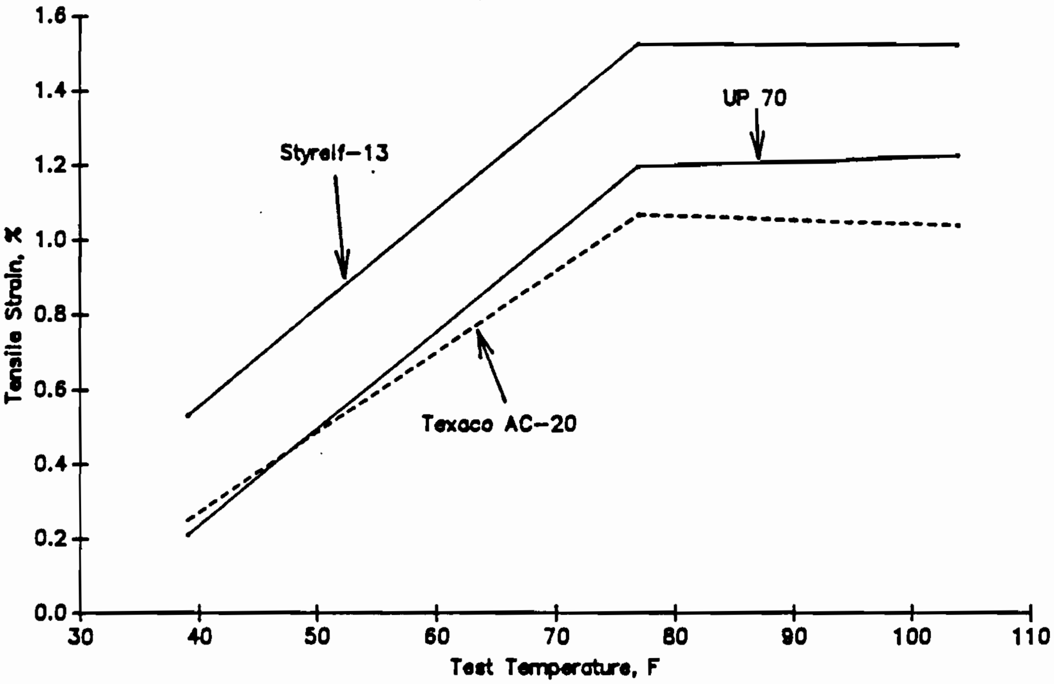

Fig B-35 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures using Standard Compaction.

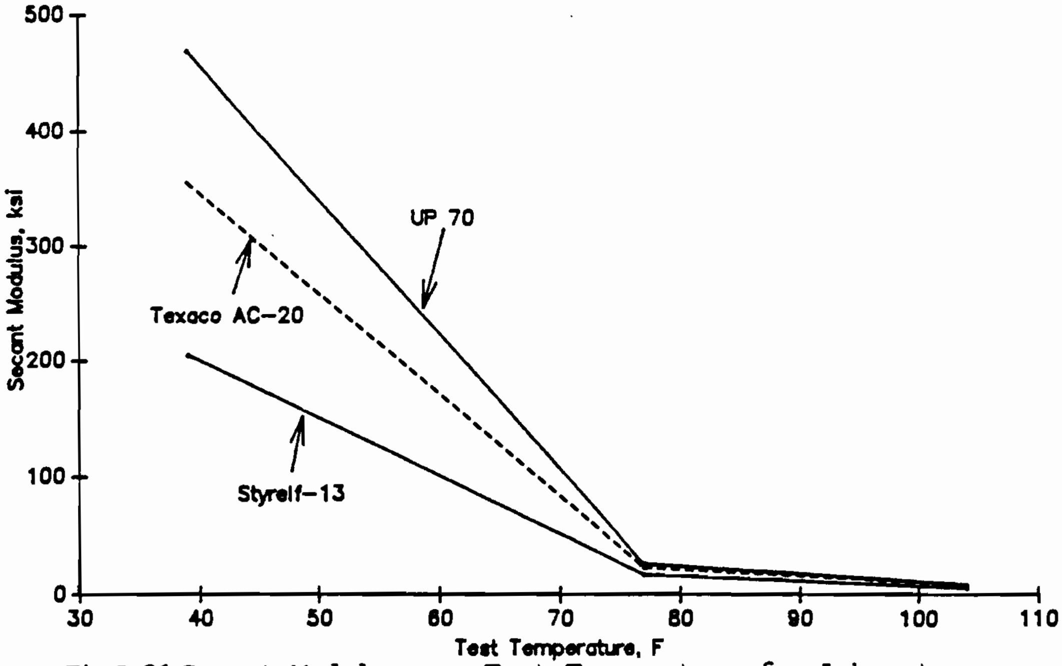

Fig B-36 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Standard Compaction

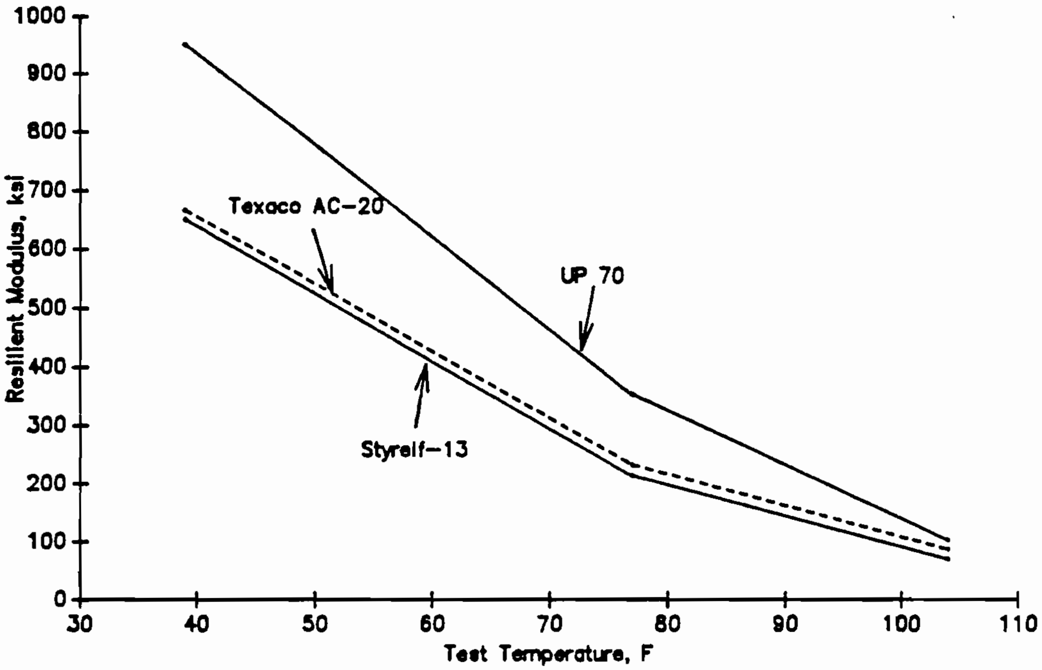

Fig B-37 Resilient Modulus vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

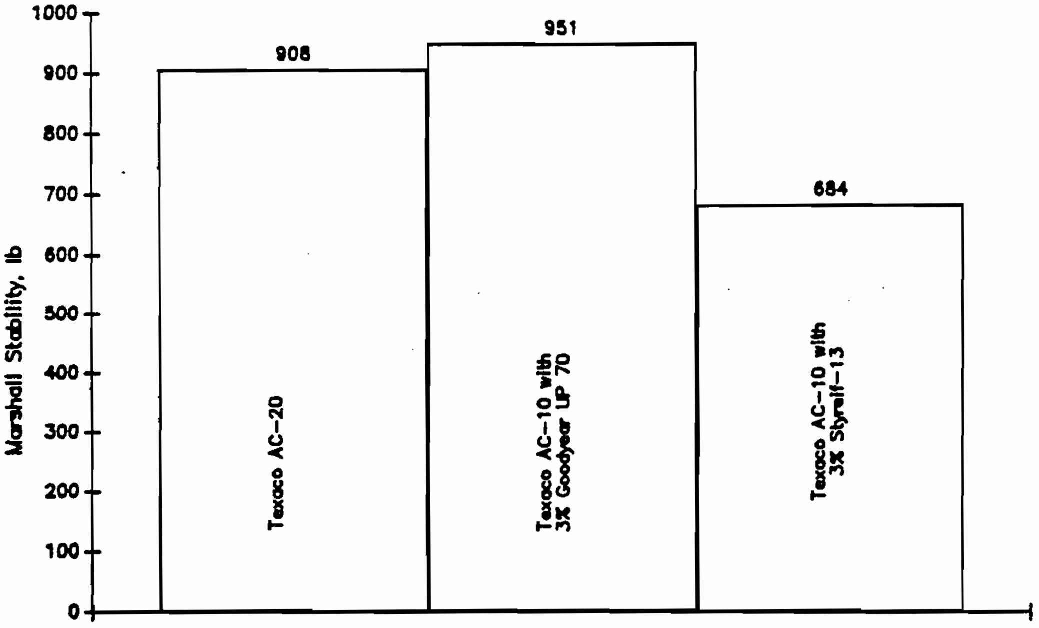

Fig B-38 Marshall Stability for Laboratory Mixtures Using Modified Compaction

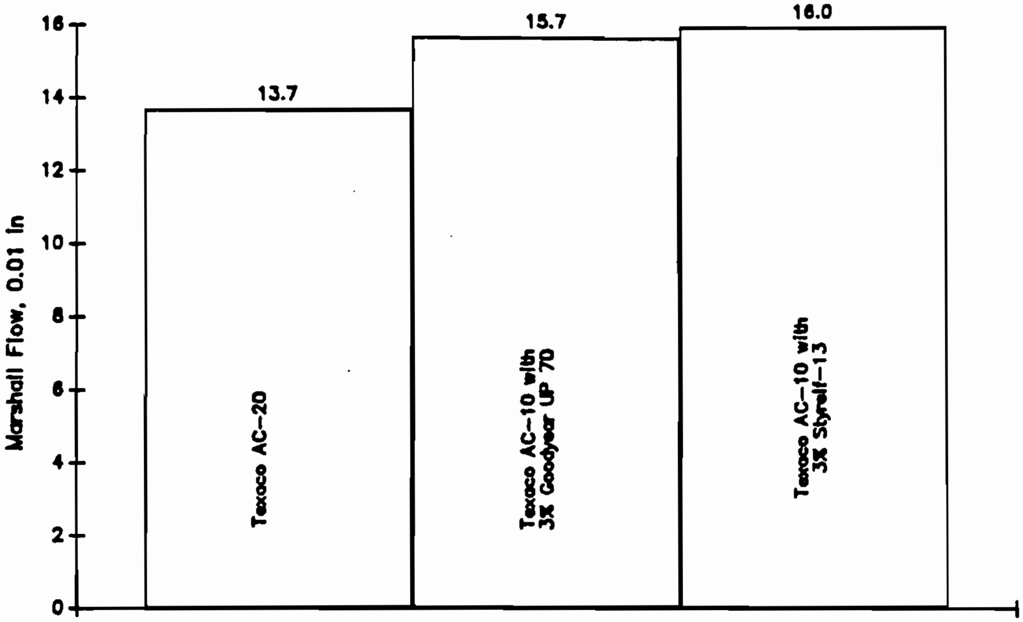

Fig B-39 Marshall Flow for Laboratory Mixtures Using Modified Compaction

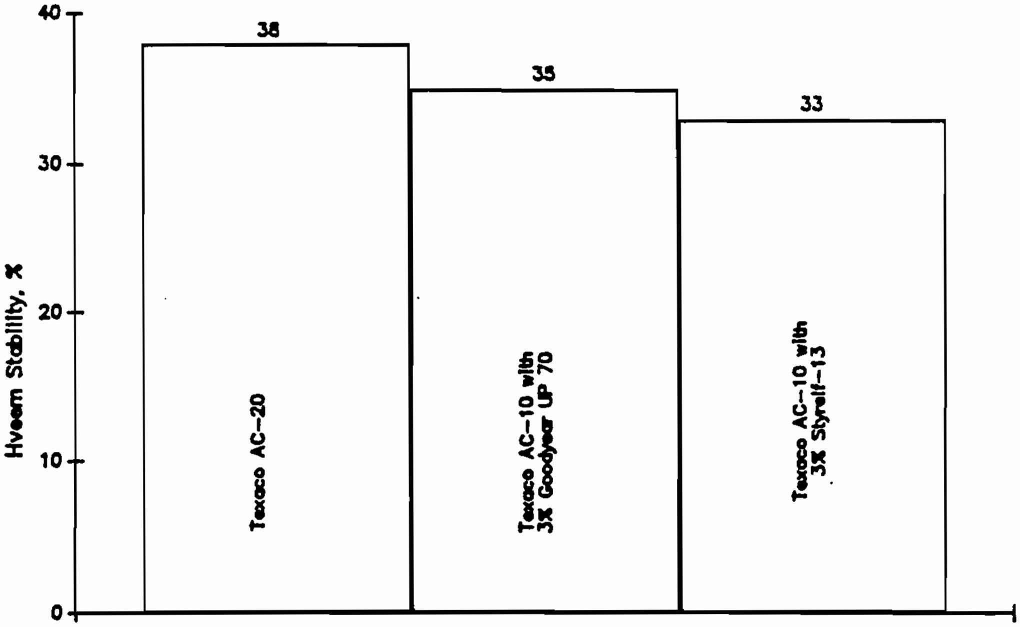

Fig B-40 Hveem Stability for Laboratory Mixtures Using Modified Compaction

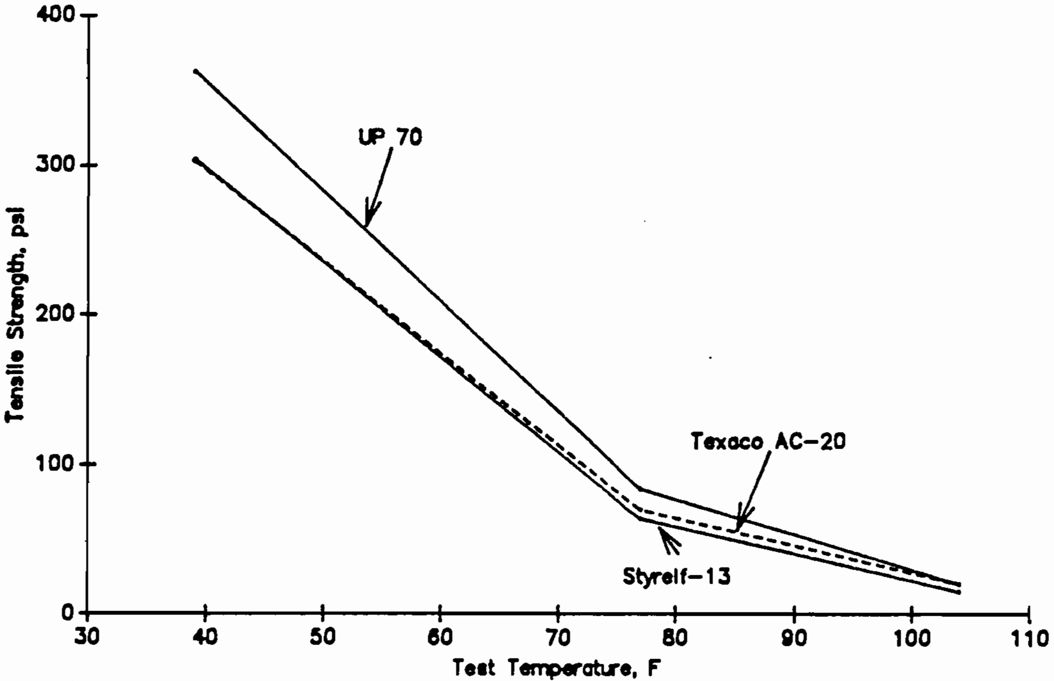

Fig B-41 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

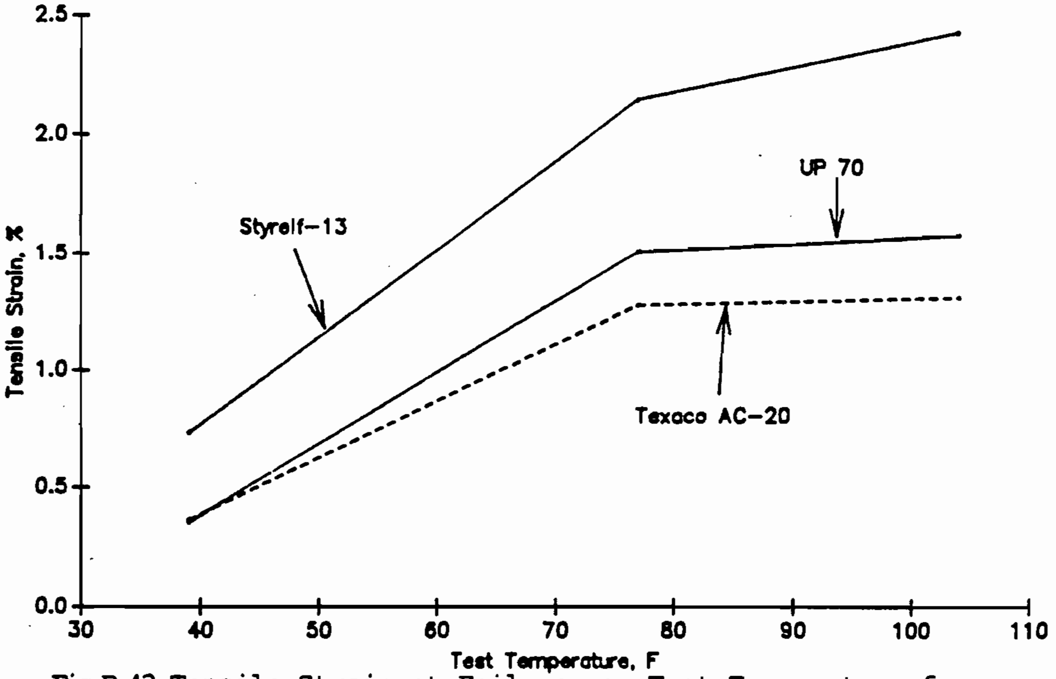

Fig B-42 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

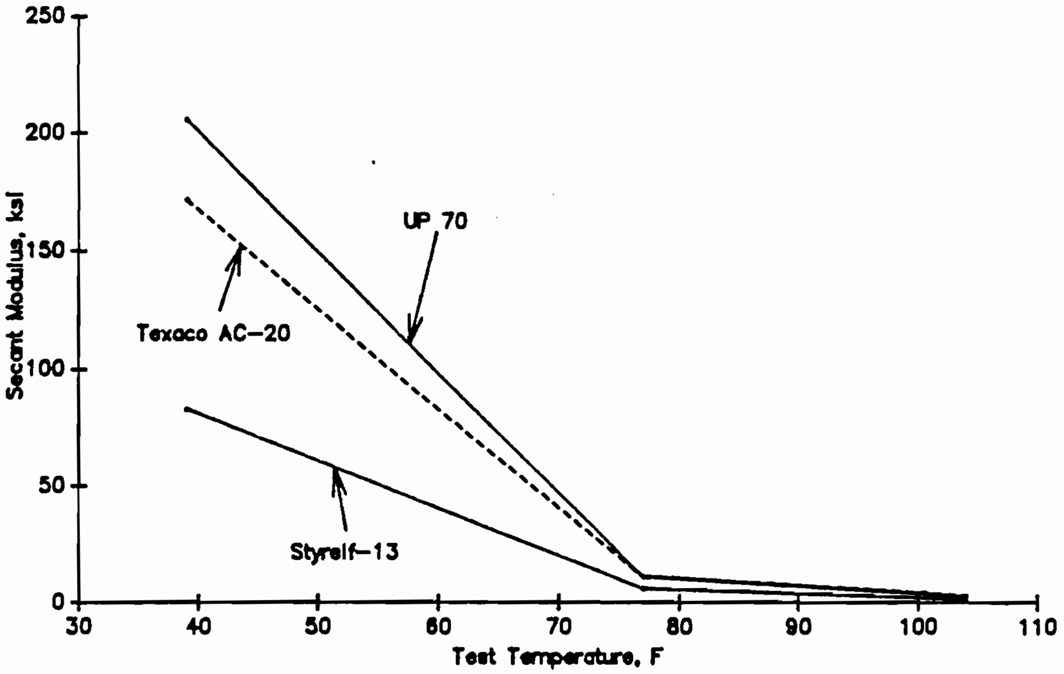

Fig B-43 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

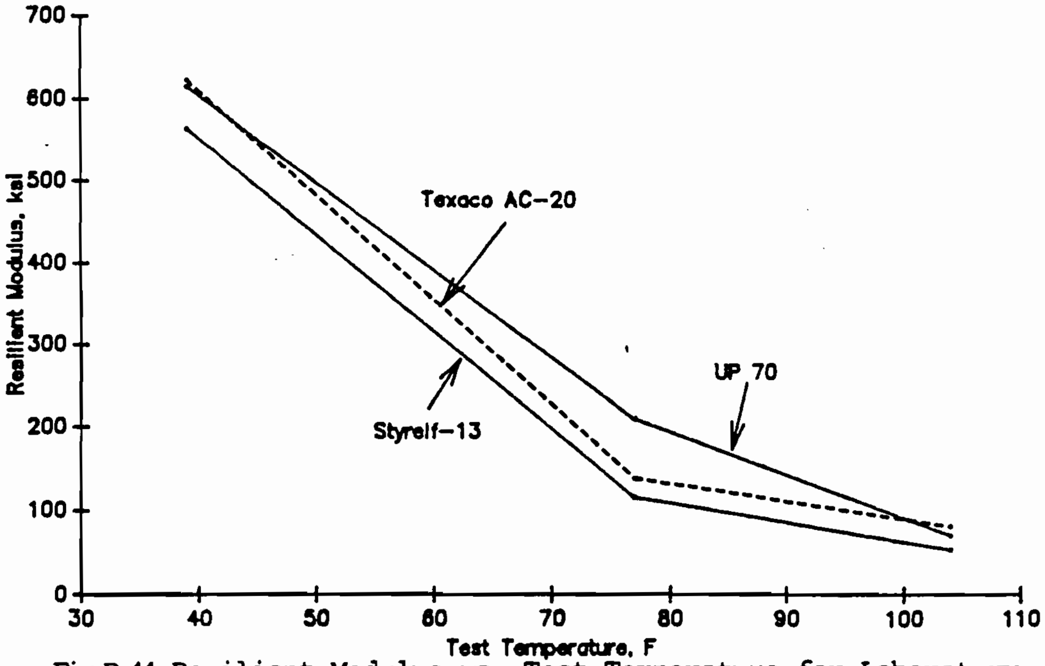

Fig B-44 Resilient Modulus vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

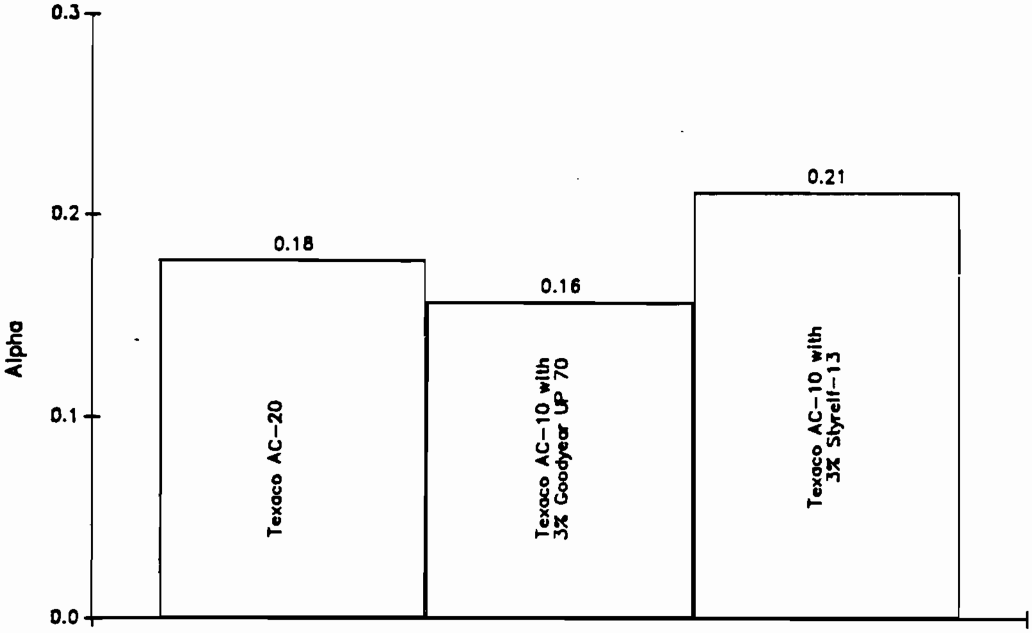

Fig B-45 Alpha Values for Laboratory Mixtures Using Modified Compaction

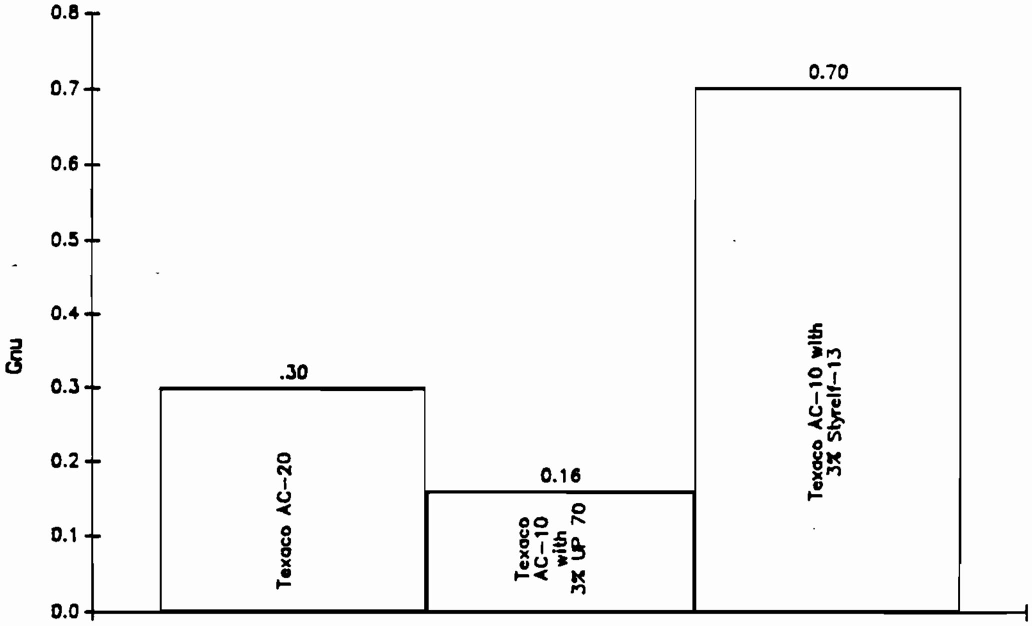

Fig B-46 Gnu Values for Laboratory Mixtures Using Modified Compaction

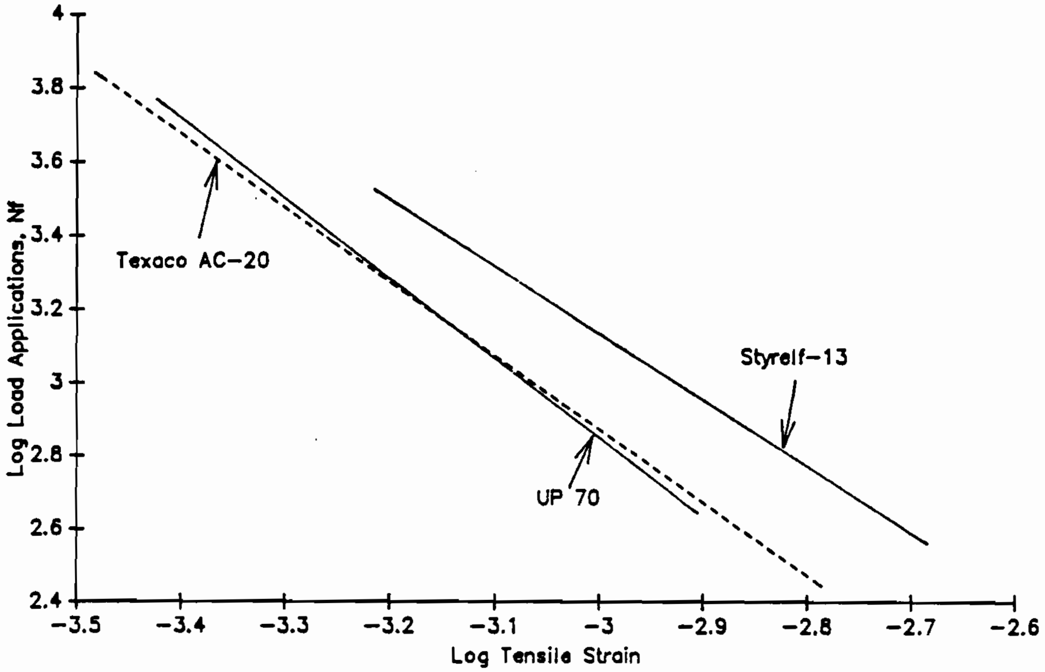

Fig B-47 Relationship between Fatigue Life and Applied Strain for Laboratory Mixtures Using Modified Compaction.

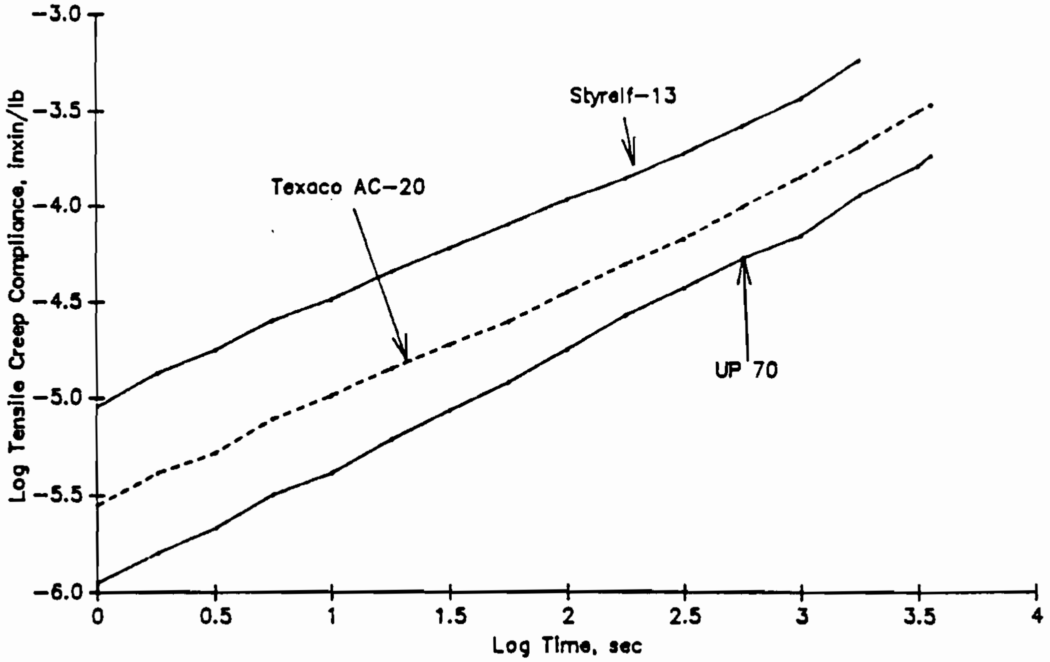

Fig B-48 Creep Compliance Curves at 60 F for Laboratory Mixtures Using Modified Compaction.

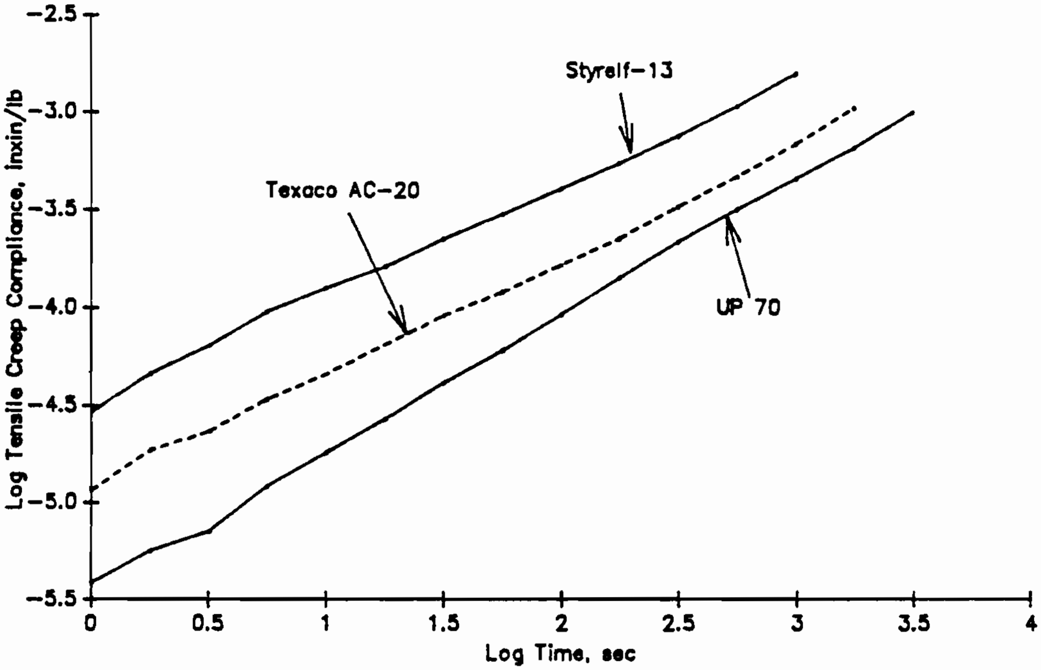

Fig B-49 Creep Compliance Curves at 77 F for Laboratory Mixtures Using Modified Compaction.

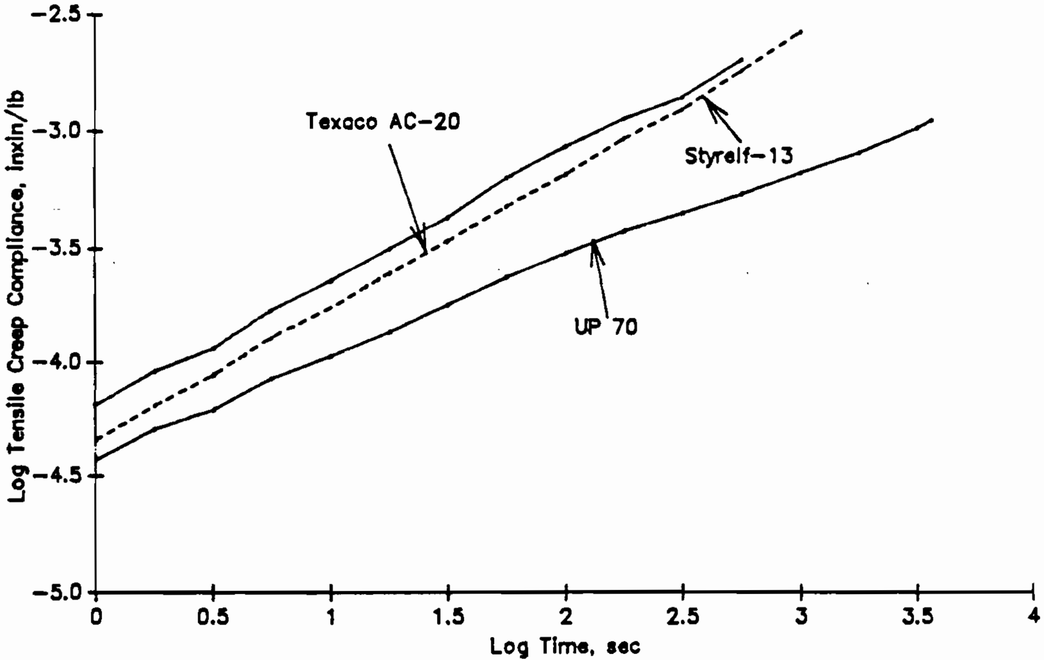

Fig B-50 Creep Compliance Curves at 90 F for Laboratory Mixtures Using Modified Compaction.

APPENDIX C

PRESENTATION OF TEST RESULTS - DISTRICT 25

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PRESENTATION OF TEST RESULTS - DISTRICT 25

The objectives of Appendix C are twofold: (1) to describe the site-specific field operations of the test sections along with a description of the materials, polymers, and construction techniques used for this field project, and (2) to present the laboratory test results of the unmodified and modified binders and laboratory mixed and plant mixed mixtures for the experimental field study in District 25 of the Texas Department of Transportation (TxDOT).

EXPERIMENTAL FIELD PROGRAM

Two test sections, control and latex UP 70, were constructed on US 287 in Donley County, Texas in September 1988. Three test sections, Styrelf-13 and Kraton D1101 at two levels of concentration, were placed in April 1989 followed by the test sections constructed in September 1988. The test sections are shown schematically in Figure C-1 and involved pavement overlay of one lane of the highway. Each test section was approximately one to one and a half inches thick. Field construction was conducted by District 25 of the TxDOT and assisted by the Center for Transportation Research, the University of Texas at Austin. The decision to include this field project in this study was made after the first two test sections (control and UP 70) had been placed. Therefore, loose samples of plant mixtures and samples of binders were not obtained from the control and UP 70 test sections.

MATERIALS

<u>ASPHALT CEMENT.</u> An AC-10 asphalt cement supplied by American Petrofina Co., Big Spring, Texas, and an AC-20 supplied by Shamrock Co., Sunray, Texas, were used for polymer modified and control mixtures, respectively.

<u>AGGREGATE.</u> Two aggregates, a crushed gravel and a sandstone

screening, were combined to produce project gradation. Gradations of individual aggregates, the project gradation, percentage of each aggregate, and the gradation specifications are given in Table C-1. The project gradation is plotted on a 0.45 power graph in Figure C-2.

POLYMER. Three polymers included in this field project consisted of a Styrene Butadiene Rubber (SBR), and a Styrene block copolymer (SBS). Sources of these polymers and designations used for this study are shown below:

SOURCE	TYPE	DESIGNATION
Goodyear	SBR	UP 70
Elf	SBS	Styrelf-13
Shell	SBS	Kraton D1101

Blending of the asphalts and the polymers was performed by the polymer manufacturers or processors in the refinery or in a distributor truck. No polymer was introduced into the asphalt in-line injection system of the plant.

Styrene Butadiene Rubber. One type of Styrene Butadiene Rubber, Ultra Pave 70, was included in this field project. The latex UP 70 was supplied by Textile Rubber and Chemical Co. The total amount of the UP 70 used in the Fina AC-10 was 3 percent.

Styrene Butadiene Styrene. The Styrelf-13 utilized was a triblock copolymer of Styrene and Butadiene. The Styrelf modified binder was blended by Elf Asphalt Aquitaine Co, Lubbock, Texas, for Fina AC-10 at 3% Styrelf-13 by the weight of total binder. The Kraton D1101 which consisted of a triblock copolymer of Styrene and Butadiene was obtained from Shell Development Co. Blends of Fina AC-10 were used at 3% and 6% kraton D1101 by weight of total binder.

FIELD OPERATION

Approximately 3000 tons of each mix were produced using a drum mix plant. Identical aggregates were utilized throughout the experiment. The Ultra Pave 70 (3 percent) , the Styrelf-13 (3 percent), and the Kraton D1101 (3 percent and 6 percent) were preblended with Fina AC-10. The Shamrock AC-20 was used for the control test section.

Mixing temperature for the Styrelf-13 and Kraton D1101 (3 percent) mixtures was about 310°F and was increased to about 350°F for mixtures containing 6 percent Kraton D1101. The initial breakdown compaction occurred between 250°F and 270°F for all mixtures. Compaction of each test section was achieved using a vibratory roller, a pneumatic roller and a steel wheel roller.

Twelve field cores were obtained from the test sections which were constructed in April 1989 soon after the construction. These cores were approximately 4 inches in diameter and one to one and a half inches in thickness. The field cores were transported to the Center for Transportation Research immediately after sampling.

PRESENTATION OF TEST RESULTS

Summaries of test results for the unmodified and modified binders are presented in Tables C-6 through C-8 and are plotted in Figures C-3 through C-32.

Summaries of test results for the unmodified and the modified mixtures and the cores are presented in Tables C-9 through C-26 and are plotted in Figures C-32 through C-52.

Table C-1 AGGREGATE GRADATION (DISTRICT 25)

	Crushed Gravel		Screenings			
	Sieve Analysis	51%	Sieve Analysis	49%	Combined Gradation	SDHPT Specification
Plus 1/2 in.	0.0	0.0	0.0	0.0	0.0	0
1/2 to 3/8 in	12.8	6.5	0.0	0.0	6.5	0-15
3/8 to No. 4	59.2	30.2	0.0	0.0	30.2	21-53
No. 4 to No. 10	25.6	13.1	17.0	8.3	21.4	11-32
Plus No. 10					58.1	54-74
No. 10 to No.40	1.2	0.6	49.1	24.1	24.7	6-32
No. 40 to No. 80	0.3	0.2	16.4	8.0	8.2	4-27
No. 80 to No. 200	0.3	0.2	11.1	5.4	5.6	3-27
Minus No. 200	0.6	0.3	6.4	3.1	3.4	1-8
Total	100.0	51.0	100.0	49.0	100.0	

TABLE C-2 Experimental Testing Program for Unmodified and Polymer-Modified Asphalt Binders
Number of Test Repetitions (District 25)

Binder		Penetration			Viscosity				Softening Point	Force Ductility		Schweyer Rheology				
		Before RTFOT		After RTFOT	Before RTFOT		After RTFOT		Before RTFOT	Before RTFOT	After RTFOT	Before RTFOT				
Asphalt	Polymer	39.2 F	77 F	77 F	140 F	275 F	140 F	275 F		39.2 F	39.2 F	39 F	60 F	77 F	90 F	140 F
Shamrock AC-20		2	2	2	2	2	2	2	2	2	2	1	1	1	1	1
Fina AC-10	Styrelf--13	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1
Fina AC-10	3% kraton D1101	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1
Fina AC-10	6% kraton D1101	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1

TABLE C-3 Experimental Testing Program for Laboratory Compacted-Laboratory Mixed Mixtures District 25

Binder		Modified Compaction												Standard Compaction				
		Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F	Creep @			Fatique Stress levels			Moisture Resistance	Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F
Asphalt	Polymer	39F	77F	104F			60F	77F	90F	15%	25%	50%		39F	77F	104F		
Shamrock AC-20		3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	Goodyear UP 70	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	Styrelf--13	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	3% kraton D1101	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	6% kraton D1101	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3

TABLE C-4 Experimental Testing Program for Laboratory Compacted-Plant Mixed Mixtures
District 25

Binder		Modified Compaction												Standard Compaction				
		Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F	Creep @			Fatique Stress levels			Moisture Resistance	Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F
Asphalt	Polymer	39F	77F	104F			60F	77F	90F	15%	25%	50%		39F	77F	104F		
Shamrock AC-20		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fina AC-10	Goodyear UP 70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fina AC-10	Styrelf--13	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	3% kraton D1101	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	6% kraton D1101	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3

* Plant mixed mixtures were not obtained.

TABLE C-5 Experimental Testing Program for Field Cores.
District 25

Binder		Resilient modulus & Indirect Tensile Strength			Marshall 140F
Asphalt	Polymer	39F	77F	104F	
Shamrock AC-20	-	3	3	3	3
Fina AC-10	Goodyear UP 70	3	3	3	3
Fina AC-10	Styrelf--13	3	3	3	3
Fina AC-10	3% kraton D1101	3	3	3	3
Fina AC-10	6% kraton D1101	3	3	3	3

Table C-6 Unmodified and Modified Asphalt Properties before RTFOT.

Parameter	Shamrock AC-20	Fina AC-10 & 3% Styrelf	Fina AC-10 & 3% Kraton	Fina AC-10 & 6% Kraton
Penetration @ 39.2 F (25 C)	9	13	12	16
100g, 5 Sec.	9	14	14	15
Avg.	9	14	13	16
Penetration @ 77 F (4 C)	67	91	83	96
100g, 5 Sec.	66	89	81	99
Avg.	67	90	82	98
Viscosity @ 140 F (60 C)	2004	2760	8171	-
Poises	1992	2780	8083	-
Avg.	1998	2770	8127	-
Viscosity @ 275 F (135 C)	628	775	589	1020
Centistokes	620	787	579	1005
Avg.	624	781	584	1013
Softening Point, F	126	128	140	147
	127	130	142	148
Avg.	127	129	141	148
Maximum True Stress, psi	124	293	467	625
	116	284	481	566
Avg.	120	289	474	596
Maximum True Strain, in/in	2.42	2.94	3.11	2.81
	2.03	2.94	3.14	2.75
Avg.	2.23	2.94	3.13	2.78
True Area , psi	143	340	469	370
	128	324	476	325
Avg.	136	332	473	347

Table C-6 (Continued)

Parameter	Shamrock AC-20	Fina AC-10 & 3% Styrelf	Fina AC-10 & 3% Kraton	Fina AC-10 & 6% Kraton
Asphalt Modulus, psi	479	219	253	138
	464	201	246	93
Avg.	472	210	250	115
Asphalt-Polymer Modulus, psi	-	292	438	840
	-	267	467	799
Avg.	-	279	452	819
Shear Susceptibility				
@ 39.2 F	4.903E-01	1.235E+00	7.989E-01	7.768E-01
@ 60 F	6.961E-01	1.215E+00	8.764E-01	8.283E-01
@ 77 F	6.637E-01	1.076E+00	8.892E-01	7.717E-01
@ 90 F	7.609E-01	1.089E+00	8.861E-01	8.088E-01
@ 140 F	8.940E-01	1.018E+00	8.852E-01	7.717E-01
Apparent Viscosity, Pascal-Second Shear Rate = 1 1/sec				
@ 39.2 F	1.340E+07	1.236E+08	2.005E+08	1.818E+08
@ 60 F	1.976E+06	1.392E+07	6.463E+06	5.337E+06
@ 77 F	2.405E+05	5.321E+05	5.441E+05	4.138E+05
@ 90 F	5.899E+04	7.120E+04	9.363E+04	9.928E+04
@ 140 F	2.357E+02	2.922E+02	8.068E+02	1.155E+03
Constant Power Viscosity, Pascal-Second				
@ 39.2 F	7.153E+07	5.839E+07	4.692E+08	4.667E+08
@ 60 F	3.372E+06	8.621E+06	8.506E+06	7.754E+06
@ 77 F	2.871E+05	5.003E+05	6.009E+05	4.969E+05
@ 90 F	5.491E+04	7.223E+04	9.326E+04	9.921E+04
@ 140 F	1.680E+02	3.077E+02	6.016E+02	6.500E+02

Table C-6 (Continued)

Parameter	Shamrock AC-20	Fina AC-10 & 3% Styrelf	Fina AC-10 & 3% Kraton	Fina AC-10 & 6% Kraton
Penetration Index PI(Pen/Pen)	-0.25	0.26	0.33	0.44
Penetration Index PI(Pen/SP)	0.21	1.35	2.55	3.92
Penetration Viscosity Number	-0.03	0.73	0.12	1.25
Stiffness Modulus @ 39.2 F, psi				
5 Sec. Loading	1160	464	435	232
20 Sec. Loading	508	218	218	131
Stiffness Modulus @ 0.1 Sec				
39.2F	7540	2900	2320	943
77F	334	203	232	160
104F	26	25	41	32
Stiffness/Temperature Slope	-0.068	-0.057	-0.049	-0.041
Apparent Viscosity/Temp. Slop	-0.086	-0.103	-0.095	-0.091
Constant Power Visco./Temp. S	-0.100	-0.097	-0.103	-0.102
Penetration Ratio, 77 F	0.68	0.63	0.57	0.69
Viscosity Ratio	2.60	2.70	1.69	-
Kinematic Viscosity Ratio	1.43	1.29	1.26	1.04
Maximum True Stress Ratio	1.70	1.58	0.89	0.70
Maximum True Strain Ratio	0.66	0.86	0.84	0.92
True Area Ratio	1.20	1.46	1.08	1.05
Asphalt Modulus Ratio	0.91	1.66	1.56	1.77
Asphalt-Polymer Modulus Ratio	-	1.43	0.81	0.51

Table C-7 Unmodified and Modified Asphalt Properties after RTFOT.

Parameter	Shamrock AC-20	Fina AC-10 & 3% Styrelf	Fina AC-10 & 3% Kraton	Fina AC-10 & 6% Kraton
Penetration @ 77 F (4 C)	44	56	47	68
100g, 5 Sec.	46	57	47	67
Avg.	45	56	47	67
Viscosity @ 140 F (60 C)	5210	7465	13788	-
Poises	5194	7496	13709	-
Avg.	5202	7481	13749	-
Viscosity @ 275 F (135 C)	892	1017	746	1052
Centistokes	896	1001	725	1048
Avg.	894	1009	736	1050
Maximum True Stress, psi	203	460	426	412
	205	451	422	419
Avg.	204	456	424	416
Maximum True Strain, in/in	1.63	2.54	2.66	2.56
	1.30	2.54	2.58	2.56
Avg.	1.47	2.54	2.62	2.56
True Area , psi	167	512	527	366
	158	457	495	361
Avg.	163	485	511	364
Asphalt Modulus, psi	433	356	388	209
	422	341	392	198
Avg.	428	349	390	204
Asphalt-Polymer Modulus, psi	-	407	375	421
	-	393	356	413
Avg.	-	400	365	417

Table C-8 Constant Stress Rheometer Results for Unmodified and Modified Binders.

Test Temp.	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosoty Pascal-Sec	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosoty Pascal-Sec
		Shamrock AC-20			Fina AC-10 + 3% Styrelf	
T = 140 F	7.17E+04	6.09E+02	1.18E+02	1.77E+05	5.39E+02	3.28E+02
	4.78E+04	3.74E+02	1.28E+02	1.13E+05	3.49E+02	3.23E+02
	2.23E+04	1.60E+02	1.40E+02	6.19E+04	1.92E+02	3.22E+02
	1.45E+04	1.00E+02	1.44E+02	2.88E+04	9.08E+01	3.17E+02
	1.00E+04	6.72E+01	1.49E+02	1.43E+04	4.56E+01	3.13E+02
	6.16E+03	3.94E+01	1.57E+02			
	4.08E+03	2.38E+01	1.71E+02			
T = 90 F	6.13E+05	2.16E+01	2.84E+04	8.99E+05	9.76E+00	9.21E+04
	3.67E+05	1.12E+01	3.27E+04	5.73E+05	6.82E+00	8.40E+04
	2.50E+05	6.83E+00	3.66E+04	4.01E+05	5.10E+00	7.86E+04
	1.50E+05	3.25E+00	4.61E+04	2.72E+05	3.51E+00	7.75E+04
	7.13E+04	1.27E+00	5.63E+04	1.58E+05	2.10E+00	7.50E+04
	3.71E+04	5.55E-01	6.68E+04	6.81E+04	9.31E-01	7.31E+04
				3.73E+04	5.50E-01	6.77E+04
T = 77 F	1.30E+06	1.16E+01	1.12E+05	1.73E+06	2.99E+00	5.78E+05
	7.69E+05	6.47E+00	1.19E+05	1.08E+06	1.92E+00	5.64E+05
	4.27E+05	2.49E+00	1.71E+05	6.24E+05	1.14E+00	5.49E+05
	2.51E+05	1.05E+00	2.39E+05	4.38E+05	8.68E-01	5.05E+05
	1.60E+05	5.00E-01	3.20E+05	2.03E+05	4.04E-01	5.01E+05
	9.07E+04	2.32E-01	3.91E+05	1.02E+05	2.17E-01	4.72E+05
	5.44E+04	1.09E-01	5.01E+05	5.70E+04	1.25E-01	4.57E+05
T = 60 F	1.56E+06	7.36E-01	2.12E+06	2.52E+06	2.34E-01	1.08E+07
	1.25E+06	4.97E-01	2.51E+06	1.32E+06	1.48E-01	8.90E+06
	7.27E+05	2.40E-01	3.03E+06	8.00E+05	9.79E-02	8.17E+06
	3.54E+05	8.66E-02	4.08E+06	5.43E+05	7.15E-02	7.59E+06
	1.90E+05	3.34E-02	5.70E+06	2.64E+05	3.66E-02	7.22E+06
	1.12E+05	1.64E-02	6.81E+06			
T = 39 F	4.48E+06	9.12E-02	4.91E+07	4.22E+06	6.08E-02	6.94E+07
	3.44E+06	6.77E-02	5.08E+07	2.75E+06	4.46E-02	6.15E+07
	2.24E+06	3.00E-02	7.47E+07	2.12E+06	3.94E-02	5.38E+07
	1.42E+06	1.08E-02	1.32E+08	1.32E+06	2.75E-02	4.78E+07
	8.50E+05	3.24E-03	2.63E+08	5.94E+05	1.33E-02	4.46E+07
	4.71E+05	1.09E-03	4.33E+08	3.05E+05	7.39E-03	4.13E+07

Table C-8 (Continued)

Test Temp.	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosoty Pascal-Sec	Shear Stress Pascal	Shear Rate 1/Sec	Apparent Viscosoty Pascal-Sec
	Fina AC-10 + 3% D1101			Fina AC-10 + 6% D1101		
T = 140 F	252757	654.6625	386	1.11E+05	3.58E+02	3.11E+02
	125428	286.1959	438	5.99E+04	1.66E+02	3.61E+02
	58153	128.4989	453	3.42E+04	8.40E+01	4.07E+02
	38009	81.7783	465	1.77E+04	3.67E+01	4.81E+02
	22805	45.3805	503	8.55E+03	1.25E+01	6.83E+02
	11022	17.9958	613			
T = 90 F	715175	9.6567	74060	7.36E+05	1.09E+01	6.75E+04
	464864	6.0527	76803	4.36E+05	6.29E+00	6.93E+04
	354012	4.4168	80151	2.79E+05	3.85E+00	7.23E+04
	232432	2.8421	81781	1.43E+05	1.74E+00	8.21E+04
	114428	1.3806	82881	6.28E+04	5.14E-01	1.22E+05
	64366	0.6438	99980			
	35759	0.3220	111064			
T = 77 F	761617	1.4764	515861	8.96E+05	2.37E+00	3.77E+05
	391689	0.6949	563665	5.29E+05	1.38E+00	3.83E+05
	304647	0.5236	581804	3.29E+05	8.19E-01	4.02E+05
	174084	0.2660	654336	1.89E+05	4.08E-01	4.64E+05
	108802	0.1631	667269	1.13E+05	1.99E-01	5.70E+05
	59841	0.0856	699101	5.29E+04	6.01E-02	8.80E+05
T = 60 F	1257023	0.1514	8305253	1.67E+06	2.50E-01	6.66E+06
	817065	0.0923	8855215	1.24E+06	1.68E-01	7.37E+06
	488842	0.0568	8612855	8.19E+05	1.02E-01	8.02E+06
	237438	0.0225	10534952	5.28E+05	6.27E-02	8.42E+06
	146653	0.0131	11157969	2.78E+05	2.81E-02	9.89E+06
T = 39 F	4888710	0.0096	509796267	3.75E+06	7.31E-03	5.13E+08
	2190286	0.0034	641791231	2.37E+06	3.40E-03	6.95E+08
	1244304	0.0018	676990317	1.26E+06	1.66E-03	7.61E+08
	901718	0.0011	812140444	9.14E+05	1.07E-03	8.51E+08
				5.38E+05	5.79E-04	9.31E+08

Table C-9 Marshall and Hveem Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES	
					STABILITY lbs	FLOW .01 in
Control: Shamrock AC-20		7.4	36	7.4	1089	17.0
		6.5	36	7.5	1198	16.0
		6.5	36	6.7	1249	16.0
	AVG.	6.8	36	7.2	1179	16.3
Fina AC-10 + 3% Styrelf		6.5	34	7.1	1528	20.0
		6.5	36	7.0	1780	21.0
		6.6	37	7.4	1624	20.0
	AVG.	6.5	36	7.2	1644	20.3
Fina AC-10 + 3% D1101		7.3	36	7.3	1630	20.0
		7.4	37	7.1	1562	20.0
		7.1	36	7.2	1745	20.0
	AVG.	7.3	36	7.2	1646	20.0
Fina AC-10 + 6% D1101		6.9	32	7.5	1519	25.0
		7.6	32	7.3	1521	22.0
		7.1	34	7.1	1347	21.0
	AVG.	7.2	33	7.3	1462	22.7

Table C-10 Marshall and Hveem Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES	
					STABILITY lbs	FLOW .01 in
Control: Shamrock AC-20		3.0	43	3.2	2207	14.0
		2.7	41	2.3	2514	15.0
		3.3	44	3.1	2480	15.0
	AVG.	3.0	43	2.9	2400	14.7
Fina AC-10 + 3% Styrelf		2.5	42	2.3	3297	17.0
		2.5	40	2.2	3105	18.0
		2.7	47	2.2	3145	17.0
	AVG.	2.6	43	2.2	3182	17.3
Fina AC-10 + 3% D1101		3.0	46	2.6	3200	16.0
		2.4	40	3.0	3014	16.0
		2.9	44	2.5	3192	17.0
	AVG.	2.8	43	2.7	3136	16.3
Fina AC-10 + 6% D1101		1.7	42	1.9	3518	18.0
		1.7	43	2.2	3430	19.0
		2.6	45	2.4	3590	19.0
	AVG.	2.0	43	2.2	3513	18.7

Table C-11 Marshall and Hveem Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES STABILITY lbs	FLOW .01 in
Fina AC-10 + 3% Styrelf		7.8	40	7.6	2054	21.0
		7.6	42	7.7	1946	21.0
		7.3	43	7.9	2021	21.0
	AVG.	7.6	42	7.7	2007	21.0
Fina AC-10 + 3% D1101		6.7	38	6.6	1723	22.0
		6.9	39	6.7	2013	24.0
		6.8	39	6.8	1856	24.0
	AVG.	6.8	39	6.7	1864	23.3
Fina AC-10 + 6% D1101		6.4	42	6.9	2218	20.0
		6.9	42	6.6	2416	20.0
		6.7	42	6.7	2272	19.5
	AVG.	6.7	42	6.7	2302	19.8

Table C-12 Marshall and Hveem Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Standard Compaction.

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES STABILITY lbs	FLOW .01 in
Fina AC-10 + 3% Styrelf		3.7	46	3.7	3676	20.0
		4.0	43	3.9	3484	19.5
		4.1	45	4.1	3565	18.5
	AVG.	3.9	45	3.9	3575	19.3
Fina AC-10 + 3% D1101		2.8	42	2.9	3182	17.5
		2.7	43	2.5	3697	19.5
		2.9	43	2.7	3487	20.0
	AVG.	2.8	43	2.7	3455	19.0
Fina AC-10 + 6% D1101		3.5	44	3.7	3790	19.5
		3.4	47	3.7	3507	18.5
		3.2	44	3.6	3737	18.5
	AVG.	3.4	45	3.7	3678	18.8

Table C-13 Indirect Tensile Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

Type MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Shamrock AC-20	39		7.2	378	0.24	316	677	0.02
			7.6	402	0.26	309	754	0.02
			7.1	416	0.33	254	842	0.05
		AVG.	7.3	399	0.28	293	758	0.03
Fina AC-10 + 3% Styrelf	39		7.0	447	0.42	215	476	0.08
			6.6	491	0.40	245	441	0.26
			7.0	464	0.40	235	821	0.12
		AVG.	6.9	467	0.40	231	579	0.15
Fina AC-10 + 3% D1101	39		7.2	409	0.40	204	508	0.28
			7.4	416	0.40	207	859	0.04
			7.3	418	0.42	201	816	0.18
		AVG.	7.3	414	0.41	204	728	0.17
Fina AC-10 + 6% D1101	39		7.3	298	1.04	57	628	0.16
			7.2	291	1.01	57	625	0.18
			6.5	268	1.04	51	465	0.29
		AVG.	7.0	286	1.03	55	573	0.21
Control: Shamrock AC-20	77		7.6	91	0.86	21.1	377	0.10
			7.5	89	-	-	286	0.21
			7.1	84	0.88	19.0	274	0.22
		AVG.	7.4	88	0.87	20.1	313	0.18
Fina AC-10 + 3% Styrelf	77		7.0	125	1.79	13.9	232	0.24
			6.1	133	1.72	15.4	272	0.19
			6.8	112	1.77	12.6	258	0.20
		AVG.	6.6	123	1.76	14.0	254	0.21
Fina AC-10 + 3% D1101	77		6.9	98	1.82	10.8	170	0.39
			7.5	101	1.82	11.1	218	0.22
			7.0	96	1.87	10.2	276	0.12
		AVG.	7.1	98	1.84	10.7	221	0.24
Fina AC-10 + 6% D1101	77		7.0	80	3.38	4.8	95	0.43
			7.1	72	3.40	4.2	77	0.50
			7.0	87	3.35	5.2	120	0.29
		AVG.	7.0	80	3.38	4.7	98	0.41

Table C-13 (Continued)

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Shamrock AC-20	104		6.5	28	1.25	4.4	107	0.26
			6.3	27	1.29	4.1	121	0.16
			7.5	25	1.26	4.0	122	0.37
			----	----	----	----	----	----
		AVG.	6.8	27	1.27	4.2	117	0.26
Fina AC-10 + 3% Styrelf	104		6.5	43	2.32	3.7	57	0.58
			6.7	45	2.26	4.0	66	0.50
			6.9	39	2.27	3.4	59	0.54
			----	----	----	----	----	----
		AVG.	6.7	42	2.28	3.7	60	0.54
Fina AC-10 + 3% D1101	104		7.2	31	2.41	2.6	45	0.59
			7.1	33	2.47	2.6	53	0.51
			7.4	30	2.58	2.3	56	0.44
			----	----	----	----	----	----
		AVG.	7.2	31	2.49	2.5	51	0.51
Fina AC-10 + 6% D1101			7.5	28	3.90	1.4	31	0.63
			6.9	28	3.64	1.5	57	0.26
			7.1	29	4.00	1.5	49	0.30
			----	----	----	----	----	----
		AVG.	7.2	28	3.85	1.5	46	0.40

Table C-14 Indirect Tensile Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Standard Compaction.

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Shamrock AC-20	39		3.2	516	0.18	567	976	0.20
			2.8	603	0.25	483	933	0.20
			2.8	587	0.22	525	1292	0.09
		AVG.	2.9	569	0.22	525	1067	0.16
Fina AC-10 + 3% Styrelf	39		2.4	666	0.44	301	1093	0.16
			2.0	715	0.47	305	974	0.15
			2.3	670	0.47	286	1029	0.25
		AVG.	2.2	684	0.46	297	1032	0.19
Fina AC-10 + 3% D1101	39		2.6	646	0.37	345	1182	0.08
			2.9	602	0.35	345	775	0.11
			2.4	627	0.35	354	843	0.31
		AVG.	2.6	625	0.36	348	933	0.17
Fina AC-10 + 6% D1101	39		1.5	521	0.92	113	692	0.28
			1.7	519	0.96	108	642	0.24
			1.9	496	0.90	109	655	0.25
		AVG.	1.7	512	0.93	110	663	0.26
Control: Shamrock AC-20	77		3.0	122	0.92	26.6	321	0.18
			3.3	120	0.82	-	355	0.22
			3.0	122	0.88	27.5	281	0.48
		AVG.	3.1	121	0.87	27.1	319	0.30
Fina AC-10 + 3% Styrelf	77		2.2	175	1.59	22.0	301	0.34
			2.2	177	1.63	21.7	303	0.31
			1.9	177	1.72	20.6	283	0.36
		AVG.	2.1	176	1.64	21.4	296	0.33
Fina AC-10 + 3% D1101	77		3.1	167	1.25	26.7	293	0.30
			2.8	171	1.17	29.1	322	0.30
			3.1	166	1.32	25.2	332	0.32
		AVG.	3.0	168	1.24	27.0	316	0.30
Fina AC-10 + 6% D1101	77		2.0	132	2.44	10.8	185	0.24
			1.9	140	2.34	12.0	160	0.40
			1.9	123	2.44	10.1	163	0.32
		AVG.	1.9	132	2.41	10.9	169	0.32

Table C-14 (Continued)

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Shamrock AC-20	104		2.4	38	1.25	6.1	103	0.48
			3.0	37	1.24	6.0	99	0.44
			2.8	39	1.26	6.1	102	0.39
			----	----	----	----	----	----
		AVG.	2.7	38	1.25	6.1	101	0.44
Fina AC-10 + 3% Styrelf	104		2.5	60	2.05	5.9	90	0.41
			2.2	62	2.18	5.7	88	0.52
			2.8	61	2.08	5.9	62	0.67
			----	----	----	----	----	----
		AVG.	2.5	61	2.10	5.8	80	0.53
Fina AC-10 + 3% D1101	104		3.1	56	2.08	5.3	61	0.64
			2.7	59	1.87	6.3	90	0.45
			2.9	61	1.94	6.2	62	0.72
			----	----	----	----	----	----
		AVG.	2.9	58	1.96	5.9	71	0.60
Fina AC-10 + 6% D1101			2.3	50	3.74	2.7	68	0.38
			2.2	50	3.41	2.9	67	0.47
			1.8	53	3.20	3.3	52	0.52
			----	----	----	----	----	----
		AVG.	2.1	51	3.45	3.0	62	0.46

Table C-15 Indirect Tensile Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Fina AC-10 + 3% Styrelf	39		7.7	434	0.37	232	584	-
			7.7	467	0.43	219	473	-
			7.6	456	0.41	224	459	-
		AVG.	7.7	452	0.40	225	505	-
Fina AC-10 + 3% D1101	39		6.7	426	0.42	202	915	-
			6.7	403	0.47	172	622	-
			6.7	411	0.47	175	654	-
		AVG.	6.7	413	0.45	183	730	-
Fina AC-10 + 6% D1101	39		6.7	404	0.77	105	638	-
			6.8	386	0.78	99	471	-
			6.8	387	0.76	101	621	-
		AVG.	6.8	393	0.77	102	577	-
Fina AC-10 + 3% Styrelf	77		7.7	141	1.23	22.9	219	-
			7.6	124	1.22	20.2	257	-
			7.7	140	1.16	24.0	313	-
		AVG.	7.7	135	1.20	22.4	263	-
Fina AC-10 + 3% D1101	77		7.0	121	1.73	14.0	291	-
			7.1	118	1.60	14.7	199	-
			6.8	115	1.83	12.6	223	-
		AVG.	7.0	118	1.72	13.7	238	-
Fina AC-10 + 6% D1101	77		6.5	116	1.79	12.9	149	-
			6.8	121	1.97	12.3	148	-
			6.8	111	2.08	10.6	202	-
		AVG.	6.7	116	1.95	11.9	166	-
Fina AC-10 + 3% Styrelf	104		7.7	45	1.69	5.3	101	0.26
			7.4	46	1.68	5.5	139	0.13
			7.5	49	1.77	5.5	131	0.23
		AVG.	7.5	47	1.71	5.5	124	0.21
Fina AC-10 + 3% D1101	104		7.0	38	2.09	3.7	83	0.28
			6.5	40	2.17	3.7	72	0.49
			6.9	37	2.31	3.2	117	0.25
		AVG.	6.8	39	2.19	3.5	91	0.34
Fina AC-10 + 6% D1101	104		6.4	41	2.69	3.1	57	0.38
			6.3	43	2.49	3.5	65	0.34
			6.5	43	2.76	3.1	63	0.44
		AVG.	6.4	43	2.65	3.2	61	0.39

Table C-16 Indirect Tensile Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Standard Compaction.

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Fina AC-10 + 3% Styrelf	39		3.8	659	0.31	422	855	-
			3.8	637	0.33	388	1042	-
			3.9	644	0.28	458	758	-
		AVG.	3.8	647	0.31	423	885	-
Fina AC-10 + 3% D1101	39		2.6	614	0.28	437	682	-
			2.4	636	0.34	370	1188	-
			2.9	638	0.36	350	938	-
		AVG.	2.6	630	0.33	386	936	-
Fina AC-10 + 6% D1101	39		3.3	495	0.68	146	765	-
			3.4	539	0.70	153	602	-
			3.5	527	0.84	126	516	-
		AVG.	3.4	520	0.74	142	628	-
Fina AC-10 + 3% Styrelf	77		3.7	213	1.17	36.4	363	-
			3.7	210	0.00	-	494	-
			3.9	208	1.09	38.0	423	-
		AVG.	3.8	210	0.75	37.2	427	-
Fina AC-10 + 3% D1101	77		2.7	204	1.25	32.6	382	-
			2.6	203	1.24	32.8	357	-
			2.4	196	1.19	32.8	167	-
		AVG.	2.6	201	1.23	32.7	302	-
Fina AC-10 + 6% D1101	77		3.4	171	1.82	18.8	226	-
			3.3	165	1.87	17.6	197	-
			3.5	162	1.81	17.8	179	-
		AVG.	3.4	166	1.83	18.1	200	-
Fina AC-10 + 3% Styrelf	104		4.0	75	1.63	9.2	122	0.33
			3.8	72	1.37	10.6	179	-
			3.7	75	1.53	9.8	128	-
		AVG.	3.8	74	1.51	9.9	143	0.33
Fina AC-10 + 3% D1101	104		2.5	73	1.78	8.1	124	0.27
			2.7	72	1.72	8.3	115	0.39
			2.9	73	1.67	8.8	123	0.25
		AVG.	2.7	73	1.72	8.4	121	0.30
Fina AC-10 + 6% D1101			3.5	60	2.49	4.8	79	0.41
			3.5	60	2.13	5.7	88	0.28
			3.5	60	2.62	4.6	83	0.39
		AVG.	3.5	60	2.41	5.0	84	0.36

Table C-17 Alpha and Gnu Parameters for Laboratory Mixed/Laboratory Compacted Mixtures.

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	RESILIEN STRAIN IN/IN	ALPHA	GNU	Ea=IN^S		R-SQUR FOR Ea=IN^S
								S	LOG(I)	
Control: SHAMROCK AC-20	77	7.3	195	13.0	5.2E-05	0.3486	0.1666	0.6514	-4.8761	0.995
		6.8	195	13.2	5.2E-05	0.3930	0.2000	0.6070	-4.7661	0.993
	AVG.	7.1	195	13.1	5.2E-05	0.3708	0.1833	0.6292	-4.8211	
Fina AC-10 + 3% Styrelf	77	7.5	271	18.3	8.1E-05	0.4424	0.5312	0.5576	-4.1147	0.997
		6.6	271	18.4	8.1E-05	0.5039	0.3732	0.4961	-4.2173	0.989
	AVG.	7.1	271	18.3	8.1E-05	0.4732	0.4522	0.5269	-4.1660	
Fina AC-10 + 3% D1101	77	7.3	215	14.5	6.5E-05	0.3998	0.3732	0.6002	-4.3934	0.995
		7.5	215	14.4	6.5E-05	0.3514	0.3197	0.6486	-4.4943	0.991
	AVG.	7.4	215	14.4	6.5E-05	0.3756	0.3465	0.6244	-4.4439	
Fina AC-10 + 6% D1101	77	7.6	175	11.6	1.1E-04	0.5250	0.8722	0.4750	-3.7083	0.993
		6.5	175	11.6	1.1E-04	0.4910	0.3749	0.5090	-4.1050	0.995
	AVG.	7.1	175	11.6	1.1E-04	0.5080	0.6236	0.4920	-3.9067	

Table C-18 Alpha and Gnu Parameters for Plant Mixed/Laboratory Compacted Mixtures.

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	RESILIEN STRAIN IN/IN	ALPHA	GNU	Ea=IN^S		R-SQUR FOR Ea=IN^S
								S	LOG(I)	
Fina AC-10 + 3% Styrelf	77	7.6	292	19.1	7.8E-05	0.4283	0.3920	0.5717	-4.2718	0.999
		7.8	292	19.0	7.8E-05	0.4171	0.2756	0.5829	-4.4332	0.999
	AVG.	7.7	292	19.1	7.8E-05	0.4227	0.3338	0.5773	-4.3525	
Fina AC-10 + 3% D1101	77	6.8	270	17.5	8.6E-05	0.4018	0.3584	0.5982	-4.2890	0.997
		6.6	270	17.7	8.3E-05	0.4124	0.2327	0.5876	-4.4822	0.981
	AVG.	6.7	270	17.6	8.5E-05	0.4071	0.2955	0.5929	-4.3856	
Fina AC-10 + 6% D1101	77	6.4	259	17.1	1.2E-04	0.4042	0.2962	0.5958	-4.2353	0.991
		6.8	260	17.1	1.2E-04	0.5000	0.4103	0.5000	-4.0177	0.994
	AVG.	6.6	259	17.1	1.2E-04	0.4521	0.3533	0.5479	-4.1265	

Table C-19 Fatigue Parameter Values for Laboratory Mixed/Laboratory Compacted Mixtures.

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	STATIC MODULUS KSI	INITIAL STRAIN IN/IN	LOAD CYCLES	FATIGUE CONSTANT K1	FATIGUE CONSTANT K2	R-SQUR FOR Nf=K1(1/Emix)^K
Control: SHAMROCK AC-20	77	7.3	195	13.0	109	1.2E-04	77000	1.72E-08	3.27	0.96
		6.8	195	13.2	109	1.2E-04	140220			
		7.0	320	21.5	109	2.0E-04	18000			
		6.6	325	22.2	109	2.0E-04	37500			
		6.9	646	44.1	109	4.0E-04	2329			
		7.3	646	43.2	109	4.0E-04	1806			
Fina AC-10 + 3% Styrelf	77	7.5	271	18.3	102	1.8E-04	19200	1.59E-07	3.02	0.94
		6.6	271	18.4	102	1.8E-04	59400			
		6.7	451	30.5	102	3.0E-04	8735			
		7.2	454	30.6	102	3.0E-04	5760			
		7.0	900	60.2	102	5.9E-04	837			
		6.4	900	61.1	102	6.0E-04	975			
Fina AC-10 + 3% D1101	77	7.3	215	14.5	78	1.9E-04	29600	2.39E-07	2.98	0.99
		7.5	215	14.4	78	1.8E-04	28800			
		7.0	360	24.2	78	3.1E-04	8000			
		7.2	360	24.2	78	3.1E-04	7200			
		7.5	703	46.9	78	6.0E-04	1000			
		7.4	705	47.7	78	6.1E-04	750			
Fina AC-10 + 6% D1101	77	7.6	175	11.6	63	1.8E-04	18786	1.49E-07	3.03	0.90
		6.5	175	11.6	63	1.8E-04	73234			
		7.2	290	19.1	63	3.0E-04	4575			
		6.9	290	19.1	63	3.0E-04	5222			
		6.8	585	38.9	63	6.2E-04	1268			
		7.6	590	38.9	63	6.2E-04	640			

Table C-20 Fatigue Parameter Values for Plant Mixed/Laboratory Compacted Mixtures.

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	STATIC MODULUS KSI	INITIAL STRAIN IN/IN	LOAD CYCLES	FATIGUE CONSTANT K1	FATIGUE CONSTANT K2	R-SQUR FOR Nf=K1(1/Emix)^K
Fina AC-10 + 3% Styrelf	77	7.6	292	19.1	110	1.7E-04	19140	1.89E-07	2.95	0.98
		7.8	292	19.0	110	1.7E-04	21800			
		7.2	513	33.2	110	3.0E-04	4130			
		7.9	513	33.5	110	3.0E-04	7090			
		7.3	1007	65.7	110	6.0E-04	539			
		7.5	1012	65.9	110	6.0E-04	539			
Fina AC-10 + 3% D1101	77	6.8	270	17.5	81	2.2E-04	16210	2.11E-07	2.99	0.99
		6.6	270	17.7	81	2.2E-04	19100			
		6.7	442	28.9	81	3.6E-04	5310			
		6.9	444	29.0	81	3.6E-04	4360			
		6.9	864	56.3	81	7.0E-04	600			
		6.7	863	56.1	81	6.9E-04	513			
Fina AC-10 + 6% D1101	77	6.4	259	17.1	86	2.0E-04	18700	1.38E-08	3.30	0.99
		6.8	260	17.1	86	2.0E-04	26100			
		6.6	438	28.9	86	3.4E-04	4600			
		6.8	434	28.5	86	3.3E-04	3160			
		6.6	870	57.3	86	6.7E-04	420			
		6.5	885	58.2	86	6.8E-04	380			

Table C-21 Creep Compliance Properties for Laboratory Mixed/ Laboratory Compacted Mixture Using Modified Compaction.

MIXTURE	TEMP. F	D1	m	Log(SHIFT FACTOR)	BETA
Control: SHAMROCK AC-20	60	2.18E-06	0.42	0.96	0.044
	77	4.15E-06	0.52		
	90	4.96E-06	0.61	-0.40	
Fina AC-10 + 3% Styrelf	60	3.53E-06	0.45	1.14	0.067
	77	1.07E-05	0.48		
	90	3.01E-05	0.45	-0.87	
Fina AC-10 + 3% D1101	60	2.44E-06	0.52	1.30	0.056
	77	1.33E-05	0.45		
	90	2.77E-05	0.38	-0.45	
Fina AC-10 + 6% D1101	60	9.45E-06	0.43	1.05	0.048
	77	2.99E-05	0.39		
	90	5.92E-05	0.31	-0.46	

Table C-22 Creep Compliance Properties for Plant Mixed/ Laboratory Compacted Mixture Using Modified Compaction.

MIXTURE	TEMP. F	D1	m	Log(SHIFT FACTOR)	BETA
Fina AC-10 + 3% Styrelf	60	2.94E-06	0.38	1.91	0.075
	77	1.49E-05	0.39		
	90	2.56E-05	0.36	-0.50	
Fina AC-10 + 3% D1101	60	4.27E-06	0.38	1.36	0.056
	77	1.18E-05	0.45		
	90	1.75E-05	0.45	-0.41	
Fina AC-10 + 6% D1101	60	5.60E-06	0.38	0.93	0.047
	77	1.76E-05	0.29		
	90	2.51E-05	0.28	-0.51	

Table C-23 Creep Compliance of Laboratory Mixed / Laboratory Compacted Mixtures Using Modified Compaction.

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
SHAMROCK AC-20 TEST TEMP = 60 , ZIGMA = 10.122 PSI				SHAMROCK AC-20 TEST TEMP = 60 , ZIGMA = 10.170 PSI			
1.0	1.10E-04	5.72E-05	2.83E-06	1.0	1.25E-04	6.50E-05	3.20E-06
1.8	1.25E-04	6.50E-05	3.21E-06	1.8	1.40E-04	7.28E-05	3.58E-06
3.2	1.39E-04	7.23E-05	3.57E-06	3.2	1.50E-04	7.80E-05	3.84E-06
5.6	1.80E-04	9.36E-05	4.62E-06	5.6	1.80E-04	9.36E-05	4.60E-06
10.0	2.18E-04	1.13E-04	5.59E-06	10.0	2.00E-04	1.04E-04	5.11E-06
18.0	2.77E-04	1.44E-04	7.10E-06	18.0	2.19E-04	1.14E-04	5.59E-06
31.6	3.53E-04	1.84E-04	9.07E-06	31.6	2.29E-04	1.19E-04	5.84E-06
56.2	4.45E-04	2.31E-04	1.14E-05	56.2	2.50E-04	1.30E-04	6.39E-06
100.0	5.95E-04	3.09E-04	1.53E-05	100.0	3.20E-04	1.66E-04	8.18E-06
177.8	8.20E-04	4.26E-04	2.11E-05	177.8	4.50E-04	2.34E-04	1.15E-05
316.2	1.10E-03	5.72E-04	2.83E-05	316.2	7.30E-04	3.80E-04	1.87E-05
562.3	1.50E-03	7.78E-04	3.84E-05	562.3	1.12E-03	5.80E-04	2.85E-05
1000.0	2.02E-03	1.05E-03	5.19E-05	1000.0	1.48E-03	7.70E-04	3.78E-05
1778.3	2.59E-03	1.35E-03	6.65E-05	1778.3	1.89E-03	9.83E-04	4.83E-05
3162.3	3.37E-03	1.75E-03	8.66E-05	3162.3	2.55E-03	1.33E-03	6.52E-05
3600.0	3.59E-03	1.86E-03	9.21E-05	3600.0	2.69E-03	1.40E-03	6.87E-05
7200.0	3.01E-03	1.57E-03		7200.0	1.93E-03	1.00E-03	
SHAMROCK AC-20 TEST TEMP = 77 , ZIGMA =4.052 PSI				SHAMROCK AC-20 TEST TEMP = 77 , ZIGMA = 4.037 PSI			
1.0	5.75E-05	2.99E-05	3.69E-06	1.0	8.50E-05	4.42E-05	5.48E-06
1.8	7.00E-05	3.64E-05	4.49E-06	1.8	1.10E-04	5.72E-05	7.09E-06
3.2	9.50E-05	4.94E-05	6.10E-06	3.2	1.33E-04	6.89E-05	8.54E-06
5.6	1.33E-04	6.89E-05	8.50E-06	5.6	1.85E-04	9.62E-05	1.19E-05
10.0	1.73E-04	8.97E-05	1.11E-05	10.0	2.40E-04	1.25E-04	1.55E-05
18.0	2.30E-04	1.20E-04	1.48E-05	18.0	3.35E-04	1.74E-04	2.16E-05
31.6	2.95E-04	1.53E-04	1.89E-05	31.6	4.45E-04	2.31E-04	2.87E-05
56.2	4.15E-04	2.16E-04	2.66E-05	56.2	5.75E-04	2.99E-04	3.70E-05
100.0	6.10E-04	3.17E-04	3.91E-05	100.0	7.35E-04	3.82E-04	4.73E-05
177.8	8.55E-04	4.45E-04	5.49E-05	177.8	1.03E-03	5.36E-04	6.63E-05
316.2	1.23E-03	6.37E-04	7.86E-05	316.2	1.40E-03	7.26E-04	8.99E-05
562.3	1.75E-03	9.10E-04	1.12E-04	562.3	1.76E-03	9.15E-04	1.13E-04
1000.0	2.36E-03	1.23E-03	1.51E-04	1000.0	2.56E-03	1.33E-03	1.65E-04
1778.3	3.01E-03	1.57E-03	1.93E-04	1778.3	3.47E-03	1.80E-03	2.24E-04
3162.3	3.64E-03	1.89E-03	2.33E-04	3162.3	4.69E-03	2.44E-03	3.02E-04
3600.0	4.10E-03	2.13E-03	2.63E-04	3600.0	5.02E-03	2.61E-03	3.23E-04
7200.0	3.80E-03	1.98E-03		7200.0	4.55E-03	2.36E-03	

Table C-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
SHAMROCK AC-20 TEST TEMP = 90 , ZIGMA = 0.830 PSI				SHAMROCK AC-20 TEST TEMP = 90 , ZIGMA = 0.853 PSI			
1.0	1.60E-05	8.32E-06	5.01E-06	1.0	1.30E-05	6.76E-06	3.96E-06
1.8	2.75E-05	1.43E-05	8.62E-06	1.8	1.85E-05	9.62E-06	5.64E-06
3.2	3.45E-05	1.79E-05	1.08E-05	3.2	2.50E-05	1.30E-05	7.62E-06
5.6	5.00E-05	2.60E-05	1.57E-05	5.6	3.75E-05	1.95E-05	1.14E-05
10.0	6.50E-05	3.38E-05	2.04E-05	10.0	5.10E-05	2.65E-05	1.55E-05
18.0	9.50E-05	4.94E-05	2.98E-05	18.0	7.65E-05	3.98E-05	2.33E-05
31.6	1.53E-04	7.93E-05	4.78E-05	31.6	1.20E-04	6.24E-05	3.66E-05
56.2	2.60E-04	1.35E-04	8.15E-05	56.2	1.80E-04	9.36E-05	5.49E-05
100.0	4.15E-04	2.16E-04	1.30E-04	100.0	2.51E-04	1.31E-04	7.65E-05
177.8	6.00E-04	3.12E-04	1.88E-04	177.8	3.55E-04	1.85E-04	1.08E-04
316.2	8.00E-04	4.16E-04	2.51E-04	316.2	4.60E-04	2.39E-04	1.40E-04
562.3	1.10E-03	5.72E-04	3.45E-04	562.3	6.75E-04	3.51E-04	2.06E-04
1000.0	1.40E-03	7.28E-04	4.39E-04	1000.0	9.25E-04	4.81E-04	2.82E-04
1778.3	1.58E-03	8.19E-04	4.93E-04	1778.3	1.17E-03	6.06E-04	3.55E-04
3162.3	1.94E-03	1.01E-03	6.06E-04	3162.3	1.62E-03	8.40E-04	4.92E-04
3600.0	1.95E-03	1.01E-03	6.11E-04	3600.0	1.85E-03	9.60E-04	5.62E-04
7200.0	1.95E-03	1.01E-03		7200.0	1.81E-03	9.39E-04	
FINA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 12.292 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 12.197 PSI			
1.0	1.65E-04	8.58E-05	3.49E-06	1.0	1.65E-04	8.58E-05	3.52E-06
1.8	2.20E-04	1.14E-04	4.65E-06	1.8	1.95E-04	1.01E-04	4.16E-06
3.2	2.70E-04	1.40E-04	5.71E-06	3.2	2.15E-04	1.12E-04	4.58E-06
5.6	3.90E-04	2.03E-04	8.25E-06	5.6	3.08E-04	1.60E-04	6.56E-06
10.0	5.10E-04	2.65E-04	1.08E-05	10.0	3.90E-04	2.03E-04	8.32E-06
18.0	6.83E-04	3.55E-04	1.44E-05	18.0	5.55E-04	2.89E-04	1.18E-05
31.6	8.85E-04	4.60E-04	1.87E-05	31.6	7.90E-04	4.11E-04	1.68E-05
56.2	1.19E-03	6.16E-04	2.51E-05	56.2	1.11E-03	5.75E-04	2.36E-05
100.0	1.52E-03	7.88E-04	3.21E-05	100.0	1.48E-03	7.70E-04	3.16E-05
177.8	1.89E-03	9.80E-04	3.99E-05	177.8	1.88E-03	9.78E-04	4.01E-05
316.2	2.37E-03	1.23E-03	5.00E-05	316.2	2.41E-03	1.25E-03	5.13E-05
562.3	2.90E-03	1.51E-03	6.12E-05	562.3	3.07E-03	1.60E-03	6.55E-05
1000.0	3.52E-03	1.83E-03	7.44E-05	1000.0	3.82E-03	1.99E-03	8.14E-05
1778.3	4.23E-03	2.20E-03	8.94E-05	1778.3	4.79E-03	2.49E-03	1.02E-04
3162.3	5.28E-03	2.74E-03	1.12E-04	3162.3	5.97E-03	3.10E-03	1.27E-04
3600.0	5.53E-03	2.87E-03	1.17E-04	3600.0	6.29E-03	3.27E-03	1.34E-04
7200.0	4.49E-03	2.33E-03		7200.0	5.37E-03	2.79E-03	

Table C-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
	FINA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 5.756 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 5.783 PSI		
1.0	1.35E-04	7.02E-05	6.10E-06	1.0	2.00E-04	1.04E-04	8.99E-06
1.8	2.50E-04	1.30E-04	1.13E-05	1.8	3.00E-04	1.56E-04	1.35E-05
3.2	3.50E-04	1.82E-04	1.58E-05	3.2	3.85E-04	2.00E-04	1.73E-05
5.6	5.55E-04	2.89E-04	2.51E-05	5.6	5.60E-04	2.91E-04	2.52E-05
10.0	8.05E-04	4.19E-04	3.64E-05	10.0	7.35E-04	3.82E-04	3.31E-05
18.0	1.26E-03	6.53E-04	5.67E-05	18.0	1.02E-03	5.31E-04	4.59E-05
31.6	1.80E-03	9.36E-04	8.13E-05	31.6	1.35E-03	7.02E-04	6.07E-05
56.2	2.43E-03	1.26E-03	1.10E-04	56.2	1.75E-03	9.08E-04	7.85E-05
100.0	3.08E-03	1.60E-03	1.39E-04	100.0	2.25E-03	1.17E-03	1.01E-04
177.8	3.85E-03	2.00E-03	1.74E-04	177.8	2.80E-03	1.46E-03	1.26E-04
316.2	4.55E-03	2.37E-03	2.06E-04	316.2	3.49E-03	1.81E-03	1.57E-04
562.3	6.00E-03	3.12E-03	2.71E-04	562.3	4.30E-03	2.24E-03	1.93E-04
1000.0	7.30E-03	3.80E-03	3.30E-04	1000.0	5.30E-03	2.76E-03	2.38E-04
1778.3	8.50E-03	4.42E-03	3.84E-04	1778.3	6.65E-03	3.46E-03	2.99E-04
3162.3	1.05E-02	~~5.44E~~-03	4.72E-04	3162.3	8.60E-03	4.47E-03	3.87E-04
3600.0	1.11E-02	5.77E-03	5.01E-04	3600.0	9.15E-03	4.76E-03	4.11E-04
7200.0	1.00E-02	5.20E-03		7200.0	8.13E-03	4.23E-03	
	FINA AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 0.880 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 0.881 PSI		
1.0	8.00E-05	4.16E-05	2.36E-05	1.0	9.50E-05	4.94E-05	2.80E-05
1.8	1.15E-04	5.98E-05	3.40E-05	1.8	1.40E-04	7.28E-05	4.13E-05
3.2	1.50E-04	7.80E-05	4.43E-05	3.2	1.80E-04	9.36E-05	5.31E-05
5.6	2.08E-04	1.08E-04	6.15E-05	5.6	2.55E-04	1.33E-04	7.53E-05
10.0	2.68E-04	1.39E-04	7.90E-05	10.0	3.30E-04	1.72E-04	9.74E-05
18.0	3.48E-04	1.81E-04	1.03E-04	18.0	4.35E-04	2.26E-04	1.28E-04
31.6	4.56E-04	2.37E-04	1.35E-04	31.6	5.62E-04	2.92E-04	1.66E-04
56.2	6.25E-04	3.25E-04	1.85E-04	56.2	6.85E-04	3.56E-04	2.02E-04
100.0	8.75E-04	4.55E-04	2.59E-04	100.0	8.95E-04	4.65E-04	2.64E-04
177.8	1.18E-03	6.11E-04	3.47E-04	177.8	1.23E-03	6.40E-04	3.63E-04
316.2	1.53E-03	7.96E-04	4.52E-04	316.2	1.65E-03	8.58E-04	4.87E-04
562.3	2.03E-03	1.05E-03	5.98E-04	562.3	2.03E-03	1.06E-03	5.99E-04
1000.0	2.51E-03	1.31E-03	7.42E-04	1000.0	2.42E-03	1.26E-03	7.13E-04
1778.3	2.97E-03	1.54E-03	8.76E-04	1778.3	2.87E-03	1.49E-03	8.47E-04
3162.3	3.45E-03	1.79E-03	1.02E-03	3162.3	3.40E-03	1.77E-03	1.00E-03
3600.0	3.58E-03	1.86E-03	1.06E-03	3600.0	3.55E-03	1.85E-03	1.05E-03
7200.0	3.39E-03	1.76E-03		7200.0	3.41E-03	1.77E-03	

Table C-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% KRATON D1101 TEST TEMP = 60 , ZIGMA = 10.634 PSI				FINA AC-10 + 3% KRATON D1101 TEST TEMP = 60 , ZIGMA = 10.523 PSI			
1.0	7.00E-05	3.64E-05	1.71E-06	1.0	1.20E-04	6.24E-05	2.97E-06
1.8	1.05E-04	5.46E-05	2.57E-06	1.8	1.55E-04	8.06E-05	3.83E-06
3.2	1.30E-04	6.76E-05	3.18E-06	3.2	1.90E-04	9.88E-05	4.70E-06
5.6	2.03E-04	1.05E-04	4.95E-06	5.6	2.75E-04	1.43E-04	6.80E-06
10.0	2.74E-04	1.42E-04	6.69E-06	10.0	3.75E-04	1.95E-04	9.27E-06
18.0	3.95E-04	2.05E-04	9.66E-06	18.0	5.00E-04	2.60E-04	1.24E-05
31.6	5.65E-04	2.94E-04	1.38E-05	31.6	6.50E-04	3.38E-04	1.61E-05
56.2	7.38E-04	3.84E-04	1.80E-05	56.2	8.80E-04	4.58E-04	2.17E-05
100.0	1.13E-03	5.85E-04	2.75E-05	100.0	1.24E-03	6.42E-04	3.05E-05
177.8	1.52E-03	7.88E-04	3.70E-05	177.8	1.74E-03	9.05E-04	4.30E-05
316.2	2.08E-03	1.08E-03	5.07E-05	316.2	2.39E-03	1.24E-03	5.89E-05
562.3	2.70E-03	1.40E-03	6.60E-05	562.3	3.23E-03	1.68E-03	7.97E-05
1000.0	3.44E-03	1.79E-03	8.40E-05	1000.0	3.84E-03	1.99E-03	9.48E-05
1778.3	4.33E-03	2.25E-03	1.06E-04	1778.3	4.53E-03	2.35E-03	1.12E-04
3162.3	5.37E-03	2.79E-03	1.31E-04	3162.3	5.63E-03	2.93E-03	1.39E-04
3600.0	5.67E-03	2.95E-03	1.39E-04	3600.0	5.93E-03	3.08E-03	1.46E-04
7200.0	4.65E-03	2.42E-03		7200.0	5.08E-03	2.64E-03	
FINA AC-10 + 3% KRATON D1101 TEST TEMP = 77 , ZIGMA =4.613 PSI				FINA AC-10 + 3% KRATON D1101 TEST TEMP = 77 , ZIGMA = 4.581 PSI			
1.0	1.40E-04	7.28E-05	7.89E-06	1.0	2.40E-04	1.25E-04	1.36E-05
1.8	2.30E-04	1.20E-04	1.30E-05	1.8	3.30E-04	1.72E-04	1.87E-05
3.2	3.15E-04	1.64E-04	1.78E-05	3.2	4.40E-04	2.29E-04	2.50E-05
5.6	4.90E-04	2.55E-04	2.76E-05	5.6	5.65E-04	2.94E-04	3.21E-05
10.0	6.80E-04	3.54E-04	3.83E-05	10.0	7.25E-04	3.77E-04	4.12E-05
18.0	9.55E-04	4.97E-04	5.38E-05	18.0	9.50E-04	4.94E-04	5.39E-05
31.6	1.33E-03	6.89E-04	7.47E-05	31.6	1.23E-03	6.37E-04	6.95E-05
56.2	1.75E-03	9.10E-04	9.87E-05	56.2	1.61E-03	8.35E-04	9.11E-05
100.0	2.24E-03	1.16E-03	1.26E-04	100.0	2.06E-03	1.07E-03	1.17E-04
177.8	2.73E-03	1.42E-03	1.54E-04	177.8	2.70E-03	1.40E-03	1.53E-04
316.2	3.40E-03	1.77E-03	1.92E-04	316.2	3.35E-03	1.74E-03	1.90E-04
562.3	4.18E-03	2.17E-03	2.35E-04	562.3	4.23E-03	2.20E-03	2.40E-04
1000.0	5.03E-03	2.61E-03	2.83E-04	1000.0	5.33E-03	2.77E-03	3.02E-04
1778.3	6.15E-03	3.20E-03	3.47E-04	1778.3	6.78E-03	3.52E-03	3.85E-04
3162.3	7.51E-03	3.91E-03	4.23E-04	3162.3	8.65E-03	4.50E-03	4.91E-04
3600.0	7.89E-03	4.10E-03	4.45E-04	3600.0	9.15E-03	4.76E-03	5.19E-04
7200.0	6.90E-03	3.59E-03		7200.0	8.13E-03	4.23E-03	

Table C-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% KRATON D1101 TEST TEMP = 90 , ZIGMA = 0.801 PSI				FINA AC-10 + 3% KRATON D1101 TEST TEMP = 90 , ZIGMA = 0.811 PSI			
1.0	5.50E-05	2.86E-05	1.79E-05	1.0	8.00E-05	4.16E-05	2.57E-05
1.8	8.25E-05	4.29E-05	2.68E-05	1.8	1.15E-04	5.98E-05	3.69E-05
3.2	1.02E-04	5.28E-05	3.30E-05	3.2	1.50E-04	7.80E-05	4.81E-05
5.6	1.50E-04	7.80E-05	4.87E-05	5.6	2.05E-04	1.07E-04	6.57E-05
10.0	1.90E-04	9.88E-05	6.17E-05	10.0	2.55E-04	1.33E-04	8.18E-05
18.0	2.54E-04	1.32E-04	8.23E-05	18.0	3.00E-04	1.56E-04	9.62E-05
31.6	3.25E-04	1.69E-04	1.06E-04	31.6	3.75E-04	1.95E-04	1.20E-04
56.2	4.05E-04	2.11E-04	1.31E-04	56.2	4.70E-04	2.44E-04	1.51E-04
100.0	5.13E-04	2.67E-04	1.66E-04	100.0	5.95E-04	3.09E-04	1.91E-04
177.8	6.40E-04	3.33E-04	2.08E-04	177.8	7.25E-04	3.77E-04	2.32E-04
316.2	8.15E-04	4.24E-04	2.65E-04	316.2	8.75E-04	4.55E-04	2.81E-04
562.3	1.00E-03	5.20E-04	3.25E-04	562.3	1.03E-03	5.33E-04	3.29E-04
1000.0	1.20E-03	6.24E-04	3.90E-04	1000.0	1.18E-03	6.11E-04	3.77E-04
1778.3	1.41E-03	7.33E-04	4.58E-04	1778.3	1.35E-03	7.00E-04	4.31E-04
3162.3	1.67E-03	8.66E-04	5.41E-04	3162.3	1.53E-03	7.93E-04	4.89E-04
3600.0	1.73E-03	9.00E-04	5.62E-04	3600.0	1.58E-03	8.19E-04	5.05E-04
7200.0	1.62E-03	8.43E-04		7200.0	1.54E-03	7.98E-04	
FINA AC-10 + 6% KRATON D1101 TEST TEMP = 60 , ZIGMA = 7.433 PSI				FINA AC-10 + 6% KRATON D1101 TEST TEMP = 60 , ZIGMA = 7.430 PSI			
1.0	2.20E-04	1.14E-04	7.70E-06	1.0	2.50E-04	1.30E-04	8.75E-06
1.8	3.10E-04	1.61E-04	1.08E-05	1.8	3.65E-04	1.90E-04	1.28E-05
3.2	3.70E-04	1.92E-04	1.29E-05	3.2	4.50E-04	2.34E-04	1.58E-05
5.6	5.45E-04	2.83E-04	1.91E-05	5.6	6.35E-04	3.30E-04	2.22E-05
10.0	6.85E-04	3.56E-04	2.40E-05	10.0	7.80E-04	4.06E-04	2.73E-05
18.0	9.25E-04	4.81E-04	3.24E-05	18.0	1.05E-03	5.44E-04	3.66E-05
31.6	1.22E-03	6.35E-04	4.27E-05	31.6	1.41E-03	7.33E-04	4.94E-05
56.2	1.59E-03	8.27E-04	5.56E-05	56.2	1.79E-03	9.31E-04	6.27E-05
100.0	2.12E-03	1.10E-03	7.40E-05	100.0	2.28E-03	1.19E-03	7.98E-05
177.8	2.69E-03	1.40E-03	9.39E-05	177.8	2.88E-03	1.50E-03	1.01E-04
316.2	3.40E-03	1.77E-03	1.19E-04	316.2	3.52E-03	1.83E-03	1.23E-04
562.3	4.39E-03	2.28E-03	1.54E-04	562.3	4.35E-03	2.26E-03	1.52E-04
1000.0	5.48E-03	2.85E-03	1.92E-04	1000.0	5.33E-03	2.77E-03	1.87E-04
1778.3	6.78E-03	3.52E-03	2.37E-04	1778.3	6.43E-03	3.34E-03	2.25E-04
3162.3	8.26E-03	4.30E-03	2.89E-04	3162.3	7.68E-03	3.99E-03	2.69E-04
3600.0	8.63E-03	4.49E-03	3.02E-04	3600.0	8.04E-03	4.18E-03	2.81E-04
7200.0	6.80E-03	3.54E-03		7200.0	6.77E-03	3.52E-03	

Table C-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 6% KRATON D1101 TEST TEMP = 77 , ZIGMA =3.208 PSI				FINA AC-10 + 6% KRATON D1101 TEST TEMP = 77 , ZIGMA = 3.311 PSI			
1.0	3.50E-04	1.82E-04	2.84E-05	1.0	2.25E-04	1.17E-04	1.77E-05
1.8	5.00E-04	2.60E-04	4.05E-05	1.8	3.25E-04	1.69E-04	2.55E-05
3.2	6.35E-04	3.30E-04	5.15E-05	3.2	4.65E-04	2.42E-04	3.65E-05
5.6	8.85E-04	4.60E-04	7.17E-05	5.6	6.75E-04	3.51E-04	5.30E-05
10.0	1.14E-03	5.90E-04	9.20E-05	10.0	8.60E-04	4.47E-04	6.75E-05
18.0	1.51E-03	7.85E-04	1.22E-04	18.0	1.14E-03	5.93E-04	8.95E-05
31.6	1.87E-03	9.73E-04	1.52E-04	31.6	1.49E-03	7.72E-04	1.17E-04
56.2	2.26E-03	1.18E-03	1.83E-04	56.2	1.88E-03	9.75E-04	1.47E-04
100.0	2.85E-03	1.48E-03	2.31E-04	100.0	2.37E-03	1.23E-03	1.86E-04
177.8	3.45E-03	1.79E-03	2.80E-04	177.8	2.92E-03	1.52E-03	2.29E-04
316.2	4.03E-03	2.10E-03	3.27E-04	316.2	3.70E-03	1.92E-03	2.91E-04
562.3	4.73E-03	2.46E-03	3.83E-04	562.3	4.68E-03	2.43E-03	3.67E-04
1000.0	5.53E-03	2.87E-03	4.48E-04	1000.0	5.60E-03	2.91E-03	4.40E-04
1778.3	6.52E-03	3.39E-03	5.28E-04	1778.3	6.65E-03	3.46E-03	5.22E-04
3162.3	7.68E-03	3.99E-03	6.22E-04	3162.3	7.50E-03	3.90E-03	5.89E-04
3600.0	7.95E-03	4.13E-03	6.44E-04	3600.0	7.85E-03	4.08E-03	6.17E-04
7200.0	6.88E-03	3.58E-03		7200.0	7.00E-03	3.64E-03	
FINA AC-10 + 6% KRATON D1101 TEST TEMP = 90 , ZIGMA = 0.801 PSI				FINA AC-10 + 6% KRATON D1101 TEST TEMP = 90 , ZIGMA = 0.818 PSI			
1.0	1.35E-04	7.02E-05	4.38E-05	1.0	1.70E-04	8.84E-05	5.40E-05
1.8	1.90E-04	9.88E-05	6.17E-05	1.8	2.10E-04	1.09E-04	6.68E-05
3.2	2.50E-04	1.30E-04	8.12E-05	3.2	2.45E-04	1.27E-04	7.79E-05
5.6	3.40E-04	1.77E-04	1.10E-04	5.6	3.10E-04	1.61E-04	9.86E-05
10.0	4.35E-04	2.26E-04	1.41E-04	10.0	3.58E-04	1.86E-04	1.14E-04
18.0	5.60E-04	2.91E-04	1.82E-04	18.0	4.18E-04	2.17E-04	1.33E-04
31.6	6.90E-04	3.59E-04	2.24E-04	31.6	5.25E-04	2.73E-04	1.67E-04
56.2	8.38E-04	4.36E-04	2.72E-04	56.2	5.85E-04	3.04E-04	1.86E-04
100.0	1.01E-03	5.25E-04	3.28E-04	100.0	8.00E-04	4.16E-04	2.54E-04
177.8	1.23E-03	6.37E-04	3.98E-04	177.8	9.50E-04	4.94E-04	3.02E-04
316.2	1.44E-03	7.49E-04	4.68E-04	316.2	1.09E-03	5.64E-04	3.45E-04
562.3	1.67E-03	8.66E-04	5.41E-04	562.3	1.15E-03	5.98E-04	3.66E-04
1000.0	1.87E-03	9.73E-04	6.07E-04	1000.0	1.28E-03	6.63E-04	4.05E-04
1778.3	2.12E-03	1.10E-03	6.87E-04	1778.3	1.46E-03	7.59E-04	4.64E-04
3162.3	2.34E-03	1.22E-03	7.60E-04	3162.3	1.69E-03	8.76E-04	5.36E-04
3600.0	2.39E-03	1.24E-03	7.74E-04	3600.0	1.76E-03	9.15E-04	5.60E-04
7200.0	2.23E-03	1.16E-03		7200.0	1.69E-03	8.79E-04	

Table C-24 Creep Compliance of Plant Mixed / Laboratory Compacted Mixtures Using Modified Compaction.

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 10.073 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 10.155 PSI			
1.0	1.50E-04	7.80E-05	3.87E-06	1	1.50E-04	7.80E-05	3.84E-06
1.8	1.75E-04	9.10E-05	4.52E-06	1.8	1.55E-04	8.06E-05	3.97E-06
3.2	2.00E-04	1.04E-04	5.16E-06	3.2	1.60E-04	8.32E-05	4.10E-06
5.6	2.40E-04	1.25E-04	6.20E-06	5.6	1.65E-04	8.58E-05	4.23E-06
10.0	3.00E-04	1.56E-04	7.75E-06	10	1.75E-04	9.10E-05	4.48E-06
18.0	4.05E-04	2.11E-04	1.05E-05	18	1.90E-04	9.88E-05	4.87E-06
31.6	5.30E-04	2.76E-04	1.37E-05	31.6	2.30E-04	1.20E-04	5.89E-06
56.2	6.80E-04	3.54E-04	1.76E-05	56.2	2.50E-04	1.30E-04	6.40E-06
100.0	8.05E-04	4.19E-04	2.08E-05	100.0	3.30E-04	1.72E-04	8.45E-06
177.8	9.70E-04	5.04E-04	2.50E-05	177.8	4.65E-04	2.42E-04	1.19E-05
316.2	1.22E-03	6.32E-04	3.14E-05	316.2	6.85E-04	3.56E-04	1.75E-05
562.3	1.61E-03	8.37E-04	4.16E-05	562.3	1.00E-03	5.20E-04	2.56E-05
1000.0	2.03E-03	1.06E-03	5.24E-05	1000.0	1.32E-03	6.84E-04	3.37E-05
1778.3	2.44E-03	1.27E-03	6.29E-05	1778.3	1.74E-03	9.05E-04	4.46E-05
3162.3	2.95E-03	1.53E-03	7.62E-05	3162.3	2.15E-03	1.12E-03	5.51E-05
3600.0	3.10E-03	1.61E-03	8.00E-05	3600.0	2.25E-03	1.17E-03	5.76E-05
7200.0	1.95E-03	1.01E-03		7200.0	1.00E-03	5.20E-04	
FINA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 5.372 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 5.372 PSI			
1.0	2.20E-04	1.14E-04	1.06E-05	1	3.35E-04	1.74E-04	1.62E-05
1.8	3.15E-04	1.64E-04	1.52E-05	1.8	4.45E-04	2.31E-04	2.15E-05
3.2	4.10E-04	2.13E-04	1.98E-05	3.2	5.60E-04	2.91E-04	2.71E-05
5.6	5.10E-04	2.65E-04	2.47E-05	5.6	7.00E-04	3.64E-04	3.39E-05
10.0	6.30E-04	3.28E-04	3.05E-05	10	8.90E-04	4.63E-04	4.31E-05
18.0	7.98E-04	4.15E-04	3.86E-05	18	1.17E-03	6.09E-04	5.66E-05
31.6	1.01E-03	5.25E-04	4.89E-05	31.6	1.48E-03	7.70E-04	7.16E-05
56.2	1.30E-03	6.74E-04	6.27E-05	56.2	1.85E-03	9.62E-04	8.96E-05
100.0	1.69E-03	8.76E-04	8.16E-05	100.0	2.28E-03	1.18E-03	1.10E-04
177.8	2.05E-03	1.06E-03	9.90E-05	177.8	2.77E-03	1.44E-03	1.34E-04
316.2	2.50E-03	1.30E-03	1.21E-04	316.2	3.34E-03	1.73E-03	1.61E-04
562.3	3.12E-03	1.62E-03	1.51E-04	562.3	3.95E-03	2.05E-03	1.91E-04
1000.0	3.87E-03	2.01E-03	1.87E-04	1000.0	4.85E-03	2.52E-03	2.35E-04
1778.3	4.75E-03	2.47E-03	2.30E-04	1778.3	6.09E-03	3.16E-03	2.95E-04
3162.3	5.95E-03	3.09E-03	2.88E-04	3162.3	7.80E-03	4.06E-03	3.78E-04
3600.0	6.26E-03	3.25E-03	3.03E-04	3600.0	8.35E-03	4.34E-03	4.04E-04
				7200.0	6.81E-03	3.54E-03	

Table C-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
	FINA AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 1.523 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 1.574 PSI		
1.0	1.55E-04	8.06E-05	2.65E-05	1	1.00E-04	5.20E-05	1.65E-05
1.8	2.10E-04	1.09E-04	3.59E-05	1.8	1.30E-04	6.76E-05	2.15E-05
3.2	2.65E-04	1.38E-04	4.52E-05	3.2	1.65E-04	8.58E-05	2.73E-05
5.6	3.50E-04	1.82E-04	5.98E-05	5.6	2.25E-04	1.17E-04	3.72E-05
10.0	4.50E-04	2.34E-04	7.68E-05	10	2.95E-04	1.53E-04	4.87E-05
18.0	5.75E-04	2.99E-04	9.82E-05	18	3.75E-04	1.95E-04	6.20E-05
31.6	7.00E-04	3.64E-04	1.20E-04	31.6	5.00E-04	2.60E-04	8.26E-05
56.2	8.50E-04	4.42E-04	1.45E-04	56.2	6.15E-04	3.20E-04	1.02E-04
100.0	1.01E-03	5.25E-04	1.72E-04	100.0	7.80E-04	4.06E-04	1.29E-04
177.8	1.18E-03	6.14E-04	2.01E-04	177.8	9.85E-04	5.12E-04	1.63E-04
316.2	1.35E-03	7.02E-04	2.31E-04	316.2	1.24E-03	6.45E-04	2.05E-04
562.3	1.53E-03	7.93E-04	2.60E-04	562.3	1.53E-03	7.96E-04	2.53E-04
1000.0	1.70E-03	8.84E-04	2.90E-04	1000.0	1.83E-03	9.52E-04	3.02E-04
1778.3	1.93E-03	1.00E-03	3.30E-04	1778.3	2.20E-03	1.14E-03	3.63E-04
3162.3	2.40E-03	1.25E-03	4.10E-04	3162.3	2.74E-03	1.42E-03	4.52E-04
3600.0	2.50E-03	1.30E-03	4.27E-04	3600.0	2.87E-03	1.49E-03	4.74E-04
7200.0	2.10E-03	1.09E-03		7200.0	2.44E-03	1.27E-03	
	FINA AC-10 + 3% KRATON D1101 TEST TEMP = 60 , ZIGMA = 7.496 PSI				FINA AC-10 + 3% KRATON D1101 TEST TEMP = 60 , ZIGMA = 10.143 PSI		
1.0	1.45E-04	7.54E-05	5.03E-06	1	2.00E-04	1.04E-04	5.13E-06
1.8	1.70E-04	8.84E-05	5.90E-06	1.8	2.30E-04	1.20E-04	5.90E-06
3.2	2.05E-04	1.07E-04	7.11E-06	3.2	2.65E-04	1.38E-04	6.79E-06
5.6	2.40E-04	1.25E-04	8.33E-06	5.6	2.95E-04	1.53E-04	7.56E-06
10.0	2.80E-04	1.46E-04	9.71E-06	10	3.60E-04	1.87E-04	9.23E-06
18.0	3.30E-04	1.72E-04	1.14E-05	18	4.30E-04	2.24E-04	1.10E-05
31.6	3.80E-04	1.98E-04	1.32E-05	31.6	5.70E-04	2.96E-04	1.46E-05
56.2	4.30E-04	2.24E-04	1.49E-05	56.2	7.10E-04	3.69E-04	1.82E-05
100.0	5.30E-04	2.76E-04	1.84E-05	100.0	9.15E-04	4.76E-04	2.35E-05
177.8	6.80E-04	3.54E-04	2.36E-05	177.8	1.21E-03	6.29E-04	3.10E-05
316.2	8.60E-04	4.47E-04	2.98E-05	316.2	1.55E-03	8.06E-04	3.97E-05
562.3	1.15E-03	5.96E-04	3.97E-05	562.3	2.08E-03	1.08E-03	5.32E-05
1000.0	1.44E-03	7.46E-04	4.98E-05	1000.0	2.73E-03	1.42E-03	6.99E-05
1778.3	1.74E-03	9.02E-04	6.02E-05	1778.3	3.38E-03	1.76E-03	8.67E-05
3162.3	2.14E-03	1.11E-03	7.42E-05	3162.3	4.26E-03	2.22E-03	1.09E-04
3600.0	2.25E-03	1.17E-03	7.81E-05	3600.0	4.47E-03	2.32E-03	1.14E-04
7200.0	1.23E-03	6.37E-04		7200.0	3.04E-03	1.58E-03	

Table C-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% KRATON D1101 TEST TEMP = 77 , ZIGMA = 5.496 PSI				FINA AC-10 + 3% KRATON D1101 TEST TEMP = 77 , ZIGMA = 5.347 PSI			
1.0	1.90E-04	9.88E-05	8.99E-06	1	3.00E-04	1.56E-04	1.46E-05
1.8	2.60E-04	1.35E-04	1.23E-05	1.8	4.00E-04	2.08E-04	1.95E-05
3.2	3.30E-04	1.72E-04	1.56E-05	3.2	5.00E-04	2.60E-04	2.43E-05
5.6	4.40E-04	2.29E-04	2.08E-05	5.6	6.00E-04	3.12E-04	2.92E-05
10.0	6.35E-04	3.30E-04	3.00E-05	10	7.15E-04	3.72E-04	3.48E-05
18.0	8.10E-04	4.21E-04	3.83E-05	18	9.45E-04	4.91E-04	4.60E-05
31.6	1.10E-03	5.72E-04	5.20E-05	31.6	1.25E-03	6.48E-04	6.06E-05
56.2	1.50E-03	7.80E-04	7.10E-05	56.2	1.57E-03	8.14E-04	7.61E-05
100.0	1.96E-03	1.02E-03	9.27E-05	100.0	1.94E-03	1.01E-03	9.41E-05
177.8	2.45E-03	1.27E-03	1.16E-04	177.8	2.45E-03	1.27E-03	1.19E-04
316.2	3.19E-03	1.66E-03	1.51E-04	316.2	3.13E-03	1.63E-03	1.52E-04
562.3	4.09E-03	2.13E-03	1.94E-04	562.3	4.10E-03	2.13E-03	1.99E-04
1000.0	5.33E-03	2.77E-03	2.52E-04	1000.0	5.19E-03	2.70E-03	2.52E-04
1778.3	7.02E-03	3.65E-03	3.32E-04	1778.3	6.69E-03	3.48E-03	3.25E-04
3162.3	9.55E-03	4.97E-03	4.52E-04	3162.3	8.79E-03	4.57E-03	4.27E-04
3600.0	1.03E-02	5.33E-03	4.85E-04	3600.0	9.39E-03	4.88E-03	4.56E-04
7200.0	8.46E-03	4.40E-03		7200.0	7.56E-03	3.93E-03	
FINA AC-10 + 3% KRATON D1101 TEST TEMP = 90 , ZIGMA = 1.610 PSI				FINA AC-10 + 3% KRATON D1101 TEST TEMP = 90 , ZIGMA = 1.595 PSI			
1.0	9.00E-05	4.68E-05	1.45E-05	1	1.10E-04	5.72E-05	1.79E-05
1.8	1.20E-04	6.24E-05	1.94E-05	1.8	1.55E-04	8.06E-05	2.53E-05
3.2	1.55E-04	8.06E-05	2.50E-05	3.2	2.00E-04	1.04E-04	3.26E-05
5.6	2.05E-04	1.07E-04	3.31E-05	5.6	2.85E-04	1.48E-04	4.65E-05
10.0	2.58E-04	1.34E-04	4.16E-05	10	4.00E-04	2.08E-04	6.52E-05
18.0	3.33E-04	1.73E-04	5.37E-05	18	5.15E-04	2.68E-04	8.40E-05
31.6	4.40E-04	2.29E-04	7.11E-05	31.6	6.50E-04	3.38E-04	1.06E-04
56.2	5.30E-04	2.76E-04	8.56E-05	56.2	8.50E-04	4.42E-04	1.39E-04
100.0	6.40E-04	3.33E-04	1.03E-04	100.0	1.09E-03	5.67E-04	1.78E-04
177.8	7.45E-04	3.87E-04	1.20E-04	177.8	1.47E-03	7.65E-04	2.40E-04
316.2	8.50E-04	4.42E-04	1.37E-04	316.2	1.83E-03	9.49E-04	2.98E-04
				562.3	2.09E-03	1.08E-03	3.40E-04
				1000.0	2.35E-03	1.22E-03	3.83E-04
				1778.3	2.76E-03	1.44E-03	4.50E-04
				3162.3	3.38E-03	1.76E-03	5.51E-04
				3600.0	3.55E-03	1.85E-03	5.79E-04
				7200.0	3.04E-03	1.58E-03	

Table C-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 6% KRATON D1101 TEST TEMP = 60 , ZIGMA = 10.575 PSI				FINA AC-10 + 6% KRATON D1101 TEST TEMP = 60 , ZIGMA = 10.158 PSI			
1.0	2.35E-04	1.22E-04	5.78E-06	1	1.20E-04	6.24E-05	3.07E-06
1.8	2.80E-04	1.46E-04	6.89E-06	1.8	2.05E-04	1.07E-04	5.25E-06
3.2	3.70E-04	1.92E-04	9.10E-06	3.2	3.25E-04	1.69E-04	8.32E-06
5.6	4.95E-04	2.57E-04	1.22E-05	5.6	4.75E-04	2.47E-04	1.22E-05
10.0	6.65E-04	3.46E-04	1.64E-05	10	5.75E-04	2.99E-04	1.47E-05
18.0	8.75E-04	4.55E-04	2.15E-05	18	6.65E-04	3.46E-04	1.70E-05
31.6	1.16E-03	6.01E-04	2.84E-05	31.6	7.50E-04	3.90E-04	1.92E-05
56.2	1.46E-03	7.57E-04	3.58E-05	56.2	8.60E-04	4.47E-04	2.20E-05
100.0	1.67E-03	8.66E-04	4.09E-05	100.0	1.06E-03	5.51E-04	2.71E-05
177.8	2.03E-03	1.06E-03	4.99E-05	177.8	1.26E-03	6.53E-04	3.21E-05
316.2	2.49E-03	1.30E-03	6.12E-05	316.2	1.57E-03	8.17E-04	4.02E-05
562.3	3.04E-03	1.58E-03	7.46E-05	562.3	2.00E-03	1.04E-03	5.12E-05
1000.0	3.64E-03	1.89E-03	8.95E-05	1000.0	2.47E-03	1.28E-03	6.32E-05
1778.3	4.44E-03	2.31E-03	1.09E-04	1778.3	3.23E-03	1.68E-03	8.27E-05
3162.3	5.36E-03	2.79E-03	1.32E-04	3162.3	4.08E-03	2.12E-03	1.04E-04
3600.0	5.59E-03	2.91E-03	1.37E-04	3600.0	4.26E-03	2.22E-03	1.09E-04
7200.0	3.55E-03	1.85E-03		7200.0	2.15E-03	1.12E-03	
FINA AC-10 + 6% KRATON D1101 TEST TEMP = 77 , ZIGMA = 5.370 PSI				FINA AC-10 + 6% KRATON D1101 TEST TEMP = 77 , ZIGMA = 5.485 PSI			
1.0	4.10E-04	2.13E-04	1.27E-05	1	6.50E-04	3.38E-04	1.99E-05
1.8	5.50E-04	2.86E-04	1.71E-05	1.8	8.65E-04	4.50E-04	2.65E-05
3.2	6.30E-04	3.28E-04	1.96E-05	3.2	1.02E-03	5.31E-04	3.13E-05
5.6	7.10E-04	3.69E-04	2.21E-05	5.6	1.21E-03	6.29E-04	3.71E-05
10.0	7.60E-04	3.95E-04	2.36E-05	10	1.49E-03	7.75E-04	4.57E-05
18.0	8.55E-04	4.45E-04	2.66E-05	18	1.79E-03	9.28E-04	5.47E-05
31.6	1.04E-03	5.38E-04	3.22E-05	31.6	1.98E-03	1.03E-03	6.05E-05
56.2	1.23E-03	6.40E-04	3.82E-05	56.2	2.33E-03	1.21E-03	7.13E-05
100.0	1.48E-03	7.70E-04	4.60E-05	100.0	2.72E-03	1.41E-03	8.34E-05
177.8	1.82E-03	9.44E-04	5.64E-05	177.8	3.19E-03	1.66E-03	9.78E-05
316.2	2.18E-03	1.13E-03	6.76E-05	316.2	3.60E-03	1.87E-03	1.10E-04
562.3	2.58E-03	1.34E-03	8.00E-05	562.3	4.15E-03	2.16E-03	1.27E-04
1000.0	3.05E-03	1.59E-03	9.48E-05	1000.0	4.85E-03	2.52E-03	1.49E-04
1778.3	3.71E-03	1.93E-03	1.15E-04	1778.3	6.01E-03	3.13E-03	1.84E-04
3162.3	4.62E-03	2.40E-03	1.44E-04	3162.3	7.28E-03	3.79E-03	2.23E-04
3600.0	4.85E-03	2.52E-03	1.51E-04	3600.0	7.59E-03	3.94E-03	2.32E-04
7200.0	2.55E-03	1.33E-03		7200.0	5.35E-03	2.78E-03	

Table C-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 6% KRATON D1101				FINA AC-10 + 6% KRATON D1101			
TEST TEMP = 90 , ZIGMA = 1.683 PSI				TEST TEMP = 90 , ZIGMA = 1.609 PSI			
1.0	1.50E-04	7.80E-05	2.32E-05	1	8.50E-05	4.42E-05	1.37E-05
1.8	2.03E-04	1.05E-04	3.13E-05	1.8	1.35E-04	7.02E-05	2.19E-05
3.2	2.30E-04	1.20E-04	3.55E-05	3.2	1.95E-04	1.01E-04	3.15E-05
5.6	2.80E-04	1.46E-04	4.33E-05	5.6	2.50E-04	1.30E-04	4.04E-05
10.0	3.60E-04	1.87E-04	5.56E-05	10	2.95E-04	1.53E-04	4.77E-05
18.0	4.60E-04	2.39E-04	7.11E-05	18	3.38E-04	1.76E-04	5.45E-05
31.6	5.80E-04	3.02E-04	8.96E-05	31.6	3.98E-04	2.07E-04	6.42E-05
56.2	7.40E-04	3.85E-04	1.14E-04	56.2	4.60E-04	2.39E-04	7.43E-05
100.0	8.60E-04	4.47E-04	1.33E-04	100.0	5.20E-04	2.70E-04	8.40E-05
177.8	9.40E-04	4.89E-04	1.45E-04	177.8	5.75E-04	2.99E-04	9.29E-05
316.2	1.01E-03	5.25E-04	1.56E-04	316.2	6.60E-04	3.43E-04	1.07E-04
562.3	1.08E-03	5.62E-04	1.67E-04	562.3	7.38E-04	3.84E-04	1.19E-04
1000.0	1.20E-03	6.22E-04	1.85E-04	1000.0	8.45E-04	4.39E-04	1.37E-04
1778.3	1.34E-03	6.94E-04	2.06E-04	1778.3	1.00E-03	5.20E-04	1.62E-04
3162.3	1.48E-03	7.67E-04	2.28E-04	3162.3	1.22E-03	6.35E-04	1.97E-04
3600.0	1.53E-03	7.96E-04	2.36E-04	3600.0	1.27E-03	6.61E-04	2.05E-04
7200.0	1.11E-03	5.75E-04		7200.0	8.70E-04	4.52E-04	

Table C-25 Moisture Sensitivity Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

MIXTURE	TEST TEMP. F		Dry Condition		Wet Condition		TSR
			AIR VOIDS %	TENSILE STRENGTH PSI	AIR VOIDS %	TENSILE STRENGTH PSI	
Control: Shamrock AC-20	77		7.6	91	6.9	79	
			7.5	89	7.1	81	
			7.1	84	7.6	85	
		AVG.	7.4	88	7.2	82	0.93
Fina AC-10 + 3% Styrelf	77		7.0	125	6.4	120	
			6.1	133	6.5	112	
			6.8	112	7.1	115	
		AVG.	6.6	123	6.7	116	0.94
Fina AC-10 + 3% D1101	77		6.9	98	6.9	100	
			7.5	101	7.4	88	
			7.0	96	7.5	92	
		AVG.	7.1	98	7.3	93	0.95
Fina AC-10 + 6% D1101	77		7.0	80	6.6	88	
			7.1	72	7.0	77	
			7.0	87	7.0	69	
		AVG.	7.0	80	6.9	78	0.98

Table C-26 Moisture Sensitivity Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

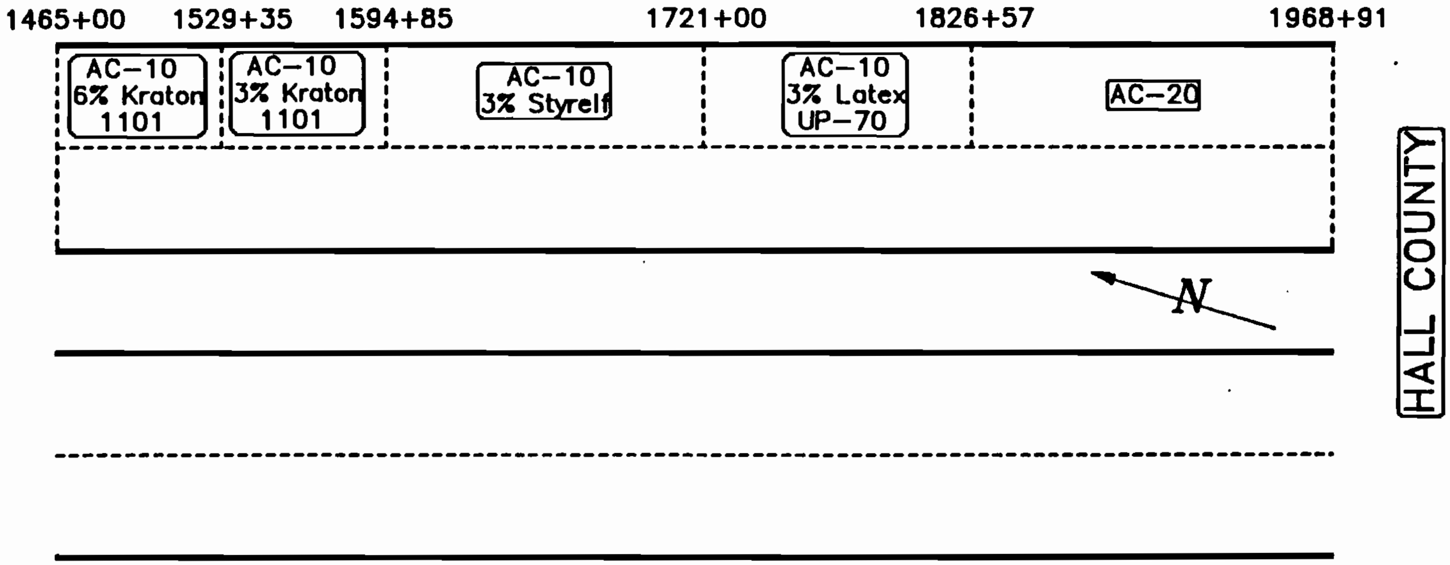
MIXTURE	TEST TEMP. F		Dry Condition		Wet Condition		TSR
			AIR VOIDS %	TENSILE STRENGTH PSI	AIR VOIDS %	TENSILE STRENGTH PSI	
Fina AC-10 + 3% Styrelf	77		7.7	141	7.5	139	
			7.6	124	7.2	110	
			7.7	140	7.6	141	
		AVG.	7.7	135	7.4	130	0.96
Fina AC-10 + 3% D1101	77		7.0	121	6.8	118	
			7.1	118	6.9	116	
			6.8	115	6.8	120	
		AVG.	7.0	118	6.8	118	1.00
Fina AC-10 + 6% D1101	77		6.5	116	6.6	108	
			6.8	121	6.4	118	
			6.8	111	6.5	114	
		AVG.	6.7	116	6.5	113	0.98

Table C-27 AGGREGATE GRADATION OF EXTRACTED CORES (DISTRICT 25)

Combined Gradation	SDHPT Specification	Styrelf AC=4.94	3% Kraton AC=5.08	6% Kraton AC=4.89
0.0	0			
6.5	0-15	6.8	6.7	6.5
30.2	21-53	29.9	29.5	30.5
21.4	11-32	22.5	20.9	20.8
58.1	54-74	59.2	57.1	57.8
24.7	6-32	23.4	25.2	25.0
8.2	4-27	8.5	8.3	8.4
5.6	3-27	5.7	5.9	5.7
3.4	1-8	3.2	3.5	3.1
100.0		100.0	100.0	100.0

51% Jarrett Pit Coarse
49% Jarrett Pit Screenings

District 25 Field Test Sections
US287 – Donley County, Beginning At The Donley–Hall County Line @ 1 Mile North Of Memphis, Texas
Date Placed: September 1988–Station 1968+91 To 1721+00
April 1989–Station 1721+00 To 1465+00



NOTE: All sections contain 1% lime

Fig C-1 Schematic Illustration of Field Test Sections.

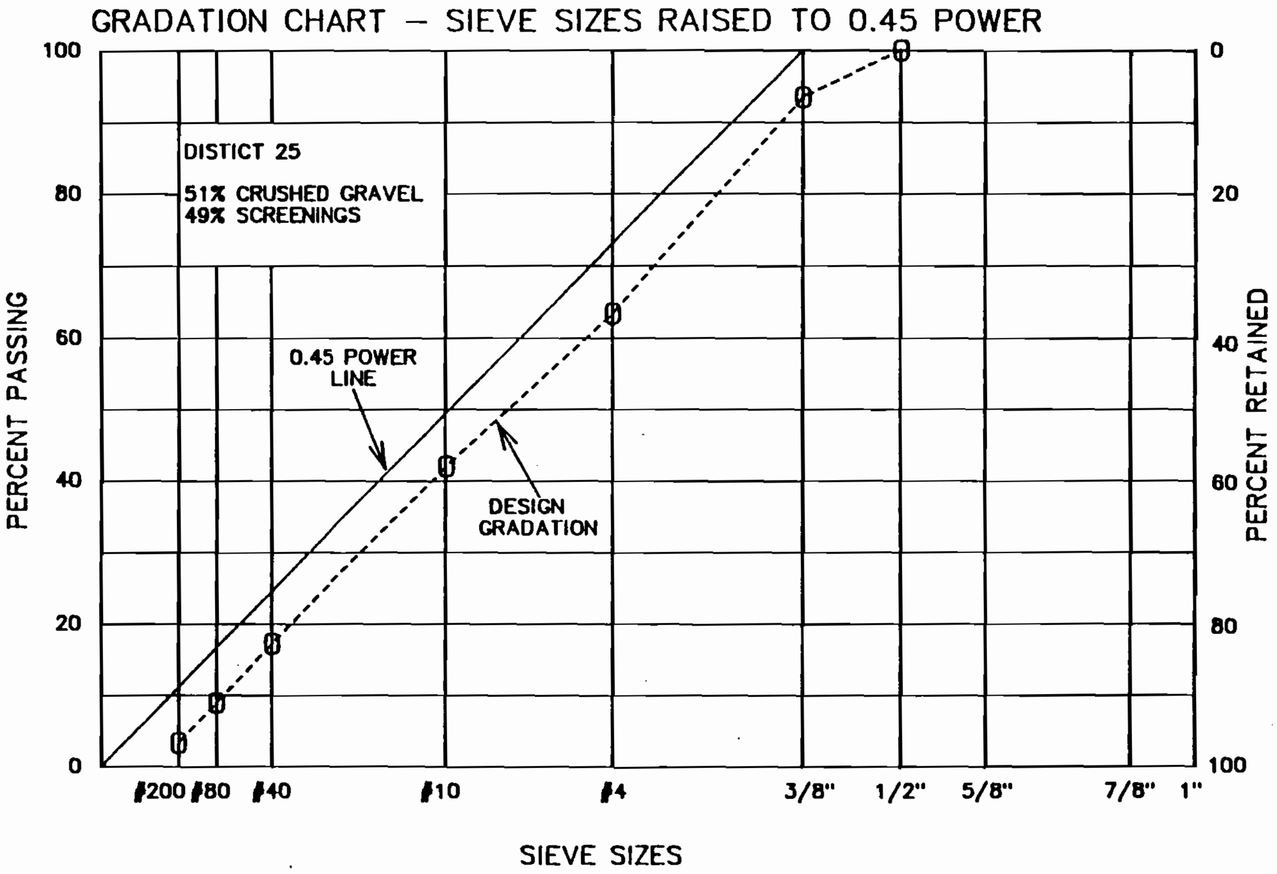


Fig C-2 Aggregate gradation Chart

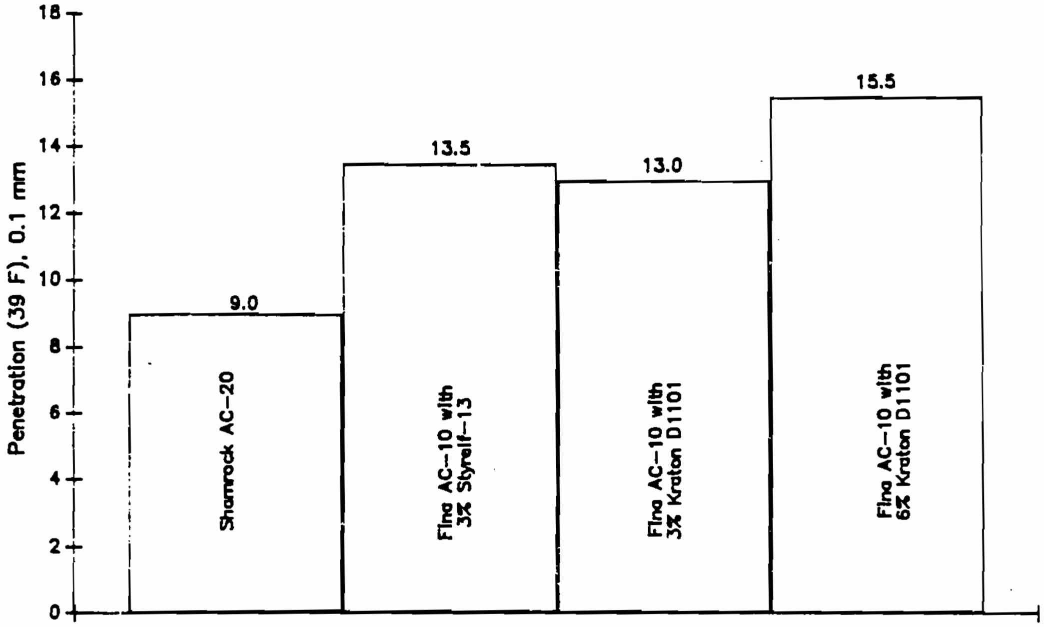


Fig C-3 Penetration at 39 F for Unmodified Shamrock and Modified Fina Binders

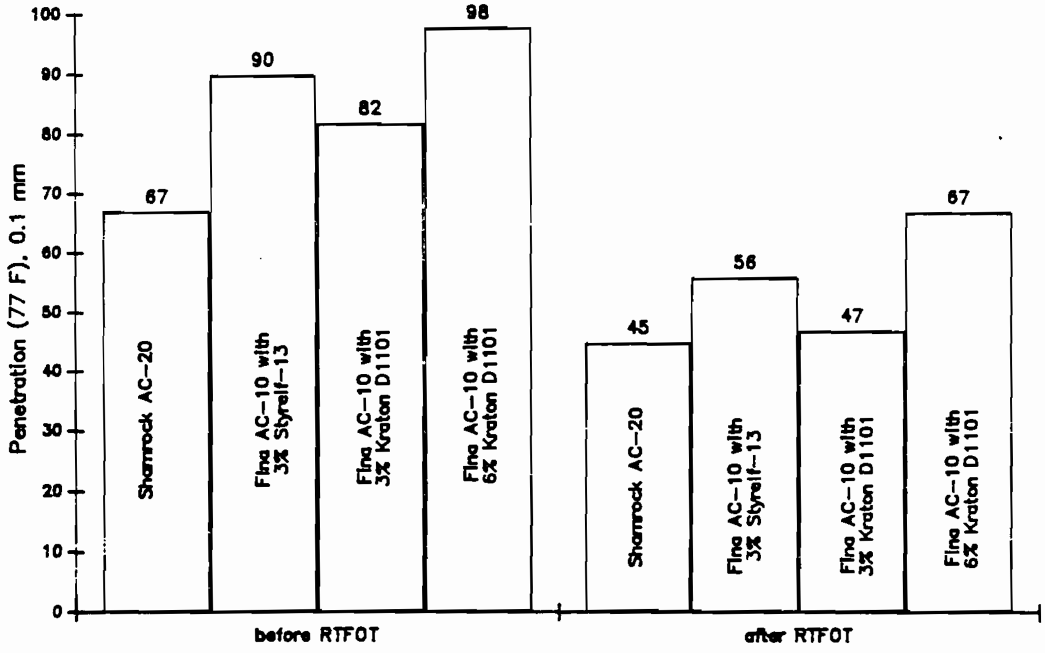


Fig C-4 Penetration at 77 F for Unmodified Shamrock and Modified Fina Binders

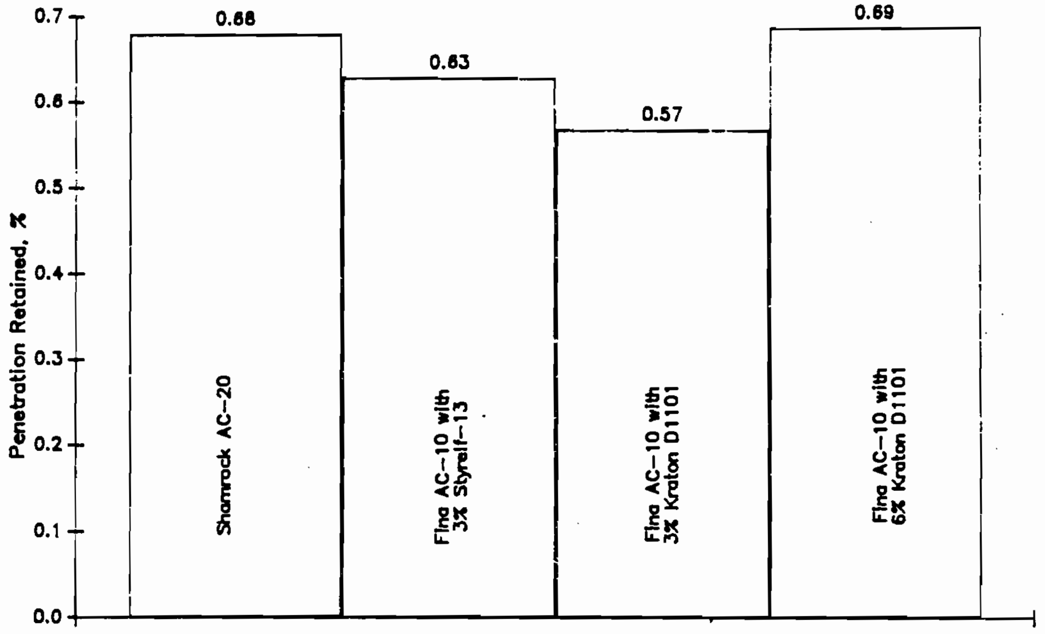


Fig C-5 Retained Penetration at 77 F for Unmodified Shamrock and Modified Fina Binders

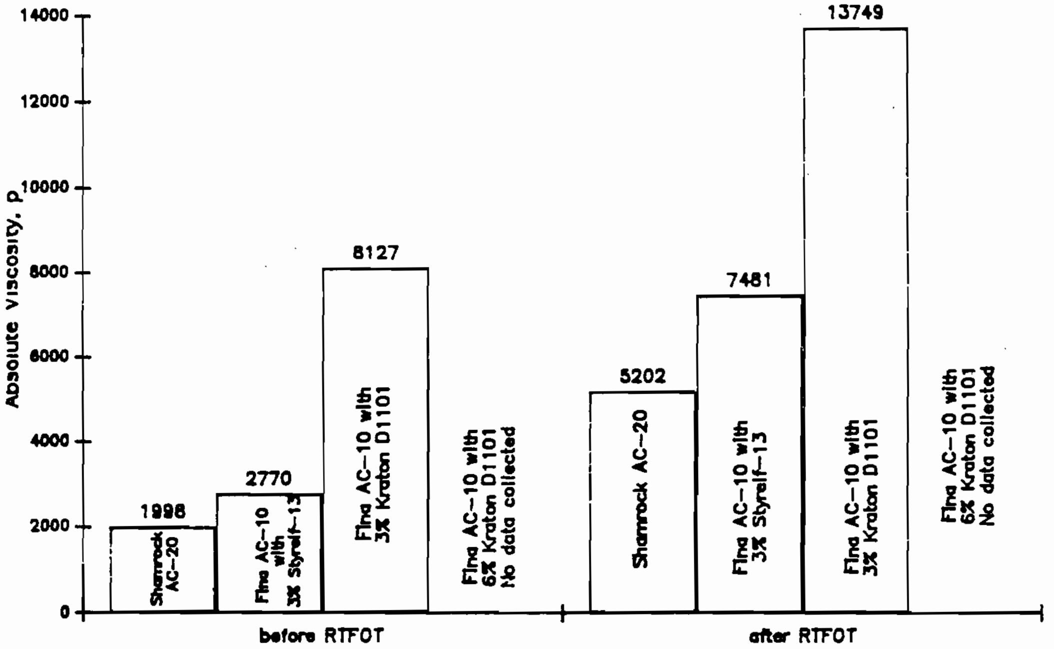


Fig C-6 Viscosity at 140 F for Unmodified Shamrock and Modified Fina Binders

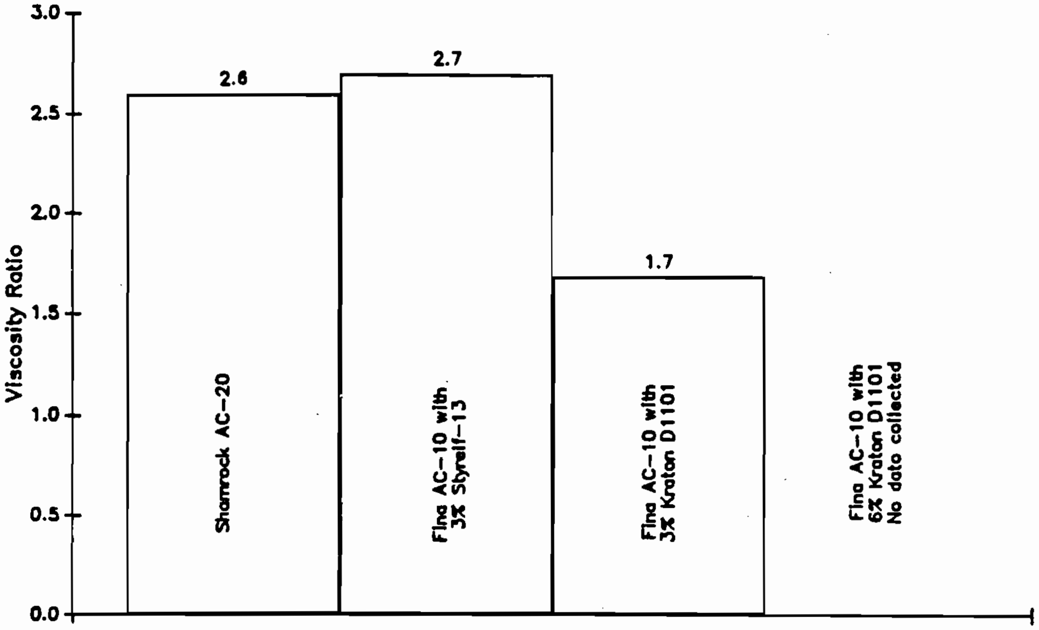


Fig C-7 Viscosity Ratio at 140 F for Unmodified Shamrock and Modified Fina Binders

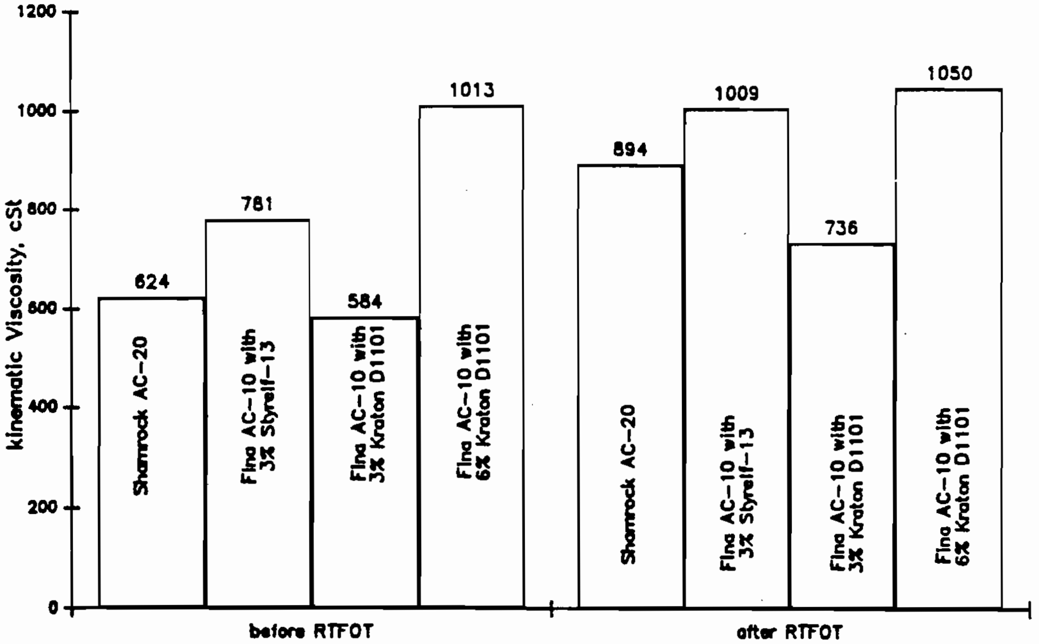


Fig C-8 Viscosity at 275 F for Unmodified Shamrock and Modified Fina Binders

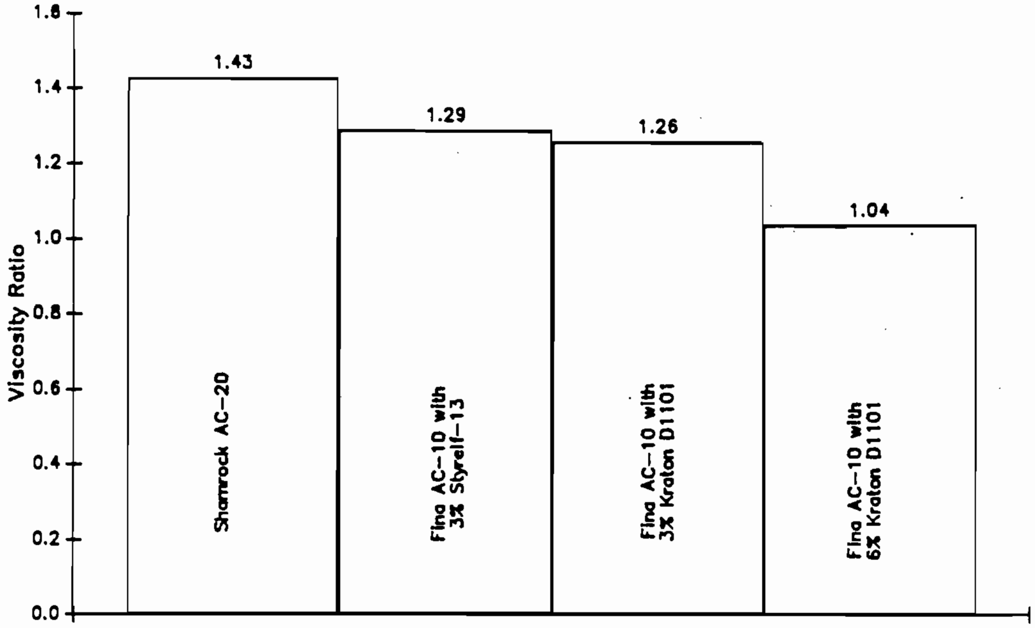


Fig C-9 Viscosity Ratio at 275 F for Unmodified Shamrock and Modified Fina Binders

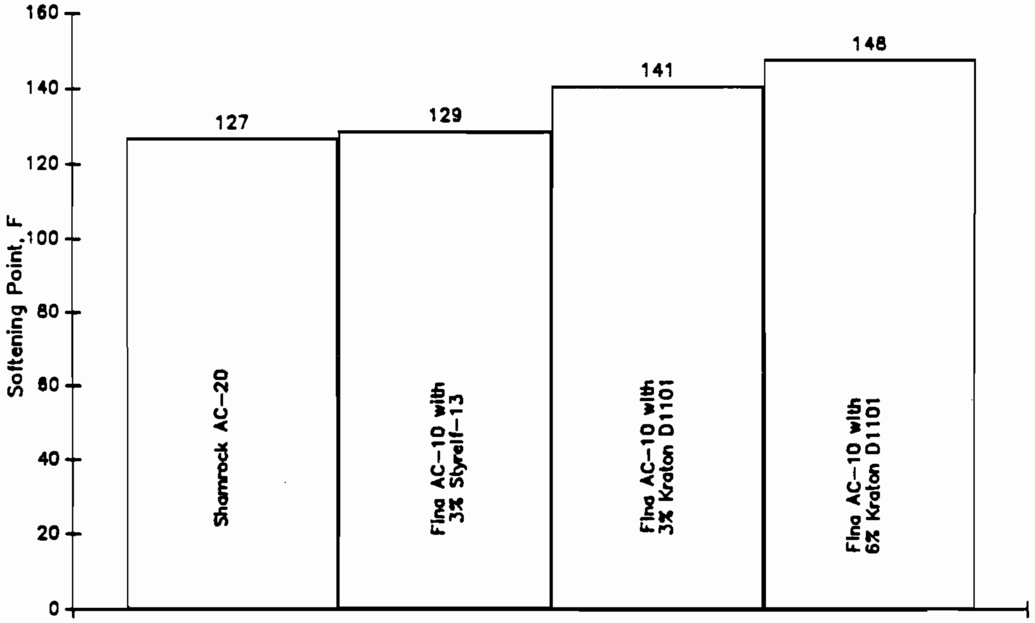


Fig C-10 Softening Point for Unmodified Shamrock and Modified Fina Binders

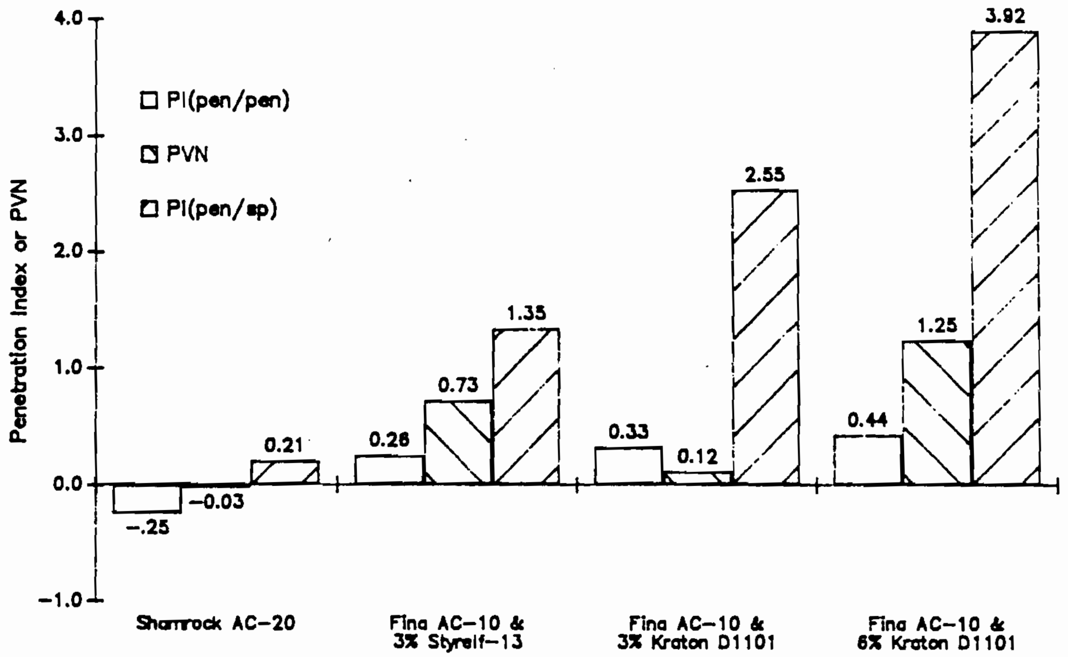


Fig C-11 Penetration Index and PVN for Unmodified Shamrock and Modified Fina Binders.

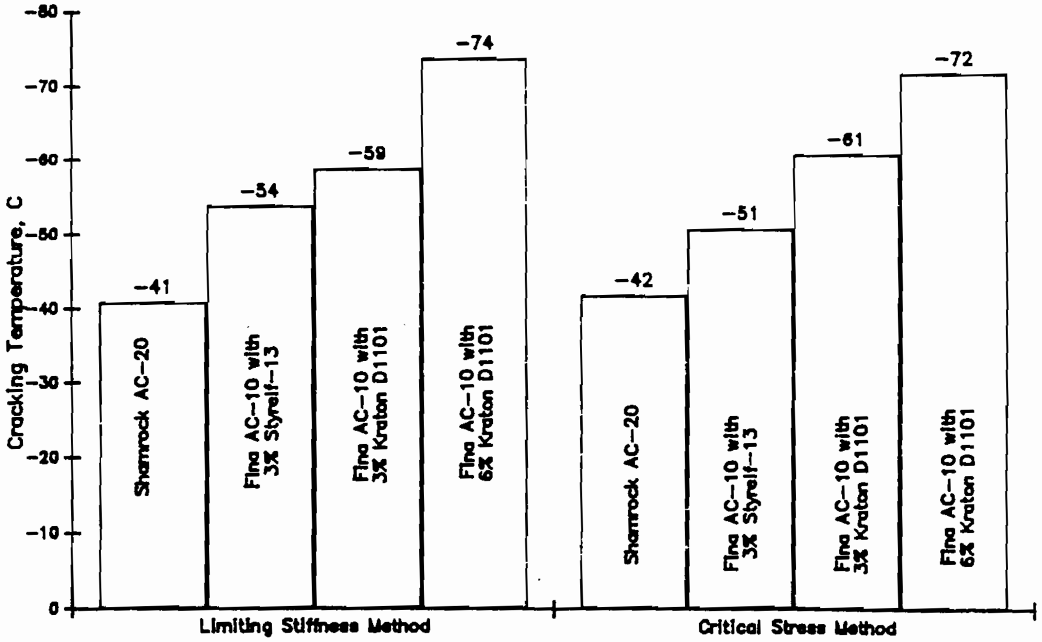


Fig C-12 Cracking Temperature for Unmodified Shamrock and Modified Fina Binders

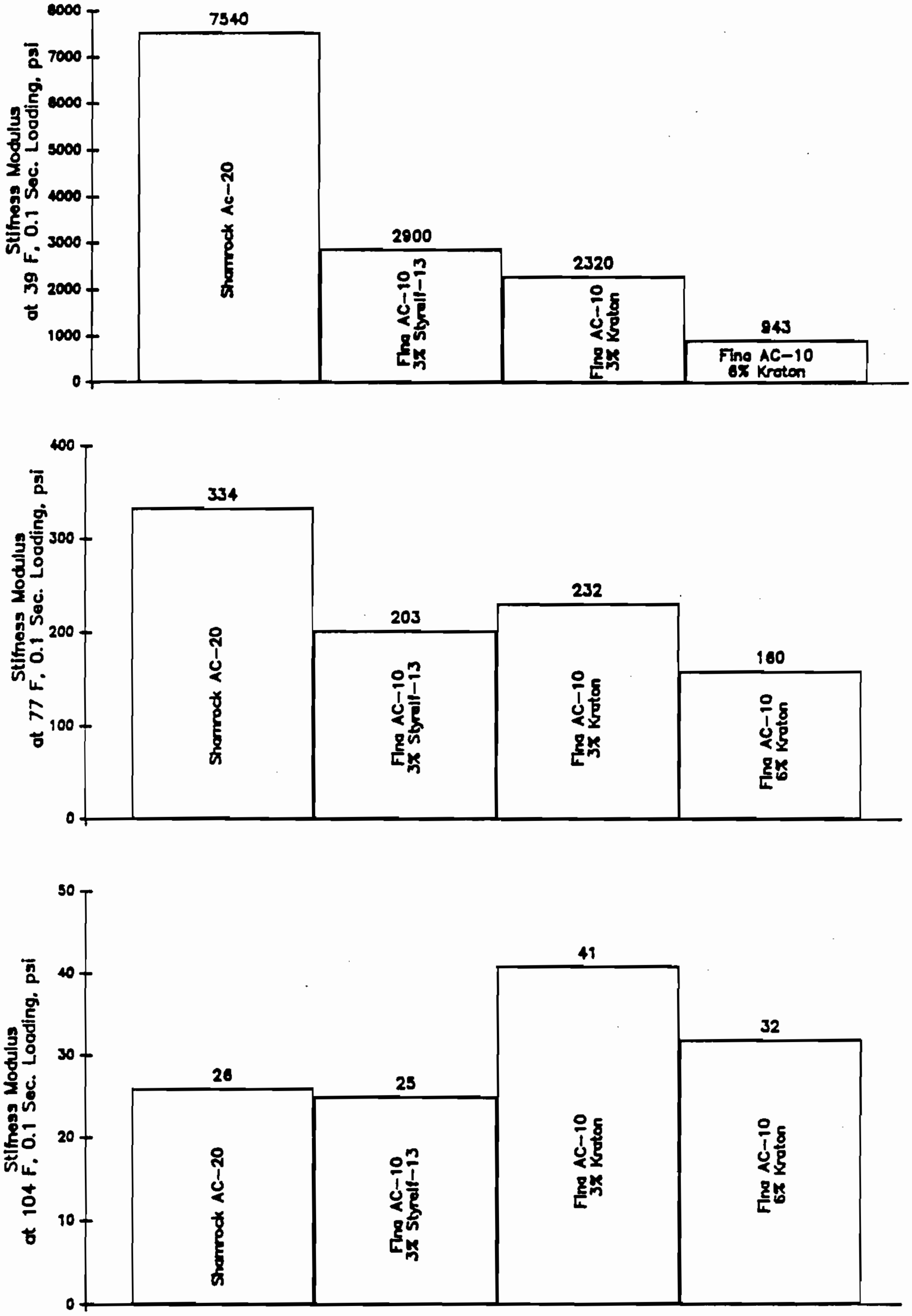


Fig C-13 Stiffness Modulus for Unmodified Shamrock and Modified Fina Binders.

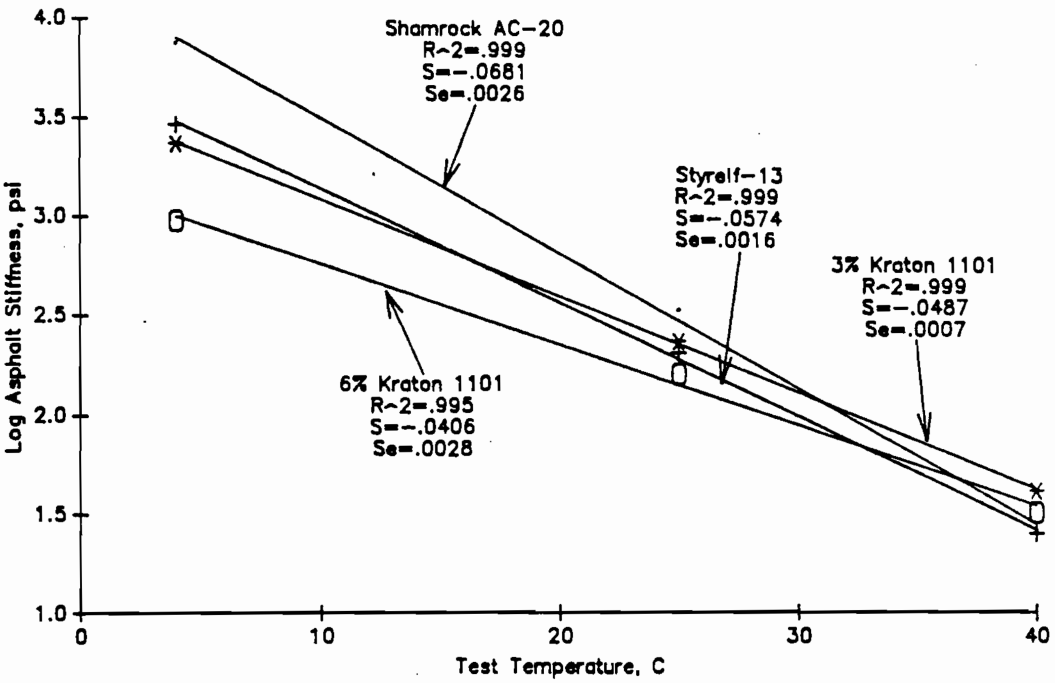


Fig C-14 Asphalt Stiffness vs. Test Temperature for Unmodified Shamrock and Modified Fina Binders.

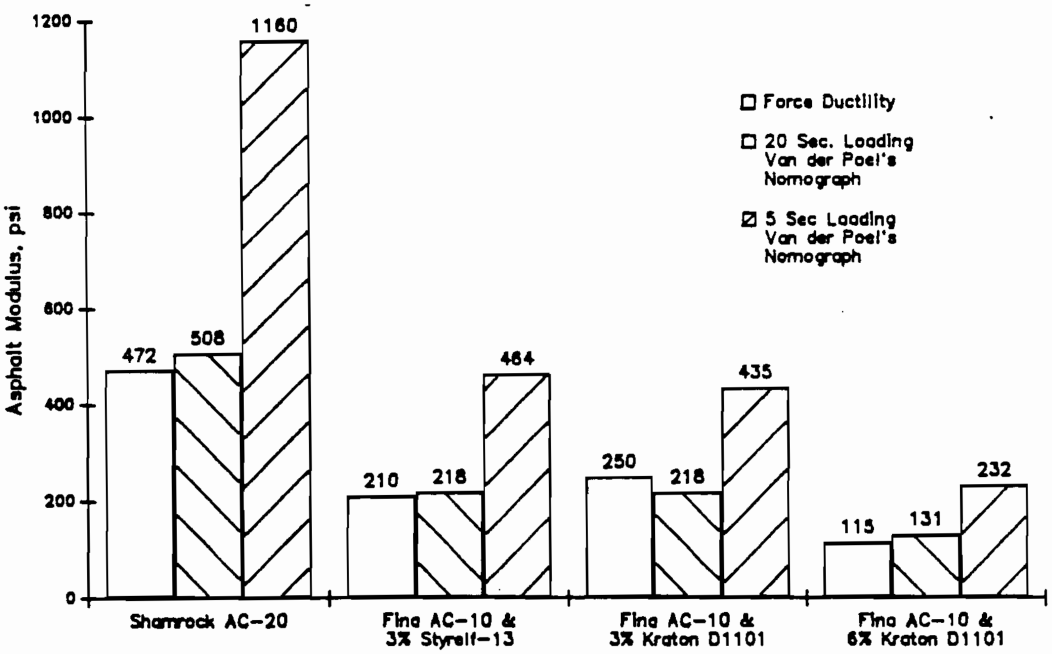


Fig C-15 Asphalt Modulus at 39 F for Unmodified Shamrock and Modified Fina Binders

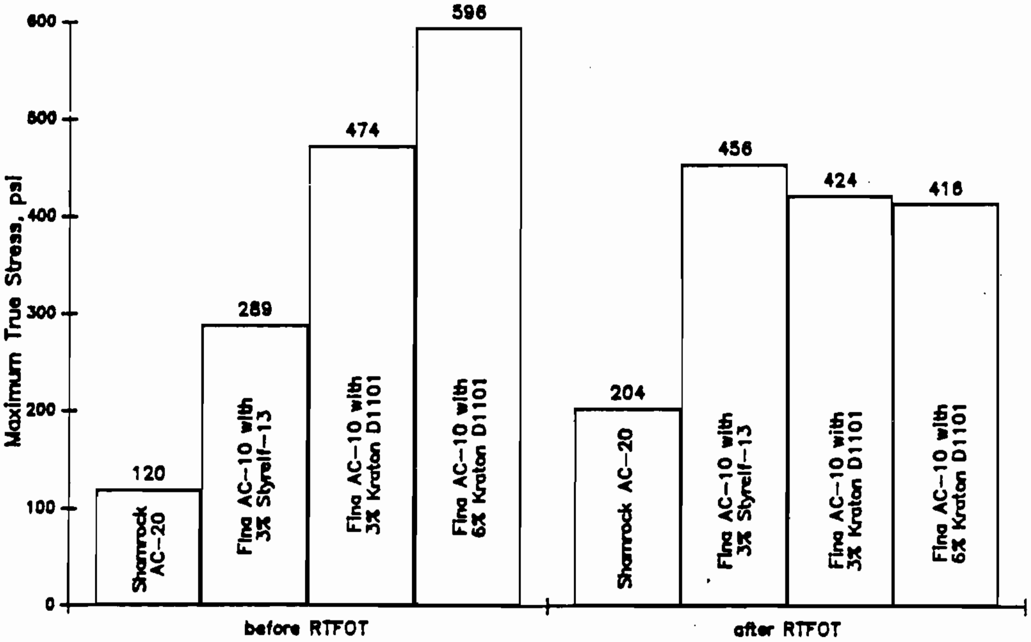


Fig C-16 Maximum True Stress at 39 F for Unmodified Shamrock and Modified Fina Binders

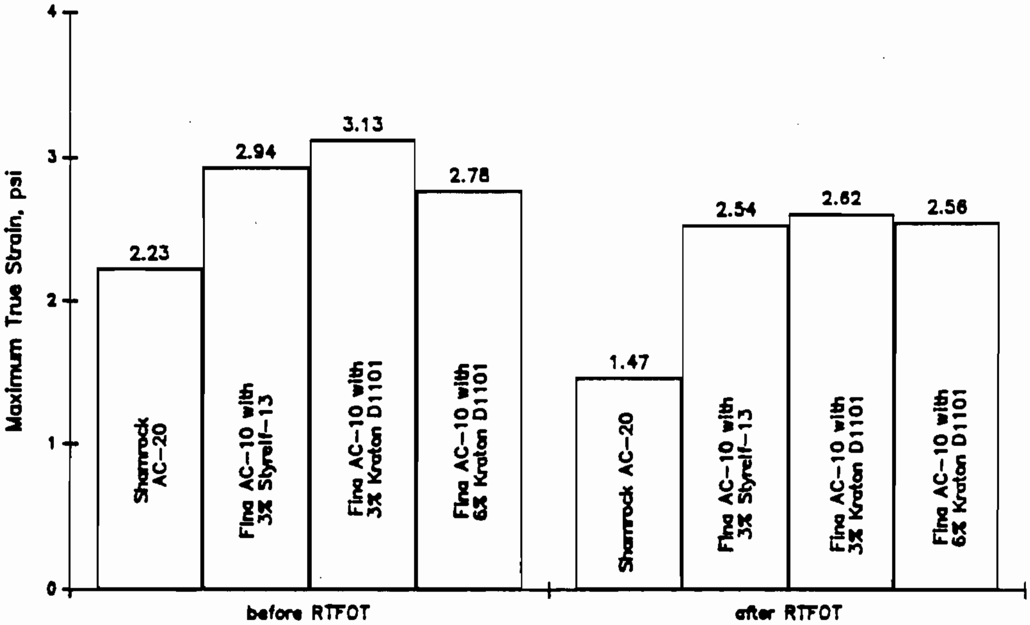


Fig C-17 Maximum True Strain at 39 F for Unmodified Shamrock and Modified Fina Binders

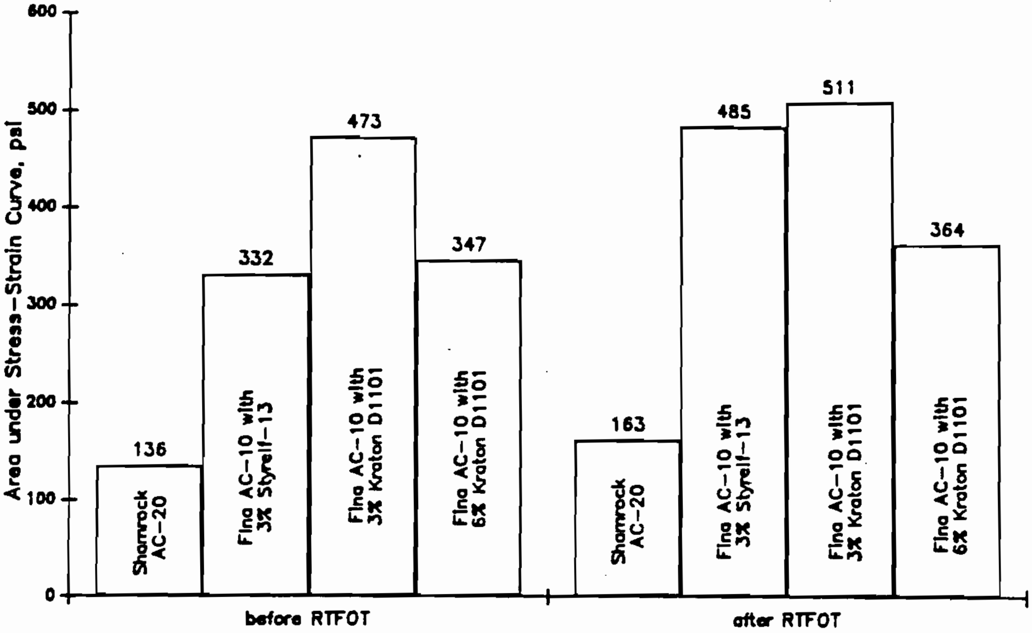


Fig C–18 Curve Area at 39 F for Unmodified Shamrock and Modified Fina Binders

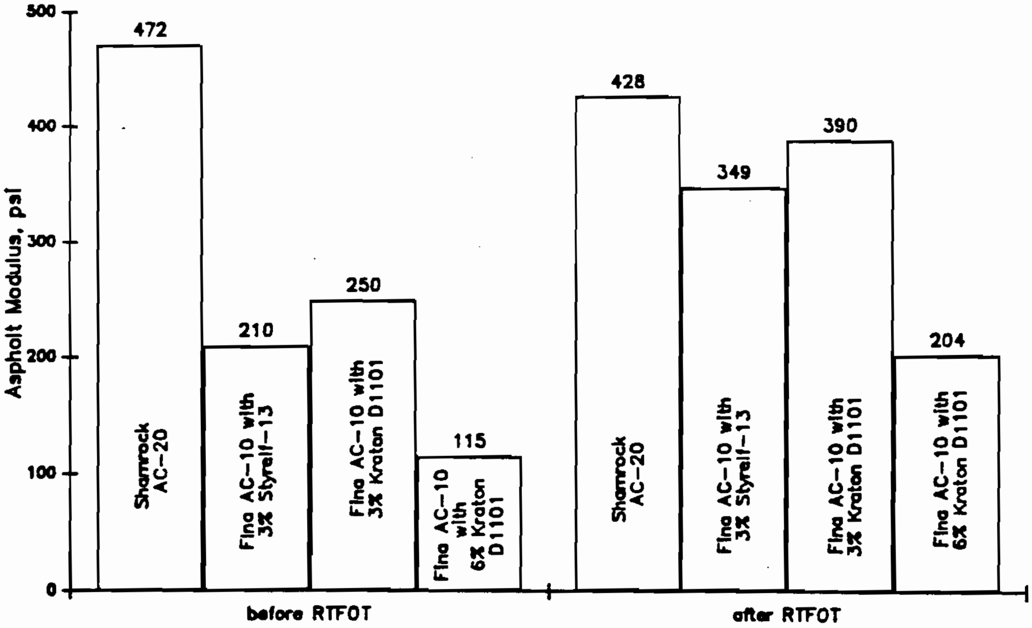


Fig C–19 Asphalt Modulus at 39 F for Unmodified Shamrock and Modified Fina Binders

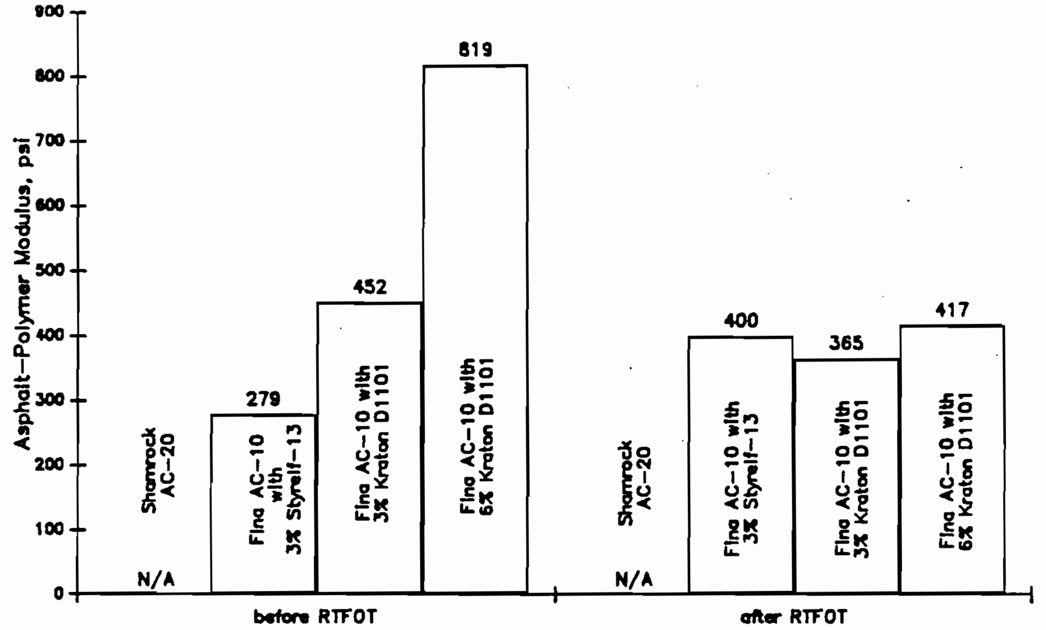


Fig C–20 Asphalt–Polymer Modulus at 39 F for Unmodified Shamrock and Modified Fina Binde

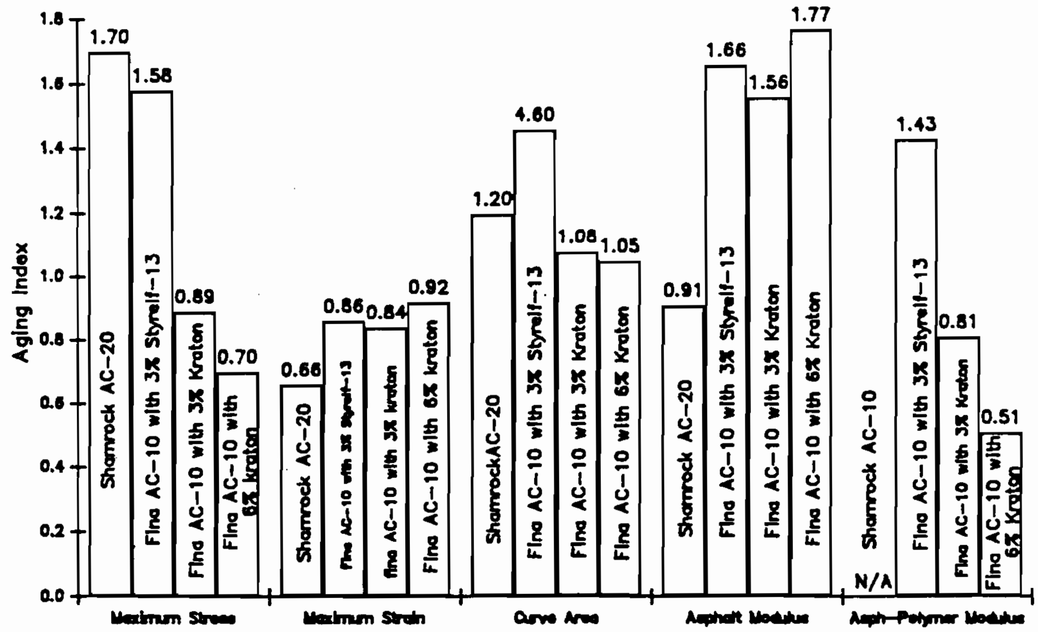


Fig C–21 Aging Index of Force Ductility Parameters for Unmodified and Modified Texaco Binders.

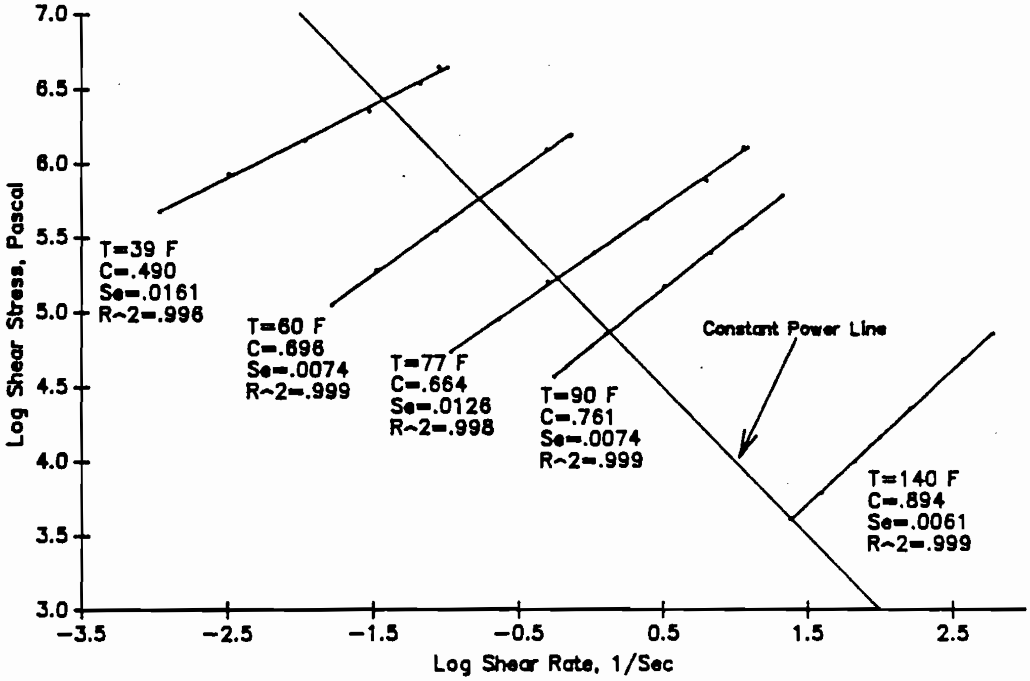


Fig C-22 Shear Stress vs. Shear Rate for Shamrock AC-20 at Different Test Temperatures.

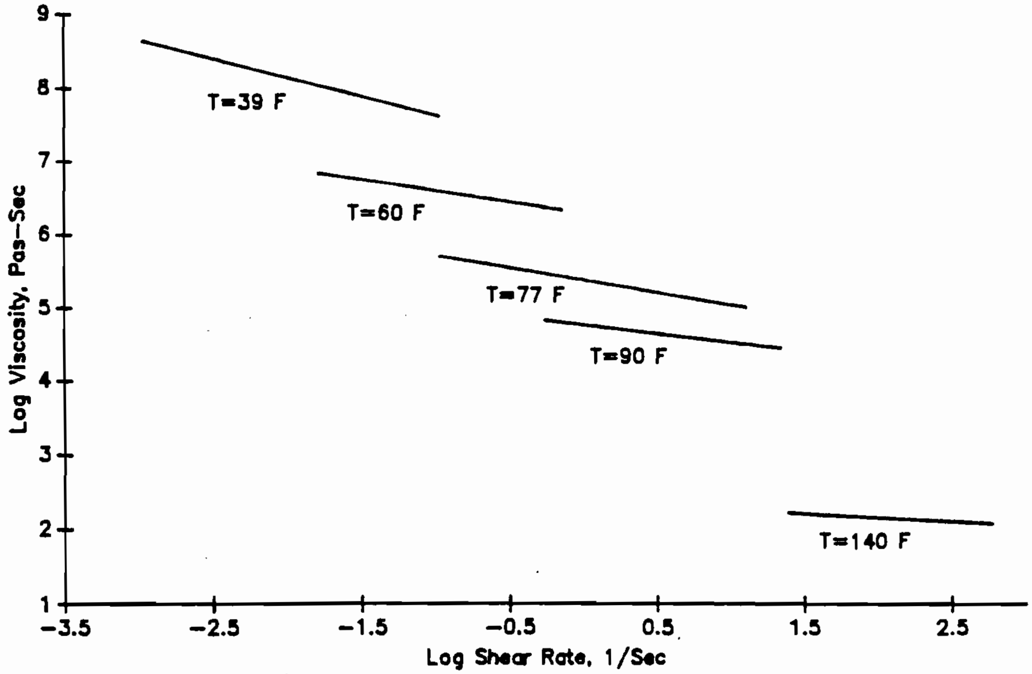


Fig C-23 Viscosity vs. Shear Rate for Shamrock AC-20 at Different Test Temperatures.

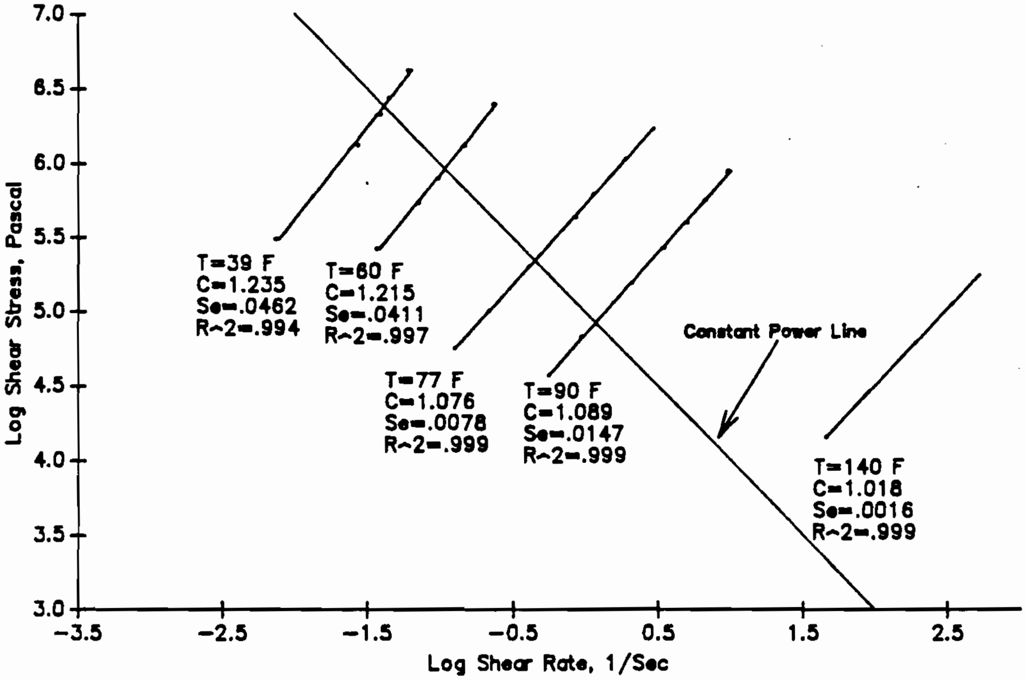


Fig C-24 Shear Stress vs. Shear Rate for Styrelf Modified Binder at Different Test Temperatures.

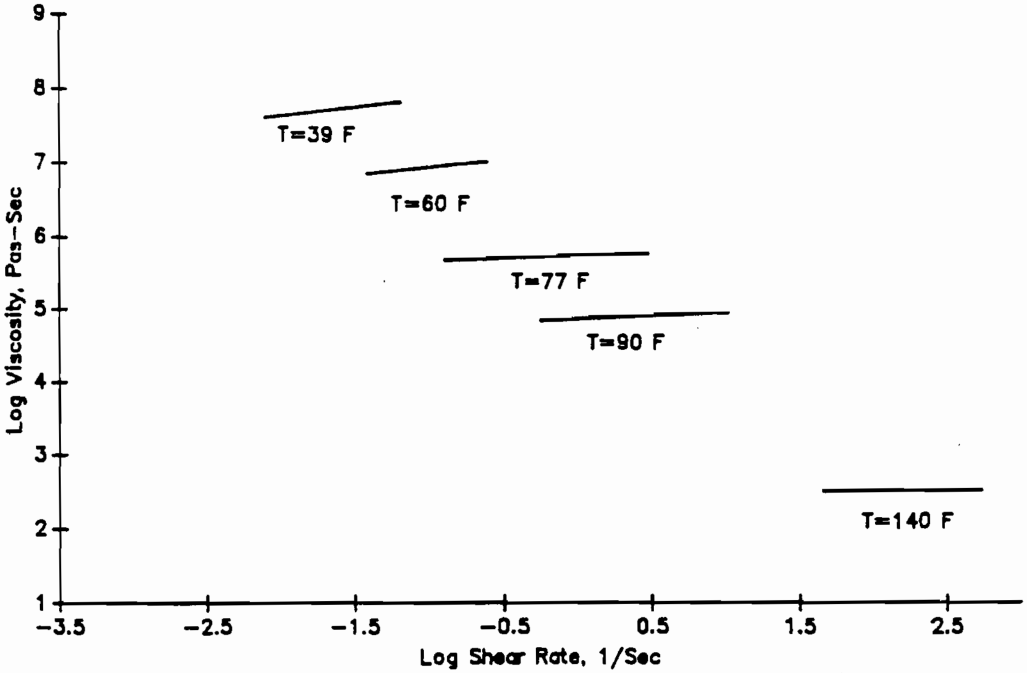


Fig C-25 Viscosity vs. Shear Rate for Styrelf Modified Binder at Different Test Temperatures.

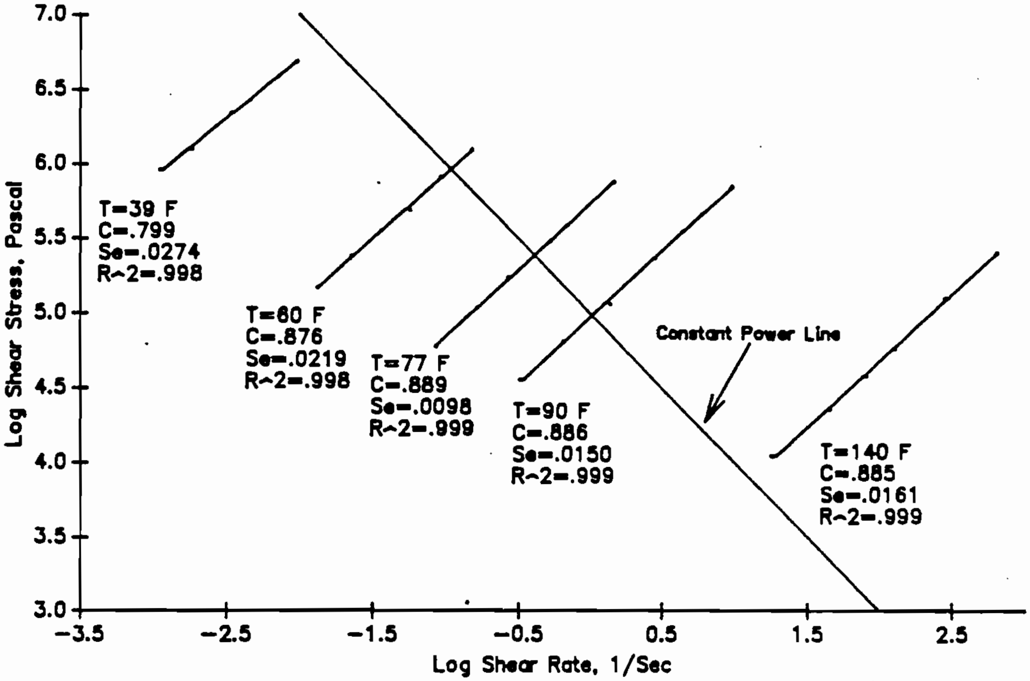


Fig C-26 Shear Stress vs. Shear Rate for 3% Kraton Binder at Different Test Temperatures.

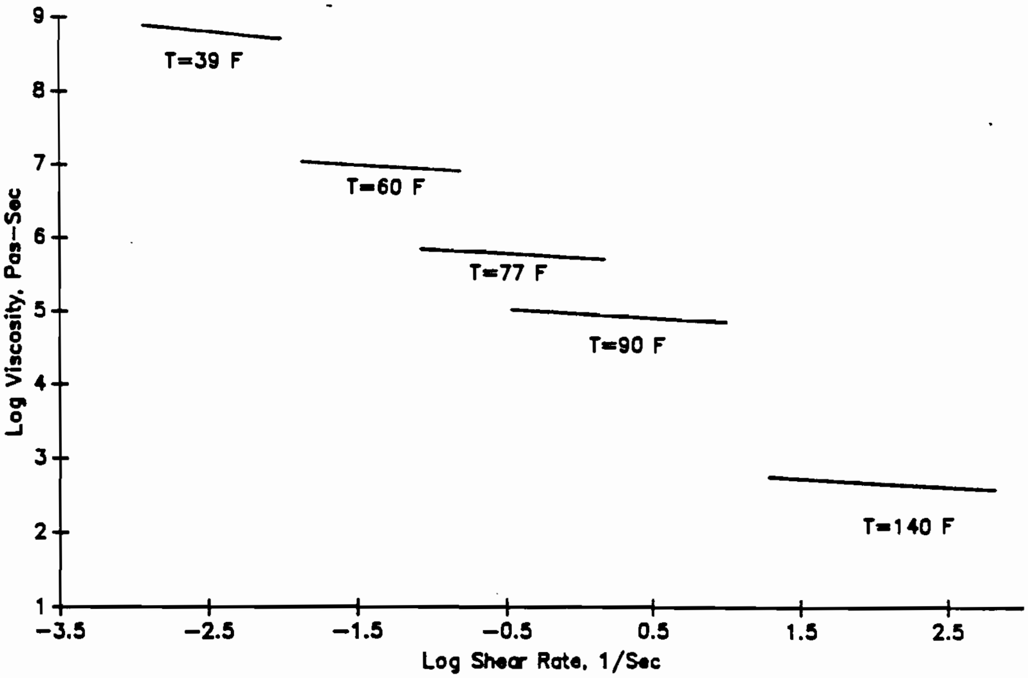


Fig C-27 Viscosity vs. Shear Rate for 3% Kraton Binder at Different Test Temperatures.

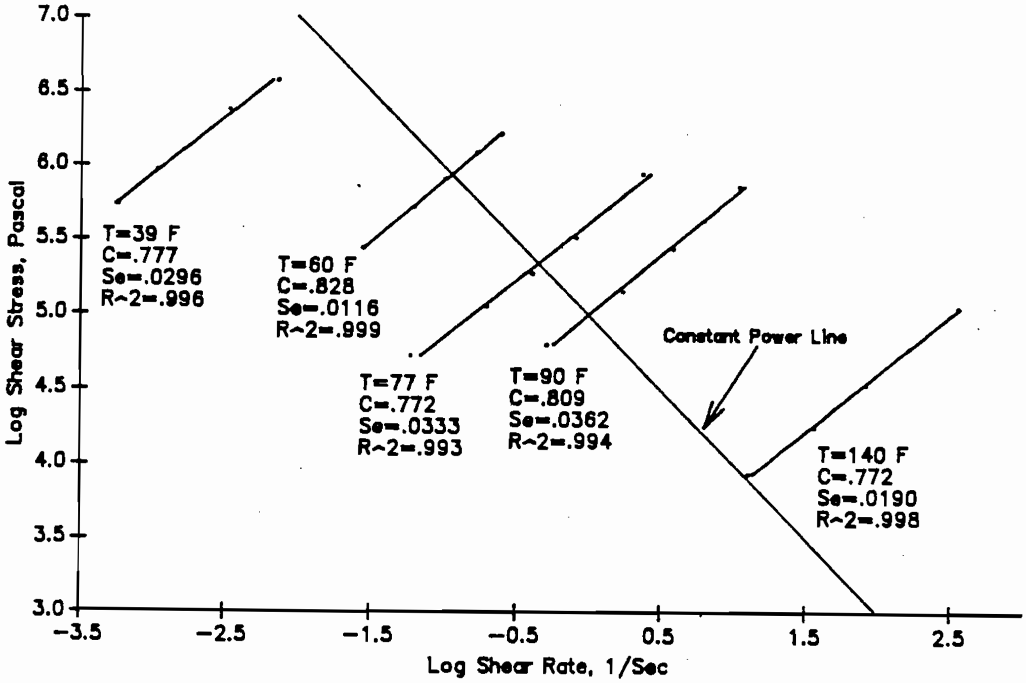


Fig C-28 Shear Stress vs. Shear Rate for 6% Kraton Binder at Different Test Temperatures.

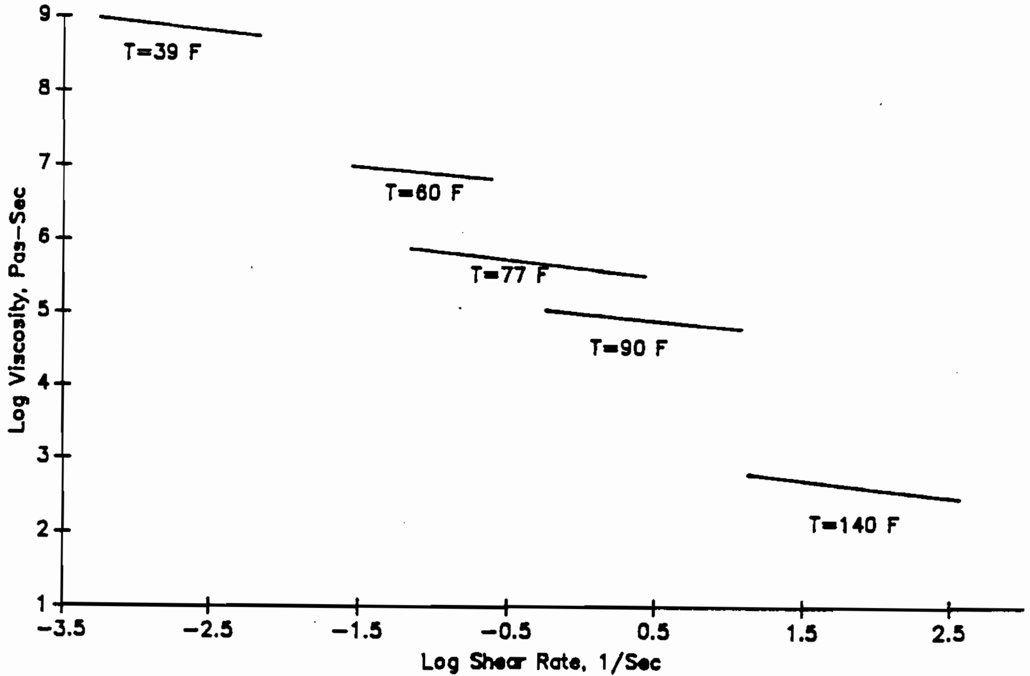


Fig C-29 Viscosity vs. Shear Rate for 6% Kraton Binder at Different Test Temperatures.

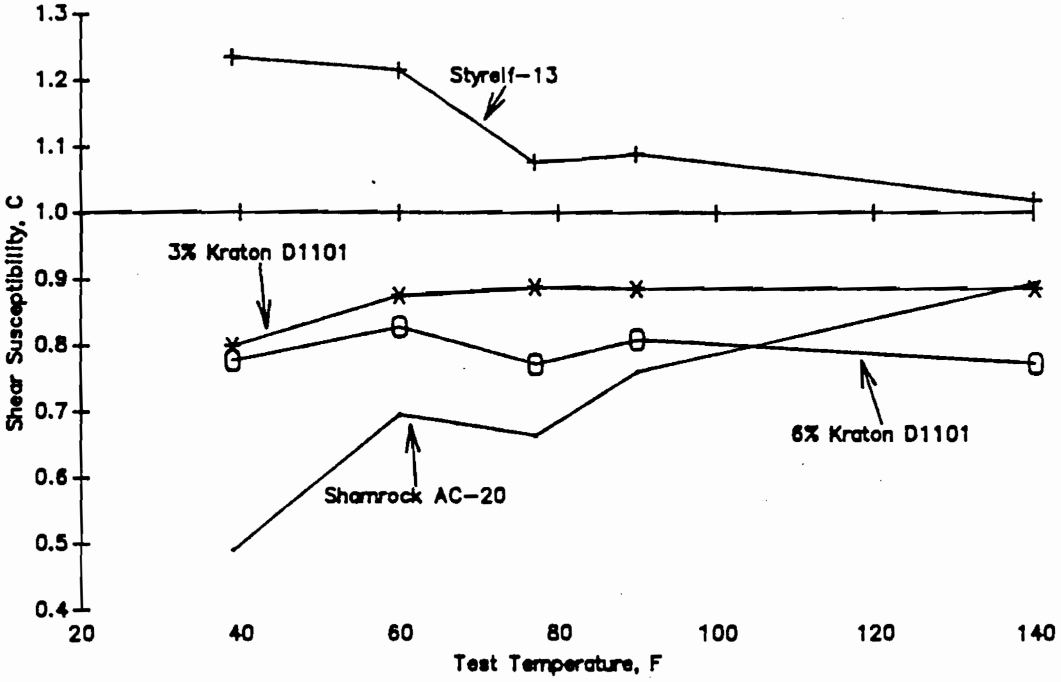


Fig C-30 Shear Susceptibility vs. Test Temperature for Unmodified Shamrock and Modified Fina Binders.

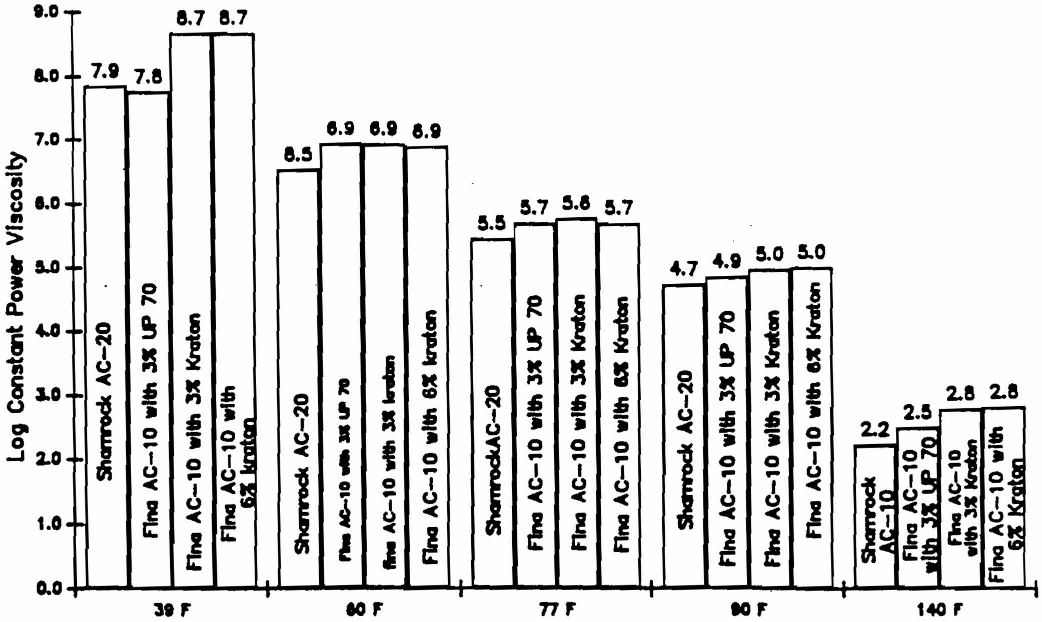


Fig C-31 Constant Power Viscosity for Unmodified and Modified Fina Binders.

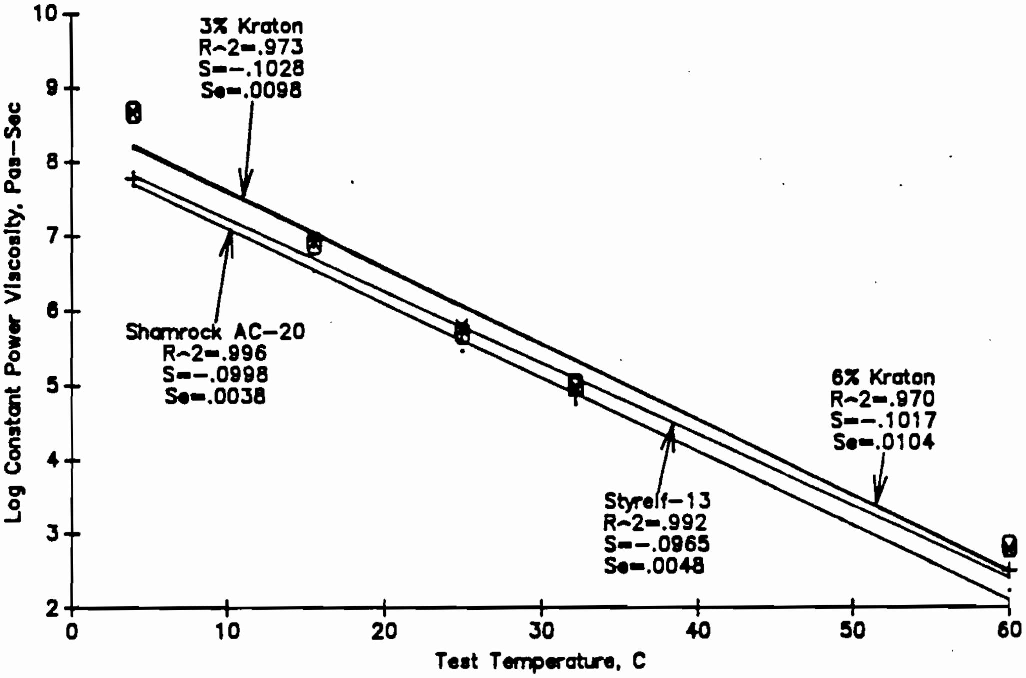


Fig C-32 Constant Power Viscosity vs. Test Temperature for Unmodified Fina Binders.

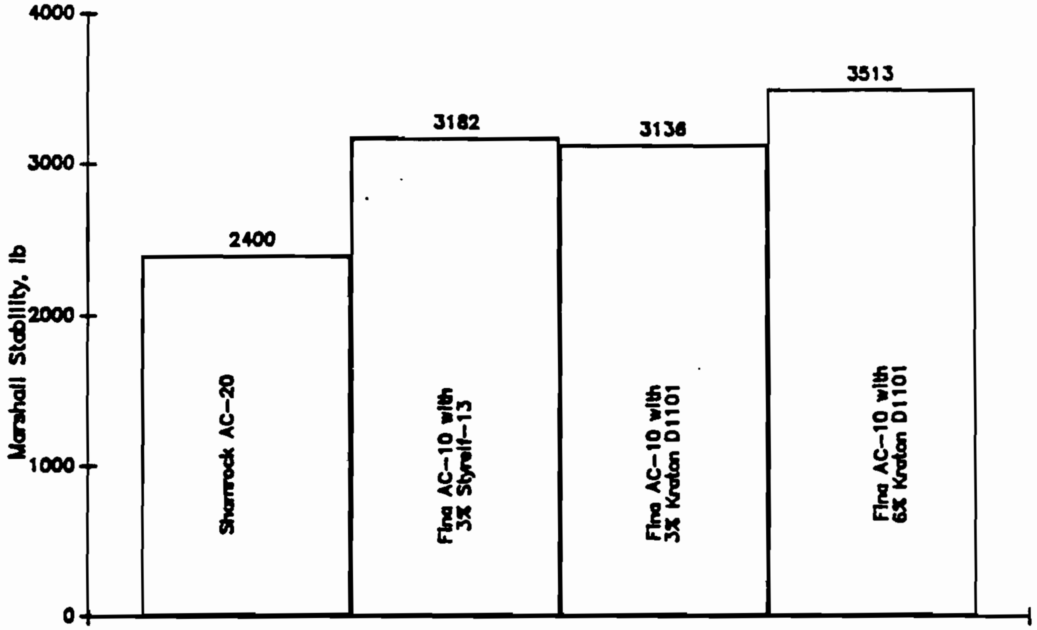


Fig C-33 Marshall Stability for Laboratory Mixtures Using Standard Compaction.

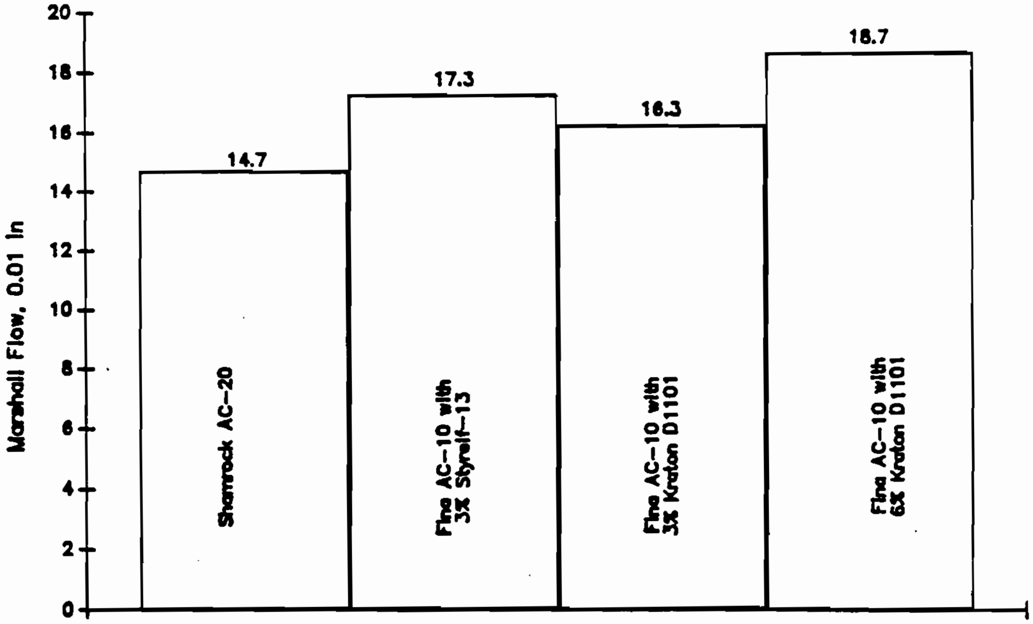


Fig C-34 Marshall Flow for Laboratory Mixtures Using Standard Compaction.

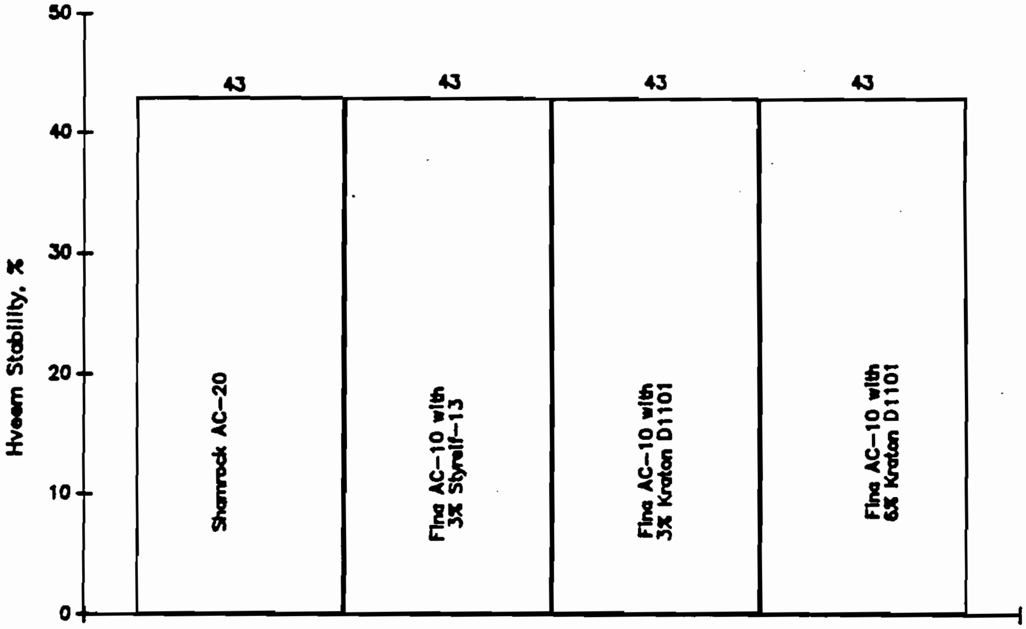


Fig C-35 Hveem Stability for Laboratory Mixtures Using Standard Compaction.

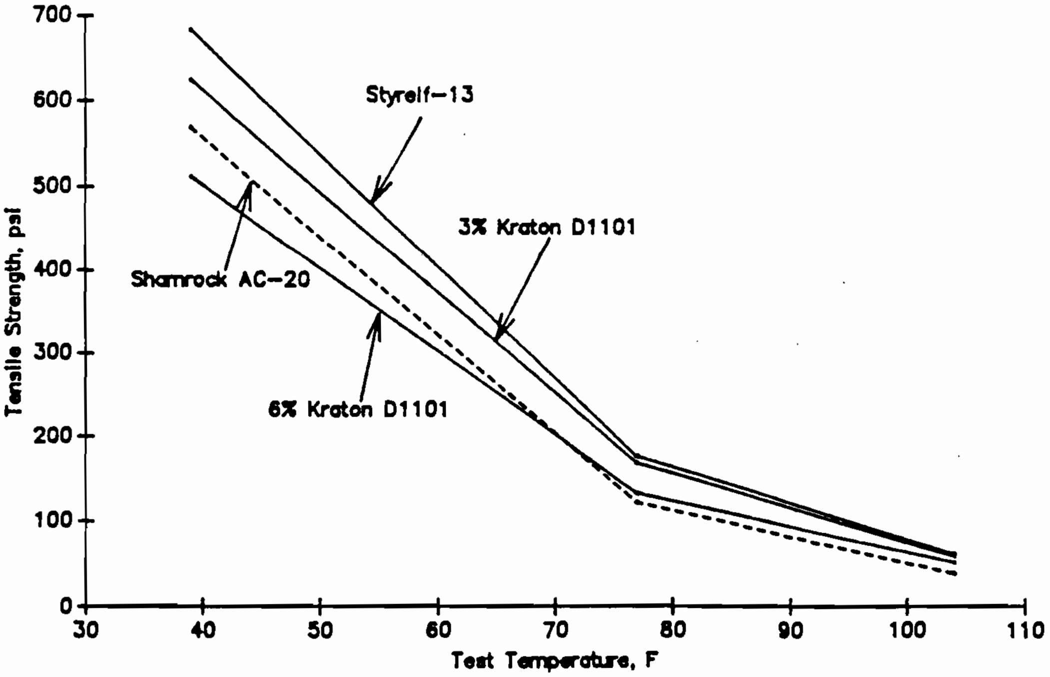


Fig C-36 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

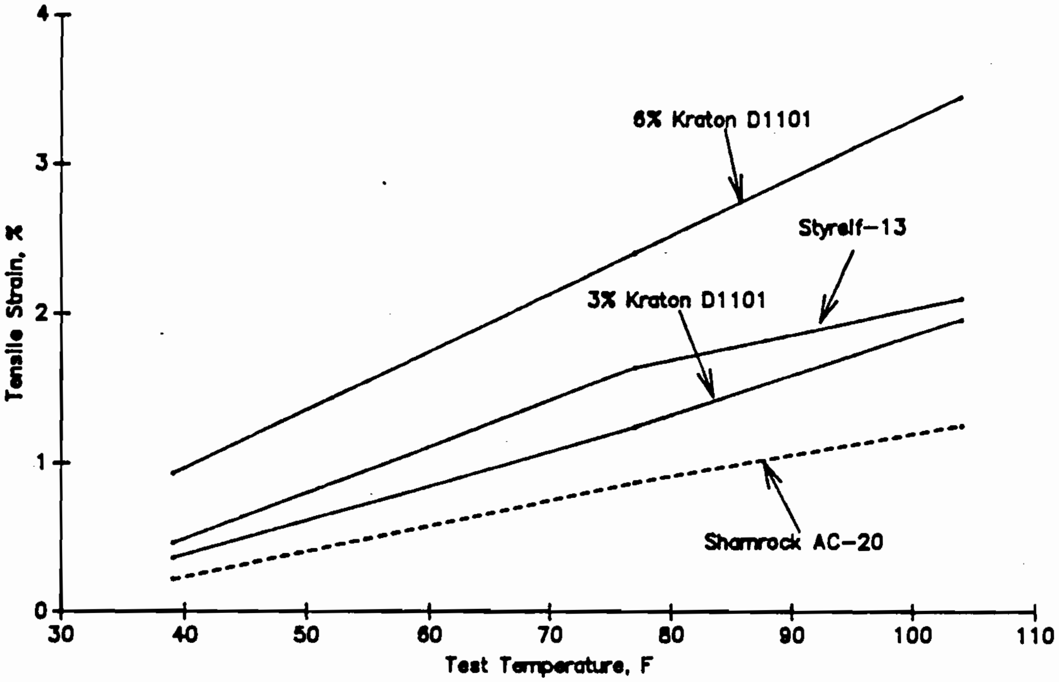


Fig C-37 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

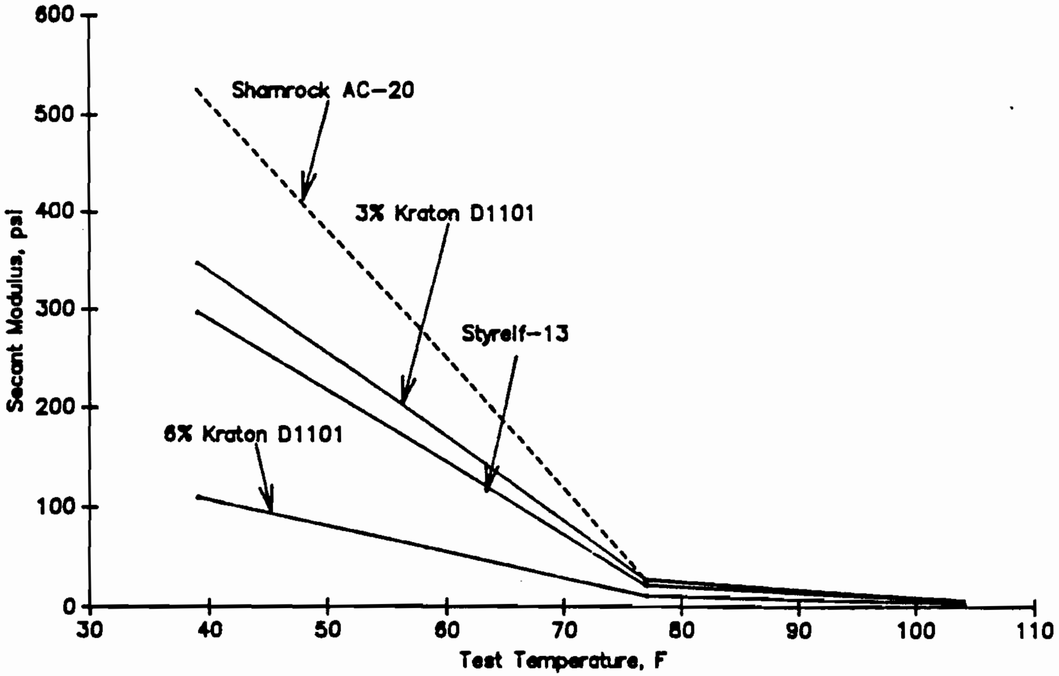


Fig C-38 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

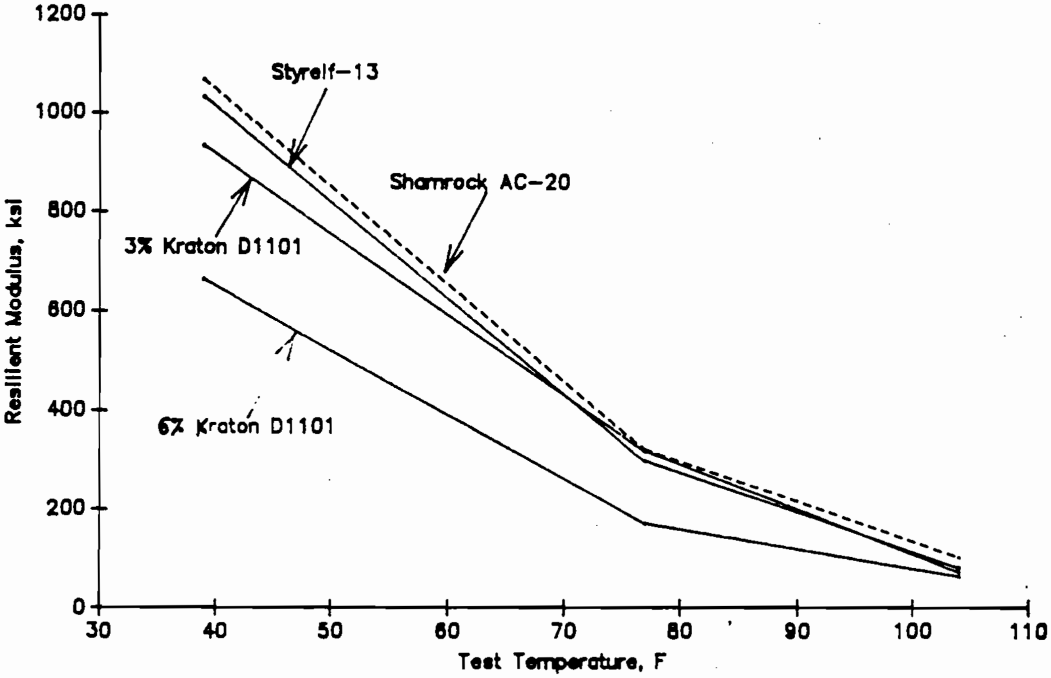


Fig C-39 Resilient Modulus vs Test Temperature for Laboratory Mixtures Using Standard Compaction.

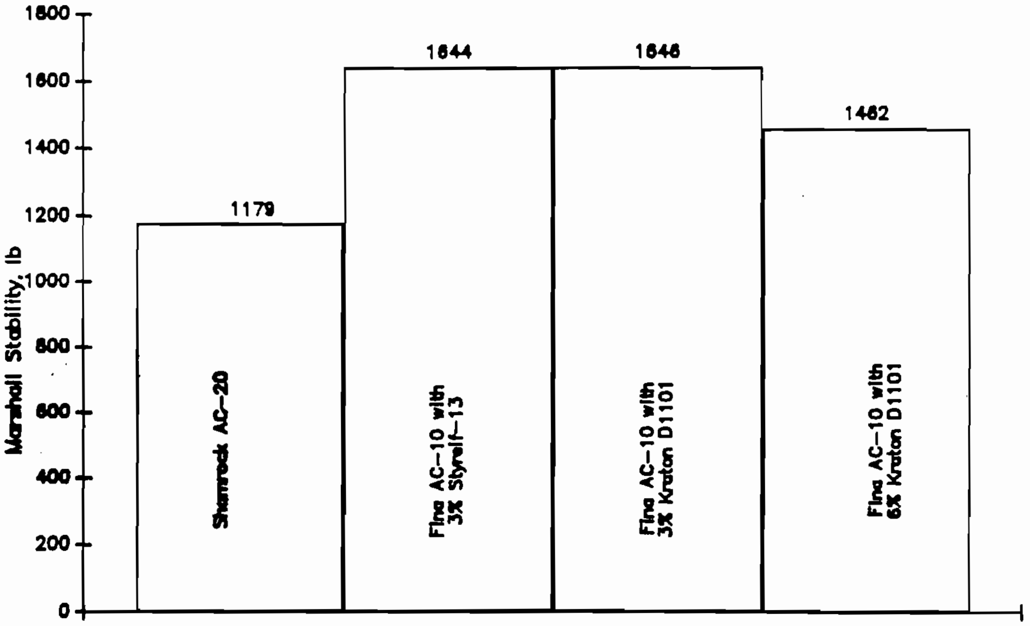


Fig C-40 Marshall Stability for Laboratory Mixtures Using Modified Compaction.

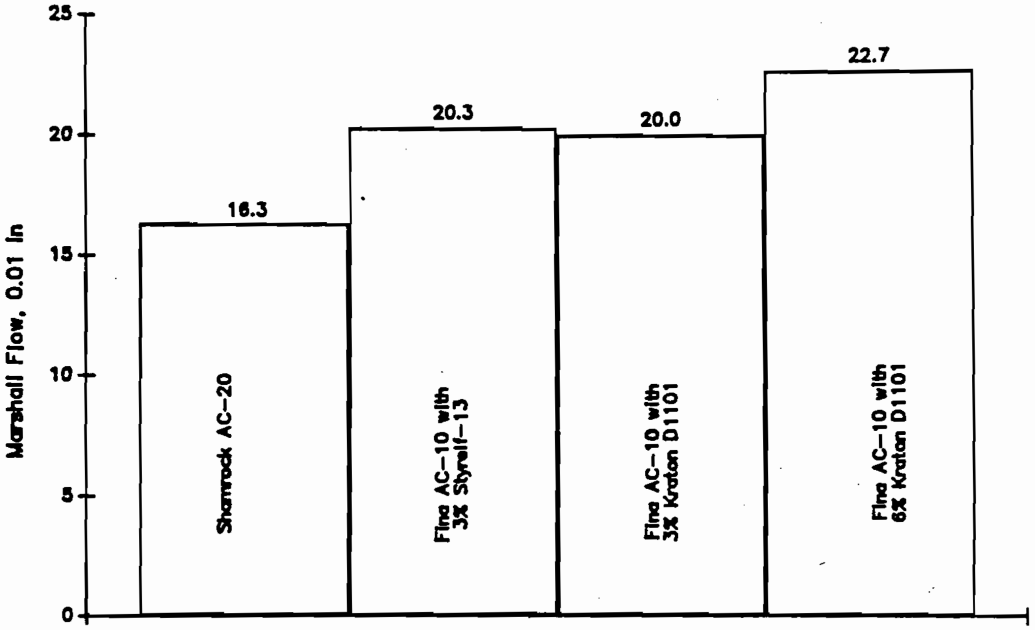


Fig C-41 Marshall Flow for Laboratory Mixtures Using Modified Compaction.

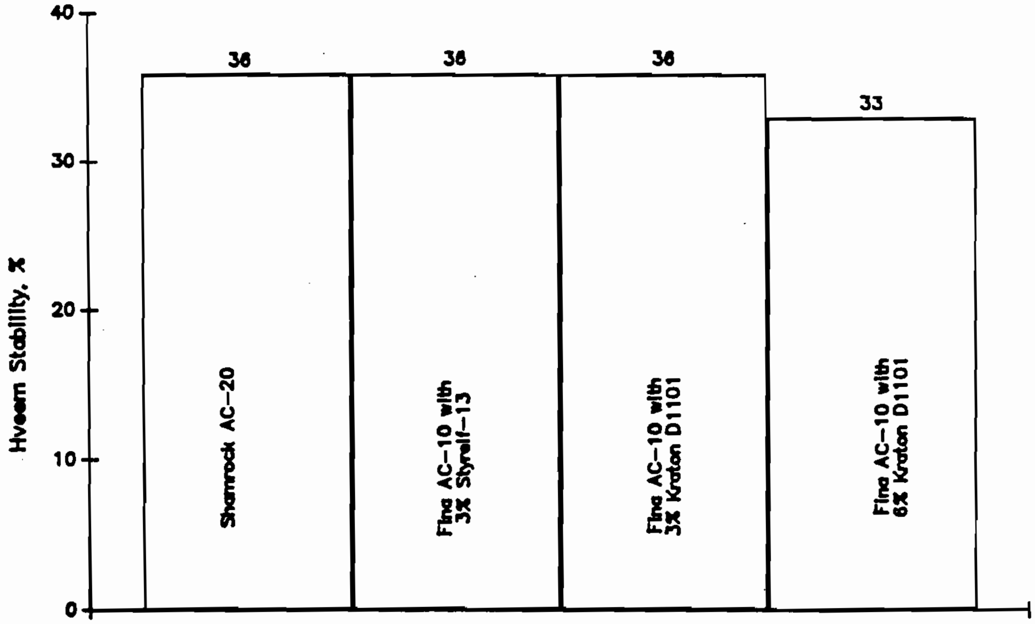


Fig C-42 Hveem Stability for Laboratory Mixtures Using Modified Compaction.

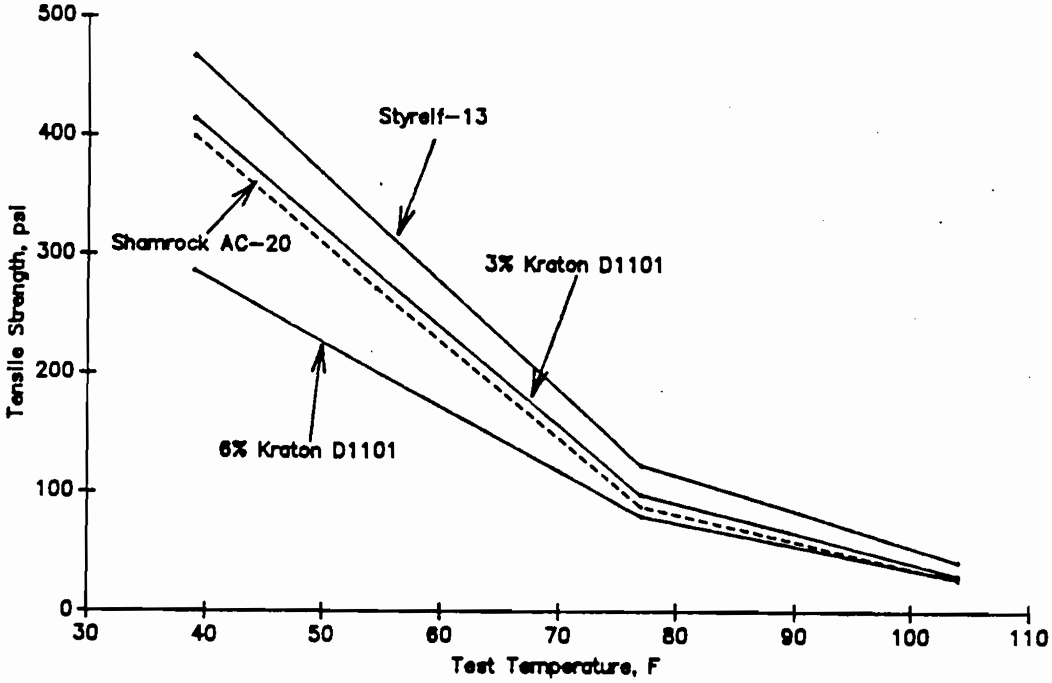


Fig C-43 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

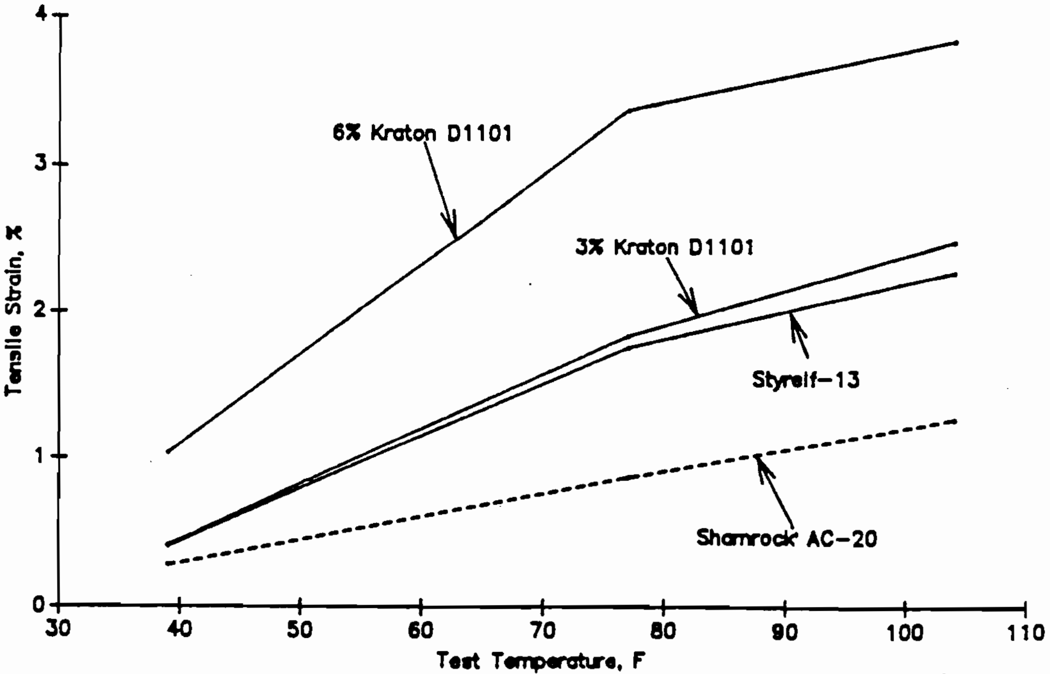


Fig C-44 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

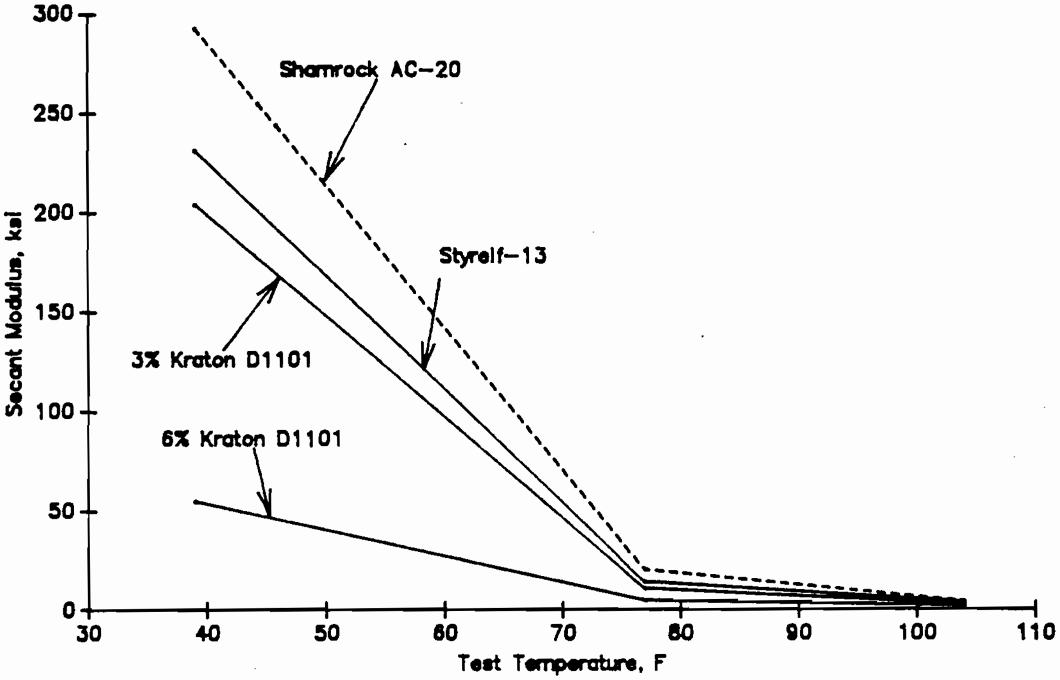


Fig C-45 Secant Modulus vs Test Temperature for Laboratory Mixtures Using Modified Compaction.

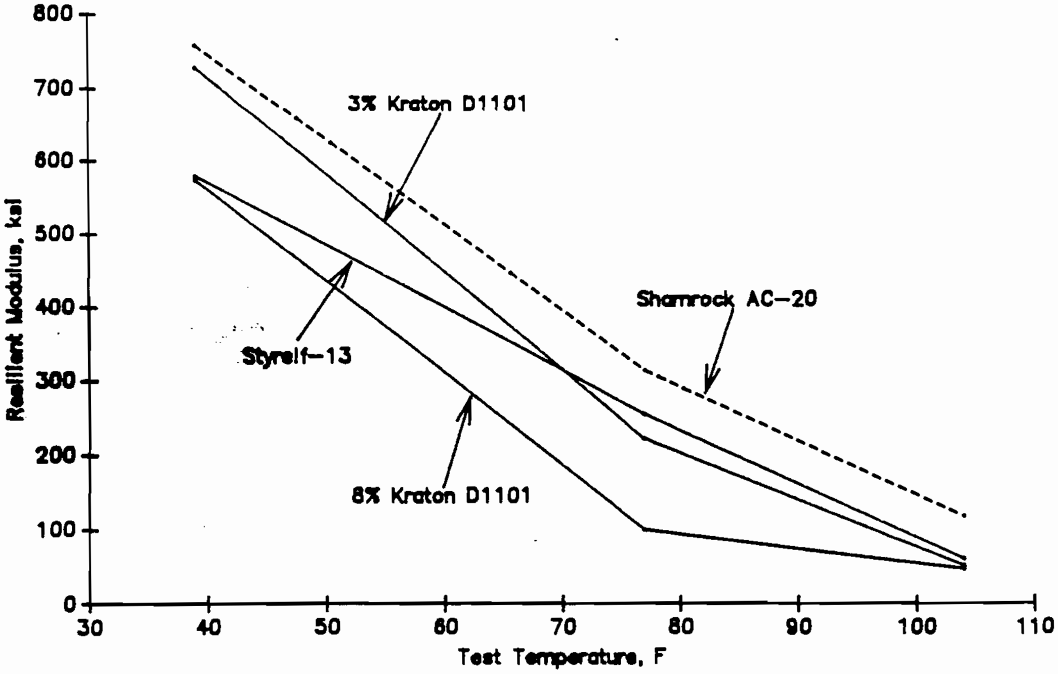


Fig C-46 Resilient Modulus vs Test Temperature for Laboratory Mixtures Using Modified Compaction.

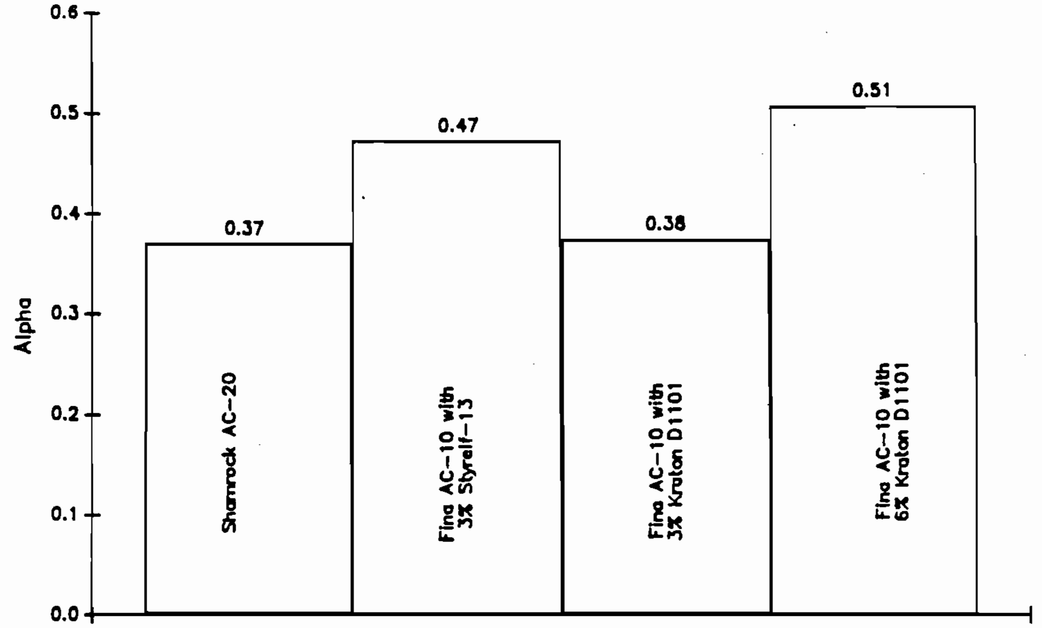


Fig C-47 Alpha Values for Laboratory Mixtures Using Modified Compaction.

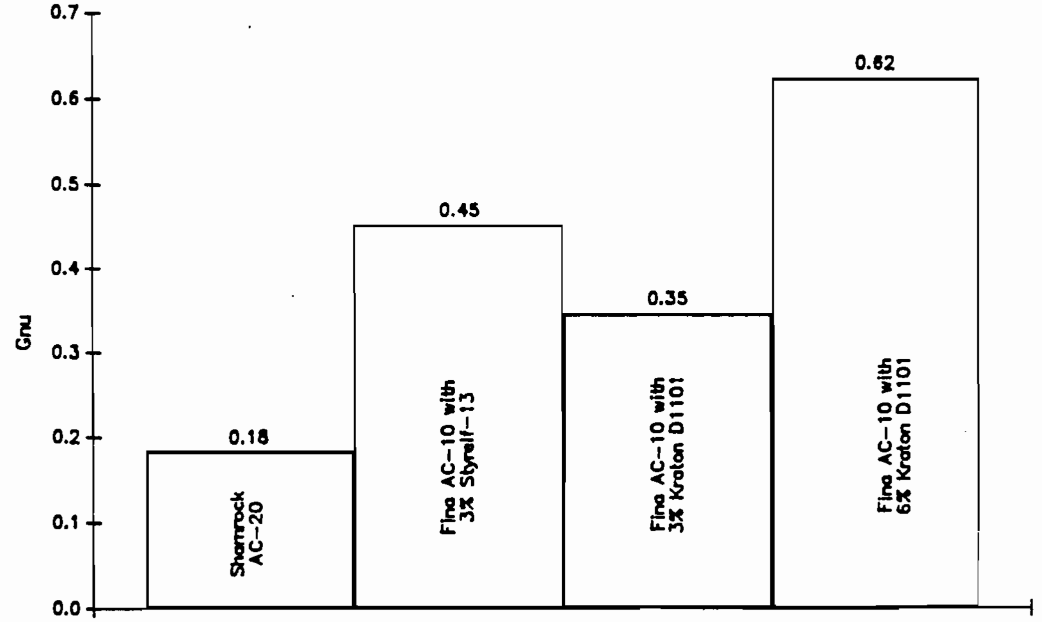


Fig C-48 Gnu Values for Laboratory Mixtures Using Modified Compaction.

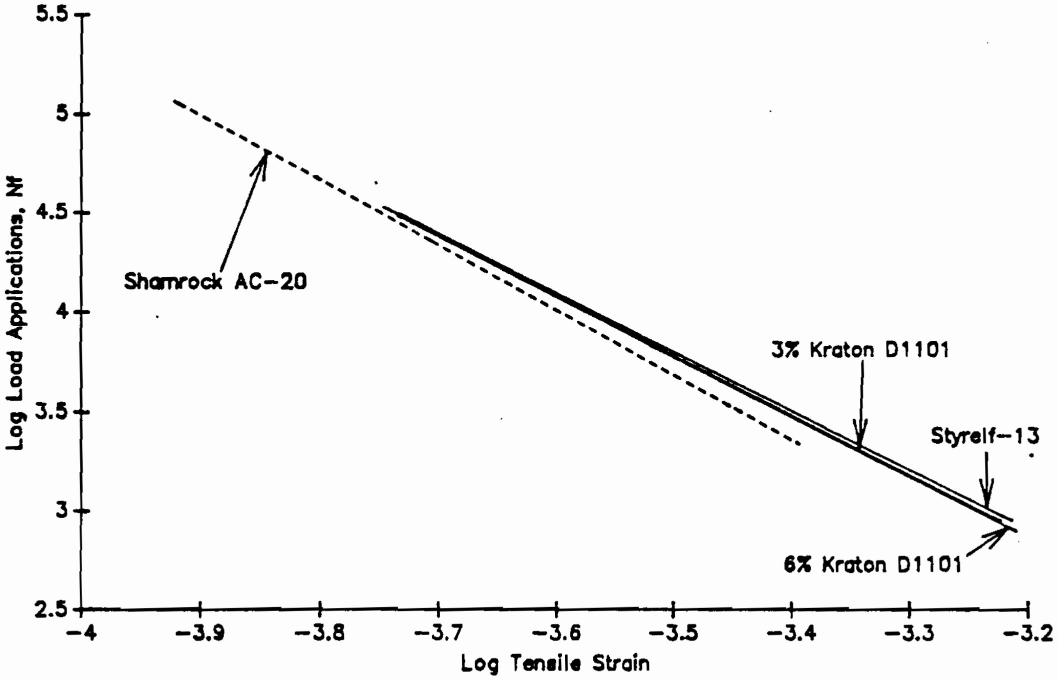


Fig C-49 Relationship between Fatigue Life and Applied Strain for Laboratory Mixtures Using Modified Compaction.

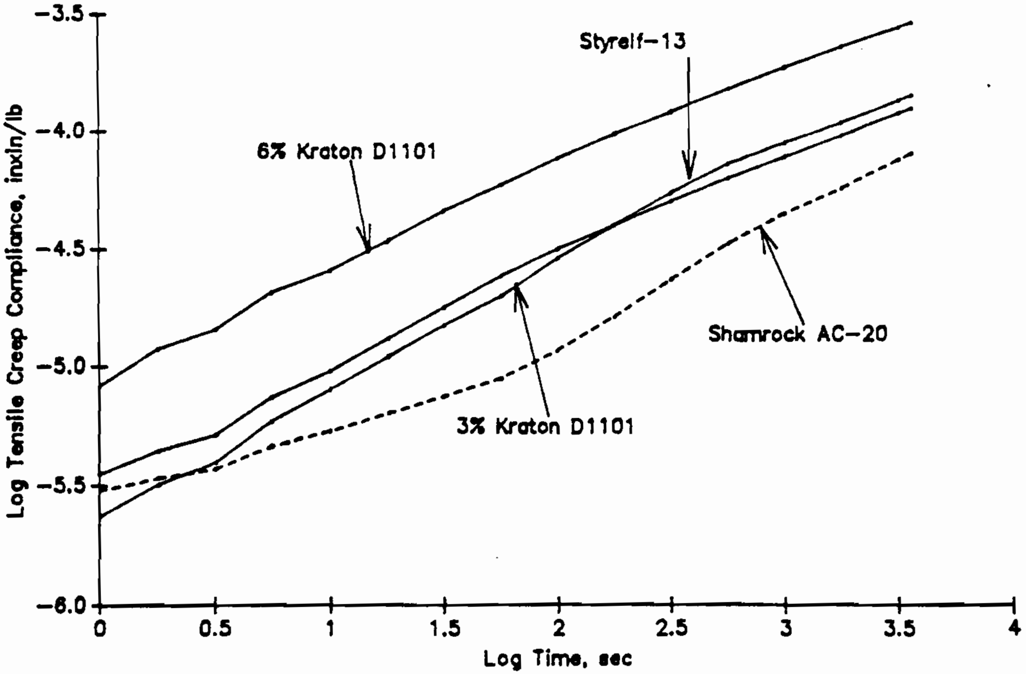


Fig C-50 Creep Compliance Curves at 60 F for Laboratory Mixtures Using Modified Compaction.

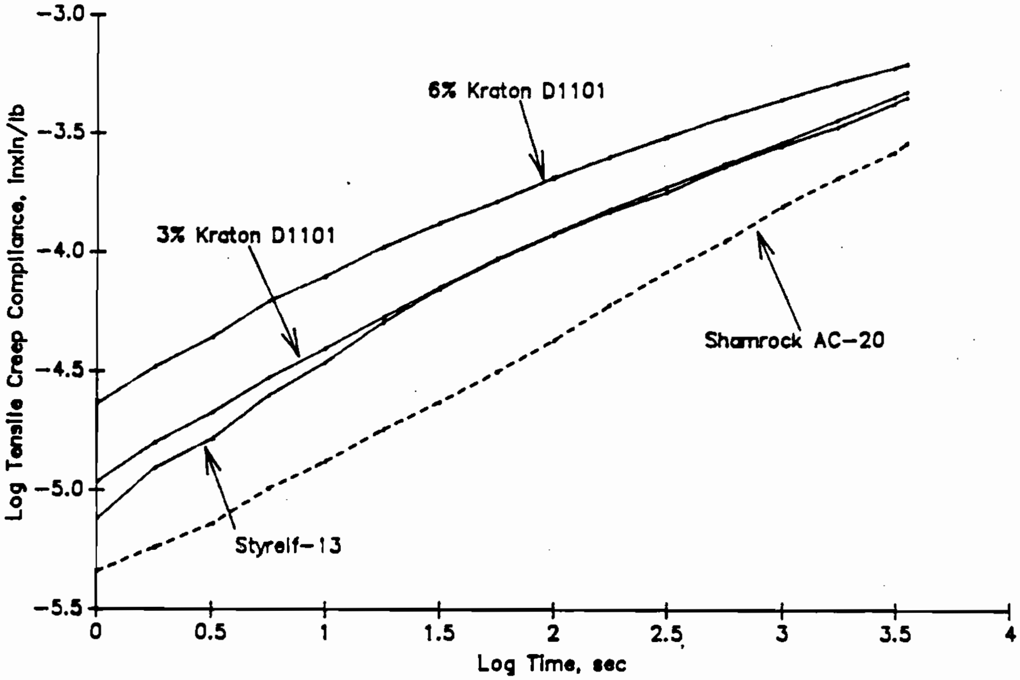


Fig C-51 Creep Compliance Curves at 77 F for Laboratory Mixtures Using Modified Compaction.

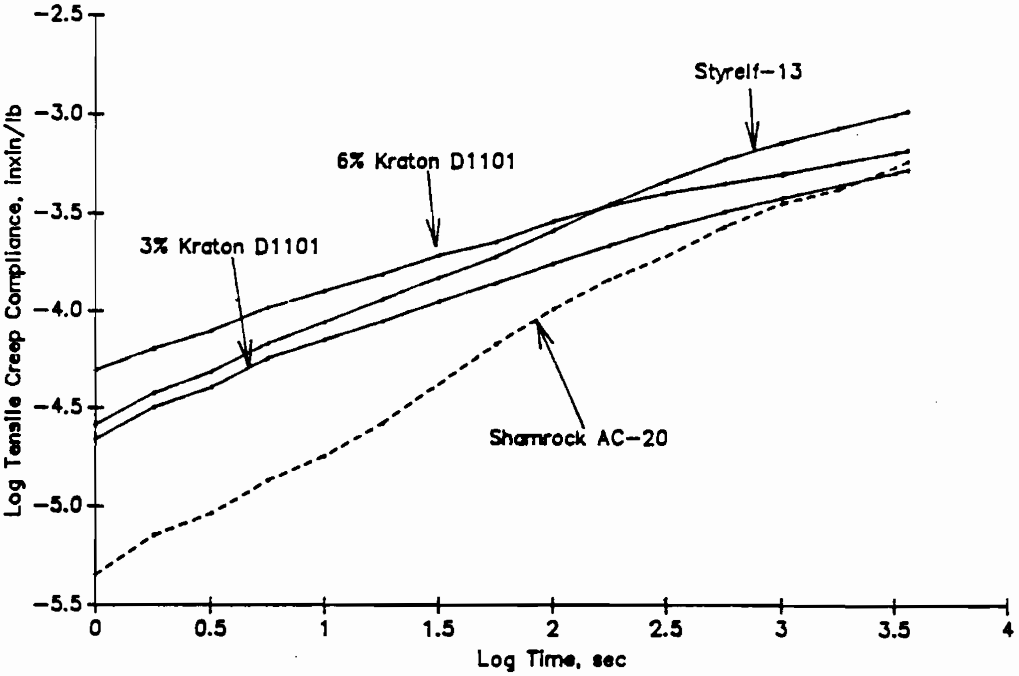


Fig C-52 Creep Compliance at 90 F for Laboratory Mixtures Using Modified Compaction.

APPENDIX D

PRESENTATION OF TEST RESULTS - DISTRICT 10

APPENDIX D

PRESENTATION OF TEST RESULTS - DISTRICT 10

The objectives of Appendix D are twofold: (1) to describe the site-specific field operations of the test sections along with a description of the materials, polymers, and construction techniques used for this field project, and (2) to present the laboratory test results of the unmodified and modified binders and laboratory mixed and plant mixed mixtures for the experimental field study in District 10 of the Texas Department Transportation (TxDOT).

EXPERIMENTAL FIELD PROGRAM

The test pavements were constructed on US 69 in Smith County, Texas, in July 1990, and involved pavement overlay of two lanes of the highway. The test sections are shown schematically in Figure D-1. Each test section was approximately two inches thick, twenty four feet wide, and 1000 feet long. A total of five test sections were constructed with four different polymers plus a control. Field construction was conducted by District 10 of the TxDOT and assisted by the Center for Transportation Research, the University of Texas at Austin. The average daily traffic (ADT) was estimated at 15500 vehicles for the test pavement.

MATERIALS

<u>ASPHALT CEMENT.</u> AC-10 asphalt cements were supplied by Gulf States Asphalt and Fina Oil & Chemical Co. and used for polymer-modified mixtures. An AC-20 asphalt cement supplied by Total Co. was used for the control test section.

<u>AGGREGATE.</u> Four aggregates, a type C limestone, a type D limestone, a limestone screening, and a field sand, were combined to produce the project gradation. Gradations of individual aggregates, the project gradation, percentage of each aggregate,

and the gradation specifications are given in Table D-1. The project gradation is plotted on a 0.45 power graph in Figure D-2.

POLYMER. Four polymers included in this field project consisted of one type of Styrene Butadiene Rubber (SBR), two types of Styrene block copolymer (SBS) and an Ethylene Vinyl Acetate (EVA). Sources of these polymers and designations used for this study are shown below.

SOURCE	TYPE	DESIGNATION
Goodyear	SBR	UP 70
Elf	SBS	Styrelf-13
Exxon	EVA	Polybilt 103
Shell	SBS	Kraton D1101

Blending of the asphalts and the polymers was performed by the polymer manufacturers or processors in the refinery or in a distributor truck. No polymer was introduced into the asphalt in-line injection system of the plant.

Ethylene Vinyl Acetate. The polybilt 103, a copolymer of Ethylene Vinyl Acetate (EVA), was obtained from Exxon Chemical Co. This polymer had a permanent polarity which was associated with the acetate group. The modified binder contained 97 percent Fina AC-10 and 3 percent polybilt 103.

Styrene Butadiene Rubber. One type of Styrene Butadiene Rubber, Ultra Pave 70, was included in this field project. The latex UP 70 was supplied by Textile Rubber and Chemical Co. The total amount of the UP 70 used in the Fina AC-10 was 3 percent.

Styrene Butadiene Styrene. The Styrelf-13 utilized was a triblock copolymer of Styrene and Butadiene. The Styrelf modified binder was blended by Elf Asphalt Co., Lubbock, Texas, for Fina

AC-10 at 3% Styrelf-13 by weight of total binder. The Kraton D1101 which consisted of a triblock copolymer of Styrene and Butadiene was obtained from Shell Development Co. The Blend of Gulf AC-10 was used at 3% Kraton D1101 by weight of total binder.

FIELD OPERATION

Approximately 600 tons of each mix were produced using a drum mix plant. Identical aggregates were utilized throughout the experiment. Two grades of asphalt cement, AC-10 and AC-20, were utilized. The Ultra Pave 70 (3 percent), Polybilt 103 (3 percent) and Styrelf-13 (3 percent) were blended with the Fina AC-10. The Kraton D1101 (3 percent) was preblended with the Gulf AC-10.

Mixing temperatures for the polybilt 103 and Styrelf-13 mixtures were 325°F, which was increased to 330°F for the UP 70 mixtures. The control asphalt, Total AC-20, and the Kraton blend were mixed at 315°F and 320°F, respectively. The initial breakdown compaction occurred between 250°F and 270°F, except for the Polybilt 103 mixtures. The polybilt modified mixtures were allowed to cool to between 200°F and 220°F before rolling, and at these temperatures the mixtures exhibited good handling characteristics. The Goodyear UP 70 modified mixture was noticeably stiffer than the other mixtures, and did not lay as smoothly. Compaction of each test section was achieved using a vibratory roller, a pneumatic roller and a steel wheel roller. Environmental conditions during construction were favorable, with early morning temperatures of approximately 65°F and afternoon temperatures of 85°F.

Twelve field cores were obtained from each test section soon after construction. These cores were approximately 4 inches in diameter and two inches in thickness. The field cores were transported to the Center for Transportation Research immediately after sampling.

PRESENTATION OF TEST RESULTS

Summaries of test results for the unmodified and modified binders are presented in Tables D-6 through D-8 and are plotted in Figures D-3 through D-14.

Summaries of test results for the unmodified and modified mixtures are presented in Tables D-9 through D-26 and are plotted in Figures D-16 through D-34.

Table D-1 AGGREGATE GRADATION (DISTRICT 10)

	TY C CR. Limestone		TY D CR. Limestone		Limestone Screenings		Field Sand			
	Sieve Analysis	30%	Sieve Analysis	35%	Sieve Analysis	15%	Sieve Analysis	20%	Combined Gradation	SDHPT Specification
7/8 to 5/8 in.	5.5	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0
5/8 to 3/8 in	77.9	23.4	9.2	3.3	0.0	0.0	0.0	0.0	26.7	0-5
3/8 to No. 4	12.1	3.6	53.6	18.8	1.6	0.2	0.2	0.0	22.6	16-42
No. 4 to No. 10	1.6	0.5	29.9	10.5	9.7	1.5	0.2	0.0	12.5	11-37
Plus No. 10	97.1	29.2	92.7	32.6	11.3	1.7	0.4	0.0	63.5	54-72
No. 10 to No.40	1.0	0.3	5.5	1.8	63.3	9.5	0.4	0.2	11.8	6-32
No. 40 to No. 80	0.4	0.1	0.5	0.2	17.5	2.6	43.5	8.7	11.6	4-27
No. 80 to No. 200	0.7	0.2	0.7	0.2	5.5	0.8	51.2	10.2	11.4	3-27
Minus No. 200	0.8	0.2	0.6	0.2	2.4	0.4	4.5	0.9	1.7	1-8
Total	100.0	30.0	100.0	35.0	100.0	15.0	100.0	20.0	100.0	

TABLE D-2 Experimental Testing Program for Unmodified and Polymer-Modified Asphalt Binders District 10

Binder		Penetration			Viscosity				Softening Point
		Before RTFOT		After RTFOT	Before RTFOT		After RTFOT		Before RTFOT
Asphalt	Polymer	39.2 F	77 F	77 F	140 F	275 F	140 F	275 F	
Total AC-10	-	2	2	2	2	2	2	2	2
Fina AC-10	Goodyear UP 70	2	2	2	2	2	2	2	2
Fina AC-10	Styrelf-13	2	2	2	2	2	2	2	2
Exxon AC-10	Exxon Polybilt 103	2	2	2	2	2	2	2	2
Gulf AC-10	Shell Kraton D1101	2	2	2	2	2	2	2	2

TABLE D-3 Experimental Testing Program for Laboratory Compacted-Laboratory Mixed Mixtures District 10

Binder		Modified Compaction												Standard Compaction				
		Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F	Creep @			Fatique Stress levels			Moisture Resistance	Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F
Asphalt	Polymer	39F	77F	104F			60F	77F	90F	15%	25%	50%		39F	77F	104F		
Total AC-10	-	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	Goodyear UP 70	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	Styrelf-13	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Exxon AC-10	Exxon Polybilt 103	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Gulf AC-10	Shell Kraton D1101	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3

TABLE D-4 Experimental Testing Program for Laboratory Compacted-Plant Mixed Mixtures
District 10

Binder		Modified Compaction												Standard Compaction				
Asphalt	Polymer	Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F	Creep @			Fatique Stress levels			Moisture Resistance	Resilient modulus & Indirect Tensile Strength			Hveem 140F	Marshall 140F
		39F	77F	104F			60F	77F	90F	15%	25%	50%		39F	77F	104F		
Total AC-10	-	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	Goodyear UP 70	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Fina AC-10	Styrelf-13	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Exxon AC-10	Exxon Polybilt 103	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3
Gulf AC-10	Shell Kraton D1101	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3	3	3

TABLE D-5 Experimental Testing Program for Field Cores. District 10

Binder		Resilient modulus & Indirect Tensile Strength			Marshall 140F
Asphalt	Polymer	39F	77F	104F	
Total AC-20	-	3	3	3	3
TFA AC-10	Goodyear UP 70	3	3	3	3
TFA AC-20	Styrelf-13	3	3	3	3
TFA AC-20	Polybilt 103	3	3	3	3
TFA AC-10	Kraton D1101	3	3	3	3

Table D-6 Unmodified and Modified Asphalt Properties before RTFOT.

Parameter	Total AC-20	Fina AC-10 & 3% UP-70	Fina AC-10 & 3% Styrelf	Exxon AC-10 & 3% Polybilt	Gulf States AC-10 & 3% Kraton
Penetration @ 39.2 F (25 C)	10	14	14	14	16
100g, 5 Sec.	9	14	13	15	17
Avg.	10	14	14	15	17
Penetration @ 77 F (4 C)	73	92	90	95	90
100g, 5 Sec.	75	94	88	97	88
Avg.	74	93	89	96	89
Viscosity @ 140 F (60 C)	2026	2245	2928	2340	3425
Poises	2048	2500	2880	2410	3515
Avg.	2037	2373	2904	2375	3470
Viscosity @ 275 F (135 C)	508	634	750	635	788
Centistokes	512	665	775	645	776
Avg.	510	650	763	640	782
Softening Point, F	128	129	135	140	147
	127	130	134	141	146
Avg.	128	130	135	141	147
Penetration Index PI(Pen/Pen)	-0.23	0.14	0.30	0.28	1.06
Penetration Index PI(Pen/SP)	0.62	1.60	2.10	3.07	3.48
Penetration Viscosity Number	-0.22	0.47	0.67	0.49	0.71
Stiffness Modulus @ 0.1 Sec					
39.2F	6525	2465	2175	2320	1600
77F	290	174	181	218	232
104F	36	37	31	31	35
Stiffness/Temperature Slope	-0.063	-0.051	-0.051	-0.052	-0.046
Penetration Ratio, 77 F	0.59	0.60	0.69	0.66	0.63
Viscosity Ratio	2.36	2.17	2.55	2.45	2.10
Kinematic Vicosity Ratio	1.80	1.45	1.44	1.94	1.35

Table D-7 Unmodified and Modified Asphalt Properties after RTFOT.

Parameter		Total AC-20	Fina AC-10 & 3% UP-70	Fina AC-10 & 3% Styrelf	Exxon AC-10 & 3% Polybilt	Gulf States AC-10 & 3% Kraton
Penetration @ 77 F (4 C)		43	55	60	63	55
100g, 5 Sec.		45	57	62	63	57
	Avg.	44	56	61	63	56
Viscosity @ 140 F (60 C)		4756	5120	7214	5718	7210
Poises		4840	5160	7618	5920	7350
	Avg.	4798	5140	7416	5819	7280
Viscosity @ 275 F (135 C)		910	925	1100	1220	1042
Centistokes		925	960	1095	1265	1068
	Avg.	918	943	1098	1243	1055

Table D-8 Summary of Predicted Cracking Temperatures for Unmodified and Modified Asphalt Binders (District 10)

Binder		Cracking Temperature	
Asphalt	Polymer	Limiting Stiffness Method	Critical Stress Method
Total AC-20		-43	-44
Fina AC-10	Goodyear UP70	-54	-55
Fina AC-10	Styrelf--13	-58	-57
Exxon AC-10	Polybilt 103	-66	-63
Gulf AC-10	3% kraton D1101	-68	-66

Table D-9 Marshall and Hveem Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES STABILITY lbs	FLOW .01 in
Control: Total AC-20		7.1	36	6.7	529	12.0
		6.7	33	7.1	459	9.5
		6.8	37	6.8	491	11.0
		-----	-----	-----	-----	-----
	AVG.	6.9	35	6.9	493	10.8
Fina AC-10 + 3% UP 70		6.7	36	6.4	488	12.0
		6.9	37	7.0	394	11.0
		6.7	36	6.4	693	12.0
		-----	-----	-----	-----	-----
	AVG.	6.8	36	6.6	525	11.7
Fina AC-10 + 3% Styrelf		6.7	36	7.4	538	14.0
		7.3	38	7.0	531	14.0
		7.2	35	7.1	531	14.0
		-----	-----	-----	-----	-----
	AVG.	7.1	36	7.2	533	14.0
Exxon AC-10 + 3% Polybilt		6.6	34	7.3	275	12.0
		7.0	34	7.2	208	11.0
		7.3	32	6.8	196	11.0
		-----	-----	-----	-----	-----
	AVG.	7.0	34	7.1	227	11.3
Gulf AC-10 + 3% Kraton D1101		6.6	34	7.3	463	13.0
		6.7	35	7.2	519	12.5
		7.0	34			
		-----	-----	-----	-----	-----
	AVG.	6.8	35	7.3	491	12.8

Table D-10 Marshall and Hveem Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES STABILITY lbs	FLOW .01 in
Control: Total AC-20		4.5	45	4.2	1307	10.0
		4.3	46	3.8	1472	11.0
		4.2	43	4.4	1298	10.0
	AVG.	4.3	45	4.1	1359	10.3
Fina AC-10 + 3% UP 70		4.5	45	4.7	1102	10.0
		4.8	45	5.2	931	10.0
		5.0	46	4.7	832	10.0
	AVG.	4.8	45	4.9	955	10.0
Fina AC-10 + 3% Styrelf		4.4	45	4.8	1181	10.0
		4.1	45	4.1	1360	10.0
		5.2	43	4.4	1373	11.0
	AVG.	4.6	45	4.4	1305	10.3
Exxon AC-10 + 3% Polybilt		3.2	43	3.4	983	9.5
		3.7	44	3.4	990	9.5
		3.8	41			
	AVG.	3.6	43	3.4	987	9.5
Gulf AC-10 + 3% Kraton D1101		5.0	42	4.8	865	9.0
		4.9	40	4.3	931	11.0
		4.7	45	4.7	845	9.0
	AVG.	4.9	42	4.6	880	9.7

Table D-11 Marshall and Hveem Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES	
					STABILITY lbs	FLOW .01 in
Control: Total AC-20		7.4	38	7.5	700	12.0
		7.1	36	7.2	731	14.0
		7.4	36	7.2	700	13.0
	AVG.	7.3	37	7.3	710	13.0
Fina AC-10 + 3% UP 70		7.3	30	7.0	357	15.0
		6.8	31	6.8	452	14.0
		7.4	28	6.9	363	14.0
	AVG.	7.2	30	6.9	391	14.3
Fina AC-10 + 3% Styrelf		7.0	35	7.4	775	16.0
		7.3	32	6.7	781	14.0
		7.2	32	6.9	750	14.0
	AVG.	7.2	33	7.0	769	14.7
Exxon AC-10 + 3% Polybilt		7.1	33	7.1	363	11.0
		6.8	34	7.0	338	11.0
		6.9	34	6.8	338	10.0
	AVG.	6.9	33	7.0	346	10.7
Gulf AC-10 + 3% Kraton D1101		6.9	34	6.7	713	15.0
		6.7	38	7.4	528	12.0
		7.1	35	6.5	620	12.0
	AVG.	6.9	36	6.9	620	13.0

Table D-12 Marshall and Hveem Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Standard Modified Compaction

MIXTURE		AIR VOIDS %	HVEEM STABILITY %	AIR VOIDS %	MARSHALL VALUES STABILITY lbs	FLOW .01 in
Control: Total AC-20		5.1	42	5.0	1610	10.0
		4.4	47	4.4	1703	11.0
		5.2	46	4.7	1637	11.0
	AVG.	4.9	45	4.7	1650	10.7
Fina AC-10 + 3% UP 70		3.7	45	3.2	1571	11.0
		3.6	42	3.7	1333	11.0
		3.5	44	3.2	1360	11.0
	AVG.	3.6	44	3.4	1421	11.0
Fina AC-10 + 3% Styrelf		4.8	37	4.4	1749	11.0
		4.5	38	3.9	1894	11.0
		4.1	40	4.7	1584	11.0
	AVG.	4.5	38	4.3	1742	11.0
Exxon AC-10 + 3% Polybilt		4.1	41	4.5	865	8.0
		4.0	39	4.4	792	9.0
		4.2	39	4.0	950	9.0
	AVG.	4.1	40	4.3	869	8.7
Gulf AC-10 + 3% Kraton D1101		4.0	42	4.5	1294	10.0
		4.8	43	4.6	1122	10.0
		5.3	41	4.8	1043	10.0
	AVG.	4.7	42	4.6	1153	10.0

Table D-13 Indirect Tensile Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	39	6.9	318	0.21	305	2084	-
		6.7	372	0.21	357	2107	-
		7.6	306	0.26	235	2167	-
		-----	-----	-----	-----	-----	-----
	AVG.	7.1	332	0.23	299	2120	-
Fina AC-10 + 3% UP 70	39	6.3	423	0.22	387	2260	-
		6.8	453	0.23	395	1892	-
		6.8	429	0.21	402	1329	-
		-----	-----	-----	-----	-----	-----
	AVG.	6.6	435	0.22	395	1827	-
Fina AC-10 + 3% Styrelf	39	7.3	377	0.24	315	2151	-
		7.6	363	0.20	357	2867	-
		7.0	450	0.32	279	2912	-
		-----	-----	-----	-----	-----	-----
	AVG.	7.3	397	0.25	317	2643	-
Exxon AC-10 + 3% Polybilt	39	7.2	282	0.75	75	922	-
		7.1	249	0.75	66	1536	-
		7.3	288	0.75	76	1256	-
		-----	-----	-----	-----	-----	-----
	AVG.	7.2	273	0.75	72	1238	-
Gulf AC-10 + 3% Kraton	39	6.9	359	0.70	102	1980	-
		7.0	340	0.57	119	1705	-
		7.2	422	0.60	141	2506	-
		-----	-----	-----	-----	-----	-----
	AVG.	7.0	374	0.62	121	2064	-

Table D-13 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	77	7.0	89	1.17	15	333	0.70
		7.1	83	1.25		446	0.35
		7.2	85	1.27	13	402	0.26
		-----	-----	-----	-----	-----	-----
	AVG.	7.1	86	1.23	14	394	0.44
Fina AC-10 + 3% UP 70	77	6.3	67	1.43	9	424	0.36
		6.6	85	1.12	15	618	0.21
		5.9	84	1.43	12	443	0.40
		-----	-----	-----	-----	-----	-----
	AVG.	6.3	79	1.33	12	495	0.32
Fina AC-10 + 3% Styrelf	77	7.1	103	2.26	9	395	0.40
		7.1	104	2.34	9	339	0.66
		7.1	95	2.16	9	542	0.23
		-----	-----	-----	-----	-----	-----
	AVG.	7.1	100	2.25	9	425	0.43
Exxon AC-10 + 3% Polybilt	77	6.8	38	1.27	6	259	0.41
		7.3	34	1.40	5	270	0.32
		6.6	40	1.30	6	281	0.36
		-----	-----	-----	-----	-----	-----
	AVG.	6.9	37	1.33	6	270	0.36
Gulf AC-10 + 3% Kraton	77	6.5	52	1.77	6	412	0.38
		7.1	62	1.82	7	262	0.45
		6.6	65	1.77	7	542	0.24
		-----	-----	-----	-----	-----	-----
	AVG.	6.7	60	1.79	7	405	0.36

Table D-13 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	104	6.9	22	1.61	2.7	174	-
		7.1	22	1.52	2.8	192	-
		7.0	19	1.64	2.3	156	-
	AVG.	7.0	21	1.59	2.6	174	-
Fina AC-10 + 3% UP 70	104	6.8	17	1.61	2.1	100	-
		7.2	19	1.30	2.8	110	-
		6.6	18	1.66	2.1	148	-
	AVG.	6.9	18	1.53	2.4	119	-
Fina AC-10 + 3% Styrelf	104	7.0	20	2.50	1.6	62	-
		7.0	21	3.07	1.4	76	-
		6.6	20	3.07	1.3	146	-
	AVG.	6.9	20	2.88	1.4	95	-
Exxon AC-10 + 3% Polybilt	104	7.1	9	1.20	1.5	105	-
		7.1	8	1.25	1.3	118	-
		7.1	8	1.51	1.1	172	-
	AVG.	7.1	8	1.32	1.3	132	-
Gulf AC-10 + 3% Kraton	104	6.4	11	1.98	1.1	151	-
		6.3	11	2.13	1.0	106	-
		6.7	11	2.18	1.0	177	-
	AVG.	6.5	11	2.10	1.0	145	-

Table D-14 Indirect Tensile Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	39	4.5	460	0.24	376	3491	-
		3.7	418	0.21	391	1793	-
		4.2	459	0.25	368	2480	-
	AVG.	4.1	446	0.24	378	2588	-
Fina AC-10 + 3% UP 70	39	4.5	504	0.22	461	1637	-
		4.1	466	0.21	437	1457	-
		4.6	497	0.23	424	1375	-
	AVG.	4.4	489	0.22	441	1490	-
Fina AC-10 + 3% Styrelf	39	4.7	521	0.32	328	2212	-
		4.2	499	0.26	383	2624	-
		5.0	528	0.26	406	1453	-
	AVG.	4.6	516	0.28	372	2097	-
Exxon AC-10 + 3% Polybilt	39	2.9	383	0.47	163	1941	-
		3.3	388	0.55	142	1684	-
		3.7	416	0.62	133	2176	-
	AVG.	3.3	396	0.55	146	1934	-
Gulf AC-10 + 3% Kraton	39	4.2	469	0.46	203	4206	-
		4.2	445	0.44	201	4457	-
		4.7	447	0.49	181	2460	-
	AVG.	4.4	454	0.47	195	3708	-

Table D-14 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	77	4.0	135	1.12	24	887	0.10
		4.1	140	1.12		892	0.11
		4.3	129	1.17	22	840	0.12
		-----	-----	-----	-----	-----	-----
	AVG.	4.1	135	1.14	23	873	0.11
Fina AC-10 + 3% UP 70	77	5.0	123	1.33	19	546	0.34
		4.9	108	1.34	16	448	0.44
		5.6	93	1.77	11	370	0.70
		-----	-----	-----	-----	-----	-----
	AVG.	5.2	108	1.48	15	455	0.49
Fina AC-10 + 3% Styrelf	77	4.7	149	1.53	19	472	0.46
		4.8	151	1.64	18	653	0.26
		4.8	148	1.56	19	535	0.40
		-----	-----	-----	-----	-----	-----
	AVG.	4.8	149	1.58	19	553	0.37
Exxon AC-10 + 3% Polybilt	77	3.7	70	1.20	12	489	0.26
		2.8	77	1.04	15	390	0.52
		3.4	70	1.07	13	404	0.50
		-----	-----	-----	-----	-----	-----
	AVG.	3.3	73	1.10	13	428	0.43
Gulf AC-10 + 3% Kraton	77	4.4	78	1.43	11	352	0.47
		4.5	83	1.51	11	413	0.29
		4.5	87	1.46	12	288	0.49
		-----	-----	-----	-----	-----	-----
	AVG.	4.5	83	1.46	11	351	0.41

Table D-14 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	104	4.1	38	1.09	7.0	158	-
		4.0	41	1.07	7.6	141	-
		4.2	38	1.09	6.9	214	-
		-----	-----	-----	-----	-----	-----
	AVG.	4.1	39	1.08	7.2	171	-
Fina AC-10 + 3% UP 70	104	4.1	26	1.40	3.8	90	-
		4.8	27	1.40	3.9	131	-
		5.6	25	1.77	2.8	89	-
		-----	-----	-----	-----	-----	-----
	AVG.	4.8	26	1.53	3.5	103	-
Fina AC-10 + 3% Styrelf	104	4.5	40	1.77	4.5	166	-
		4.7	39	1.82	4.3	167	-
		4.3	39	1.87	4.1	95	-
		-----	-----	-----	-----	-----	-----
	AVG.	4.5	39	1.82	4.3	143	-
Exxon AC-10 + 3% Polybilt	104	3.7	18	1.14	3.2	139	-
		3.5	19	1.20	3.2	104	-
		3.7	19	1.09	3.4	101	-
		-----	-----	-----	-----	-----	-----
	AVG.	3.6	19	1.14	3.3	115	-
Gulf AC-10 + 3% Kraton	104	4.9	18	1.82	1.9	83	-
		4.5	19	1.77	2.2	107	-
		4.8	19	1.82	2.1	96	-
		-----	-----	-----	-----	-----	-----
	AVG.	4.7	19	1.80	2.1	95	-

Table D-15 Indirect Tensile Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	39	7.6	337	0.18	370	1857	-
		7.2	312	0.18	353	2230	-
		7.1	367	0.21	344	2238	-
	AVG.	7.3	339	0.19	356	2108	-
Fina AC-10 + 3% UP 70	39	7.3	356	0.33	214	1402	-
		7.3	347	0.38	180	1672	-
		7.0	389	0.26	299	1200	-
	AVG.	7.2	364	0.33	231	1425	-
Fina AC-10 + 3% Styrelf	39	6.9	400	0.34	236	1770	-
		7.5	423	0.29	295	2056	-
		7.3	410	0.27	303	2685	-
	AVG.	7.2	411	0.30	278	2170	-
Exxon AC-10 + 3% Polybilt	39	6.7	311	0.65	95	1447	-
		7.2	271	0.57	95	1562	-
		7.2	244	0.57	85	1364	-
	AVG.	7.0	275	0.60	92	1458	-
Gulf AC-10 + 3% Kraton	39	6.7	266	0.47	114	1230	-
		6.8	304	0.52	117	2029	-
		6.9	339	0.52	130	1351	-
	AVG.	6.8	303	0.50	120	1537	-

Table D-15 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	77	7.5	95	1.14	17	621	-
		7.2	92	1.14		654	-
		7.3	90	1.20	15	742	-
	AVG.	7.3	92	1.16	16	672	-
Fina AC-10 + 3% UP 70	77	7.2	73	1.77	8	314	-
		7.3	71	1.77	8	329	-
		7.5	78	1.98	8	241	-
	AVG.	7.3	74	1.84	8	294	-
Fina AC-10 + 3% Styrelf	77	6.9	108	1.92	11	171	-
		7.0	95	1.98	10	359	-
		7.0	103	1.92	11	441	-
	AVG.	7.0	102	1.94	11	324	-
Exxon AC-10 + 3% Polybilt	77	7.2	40	1.66	5	249	-
		6.6	47	1.51	6	221	-
		6.8	46	1.69	5	218	-
	AVG.	6.9	44	1.62	6	229	-
Gulf AC-10 + 3% Kraton	77	7.0	65	1.64	8	265	-
		6.9	72	1.59	9	423	-
		7.0	68	1.66	8	273	-
	AVG.	7.0	69	1.63	8	320	-

Table D-15 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	104	7.3	24	1.46	3.3	234	-
		7.3	25	1.51	3.3	177	-
		6.9	24	1.51	3.2	160	-
		-----	-----	-----	-----	-----	-----
	AVG.	7.2	24	1.49	3.2	190	-
Fina AC-10 + 3% UP 70	104	7.4	10	1.98	1.1	133	-
		7.2	12	1.87	1.3	204	-
		7.3	13	2.03	1.3	199	-
		-----	-----	-----	-----	-----	-----
	AVG.	7.3	12	1.96	1.2	179	-
Fina AC-10 + 3% Styrelf	104	6.9	24	2.50	1.9	184	-
		7.1	23	2.08	2.2	148	-
		7.2	22	2.18	2.0	202	-
		-----	-----	-----	-----	-----	-----
	AVG.	7.1	23	2.25	2.0	178	-
Exxon AC-10 + 3% Polybilt	104	6.6	11	1.46	1.5	165	-
		7.1	8	1.33	1.2	163	-
		7.2	8	1.40	1.2	133	-
		-----	-----	-----	-----	-----	-----
	AVG.	7.0	9	1.40	1.3	154	-
Gulf AC-10 + 3% Kraton	104	7.1	13	1.82	1.4	111	-
		6.5	11	2.18	1.0	130	-
		6.6	14	1.98	1.4	186	-
		-----	-----	-----	-----	-----	-----
	AVG.	6.7	13	1.99	1.3	142	-

Table D-16 Indirect Tensile Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Standard Compaction

MIXTURE	TEST TEMP. F		AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	39		4.6	459	0.21	441	3495	-
			4.7	455	0.21	437	2758	-
			5.0	450	0.21	432	2295	-
			-----	-----	-----	-----	-----	-----
		AVG.	4.8	455	0.21	437	2849	-
Fina AC-10 + 3% UP 70	39		3.4	495	0.21	475	2290	-
			3.5	566	0.29	388	1351	-
			4.1	565	0.29	395	1368	-
			-----	-----	-----	-----	-----	-----
		AVG.	3.7	542	0.26	419	1670	-
Fina AC-10 + 3% Styrelf	39		4.3	562	0.23	479	2677	-
			4.3	525	0.21	504	2640	-
			3.8	584	0.25	467	3466	-
			-----	-----	-----	-----	-----	-----
		AVG.	4.1	557	0.23	484	2928	-
Exxon AC-10 + 3% Polybilt	39		4.0	373	0.57	130	1812	-
			4.1	384	0.57	134	2051	-
			3.7	384	0.52	147	1854	-
			-----	-----	-----	-----	-----	-----
		AVG.	3.9	380	0.55	137	1906	-
Gulf AC-10 + 3% Kraton	39		4.3	466	0.39	239	2106	-
			4.5	485	0.52	186	1821	-
			4.7	443	0.47	189	2194	-
			-----	-----	-----	-----	-----	-----
		AVG.	4.5	465	0.46	205	2040	-

Table D-16 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	77	4.3	144	0.78	37	847	-
		5.1	137	0.73		629	-
		4.6	140	0.68	41	676	-
	AVG.	4.7	140	0.73	39	717	-
Fina AC-10 + 3% UP 70	77	3.3	143	1.25	23	831	-
		3.3	133	1.14	23	472	-
		3.9	128	1.25	21	891	-
	AVG.	3.5	135	1.21	22	731	-
Fina AC-10 + 3% Styrelf	77	4.0	164	1.52	22	561	-
		3.8	171	1.46	23	598	-
		4.3	156	1.56	20	741	-
	AVG.	4.0	164	1.51	22	633	-
Exxon AC-10 + 3% Polybilt	77	3.5	77	1.12	14	244	-
		4.0	73	1.14	13	447	-
		4.0	72	1.14	13	379	-
	AVG.	3.8	74	1.14	13	357	-
Gulf AC-10 + 3% Kraton	77	5.4	97	1.27	15	593	-
		4.5	100	1.30	15	327	-
		4.7	91	1.40	13	291	-
	AVG.	4.9	96	1.33	15	404	-

Table D-16 (Continued)

MIXTURE	TEST TEMP. F	AIR VOIDS %	INDIRECT TENSILE STRENGTH PSI	STRAIN AT FAILURE %	SECANT MODULUS KSI	RESILIENT MODULUS KSI	POISSON'S RATIO
Control: Total AC-20	104	5.1	40	1.25	6.3	217	-
		4.5	45	1.09	8.2	150	-
		4.1	44	1.09	8.1	241	-
		-----	-----	-----	-----	-----	-----
	AVG.	4.6	43	1.14	7.5	203	-
Fina AC-10 + 3% UP 70	104	3.2	33	1.25	5.3	206	-
		3.5	31	1.22	5.1	218	-
		3.3	32	1.30	5.0	144	-
		-----	-----	-----	-----	-----	-----
	AVG.	3.3	32	1.26	5.1	189	-
Fina AC-10 + 3% Styrelf	104	4.4	40	1.66	4.8	254	-
		3.6	43	1.61	5.4	150	-
		3.6	44	1.72	5.1	152	-
		-----	-----	-----	-----	-----	-----
	AVG.	3.9	43	1.66	5.1	185	-
Exxon AC-10 + 3% Polybilt	104	4.0	19	1.09	3.4	145	-
		4.4	16	1.25	2.6	161	-
		3.6	20	1.04	3.8	148	-
		-----	-----	-----	-----	-----	-----
	AVG.	4.0	18	1.13	3.3	151	-
Gulf AC-10 + 3% Kraton	104	4.6	22	1.98	2.2	169	-
		4.1	22	1.66	2.6	141	-
		4.3	21	1.56	2.7	164	-
		-----	-----	-----	-----	-----	-----
	AVG.	4.3	22	1.73	2.5	158	-

Table D-17 Alpha and Gnu Parameters for Laboratory Mixed/Laboratory Compacted Mixtures.

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	RESILIEN STRAIN IN/IN	ALPHA	GNU	Ea=IN^S		R-SQUR FOR Ea=IN^S
								S	LOG(I)	
Control: TOTAL AC-20	77	7.0	63	4.5	2.3E-05	0.2355	0.2620	0.7645	-5.1056	0.995
		6.9	63	4.5	2.3E-05	0.2149	0.2150	0.7851	-5.2030	0.994
	AVG.	7.0	63	4.5	2.3E-05	0.2252	0.2385	0.7748	-5.1543	
Fina AC-10 + 3% UP-70	77	6.7	53	3.9	1.6E-05	0.2114	0.4565	0.7886	-5.0390	0.998
		6.9	53	3.9	1.6E-05	0.1799	0.1787	0.8201	-5.4634	0.993
	AVG.	6.8	53	3.9	1.6E-05	0.1957	0.3176	0.8044	-5.2512	
Fina AC-10 + 3% Styrelf	77	6.9	68	4.8	2.4E-05	0.2366	0.2365	0.7634	-5.1340	0.996
		7.2	68	4.8	2.4E-05	0.1991	0.4662	0.8009	-4.8601	0.996
	AVG.	7.1	68	4.8	2.4E-05	0.2179	0.3513	0.7822	-4.9971	
Fina AC-10 + 3% POLYBILT	77	7.2	23	1.6	1.2E-05	0.3459	1.7545	0.6541	-4.4887	0.990
		7.4	23	1.6	1.2E-05	0.3218	1.9318	0.6782	-4.4626	0.989
	AVG.	7.3	23	1.6	1.2E-05	0.3339	1.8432	0.6662	-4.4757	
Fina AC-10 + 3% D1101	77	6.9	38	2.7	1.5E-05	0.1342	0.2879	0.8658	-5.3103	0.996
		6.7	38	2.7	1.5E-05	0.1816	0.7615	0.8184	-4.8634	0.997
	AVG.	6.8	38	2.7	1.5E-05	0.1579	0.5247	0.8421	-5.0869	

Table D-18 Alpha and Gnu Parameters for Plant Mixed/Laboratory Compacted Mixtures.

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	RESILIEN STRAIN IN/IN	ALPHA	GNU	Ea=IN^S		R-SQUR FOR Ea=IN^S
								S	LOG(I)	
Control: TOTAL AC-20	77	7.3	98	7.0	2.1E-05	0.2995	1.4098	0.7005	-4.3734	0.988
		7.3	98	7.0	2.1E-05	0.3344	0.9440	0.6656	-4.5254	0.980
	AVG.	7.3	98	7.0	2.1E-05	0.3170	1.1769	0.6831	-4.4494	
Fina AC-10 + 3% UP-70	77	7.1	58	4.0	2.8E-05	0.1442	0.2726	0.8558	-5.0474	0.994
		7.1	58	4.1	2.1E-05	0.2159	0.3080	0.7841	-5.0863	0.995
	AVG.	7.1	58	4.1	2.5E-05	0.1801	0.2903	0.8200	-5.0669	
Fina AC-10 + 3% Styrelf	77	6.9	98	7.0	5.1E-05	0.4094	0.6712	0.5906	-4.2404	0.998
		6.9	98	6.9	3.8E-05	0.3362	0.7298	0.6638	-4.3827	0.997
	AVG.	6.9	98	6.9	4.4E-05	0.3728	0.7005	0.6272	-4.3116	
Fina AC-10 + 3% POLYBILT	77	6.9	23	1.7	1.5E-05	0.1721	0.4687	0.8279	-5.0857	0.993
		6.6	38	2.7	2.4E-05	0.1236	0.3390	0.8764	-5.0332	0.998
	AVG.	6.8	31	2.2	1.9E-05	0.1479	0.4039	0.8522	-5.0595	
Fina AC-10 + 3% D1101	77	7.0	48	3.4	2.3E-05	0.1528	0.3744	0.8472	-5.0000	0.999
		7.1	28	2.0	1.3E-05	0.2272	0.6162	0.7728	-4.9778	0.999
	AVG.	7.1	38	2.7	1.8E-05	0.1900	0.4953	0.8100	-4.9889	

Table D-19 Fatigue Parameter Values for Laboratory Mixed/Laboratory Compacted Mixtures.

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	STATIC MODULUS KSI	INITIAL STRAIN IN/IN	LOAD CYCLES	FATIGUE CONSTANT K1	FATIGUE CONSTANT K2	R-SQUR FOR Nf=K1(1/Emix)^K
Control: TOTAL AC-20	77	7.0	63	4.5	46	9.7E-05	23235	5.04E-03	1.66	0.980
		6.9	63	4.5	46	9.7E-05	21688			
		7.1	178	12.6	46	2.7E-04	5330			
		7.7	178	12.7	46	2.8E-04	4969			
		7.0	298	21.3	46	4.6E-04	1766			
		7.0	298	21.3	46	4.6E-04	1404			
Fina AC-10 + 3% UP-70	77	6.7	53	3.9	37	1.0E-04	16575	4.32E-04	1.91	0.992
		6.9	53	3.9	37	1.0E-04	18550			
		6.7	163	11.8	37	3.2E-04	2028			
		6.9	163	11.8	37	3.2E-04	1931			
		6.7	269	19.3	37	5.2E-04	1000			
		6.6	269	19.5	37	5.3E-04	670			
Fina AC-10 + 3% Styrelf	77	6.9	68	4.8	25	1.9E-04	22915	2.13E-03	1.88	0.996
		7.2	68	4.8	25	1.9E-04	18600			
		7.0	208	14.6	25	5.9E-04	2850			
		6.9	208	14.7	25	5.9E-04	2738			
		7.2	348	24.9	25	1.0E-03	881			
		7.0	348	25.0	25	1.0E-03	930			
Fina AC-10 + 3% POLYBILT	77	7.2	23	1.6	16	9.9E-05	10225	2.65E-03	1.64	0.994
		7.4	23	1.6	16	1.0E-04	9935			
		7.0	78	5.5	16	3.4E-04	1106			
		7.2	78	5.4	16	3.4E-04	1500			
		6.8	128	8.9	16	5.5E-04	626			
		7.2	128	8.9	16	5.6E-04	586			
Fina AC-10 + 3% D1101	77	6.9	38	2.7	28	9.8E-05	16938	5.36E-03	1.61	0.957
		6.7	38	2.7	28	9.7E-05	12719			
		0.8	123	8.9	28	3.2E-04	3864			
		6.6	123	8.9	28	3.2E-04	2220			
		7.5	208	14.7	28	5.3E-04	849			
		7.0	208	15.0	28	5.3E-04	909			

Table D-20 Fatigue Parameter Values for Plant Mixed/Laboratory Compacted Mixtures.

MIXTURE	TEST TEMP. F	AIR VOIDS %	LOAD LBS	INDIRECT TENSILE STRESS PSI	STATIC MODULUS KSI	INITIAL STRAIN IN/IN	LOAD CYCLES	FATIGUE CONSTANT		R-SQUR FOR Nf=K1(1/Emix)^K
								K1	K2	
Control: TOTAL AC-20	77	7.3	98	7.0	43	1.6E-04	14313	7.84E-04	1.95	0.954
		7.3	98	7.0	43	1.6E-04	21213			
		7.3	188	13.6	43	3.2E-04	5794			
		7.6	188	13.6	43	3.2E-04	6975			
		7.2	318	22.7	43	5.3E-04	1928			
		7.2	318	22.9	43	5.3E-04	1485			
Fina AC-10 + 3% UP-70	77	7.1	58	4.0	25	1.6E-04	16738	5.89E-03	1.66	0.967
		7.0	33	2.3	25	9.3E-05	23308			
		7.0	158	11.1	25	4.5E-04	2746			
		6.9	98	6.9	25	2.8E-04	3660			
		7.2	258	18.0	25	7.2E-04	878			
		7.2	258	17.9	25	7.2E-04	920			
Fina AC-10 + 3% Styrelf	77	6.9	98	7.0	29	2.4E-04	19790	7.90E-03	1.74	0.979
		6.9	73	5.1	29	1.8E-04	20510			
		6.9	208	15.0	29	5.2E-04	4350			
		6.6	208	14.9	29	5.1E-04	4410			
		7.2	358	25.4	29	8.8E-04	1470			
		6.9	358	25.6	29	8.8E-04	1560			
Fina AC-10 + 3% POLYBILT	77	6.9	23	1.7	14	1.2E-04	17996	2.01E-03	1.77	0.991
		6.6	38	2.7	14	2.0E-04	5940			
		7.2	88	6.3	14	4.5E-04	1950			
		7.3	88	6.2	14	4.4E-04	1823			
		7.1	148	10.6	14	7.5E-04	595			
		7.2	148	10.7	14	7.6E-04	620			
Fina AC-10 + 3% D1101	77	7.2	48	3.4	28	1.2E-04	18088	7.23E-04	1.86	0.990
		7.2	28	2.0	28	7.1E-05	32070			
		6.8	138	10.0	28	3.6E-04	2165			
		6.9	138	9.7	28	3.5E-04	1884			
		7.0	233	16.6	28	5.9E-04	668			
		7.1	233	16.8	28	6.0E-04	754			

Table D-21 Creep Compliance Properties for Laboratory Mixed/ Laboratory Compacted Mixture Using Modified Compaction.

MIXTURE	TEMP. F	D1	m	Log(SHIFT FACTOR)	BETA
Control: Total AC-20	60	1.46E-06	0.67	0.77	0.038
	77	5.26E-06	0.65		
	90	7.16E-06	0.73	-0.41	
Fina AC-10 + 3% UP 70	60	2.09E-06	0.64	0.54	0.028
	77	4.06E-06	0.67		
	90	6.53E-06	0.68	-0.32	
Fian AC-10 + 3% Styrelf	60	2.83E-06	0.63	0.40	0.034
	77	5.81E-06	0.60		
	90	9.44E-06	0.69	-0.59	
Exxon AC-10 + 3% Polybilt	60	8.64E-06	0.62	0.39	0.016
	77	1.34E-05	0.66		
	90	1.89E-05	0.61	-0.12	
Gulf AC-10 + 3% Kraton	60	1.84E-06	0.70	0.63	0.039
	77	5.76E-06	0.66		
	90	1.37E-05	0.65	-0.53	

Table D-22 Creep Compliance Properties for Plant Mixed/ Laboratory Compacted Mixture Using Modified Compaction.

MIXTURE	TEMP. F	D1	m	Log(SHIFT FACTOR)	BETA
Control: Total AC-20	60	2.23E-06	0.522	1.01	0.066
	77	4.79E-06	0.682		
	90	9.53E-06	0.961	-0.95	
Fina AC-10 + 3% UP 70	60	2.66E-06	0.661	0.71	0.038
	77	7.89E-06	0.662		
	90	1.68E-05	0.638	-0.45	
Fian AC-10 + 3% Styrelf	60	3.02E-06	0.580	0.52	0.028
	77	4.63E-06	0.656		
	90	7.03E-06	0.680	-0.34	
Exxon AC-10 + 3% Polybilt	60	5.32E-06	0.632	0.43	0.027
	77	7.94E-06	0.707		
	90	1.76E-05	0.658	-0.38	
Gulf AC-10 + 3% Kraton	60	2.46E-06	0.662	0.32	0.033
	77	4.63E-06	0.623		
	90	1.09E-05	0.638	-0.63	

Table D-23 Creep Compliance of Laboratory Mixed / Laboratory Compacted Mixtures Using Modified Compaction.

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TOTAL AC-20 TEST TEMP = 60 , ZIGMA = 7.279 PSI				TOTAL AC-20 TEST TEMP = 60 , ZIGMA = 7.422 PSI			
1.0	4.50E-05	2.34E-05	1.61E-06	1.0	6.25E-05	3.25E-05	2.19E-06
1.8	5.50E-05	2.86E-05	1.96E-06	1.8	8.75E-05	4.55E-05	3.07E-06
3.2	6.50E-05	3.38E-05	2.32E-06	3.2	1.13E-04	5.85E-05	3.94E-06
5.6	9.00E-05	4.68E-05	3.22E-06	5.6	1.55E-04	8.06E-05	5.43E-06
10.0	1.25E-04	6.50E-05	4.47E-06	10.0	2.15E-04	1.12E-04	7.53E-06
18.0	1.90E-04	9.88E-05	6.79E-06	18.0	3.15E-04	1.64E-04	1.10E-05
31.6	2.85E-04	1.48E-04	1.02E-05	31.6	4.73E-04	2.46E-04	1.66E-05
56.2	4.80E-04	2.50E-04	1.71E-05	56.2	7.10E-04	3.69E-04	2.49E-05
100.0	7.20E-04	3.74E-04	2.57E-05	100.0	1.01E-03	5.25E-04	3.54E-05
177.8	1.15E-03	5.98E-04	4.11E-05	177.8	1.45E-03	7.54E-04	5.08E-05
316.2	1.80E-03	9.36E-04	6.43E-05	316.2	2.03E-03	1.05E-03	7.10E-05
562.3	2.95E-03	1.53E-03	1.05E-04	562.3	2.69E-03	1.40E-03	9.43E-05
1000.0	4.70E-03	2.44E-03	1.68E-04	1000.0	4.00E-03	2.08E-03	1.40E-04
1778.3	7.38E-03	3.84E-03	2.63E-04	1778.3	5.75E-03	2.99E-03	2.01E-04
3162.3	1.28E-02	6.63E-03	4.56E-04	3162.3	8.40E-03	4.37E-03	2.94E-04
3600.0	1.40E-02	7.26E-03	4.98E-04	3600.0	9.15E-03	4.76E-03	3.21E-04
7200.0	1.27E-02	6.61E-03		7200.0	8.60E-03	4.47E-03	3.01E-04
TOTAL AC-20 TEST TEMP = 77 , ZIGMA = 2.415 PSI				TOTAL AC-20 TEST TEMP = 77 , ZIGMA = 2.514 PSI			
1.0	3.00E-05	1.56E-05	3.23E-06	1.0	8.50E-05	4.42E-05	8.79E-06
1.8	3.90E-05	2.03E-05	4.20E-06	1.8	1.40E-04	7.28E-05	1.45E-05
3.2	5.00E-05	2.60E-05	5.38E-06	3.2	1.70E-04	8.84E-05	1.76E-05
5.6	6.15E-05	3.20E-05	6.62E-06	5.6	2.25E-04	1.17E-04	2.33E-05
10.0	8.50E-05	4.42E-05	9.15E-06	10.0	2.85E-04	1.48E-04	2.95E-05
18.0	1.46E-04	7.59E-05	1.57E-05	18.0	4.03E-04	2.09E-04	4.16E-05
31.6	2.49E-04	1.30E-04	2.68E-05	31.6	6.35E-04	3.30E-04	6.57E-05
56.2	4.35E-04	2.26E-04	4.68E-05	56.2	1.05E-03	5.46E-04	1.09E-04
100.0	6.68E-04	3.47E-04	7.19E-05	100.0	1.64E-03	8.53E-04	1.70E-04
177.8	9.50E-04	4.94E-04	1.02E-04	177.8	2.08E-03	1.08E-03	2.15E-04
316.2	1.35E-03	7.02E-04	1.45E-04	316.2	2.34E-03	1.21E-03	2.42E-04
562.3	1.95E-03	1.01E-03	2.10E-04	562.3	2.98E-03	1.55E-03	3.08E-04
1000.0	2.80E-03	1.46E-03	3.02E-04	1000.0	4.63E-03	2.41E-03	4.78E-04
1778.3	4.45E-03	2.31E-03	4.79E-04	1778.3	7.80E-03	4.06E-03	8.07E-04
3162.3	9.20E-03	4.78E-03	9.91E-04	3162.3	1.30E-02	6.74E-03	1.34E-03
3600.0	1.13E-02	5.88E-03	1.22E-03	3600.0	1.46E-02	7.59E-03	1.51E-03
7200.0	1.12E-02	5.83E-03		7200.0	1.42E-02	7.37E-03	

Table D-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TOTAL AC-20 TEST TEMP = 90 , ZIGMA = 1.366 PSI				TOTAL AC-20 TEST TEMP = 90 , ZIGMA = 1.005 PSI			
1.0	7.50E-05	3.90E-05	1.43E-05	1.0	1.50E-05	7.80E-06	3.88E-06
1.8	9.00E-05	4.68E-05	1.71E-05	1.8	2.20E-05	1.14E-05	5.69E-06
3.2	1.50E-04	7.80E-05	2.86E-05	3.2	2.70E-05	1.40E-05	6.99E-06
5.6	2.00E-04	1.04E-04	3.81E-05	5.6	3.60E-05	1.87E-05	9.32E-06
10.0	2.50E-04	1.30E-04	4.76E-05	10.0	5.25E-05	2.73E-05	1.36E-05
18.0	3.50E-04	1.82E-04	6.66E-05	18.0	8.75E-05	4.55E-05	2.26E-05
31.6	7.00E-04	3.64E-04	1.33E-04	31.6	1.30E-04	6.76E-05	3.36E-05
56.2	9.00E-04	4.68E-04	1.71E-04	56.2	2.08E-04	1.08E-04	5.37E-05
100.0	1.75E-03	9.10E-04	3.33E-04	100.0	3.60E-04	1.87E-04	9.32E-05
177.8	2.75E-03	1.43E-03	5.24E-04	177.8	6.25E-04	3.25E-04	1.62E-04
316.2	4.25E-03	2.21E-03	8.09E-04	316.2	1.04E-03	5.38E-04	2.68E-04
562.3	7.25E-03	3.77E-03	1.38E-03	562.3	1.74E-03	9.02E-04	4.49E-04
1000.0	9.25E-03	4.81E-03	1.76E-03	1000.0	2.85E-03	1.48E-03	7.37E-04
1778.3	1.25E-02	6.50E-03	2.38E-03	1778.3	3.65E-03	1.90E-03	9.44E-04
3162.3	1.63E-02	8.45E-03	3.09E-03	3162.3	5.95E-03	3.09E-03	1.54E-03
3600.0	1.68E-02	8.71E-03	3.19E-03	3600.0	6.08E-03	3.16E-03	1.57E-03
7200.0	1.62E-02	8.43E-03		7200.0	9.93E-03	5.16E-03	
FINA AC-10 + 3% UP-70 TEST TEMP = 60 , ZIGMA = 7.525 PSI				FINA AC-10 + 3% UP-70 TEST TEMP = 60 , ZIGMA = 7.515 PSI			
1.0	5.00E-05	2.60E-05	1.73E-06	1.0	9.00E-05	4.68E-05	3.11E-06
1.8	6.70E-05	3.48E-05	2.32E-06	1.8	1.25E-04	6.50E-05	4.33E-06
3.2	8.00E-05	4.16E-05	2.76E-06	3.2	1.73E-04	8.97E-05	5.97E-06
5.6	1.15E-04	5.98E-05	3.97E-06	5.6	2.40E-04	1.25E-04	8.31E-06
10.0	1.80E-04	9.36E-05	6.22E-06	10.0	3.30E-04	1.72E-04	1.14E-05
18.0	2.53E-04	1.31E-04	8.73E-06	18.0	4.78E-04	2.48E-04	1.65E-05
31.6	3.28E-04	1.70E-04	1.13E-05	31.6	6.95E-04	3.61E-04	2.41E-05
56.2	4.63E-04	2.41E-04	1.60E-05	56.2	1.04E-03	5.41E-04	3.60E-05
100.0	7.03E-04	3.65E-04	2.43E-05	100.0	1.58E-03	8.19E-04	5.45E-05
177.8	1.04E-03	5.38E-04	3.58E-05	177.8	2.13E-03	1.11E-03	7.35E-05
316.2	1.48E-03	7.67E-04	5.10E-05	316.2	2.95E-03	1.53E-03	1.02E-04
562.3	2.30E-03	1.20E-03	7.95E-05	562.3	3.93E-03	2.04E-03	1.36E-04
1000.0	3.40E-03	1.77E-03	1.17E-04	1000.0	6.35E-03	3.30E-03	2.20E-04
1778.3	5.25E-03	2.73E-03	1.81E-04	1778.3	9.10E-03	4.73E-03	3.15E-04
3162.3	8.85E-03	4.60E-03	3.06E-04	3162.3	1.52E-02	7.91E-03	5.26E-04
3600.0	9.73E-03	5.06E-03	3.36E-04	3600.0	1.71E-02	8.89E-03	5.92E-04
7200.0	8.48E-03	4.41E-03		7200.0	1.71E-02	8.89E-03	

Table D-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% UP-70 TEST TEMP = 77 , ZIGMA = 1.376 PSI				FINA AC-10 + 3% UP-70 TEST TEMP = 77 , ZIGMA = 1.389 PSI			
1.0	3.00E-05	1.56E-05	5.67E-06	1.0	3.75E-05	1.95E-05	7.02E-06
1.8	4.00E-05	2.08E-05	7.56E-06	1.8	5.75E-05	2.99E-05	1.08E-05
3.2	4.75E-05	2.47E-05	8.98E-06	3.2	7.90E-05	4.11E-05	1.48E-05
5.6	5.25E-05	2.73E-05	9.92E-06	5.6	1.03E-04	5.33E-05	1.92E-05
10.0	6.00E-05	3.12E-05	1.13E-05	10.0	1.27E-04	6.61E-05	2.38E-05
18.0	7.75E-05	4.03E-05	1.46E-05	18.0	1.63E-04	8.48E-05	3.05E-05
31.6	1.10E-04	5.72E-05	2.08E-05	31.6	2.10E-04	1.09E-04	3.93E-05
56.2	1.70E-04	8.84E-05	3.21E-05	56.2	2.33E-04	1.21E-04	4.35E-05
100.0	2.63E-04	1.37E-04	4.96E-05	100.0	2.68E-04	1.39E-04	5.01E-05
177.8	3.35E-04	1.74E-04	6.33E-05	177.8	4.50E-04	2.34E-04	8.43E-05
316.2	7.25E-04	3.77E-04	1.37E-04	316.2	7.60E-04	3.95E-04	1.42E-04
562.3	1.60E-03	8.32E-04	3.02E-04	562.3	1.23E-03	6.37E-04	2.29E-04
1000.0	3.23E-03	1.68E-03	6.09E-04	1000.0	1.95E-03	1.01E-03	3.65E-04
1778.3	6.23E-03	3.24E-03	1.18E-03	1778.3	2.80E-03	1.46E-03	5.24E-04
3162.3	1.13E-02	5.85E-03	2.13E-03	3162.3	4.46E-03	2.32E-03	8.35E-04
3600.0	1.30E-02	6.74E-03	2.45E-03	3600.0	4.97E-03	2.58E-03	9.30E-04
7200.0	1.29E-02	6.68E-03		7200.0	4.63E-03	2.41E-03	
FINA AC-10 + 3% UP-70 TEST TEMP = 90 , ZIGMA = 0.868 PSI				FINA AC-10 + 3% UP-70 TEST TEMP = 90 , ZIGMA = 0.875 PSI			
1.0	2.00E-05	1.04E-05	5.99E-06	1.0	1.75E-05	9.10E-06	5.20E-06
1.8	3.15E-05	1.64E-05	9.44E-06	1.8	2.65E-05	1.38E-05	7.88E-06
3.2	4.75E-05	2.47E-05	1.42E-05	3.2	3.75E-05	1.95E-05	1.11E-05
5.6	8.25E-05	4.29E-05	2.47E-05	5.6	5.40E-05	2.81E-05	1.60E-05
10.0	1.55E-04	8.06E-05	4.64E-05	10.0	7.75E-05	4.03E-05	2.30E-05
18.0	2.65E-04	1.38E-04	7.94E-05	18.0	9.75E-05	5.07E-05	2.90E-05
31.6	4.30E-04	2.24E-04	1.29E-04	31.6	1.29E-04	6.71E-05	3.83E-05
56.2	6.80E-04	3.54E-04	2.04E-04	56.2	1.90E-04	9.88E-05	5.65E-05
100.0	8.58E-04	4.46E-04	2.57E-04	100.0	2.65E-04	1.38E-04	7.88E-05
177.8	1.11E-03	5.77E-04	3.33E-04	177.8	3.75E-04	1.95E-04	1.11E-04
316.2	1.45E-03	7.52E-04	4.33E-04	316.2	5.45E-04	2.83E-04	1.62E-04
562.3	1.96E-03	1.02E-03	5.87E-04	562.3	8.40E-04	4.37E-04	2.50E-04
1000.0	2.75E-03	1.43E-03	8.24E-04	1000.0	1.30E-03	6.76E-04	3.86E-04
1778.3	4.10E-03	2.13E-03	1.23E-03	1778.3	2.34E-03	1.22E-03	6.95E-04
3162.3	6.40E-03	3.33E-03	1.92E-03	3162.3	4.00E-03	2.08E-03	1.19E-03
3600.0	7.15E-03	3.72E-03	2.14E-03	3600.0	4.55E-03	2.37E-03	1.35E-03
7200.0	7.20E-03	3.74E-03		7200.0	4.57E-03	2.37E-03	

Table D-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 7.348 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 7.371 PSI			
1.0	5.50E-05	2.86E-05	1.95E-06	1.0	1.15E-04	5.98E-05	4.06E-06
1.8	8.75E-05	4.55E-05	3.10E-06	1.8	1.50E-04	7.80E-05	5.29E-06
3.2	1.30E-04	6.76E-05	4.60E-06	3.2	2.00E-04	1.04E-04	7.06E-06
5.6	2.30E-04	1.20E-04	8.14E-06	5.6	2.60E-04	1.35E-04	9.17E-06
10.0	3.23E-04	1.68E-04	1.14E-05	10.0	3.65E-04	1.90E-04	1.29E-05
18.0	4.70E-04	2.44E-04	1.66E-05	18.0	5.10E-04	2.65E-04	1.80E-05
31.6	7.10E-04	3.69E-04	2.51E-05	31.6	7.35E-04	3.82E-04	2.59E-05
56.2	9.28E-04	4.82E-04	3.28E-05	56.2	1.07E-03	5.57E-04	3.78E-05
100.0	1.33E-03	6.89E-04	4.69E-05	100.0	1.53E-03	7.93E-04	5.38E-05
177.8	1.88E-03	9.75E-04	6.64E-05	177.8	2.15E-03	1.12E-03	7.59E-05
316.2	2.65E-03	1.38E-03	9.38E-05	316.2	3.10E-03	1.61E-03	1.09E-04
562.3	3.83E-03	1.99E-03	1.35E-04	562.3	4.55E-03	2.37E-03	1.61E-04
1000.0	5.50E-03	2.86E-03	1.95E-04	1000.0	6.70E-03	3.48E-03	2.36E-04
1778.3	8.30E-03	4.32E-03	2.94E-04	1778.3	1.01E-02	5.23E-03	3.55E-04
3162.3	1.29E-02	6.71E-03	4.57E-04	3162.3	1.56E-02	8.09E-03	5.49E-04
3600.0	1.43E-02	7.44E-03	5.06E-04	3600.0	1.73E-02	8.97E-03	6.09E-04
7200.0	1.25E-02	6.50E-03		7200.0	1.60E-02	8.32E-03	
FINA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 3.834 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 3.771 PSI			
1.0	1.05E-04	5.46E-05	7.12E-06	1.0	7.00E-05	3.64E-05	4.83E-06
1.8	1.60E-04	8.32E-05	1.09E-05	1.8	1.05E-04	5.46E-05	7.24E-06
3.2	2.20E-04	1.14E-04	1.49E-05	3.2	1.50E-04	7.80E-05	1.03E-05
5.6	3.20E-04	1.66E-04	2.17E-05	5.6	2.00E-04	1.04E-04	1.38E-05
10.0	4.23E-04	2.20E-04	2.87E-05	10.0	2.58E-04	1.34E-04	1.78E-05
18.0	5.58E-04	2.90E-04	3.78E-05	18.0	3.75E-04	1.95E-04	2.59E-05
31.6	7.75E-04	4.03E-04	5.26E-05	31.6	4.55E-04	2.37E-04	3.14E-05
56.2	1.14E-03	5.90E-04	7.70E-05	56.2	6.30E-04	3.28E-04	4.34E-05
100.0	1.47E-03	7.62E-04	9.94E-05	100.0	9.43E-04	4.90E-04	6.50E-05
177.8	1.95E-03	1.01E-03	1.32E-04	177.8	1.35E-03	7.02E-04	9.31E-05
316.2	2.75E-03	1.43E-03	1.87E-04	316.2	2.10E-03	1.09E-03	1.45E-04
562.3	3.88E-03	2.02E-03	2.63E-04	562.3	2.80E-03	1.46E-03	1.93E-04
1000.0	5.60E-03	2.91E-03	3.80E-04	1000.0	3.70E-03	1.92E-03	2.55E-04
1778.3	8.58E-03	4.46E-03	5.82E-04	1778.3	5.40E-03	2.81E-03	3.72E-04
3162.3	1.44E-02	7.46E-03	9.73E-04	3162.3	1.10E-02	5.72E-03	7.59E-04
3600.0	1.65E-02	8.58E-03	1.12E-03	3600.0	1.35E-02	7.02E-03	9.31E-04
7200.0	1.66E-02	8.61E-03		7200.0	1.32E-02	6.84E-03	

Table D-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 0.847 PSI				TEXACO AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 0.849 PSI			
1.0	2.50E-05	1.30E-05	7.68E-06	1.0	5.00E-05	2.60E-05	1.53E-05
1.8	4.00E-05	2.08E-05	1.23E-05	1.8	7.00E-05	3.64E-05	2.14E-05
3.2	5.50E-05	2.86E-05	1.69E-05	3.2	9.50E-05	4.94E-05	2.91E-05
5.6	7.50E-05	3.90E-05	2.30E-05	5.6	1.40E-04	7.28E-05	4.29E-05
10.0	9.00E-05	4.68E-05	2.76E-05	10.0	2.00E-04	1.04E-04	6.13E-05
18.0	1.10E-04	5.72E-05	3.38E-05	18.0	2.95E-04	1.53E-04	9.04E-05
31.6	1.45E-04	7.54E-05	4.45E-05	31.6	4.20E-04	2.18E-04	1.29E-04
56.2	2.20E-04	1.14E-04	6.75E-05	56.2	5.75E-04	2.99E-04	1.76E-04
100.0	3.95E-04	2.05E-04	1.21E-04	100.0	7.90E-04	4.11E-04	2.42E-04
177.8	7.25E-04	3.77E-04	2.23E-04	177.8	1.20E-03	6.24E-04	3.68E-04
316.2	1.10E-03	5.72E-04	3.38E-04	316.2	1.90E-03	9.88E-04	5.82E-04
562.3	1.58E-03	8.19E-04	4.84E-04	562.3	2.90E-03	1.51E-03	8.88E-04
1000.0	2.58E-03	1.34E-03	7.91E-04	1000.0	4.40E-03	2.29E-03	1.35E-03
1778.3	4.25E-03	2.21E-03	1.30E-03	1778.3	6.60E-03	3.43E-03	2.02E-03
3162.3	9.40E-03	4.89E-03	2.89E-03	3162.3	1.10E-02	5.70E-03	3.35E-03
3600.0	1.00E-02	5.20E-03	3.07E-03	3600.0	1.29E-02	6.71E-03	3.95E-03
7200.0	6.20E-03	3.22E-03		7200.0	9.95E-03	5.17E-03	
FINA AC-10 + 3% POLYBILT TEST TEMP = 60 , ZIGMA = 3.817 PSI				FINA AC-10 + 3% POLYBILT TEST TEMP = 60 , ZIGMA = 3.779 PSI			
1.0	1.50E-04	7.80E-05	1.02E-05	1.0	1.10E-04	5.72E-05	7.57E-06
1.8	2.10E-04	1.09E-04	1.43E-05	1.8	1.75E-04	9.10E-05	1.20E-05
3.2	3.00E-04	1.56E-04	2.04E-05	3.2	2.35E-04	1.22E-04	1.62E-05
5.6	4.30E-04	2.24E-04	2.93E-05	5.6	3.20E-04	1.66E-04	2.20E-05
10.0	5.80E-04	3.02E-04	3.95E-05	10.0	4.40E-04	2.29E-04	3.03E-05
18.0	8.45E-04	4.39E-04	5.76E-05	18.0	6.25E-04	3.25E-04	4.30E-05
31.6	1.26E-03	6.53E-04	8.55E-05	31.6	9.15E-04	4.76E-04	6.30E-05
56.2	1.73E-03	8.97E-04	1.18E-04	56.2	1.36E-03	7.05E-04	9.32E-05
100.0	2.46E-03	1.28E-03	1.67E-04	100.0	1.99E-03	1.03E-03	1.37E-04
177.8	3.35E-03	1.74E-03	2.28E-04	177.8	2.75E-03	1.43E-03	1.89E-04
316.2	4.55E-03	2.37E-03	3.10E-04	316.2	4.10E-03	2.13E-03	2.82E-04
562.3	6.40E-03	3.33E-03	4.36E-04	562.3	5.95E-03	3.09E-03	4.09E-04
1000.0	9.40E-03	4.89E-03	6.40E-04	1000.0	9.35E-03	4.86E-03	6.43E-04
1778.3	1.59E-02	8.27E-03	1.08E-03	1778.3	1.65E-02	8.58E-03	1.14E-03

Table D-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% POLYBILT TEST TEMP = 77 , ZIGMA = 0.998 PSI				FINA AC-10 + 3% POLYBILT TEST TEMP = 77 , ZIGMA = 0.988 PSI			
1.0	3.50E-05	1.82E-05	9.12E-06	1.0	6.50E-05	3.38E-05	1.71E-05
1.8	6.00E-05	3.12E-05	1.56E-05	1.8	1.08E-04	5.59E-05	2.83E-05
3.2	7.25E-05	3.77E-05	1.89E-05	3.2	1.55E-04	8.06E-05	4.08E-05
5.6	9.75E-05	5.07E-05	2.54E-05	5.6	2.35E-04	1.22E-04	6.19E-05
10.0	1.38E-04	7.15E-05	3.58E-05	10.0	3.08E-04	1.60E-04	8.09E-05
18.0	2.40E-04	1.25E-04	6.25E-05	18.0	4.00E-04	2.08E-04	1.05E-04
31.6	3.80E-04	1.98E-04	9.90E-05	31.6	5.68E-04	2.95E-04	1.49E-04
56.2	5.88E-04	3.06E-04	1.53E-04	56.2	8.43E-04	4.38E-04	2.22E-04
100.0	8.15E-04	4.24E-04	2.12E-04	100.0	1.29E-03	6.71E-04	3.40E-04
177.8	1.10E-03	5.72E-04	2.87E-04	177.8	2.00E-03	1.04E-03	5.26E-04
316.2	1.63E-03	8.45E-04	4.23E-04	316.2	3.25E-03	1.69E-03	8.55E-04
562.3	2.53E-03	1.31E-03	6.58E-04	562.3	4.90E-03	2.55E-03	1.29E-03
1000.0	4.25E-03	2.21E-03	1.11E-03	1000.0	7.75E-03	4.03E-03	2.04E-03
1778.3	8.95E-03	4.65E-03	2.33E-03	1778.3	1.34E-02	6.94E-03	3.51E-03
FINA AC-10 + 3% POLYBILT TEST TEMP = 90 , ZIGMA = 0.840 PSI				FINA AC-10 + 3% POLYBILT TEST TEMP = 90 , ZIGMA = 0.726 PSI			
1.0	4.50E-05	2.34E-05	1.39E-05	1.0	6.00E-05	3.12E-05	2.15E-05
1.8	7.25E-05	3.77E-05	2.24E-05	1.8	9.00E-05	4.68E-05	3.22E-05
3.2	1.00E-04	5.20E-05	3.10E-05	3.2	1.20E-04	6.24E-05	4.30E-05
5.6	1.60E-04	8.32E-05	4.95E-05	5.6	1.70E-04	8.84E-05	6.09E-05
10.0	2.48E-04	1.29E-04	7.66E-05	10.0	2.43E-04	1.26E-04	8.69E-05
18.0	3.33E-04	1.73E-04	1.03E-04	18.0	3.48E-04	1.81E-04	1.24E-04
31.6	4.85E-04	2.52E-04	1.50E-04	31.6	4.93E-04	2.56E-04	1.76E-04
56.2	6.90E-04	3.59E-04	2.14E-04	56.2	6.83E-04	3.55E-04	2.44E-04
100.0	9.55E-04	4.97E-04	2.96E-04	100.0	9.88E-04	5.14E-04	3.54E-04
177.8	1.33E-03	6.89E-04	4.10E-04	177.8	1.35E-03	7.02E-04	4.84E-04
316.2	1.90E-03	9.88E-04	5.88E-04	316.2	1.78E-03	9.23E-04	6.36E-04
562.3	2.80E-03	1.46E-03	8.67E-04	562.3	2.39E-03	1.24E-03	8.56E-04
1000.0	4.10E-03	2.13E-03	1.27E-03	1000.0	3.13E-03	1.63E-03	1.12E-03
1778.3	6.58E-03	3.42E-03	2.04E-03	1778.3	4.30E-03	2.23E-03	1.54E-03
3162.3	1.03E-02	5.36E-03	3.19E-03	3162.3	6.09E-03	3.17E-03	2.18E-03
3600.0	1.15E-02	5.97E-03	3.55E-03	3600.0	6.65E-03	3.46E-03	2.38E-03
7200.0	9.53E-03	4.95E-03		7200.0	4.65E-03	2.42E-03	

Table D-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
	FINA AC-10 + 3% D1101 TEST TEMP = 60 , ZIGMA = 3.870 PSI				FINA AC-10 + 3% D1101 TEST TEMP = 60 , ZIGMA = 3.327 PSI		
1.0	4.50E-05	2.34E-05	3.02E-06	1.0	5.00E-06	2.60E-06	3.91E-07
1.8	7.50E-05	3.90E-05	5.04E-06	1.8	1.00E-05	5.20E-06	7.82E-07
3.2	1.08E-04	5.59E-05	7.22E-06	3.2	1.50E-05	7.80E-06	1.17E-06
5.6	1.55E-04	8.06E-05	1.04E-05	5.6	2.50E-05	1.30E-05	1.95E-06
10.0	2.50E-04	1.30E-04	1.68E-05	10.0	2.60E-05	1.35E-05	2.03E-06
18.0	3.50E-04	1.82E-04	2.35E-05	18.0	4.00E-05	2.08E-05	3.13E-06
31.6	5.45E-04	2.83E-04	3.66E-05	31.6	6.00E-05	3.12E-05	4.69E-06
56.2	8.48E-04	4.41E-04	5.69E-05	56.2	1.03E-04	5.33E-05	8.01E-06
100.0	1.21E-03	6.29E-04	8.13E-05	100.0	1.65E-04	8.58E-05	1.29E-05
177.8	1.75E-03	9.10E-04	1.18E-04	177.8	2.65E-04	1.38E-04	2.07E-05
316.2	2.47E-03	1.28E-03	1.66E-04	316.2	4.30E-04	2.24E-04	3.36E-05
562.3	3.53E-03	1.83E-03	2.37E-04	562.3	6.55E-04	3.41E-04	5.12E-05
1000.0	5.05E-03	2.63E-03	3.39E-04	1000.0	1.14E-03	5.93E-04	8.91E-05
1778.3	7.52E-03	3.91E-03	5.05E-04	1778.3	1.64E-03	8.53E-04	1.28E-04
3162.3	1.16E-02	6.02E-03	7.78E-04	3162.3	3.89E-03	2.02E-03	3.04E-04
3600.0	1.28E-02	6.66E-03	8.60E-04	3600.0	4.34E-03	2.26E-03	3.39E-04
7200.0	1.13E-02	5.88E-03		7200.0	3.16E-03	1.64E-03	
	FINA AC-10 + 3% D1101 TEST TEMP = 77 , ZIGMA = 2.464 PSI				FINA AC-10 + 3% D1101 TEST TEMP = 77 , ZIGMA = 2.392 PSI		
1.0	6.00E-05	3.12E-05	6.33E-06	1.0	4.00E-05	2.08E-05	4.35E-06
1.8	1.00E-04	5.20E-05	1.06E-05	1.8	6.75E-05	3.51E-05	7.34E-06
3.2	1.43E-04	7.41E-05	1.50E-05	3.2	9.25E-05	4.81E-05	1.01E-05
5.6	2.15E-04	1.12E-04	2.27E-05	5.6	1.40E-04	7.28E-05	1.52E-05
10.0	3.05E-04	1.59E-04	3.22E-05	10.0	1.95E-04	1.01E-04	2.12E-05
18.0	4.43E-04	2.30E-04	4.67E-05	18.0	2.68E-04	1.39E-04	2.91E-05
31.6	6.50E-04	3.38E-04	6.86E-05	31.6	3.94E-04	2.05E-04	4.28E-05
56.2	9.70E-04	5.04E-04	1.02E-04	56.2	5.88E-04	3.06E-04	6.39E-05
100.0	1.42E-03	7.36E-04	1.49E-04	100.0	8.45E-04	4.39E-04	9.19E-05
177.8	2.10E-03	1.09E-03	2.22E-04	177.8	1.19E-03	6.19E-04	1.29E-04
316.2	2.85E-03	1.48E-03	3.01E-04	316.2	1.88E-03	9.75E-04	2.04E-04
562.3	4.25E-03	2.21E-03	4.49E-04	562.3	2.85E-03	1.48E-03	3.10E-04
1000.0	5.85E-03	3.04E-03	6.17E-04	1000.0	4.15E-03	2.16E-03	4.51E-04
1778.3	8.10E-03	4.21E-03	8.55E-04	1778.3	6.30E-03	3.28E-03	6.85E-04
3162.3	1.28E-02	6.63E-03	1.35E-03	3162.3	9.88E-03	5.14E-03	1.07E-03
3600.0	1.43E-02	7.44E-03	1.51E-03	3600.0	1.10E-02	5.71E-03	1.19E-03
7200.0	1.45E-02	7.54E-03		7200.0	1.09E-02	5.67E-03	

Table D-23 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% D1101 TEST TEMP = 90 , ZIGMA = 0.846 PSI				FINA AC-10 + 3% D1101 TEST TEMP = 90 , ZIGMA = 0.873 PSI			
1.0	6.00E-05	3.12E-05	1.84E-05	1.0	2.00E-05	1.04E-05	5.96E-06
1.8	1.00E-04	5.20E-05	3.07E-05	1.8	3.50E-05	1.82E-05	1.04E-05
3.2	1.50E-04	7.80E-05	4.61E-05	3.2	5.25E-05	2.73E-05	1.56E-05
5.6	2.00E-04	1.04E-04	6.15E-05	5.6	7.90E-05	4.11E-05	2.35E-05
10.0	2.85E-04	1.48E-04	8.76E-05	10.0	1.20E-04	6.24E-05	3.57E-05
18.0	4.20E-04	2.18E-04	1.29E-04	18.0	1.80E-04	9.36E-05	5.36E-05
31.6	6.05E-04	3.15E-04	1.86E-04	31.6	2.55E-04	1.33E-04	7.60E-05
56.2	8.65E-04	4.50E-04	2.66E-04	56.2	3.60E-04	1.87E-04	1.07E-04
100.0	1.16E-03	6.01E-04	3.55E-04	100.0	5.28E-04	2.74E-04	1.57E-04
177.8	1.70E-03	8.84E-04	5.23E-04	177.8	7.65E-04	3.98E-04	2.28E-04
316.2	2.50E-03	1.30E-03	7.68E-04	316.2	1.10E-03	5.72E-04	3.28E-04
562.3	3.65E-03	1.90E-03	1.12E-03	562.3	1.53E-03	7.93E-04	4.54E-04
1000.0	5.50E-03	2.86E-03	1.69E-03	1000.0	2.14E-03	1.11E-03	6.37E-04
1778.3	8.30E-03	4.32E-03	2.55E-03	1778.3	2.67E-03	1.39E-03	7.95E-04
3162.3	1.36E-02	7.07E-03	4.18E-03	3162.3	3.25E-03	1.69E-03	9.68E-04
3600.0	1.50E-02	7.80E-03	4.61E-03	3600.0	3.35E-03	1.74E-03	9.98E-04
7200.0	1.24E-02	6.42E-03		7200.0	2.16E-03	1.12E-03	

Table D-24 Creep Compliance of Plant Mixed / Laboratory Compacted Mixtures Using Modified Compaction.

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TOTAL AC-20				TOTAL AC-20			
TEST TEMP = 60 , ZIGMA = 7.480 PSI				TEST TEMP = 60 , ZIGMA = 7.536 PSI			
1.0	5.00E-05	2.60E-05	1.74E-06	1.0	9.50E-05	4.94E-05	3.28E-06
1.8	8.50E-05	4.42E-05	2.96E-06	1.8	1.15E-04	5.98E-05	3.97E-06
3.2	1.10E-04	5.72E-05	3.82E-06	3.2	1.45E-04	7.54E-05	5.00E-06
5.6	1.45E-04	7.54E-05	5.04E-06	5.6	1.70E-04	8.84E-05	5.87E-06
10.0	1.90E-04	9.88E-05	6.61E-06	10.0	2.15E-04	1.12E-04	7.42E-06
18.0	2.48E-04	1.29E-04	8.60E-06	18.0	2.70E-04	1.40E-04	9.32E-06
31.6	3.53E-04	1.83E-04	1.23E-05	31.6	3.53E-04	1.83E-04	1.22E-05
56.2	4.90E-04	2.55E-04	1.70E-05	56.2	4.73E-04	2.46E-04	1.63E-05
100.0	6.70E-04	3.48E-04	2.33E-05	100.0	6.55E-04	3.41E-04	2.26E-05
177.8	8.30E-04	4.32E-04	2.89E-05	177.8	8.50E-04	4.42E-04	2.93E-05
316.2	1.37E-03	7.13E-04	4.76E-05	316.2	1.15E-03	5.98E-04	3.97E-05
562.3	2.10E-03	1.09E-03	7.30E-05	562.3	1.51E-03	7.85E-04	5.21E-05
1000.0	2.72E-03	1.41E-03	9.46E-05	1000.0	2.16E-03	1.12E-03	7.45E-05
1778.3	3.77E-03	1.96E-03	1.31E-04	1778.3	3.11E-03	1.62E-03	1.07E-04
3162.3	4.82E-03	2.51E-03	1.68E-04	3162.3	4.50E-03	2.34E-03	1.55E-04
3600.0	5.22E-03	2.71E-03	1.81E-04	3600.0	4.88E-03	2.54E-03	1.68E-04
7200.0	4.57E-03	2.38E-03		7200.0	4.30E-03	2.24E-03	1.48E-04
TOTAL AC-20				TOTAL AC-20			
TEST TEMP = 77 , ZIGMA = 2.418 PSI				TEST TEMP = 77 , ZIGMA = 3.871 PSI			
1.0	4.00E-05	2.08E-05	4.30E-06	1.0	1.15E-04	5.98E-05	7.73E-06
1.8	7.00E-05	3.64E-05	7.53E-06	1.8	1.70E-04	8.84E-05	1.14E-05
3.2	9.00E-05	4.68E-05	9.68E-06	3.2	2.25E-04	1.17E-04	1.51E-05
5.6	1.10E-04	5.72E-05	1.18E-05	5.6	3.00E-04	1.56E-04	2.02E-05
10.0	1.40E-04	7.28E-05	1.51E-05	10.0	4.08E-04	2.12E-04	2.74E-05
18.0	2.00E-04	1.04E-04	2.15E-05	18.0	5.08E-04	2.64E-04	3.41E-05
31.6	2.90E-04	1.51E-04	3.12E-05	31.6	8.10E-04	4.21E-04	5.44E-05
56.2	4.70E-04	2.44E-04	5.05E-05	56.2	1.13E-03	5.85E-04	7.56E-05
100.0	8.10E-04	4.21E-04	8.71E-05	100.0	1.48E-03	7.70E-04	9.94E-05
177.8	1.20E-03	6.24E-04	1.29E-04	177.8	2.10E-03	1.09E-03	1.41E-04
316.2	1.75E-03	9.10E-04	1.88E-04	316.2	3.30E-03	1.72E-03	2.22E-04
562.3	2.50E-03	1.30E-03	2.69E-04	562.3	4.50E-03	2.34E-03	3.02E-04
1000.0	4.50E-03	2.34E-03	4.84E-04	1000.0	6.45E-03	3.35E-03	4.33E-04
1778.3	8.50E-03	4.42E-03	9.14E-04	1778.3	1.04E-02	5.38E-03	6.95E-04
3162.3	1.83E-02	9.49E-03	1.96E-03	3162.3	2.13E-02	1.11E-02	1.43E-03
3600.0	2.23E-02	1.16E-02	2.39E-03	3600.0	2.55E-02	1.33E-02	1.71E-03
7200.0	2.15E-02	1.12E-02		7200.0	2.49E-02	1.30E-02	

Table D-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
TOTAL AC-20 TEST TEMP = 90 , ZIGMA = 1.348 PSI				TOTAL AC-20 TEST TEMP = 90 , ZIGMA = 1.729 PSI			
1.0	1.00E-04	5.20E-05	1.93E-05	1.0	2.75E-05	1.43E-05	4.14E-06
1.8	1.75E-04	9.10E-05	3.38E-05	1.8	4.00E-05	2.08E-05	6.02E-06
3.2	2.35E-04	1.22E-04	4.53E-05	3.2	6.00E-05	3.12E-05	9.02E-06
5.6	4.00E-04	2.08E-04	7.72E-05	5.6	8.75E-05	4.55E-05	1.32E-05
10.0	7.35E-04	3.82E-04	1.42E-04	10.0	1.15E-04	5.98E-05	1.73E-05
18.0	1.25E-03	6.50E-04	2.41E-04	18.0	1.65E-04	8.58E-05	2.48E-05
31.6	2.40E-03	1.25E-03	4.63E-04	31.6	2.23E-04	1.16E-04	3.35E-05
56.2	4.05E-03	2.11E-03	7.81E-04	56.2	3.30E-04	1.72E-04	4.96E-05
100.0	7.35E-03	3.82E-03	1.42E-03	100.0	5.25E-04	2.73E-04	7.90E-05
177.8	1.30E-02	6.76E-03	2.51E-03	177.8	8.50E-04	4.42E-04	1.28E-04
316.2	2.55E-02	1.33E-02	4.92E-03	316.2	1.65E-03	8.58E-04	2.48E-04
562.3	4.85E-02	2.52E-02	9.36E-03	562.3	3.35E-03	1.74E-03	5.04E-04
1000.0	7.75E-02	4.03E-02	1.50E-02	1000.0	5.90E-03	3.07E-03	8.87E-04
FINA AC-10 + 3% UP-70 TEST TEMP = 60 , ZIGMA = 7.341 PSI				FINA AC-10 + 3% UP-70 TEST TEMP = 60 , ZIGMA = 7.262 PSI			
1.0	8.50E-05	4.42E-05	3.01E-06	1.0	9.50E-05	4.94E-05	3.40E-06
1.8	1.15E-04	5.98E-05	4.07E-06	1.8	1.25E-04	6.50E-05	4.48E-06
3.2	1.55E-04	8.06E-05	5.49E-06	3.2	1.65E-04	8.58E-05	5.91E-06
5.6	2.18E-04	1.13E-04	7.70E-06	5.6	2.50E-04	1.30E-04	8.95E-06
10.0	3.05E-04	1.59E-04	1.08E-05	10.0	3.70E-04	1.92E-04	1.32E-05
18.0	4.20E-04	2.18E-04	1.49E-05	18.0	5.40E-04	2.81E-04	1.93E-05
31.6	5.70E-04	2.96E-04	2.02E-05	31.6	8.00E-04	4.16E-04	2.86E-05
56.2	8.40E-04	4.37E-04	2.98E-05	56.2	1.12E-03	5.80E-04	3.99E-05
100.0	1.26E-03	6.55E-04	4.46E-05	100.0	1.66E-03	8.63E-04	5.94E-05
177.8	1.84E-03	9.57E-04	6.52E-05	177.8	2.33E-03	1.21E-03	8.34E-05
316.2	2.64E-03	1.37E-03	9.35E-05	316.2	3.33E-03	1.73E-03	1.19E-04
562.3	3.95E-03	2.05E-03	1.40E-04	562.3	5.08E-03	2.64E-03	1.82E-04
1000.0	5.55E-03	2.89E-03	1.97E-04	1000.0	8.13E-03	4.23E-03	2.91E-04
1778.3	7.95E-03	4.13E-03	2.82E-04	1778.3	1.35E-02	7.04E-03	4.85E-04
3162.3	1.13E-02	5.88E-03	4.00E-04	3162.3	2.48E-02	1.29E-02	8.87E-04
3600.0	1.24E-02	6.45E-03	4.39E-04	3600.0	2.89E-02	1.50E-02	1.04E-03
7200.0	1.17E-02	6.06E-03		7200.0	2.74E-02	1.42E-02	

Table D-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% UP-70 TEST TEMP = 77 , ZIGMA = 6.664 PSI				FINA AC-10 + 3% UP-70 TEST TEMP = 77 , ZIGMA = 3.907 PSI			
1.0	3.25E-04	1.69E-04	1.27E-05	1.0	8.50E-05	4.42E-05	5.66E-06
1.8	4.50E-04	2.34E-04	1.76E-05	1.8	1.10E-04	5.72E-05	7.32E-06
3.2	5.65E-04	2.94E-04	2.20E-05	3.2	2.25E-04	1.17E-04	1.50E-05
5.6	6.65E-04	3.46E-04	2.60E-05	5.6	3.20E-04	1.66E-04	2.13E-05
10.0	9.50E-04	4.94E-04	3.71E-05	10.0	4.40E-04	2.29E-04	2.93E-05
18.0	1.33E-03	6.89E-04	5.17E-05	18.0	5.75E-04	2.99E-04	3.83E-05
31.6	2.03E-03	1.05E-03	7.90E-05	31.6	8.40E-04	4.37E-04	5.59E-05
56.2	3.15E-03	1.64E-03	1.23E-04	56.2	1.36E-03	7.05E-04	9.02E-05
100.0	5.18E-03	2.69E-03	2.02E-04	100.0	1.68E-03	8.71E-04	1.11E-04
177.8	8.40E-03	4.37E-03	3.28E-04	177.8	2.61E-03	1.35E-03	1.73E-04
316.2	1.09E-02	5.67E-03	4.25E-04	316.2	3.90E-03	2.03E-03	2.60E-04
562.3	2.54E-02	1.32E-02	9.91E-04	562.3	5.50E-03	2.86E-03	3.66E-04
FINA AC-10 + 3% UP-70 TEST TEMP = 90 , ZIGMA = 0.997 PSI				FINA AC-10 + 3% UP-70 TEST TEMP = 90 , ZIGMA = 0.839 PSI			
1.0	8.00E-05	4.16E-05	2.09E-05	1.0	5.00E-05	2.60E-05	1.55E-05
1.8	1.15E-04	5.98E-05	3.00E-05	1.8	7.50E-05	3.90E-05	2.32E-05
3.2	1.48E-04	7.67E-05	3.85E-05	3.2	1.00E-04	5.20E-05	3.10E-05
5.6	2.08E-04	1.08E-04	5.41E-05	5.6	1.50E-04	7.80E-05	4.65E-05
10.0	2.75E-04	1.43E-04	7.17E-05	10.0	2.00E-04	1.04E-04	6.20E-05
18.0	3.80E-04	1.98E-04	9.91E-05	18.0	3.00E-04	1.56E-04	9.30E-05
31.6	5.40E-04	2.81E-04	1.41E-04	31.6	4.00E-04	2.08E-04	1.24E-04
56.2	7.70E-04	4.00E-04	2.01E-04	56.2	6.00E-04	3.12E-04	1.86E-04
100.0	1.21E-03	6.29E-04	3.16E-04	100.0	1.40E-03	7.28E-04	4.34E-04
177.8	1.85E-03	9.62E-04	4.83E-04	177.8	1.88E-03	9.75E-04	5.81E-04
316.2	2.75E-03	1.43E-03	7.17E-04	316.2	2.06E-03	1.07E-03	6.37E-04
562.3	4.05E-03	2.11E-03	1.06E-03	562.3	2.36E-03	1.22E-03	7.30E-04
1000.0	6.30E-03	3.28E-03	1.64E-03	1000.0	3.11E-03	1.61E-03	9.62E-04
1778.3	1.09E-02	5.67E-03	2.84E-03	1778.3	4.60E-03	2.39E-03	1.42E-03
3162.3	0.00E+00	0.00E+00	0.00E+00				
3600.0	0.00E+00	0.00E+00	0.00E+00				
7200.0	0.00E+00	0.00E+00					

Table D-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% STYRELF TEST TEMP = 60 , ZIGMA = 7.405 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 60 . ZIGMA = 7.408 PSI			
1.0	1.00E-04	5.20E-05	3.51E-06	1.0	9.50E-05	4.94E-05	3.33E-06
1.8	1.40E-04	7.28E-05	4.92E-06	1.8	1.15E-04	5.98E-05	4.04E-06
3.2	1.85E-04	9.62E-05	6.50E-06	3.2	1.45E-04	7.54E-05	5.09E-06
5.6	2.60E-04	1.35E-04	9.13E-06	5.6	1.90E-04	9.88E-05	6.67E-06
10.0	3.60E-04	1.87E-04	1.26E-05	10.0	2.56E-04	1.33E-04	8.99E-06
18.0	5.00E-04	2.60E-04	1.76E-05	18.0	3.83E-04	1.99E-04	1.34E-05
31.6	6.60E-04	3.43E-04	2.32E-05	31.6	5.85E-04	3.04E-04	2.05E-05
56.2	8.55E-04	4.45E-04	3.00E-05	56.2	9.00E-04	4.68E-04	3.16E-05
100.0	1.19E-03	6.19E-04	4.18E-05	100.0	1.35E-03	7.00E-04	4.72E-05
177.8	1.58E-03	8.19E-04	5.53E-05	177.8	1.80E-03	9.36E-04	6.32E-05
316.2	2.10E-03	1.09E-03	7.37E-05	316.2	2.50E-03	1.30E-03	8.78E-05
562.3	2.98E-03	1.55E-03	1.04E-04	562.3	3.43E-03	1.78E-03	1.20E-04
1000.0	4.33E-03	2.25E-03	1.52E-04	1000.0	4.78E-03	2.48E-03	1.68E-04
1778.3	6.58E-03	3.42E-03	2.31E-04	1778.3	6.75E-03	3.51E-03	2.37E-04
3162.3	1.02E-02	5.32E-03	3.59E-04	3162.3	9.78E-03	5.08E-03	3.43E-04
3600.0	1.11E-02	5.76E-03	3.89E-04	3600.0	1.07E-02	5.57E-03	3.76E-04
7200.0	1.06E-02	5.50E-03		7200.0	9.80E-03	5.10E-03	
FINA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 1.350 PSI				FINA AC-10 + 3% STYRELF TEST TEMP = 77 , ZIGMA = 1.344 PSI			
1.0	3.50E-05	1.82E-05	6.74E-06	1.0	2.75E-05	1.43E-05	5.32E-06
1.8	4.50E-05	2.34E-05	8.67E-06	1.8	4.40E-05	2.29E-05	8.51E-06
3.2	5.50E-05	2.86E-05	1.06E-05	3.2	5.60E-05	2.91E-05	1.08E-05
5.6	7.20E-05	3.74E-05	1.39E-05	5.6	8.10E-05	4.21E-05	1.57E-05
10.0	8.90E-05	4.63E-05	1.71E-05	10.0	1.07E-04	5.54E-05	2.06E-05
18.0	1.34E-04	6.97E-05	2.58E-05	18.0	1.36E-04	7.05E-05	2.62E-05
31.6	1.75E-04	9.10E-05	3.37E-05	31.6	2.13E-04	1.11E-04	4.12E-05
56.2	2.23E-04	1.16E-04	4.29E-05	56.2	3.25E-04	1.69E-04	6.29E-05
100.0	3.05E-04	1.59E-04	5.88E-05	100.0	5.08E-04	2.64E-04	9.82E-05
177.8	4.35E-04	2.26E-04	8.38E-05	177.8	8.00E-04	4.16E-04	1.55E-04
316.2	7.20E-04	3.74E-04	1.39E-04	316.2	1.14E-03	5.93E-04	2.21E-04
562.3	1.13E-03	5.85E-04	2.17E-04	562.3	1.62E-03	8.40E-04	3.12E-04
1000.0	1.90E-03	9.88E-04	3.66E-04	1000.0	2.68E-03	1.39E-03	5.18E-04
1778.3	3.13E-03	1.63E-03	6.02E-04	1778.3	4.17E-03	2.17E-03	8.06E-04
3162.3	5.30E-03	2.76E-03	1.02E-03	3162.3	6.55E-03	3.41E-03	1.27E-03
3600.0	6.05E-03	3.15E-03	1.17E-03	3600.0	7.28E-03	3.78E-03	1.41E-03
7200.0	5.55E-03	2.89E-03		7200.0	7.03E-03	3.65E-03	

Table D-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 0.855 PSI				TEXACO AC-10 + 3% STYRELF TEST TEMP = 90 , ZIGMA = 0.855 PSI			
1.0	5.00E-06	2.60E-06	1.52E-06	1.0	4.00E-05	2.08E-05	1.22E-05
1.8	1.00E-05	5.20E-06	3.04E-06	1.8	6.00E-05	3.12E-05	1.82E-05
3.2	1.50E-05	7.80E-06	4.56E-06	3.2	8.25E-05	4.29E-05	2.51E-05
5.6	2.00E-05	1.04E-05	6.08E-06	5.6	1.23E-04	6.37E-05	3.73E-05
10.0	4.00E-05	2.08E-05	1.22E-05	10.0	1.75E-04	9.10E-05	5.32E-05
18.0	7.50E-05	3.90E-05	2.28E-05	18.0	2.53E-04	1.31E-04	7.68E-05
31.6	1.25E-04	6.50E-05	3.80E-05	31.6	3.93E-04	2.04E-04	1.19E-04
56.2	2.05E-04	1.07E-04	6.24E-05	56.2	5.95E-04	3.09E-04	1.81E-04
100.0	3.10E-04	1.61E-04	9.43E-05	100.0	8.90E-04	4.63E-04	2.71E-04
177.8	4.50E-04	2.34E-04	1.37E-04	177.8	1.20E-03	6.24E-04	3.65E-04
316.2	6.50E-04	3.38E-04	1.98E-04	316.2	1.55E-03	8.06E-04	4.71E-04
562.3	1.10E-03	5.72E-04	3.35E-04	562.3	2.10E-03	1.09E-03	6.39E-04
1000.0	1.85E-03	9.62E-04	5.63E-04	1000.0	2.92E-03	1.52E-03	8.87E-04
1778.3	3.15E-03	1.64E-03	9.58E-04	1778.3	4.05E-03	2.11E-03	1.23E-03
3162.3	5.35E-03	2.78E-03	1.63E-03	3162.3	6.18E-03	3.21E-03	1.88E-03
3600.0	5.60E-03	2.91E-03	1.70E-03	3600.0	6.58E-03	3.42E-03	2.00E-03
7200.0	4.10E-03	2.13E-03		7200.0	5.13E-03	2.67E-03	
FINA AC-10 + 3% POLYBILT TEST TEMP = 60 , ZIGMA = 3.868 PSI				FINA AC-10 + 3% POLYBILT TEST TEMP = 60 , ZIGMA = 7.504 PSI			
1.0	1.10E-04	5.72E-05	7.40E-06	1.0	1.50E-04	7.80E-05	5.20E-06
1.8	1.50E-04	7.80E-05	1.01E-05	1.8	2.25E-04	1.17E-04	7.80E-06
3.2	1.90E-04	9.88E-05	1.28E-05	3.2	2.95E-04	1.53E-04	1.02E-05
5.6	2.45E-04	1.27E-04	1.65E-05	5.6	4.20E-04	2.18E-04	1.46E-05
10.0	3.25E-04	1.69E-04	2.19E-05	10.0	5.15E-04	2.68E-04	1.78E-05
18.0	4.60E-04	2.39E-04	3.09E-05	18.0	7.05E-04	3.67E-04	2.44E-05
31.6	6.70E-04	3.48E-04	4.50E-05	31.6	1.10E-03	5.72E-04	3.81E-05
56.2	9.05E-04	4.71E-04	6.08E-05	56.2	1.72E-03	8.95E-04	5.96E-05
100.0	1.39E-03	7.23E-04	9.35E-05	100.0	2.72E-03	1.41E-03	9.43E-05
177.8	1.93E-03	1.00E-03	1.29E-04	177.8	4.30E-03	2.24E-03	1.49E-04
316.2	2.75E-03	1.43E-03	1.85E-04	316.2	6.65E-03	3.46E-03	2.30E-04
562.3	3.90E-03	2.03E-03	2.62E-04	562.3	9.40E-03	4.89E-03	3.26E-04
1000.0	5.75E-03	2.99E-03	3.87E-04	1000.0	1.97E-02	1.02E-02	6.81E-04
1778.3	8.95E-03	4.65E-03	6.02E-04				
3162.3	1.46E-02	7.57E-03	9.78E-04				
3600.0	1.64E-02	8.50E-03	1.10E-03				
7200.0	1.58E-02	8.19E-03	1.06E-03				

Table D-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% POLYBILT TEST TEMP = 77 , ZIGMA =1.225 PSI				FINA AC-10 + 3% POLYBILT TEST TEMP = 77 , ZIGMA = 0.995 PSI			
1.0	3.50E-05	1.82E-05	7.43E-06	1.0	4.00E-05	2.08E-05	1.05E-05
1.8	5.50E-05	2.86E-05	1.17E-05	1.8	5.75E-05	2.99E-05	1.50E-05
3.2	7.75E-05	4.03E-05	1.65E-05	3.2	7.75E-05	4.03E-05	2.03E-05
5.6	1.15E-04	5.98E-05	2.44E-05	5.6	1.10E-04	5.72E-05	2.87E-05
10.0	1.65E-04	8.58E-05	3.50E-05	10.0	1.50E-04	7.80E-05	3.92E-05
18.0	2.40E-04	1.25E-04	5.09E-05	18.0	2.20E-04	1.14E-04	5.75E-05
31.6	3.45E-04	1.79E-04	7.32E-05	31.6	3.60E-04	1.87E-04	9.41E-05
56.2	4.85E-04	2.52E-04	1.03E-04	56.2	5.93E-04	3.08E-04	1.55E-04
100.0	6.85E-04	3.56E-04	1.45E-04	100.0	9.75E-04	5.07E-04	2.55E-04
177.8	9.50E-04	4.94E-04	2.02E-04	177.8	1.55E-03	8.06E-04	4.05E-04
316.2	1.37E-03	7.10E-04	2.90E-04	316.2	2.50E-03	1.30E-03	6.53E-04
562.3	2.02E-03	1.05E-03	4.28E-04	562.3	3.75E-03	1.95E-03	9.80E-04
1000.0	3.03E-03	1.57E-03	6.42E-04	1000.0	5.85E-03	3.04E-03	1.53E-03
1778.3	4.95E-03	2.57E-03	1.05E-03	1778.3	9.60E-03	4.99E-03	2.51E-03
FINA AC-10 + 3% POLYBILT TEST TEMP = 90 , ZIGMA = 0.856 PSI				FINA AC-10 + 3% POLYBILT TEST TEMP = 90 , ZIGMA = 0.876 PSI			
1.0	5.50E-05	2.86E-05	1.67E-05	1.0	7.00E-05	3.64E-05	2.08E-05
1.8	9.00E-05	4.68E-05	2.73E-05	1.8	1.03E-04	5.33E-05	3.04E-05
3.2	1.30E-04	6.76E-05	3.95E-05	3.2	1.30E-04	6.76E-05	3.86E-05
5.6	1.85E-04	9.62E-05	5.62E-05	5.6	1.70E-04	8.84E-05	5.05E-05
10.0	2.70E-04	1.40E-04	8.20E-05	10.0	2.18E-04	1.13E-04	6.46E-05
18.0	4.08E-04	2.12E-04	1.24E-04	18.0	2.98E-04	1.55E-04	8.83E-05
31.6	6.20E-04	3.22E-04	1.88E-04	31.6	4.35E-04	2.26E-04	1.29E-04
56.2	9.55E-04	4.97E-04	2.90E-04	56.2	6.63E-04	3.45E-04	1.97E-04
100.0	1.50E-03	7.80E-04	4.56E-04	100.0	1.02E-03	5.31E-04	3.03E-04
177.8	2.10E-03	1.09E-03	6.38E-04	177.8	1.40E-03	7.28E-04	4.16E-04
316.2	3.03E-03	1.57E-03	9.19E-04	316.2	1.85E-03	9.62E-04	5.49E-04
562.3	4.48E-03	2.33E-03	1.36E-03	562.3	2.66E-03	1.38E-03	7.90E-04
1000.0	7.40E-03	3.85E-03	2.25E-03	1000.0	3.80E-03	1.98E-03	1.13E-03
1778.3	1.30E-02	6.76E-03	3.95E-03	1778.3	5.48E-03	2.85E-03	1.63E-03
				3162.3	9.00E-03	4.68E-03	2.67E-03
				3600.0	1.03E-02	5.34E-03	3.05E-03
				7200.0	7.93E-03	4.12E-03	

Table D-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
FINA AC-10 + 3% D1101 TEST TEMP = 60 , ZIGMA = 3.194 PSI				FINA AC-10 + 3% D1101 TEST TEMP = 60 , ZIGMA = 3.152 PSI			
1.0	7.50E-06	3.90E-06	6.11E-07	1.0	5.00E-05	2.60E-05	4.13E-06
1.8	1.50E-05	7.80E-06	1.22E-06	1.8	8.50E-05	4.42E-05	7.01E-06
3.2	2.00E-05	1.04E-05	1.63E-06	3.2	1.18E-04	6.11E-05	9.69E-06
5.6	3.00E-05	1.56E-05	2.44E-06	5.6	1.70E-04	8.84E-05	1.40E-05
10.0	4.00E-05	2.08E-05	3.26E-06	10.0	2.30E-04	1.20E-04	1.90E-05
18.0	5.00E-05	2.60E-05	4.07E-06	18.0	3.43E-04	1.78E-04	2.83E-05
31.6	7.00E-05	3.64E-05	5.70E-06	31.6	5.04E-04	2.62E-04	4.15E-05
56.2	1.02E-04	5.28E-05	8.26E-06	56.2	6.85E-04	3.56E-04	5.65E-05
100.0	1.33E-04	6.89E-05	1.08E-05	100.0	1.01E-03	5.23E-04	8.29E-05
177.8	2.25E-04	1.17E-04	1.83E-05	177.8	1.48E-03	7.67E-04	1.22E-04
316.2	3.85E-04	2.00E-04	3.13E-05	316.2	2.18E-03	1.13E-03	1.79E-04
562.3	6.40E-04	3.33E-04	5.21E-05	562.3	3.26E-03	1.70E-03	2.69E-04
1000.0	1.03E-03	5.33E-04	8.35E-05	1000.0	4.88E-03	2.54E-03	4.02E-04
1778.3	1.78E-03	9.23E-04	1.45E-04	1778.3	6.93E-03	3.60E-03	5.71E-04
3162.3	3.15E-03	1.64E-03	2.56E-04	3162.3	1.04E-02	5.38E-03	8.54E-04
3600.0	3.50E-03	1.82E-03	2.85E-04	3600.0	1.12E-02	5.84E-03	9.26E-04
7200.0	2.98E-03	1.55E-03		7200.0	1.08E-02	5.62E-03	
FINA AC-10 + 3% D1101 TEST TEMP = 77 , ZIGMA = 2.376 PSI				FINA AC-10 + 3% D1101 TEST TEMP = 77 , ZIGMA = 2.470 PSI			
1.0	5.00E-05	2.60E-05	5.47E-06	1.0	3.00E-05	1.56E-05	3.16E-06
1.8	8.50E-05	4.42E-05	9.30E-06	1.8	5.00E-05	2.60E-05	5.26E-06
3.2	1.10E-04	5.72E-05	1.20E-05	3.2	7.35E-05	3.82E-05	7.74E-06
5.6	1.70E-04	8.84E-05	1.86E-05	5.6	9.25E-05	4.81E-05	9.74E-06
10.0	2.88E-04	1.50E-04	3.15E-05	10.0	1.22E-04	6.32E-05	1.28E-05
18.0	3.45E-04	1.79E-04	3.78E-05	18.0	1.63E-04	8.45E-05	1.71E-05
31.6	5.00E-04	2.60E-04	5.47E-05	31.6	2.03E-04	1.05E-04	2.13E-05
56.2	6.65E-04	3.46E-04	7.28E-05	56.2	2.50E-04	1.30E-04	2.63E-05
100.0	1.03E-03	5.33E-04	1.12E-04	100.0	3.50E-04	1.82E-04	3.68E-05
177.8	1.48E-03	7.67E-04	1.61E-04	177.8	5.00E-04	2.60E-04	5.26E-05
316.2	2.20E-03	1.14E-03	2.41E-04	316.2	9.85E-04	5.12E-04	1.04E-04
562.3	2.78E-03	1.44E-03	3.04E-04	562.3	1.75E-03	9.10E-04	1.84E-04
1000.0	3.80E-03	1.98E-03	4.16E-04	1000.0	2.73E-03	1.42E-03	2.87E-04
1778.3	5.13E-03	2.67E-03	5.61E-04	1778.3	3.76E-03	1.96E-03	3.96E-04
3162.3	7.23E-03	3.76E-03	7.91E-04	3162.3	6.45E-03	3.35E-03	6.79E-04
3600.0	7.85E-03	4.08E-03	8.59E-04	3600.0	7.45E-03	3.87E-03	7.84E-04
7200.0	7.75E-03	4.03E-03		7200.0	7.30E-03	3.80E-03	

Table D-24 (Continued)

TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB	TIME SEC.	TOTAL HORIZONTAL DEFORMATION IN	TENSILE STRAIN IN/IN	TENSILE CREEP COMPLIANCE IN^2/LB
	FINA AC-10 + 3% D1101				FINA AC-10 + 3% D1101		
	TEST TEMP = 90 , ZIGMA = 0.858 PSI				TEST TEMP = 90 , ZIGMA = 0.859 PSI		
1.0	2.50E-05	1.30E-05	7.58E-06	1.0	2.50E-05	1.30E-05	7.57E-06
1.8	7.50E-05	3.90E-05	2.27E-05	1.8	3.50E-05	1.82E-05	1.06E-05
3.2	9.50E-05	4.94E-05	2.88E-05	3.2	5.50E-05	2.86E-05	1.67E-05
5.6	1.25E-04	6.50E-05	3.79E-05	5.6	8.00E-05	4.16E-05	2.42E-05
10.0	1.75E-04	9.10E-05	5.30E-05	10.0	1.15E-04	5.98E-05	3.48E-05
18.0	3.25E-04	1.69E-04	9.85E-05	18.0	1.70E-04	8.84E-05	5.15E-05
31.6	4.75E-04	2.47E-04	1.44E-04	31.6	2.05E-04	1.07E-04	6.21E-05
56.2	8.25E-04	4.29E-04	2.50E-04	56.2	3.35E-04	1.74E-04	1.01E-04
100.0	1.30E-03	6.76E-04	3.94E-04	100.0	4.80E-04	2.50E-04	1.45E-04
177.8	1.78E-03	9.23E-04	5.38E-04	177.8	7.45E-04	3.87E-04	2.26E-04
316.2	2.18E-03	1.13E-03	6.59E-04	316.2	1.10E-03	5.70E-04	3.31E-04
562.3	2.63E-03	1.37E-03	7.96E-04	562.3	1.55E-03	8.06E-04	4.69E-04
1000.0	3.33E-03	1.73E-03	1.01E-03	1000.0	2.40E-03	1.25E-03	7.25E-04
1778.3	4.13E-03	2.15E-03	1.25E-03	1778.3	3.55E-03	1.84E-03	1.07E-03
3162.3	4.98E-03	2.59E-03	1.51E-03	3162.3	5.10E-03	2.65E-03	1.54E-03
3600.0	5.18E-03	2.69E-03	1.57E-03	3600.0	5.40E-03	2.81E-03	1.63E-03
7200.0	3.63E-03	1.89E-03		7200.0	3.60E-03	1.87E-03	

Table D-25 Moisture Sensitivity Test Results for Laboratory Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

MIXTURE	TEST TEMP. F		Dry Condition AIR VOIDS %	Dry Condition TENSILE STRENGTH PSI	Wet Condition AIR VOIDS %	Wet Condition TENSILE STRENGTH PSI	TSR
Control: Total AC-20	77		7.0	89	6.6	50	
			7.1	83	6.9	50	
			7.2	85	6.8	52	
			-----	-----	----	----	
		AVG.	7.1	86	6.8	51	0.59
Fina AC-10 + 3% UP 70	77		6.3	67	6.7	61	
			6.6	85	6.8	54	
			5.9	84	6.9	67	
			-----	-----	----	----	
		AVG.	6.3	79	6.8	61	0.77
Fina AC-10 + 3% Styrelf	77		7.1	103	7.2	57	
			7.1	104	7.0	72	
			7.1	95	7.4	52	
			-----	-----	----	----	
		AVG.	7.1	100	7.2	61	0.60
Exxon AC-10 + 3% Polybilt	77		6.8	38	6.8	26	
			7.3	34	6.5	32	
			6.6	40	7.0	29	
			-----	-----	----	----	
		AVG.	6.9	37	6.8	29	0.78
Gulf AC-10 + 3% Kraton	77		6.5	52	7.2	41	
			7.1	62	6.8	50	
			6.6	65	7.2	45	
			-----	-----	----	----	
		AVG.	6.7	60	7.1	45	0.76

Table D-26 Moisture Sensitivity Test Results for Plant Mixed/Laboratory Compacted Mixtures Using Modified Compaction.

MIXTURE	TEST TEMP. F	Dry Condition AIR VOIDS %	Dry Condition TENSILE STRENGTH PSI	Wet Condition AIR VOIDS %	Wet Condition TENSILE STRENGTH PSI	TSR
Control: Total AC-20	77	7.5	95	7.4	59	
		7.2	92	7.3	56	
		7.3	90	7.6	49	
	AVG.	7.3	92	7.4	55	0.59
Fina AC-10 + 3% UP 70	77	7.2	73	7.3	53	
		7.3	71	7.1	59	
		7.5	78	7.1	60	
	AVG.	7.3	74	7.2	57	0.77
Fina AC-10 + 3% Styrelf	77	6.9	108	7.2	80	
		7.0	95	7.0	78	
		7.0	103	6.8	72	
	AVG.	7.0	102	7.0	76	0.75
Exxon AC-10 + 3% Polybilt	77	7.2	40	7.4	43	
		6.6	47	6.5	37	
		6.8	46	7.2	34	
	AVG.	6.9	44	7.0	38	0.86
Gulf AC-10 + 3% Kraton	77	7.0	65	7.0	29	
		6.9	72	6.9	56	
		7.0	68	7.0	57	
	AVG.	7.0	69	7.0	47	0.69

Table D-27 AGGREGATE GRADATION OF EXTRACTED CORES (DISTRICT 10)

Combined Gradation	SDHPT Specification	AC-20 AC=4.81	Latex AC=4.65	Styrelf AC=4.67	Exxon AC=4.72	Kraton AC=4.73
1.7	0-5	0	0	0	0	0
26.7	16-42	26.9	28.1	30.2	26.8	27.1
22.6	11-37	23.2	22.4	22.2	24.2	22.5
12.5	11-32	12.8	13.7	12.1	12.5	13.5
63.5	54-72	62.9	64.2	64.5	63.5	63.1
11.8	6-32	11.5	9.5	10.2	11.6	12.5
11.6	4-27	11.3	11.1	11.4	11.5	11.6
11.4	3-27	12.2	13.1	11.5	11.5	10.4
1.7	1-8	2.1	2.1	2.4	1.9	2.4
100.0		100.0	100.0	100.0	100.0	100.0

	Producer
Type C Coarse Limestone	Boorheim Field Richland
Type D Coarse Limestone	Boorheim Field Richland
Screenings	Boorheim Field Richland
Field Sand	Riley Pit

District 10 Field Test Sections
US69 – Smith County
Date Placed: July 1990

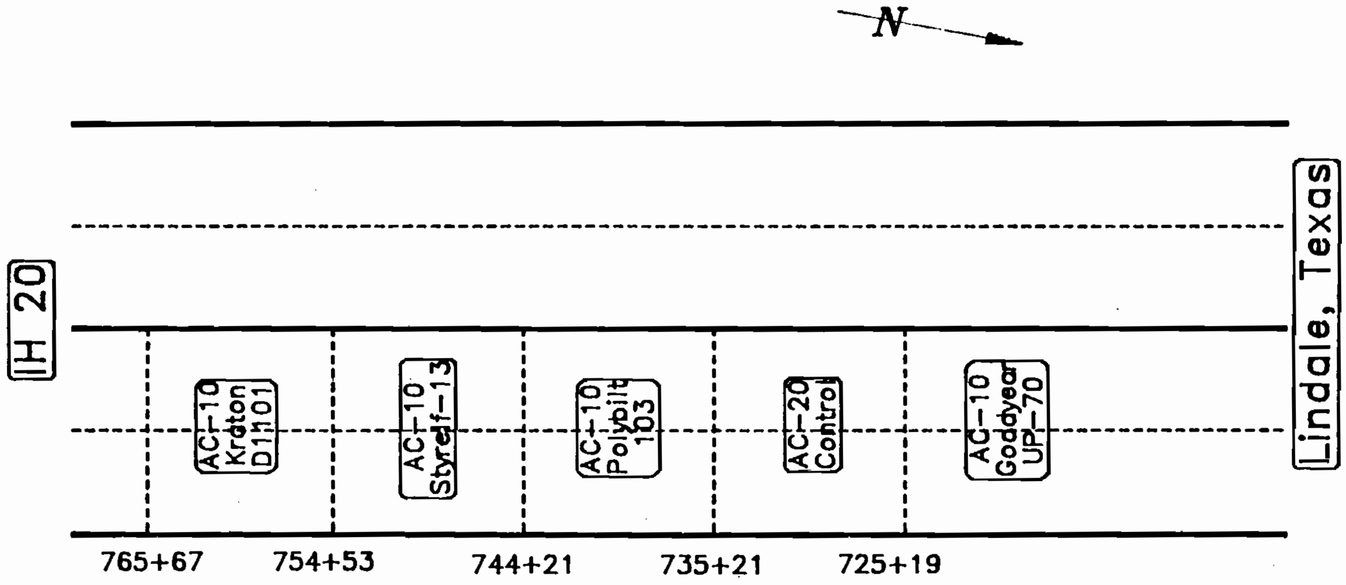


Fig. D-1 Schematic Illustration of Field Test Section.

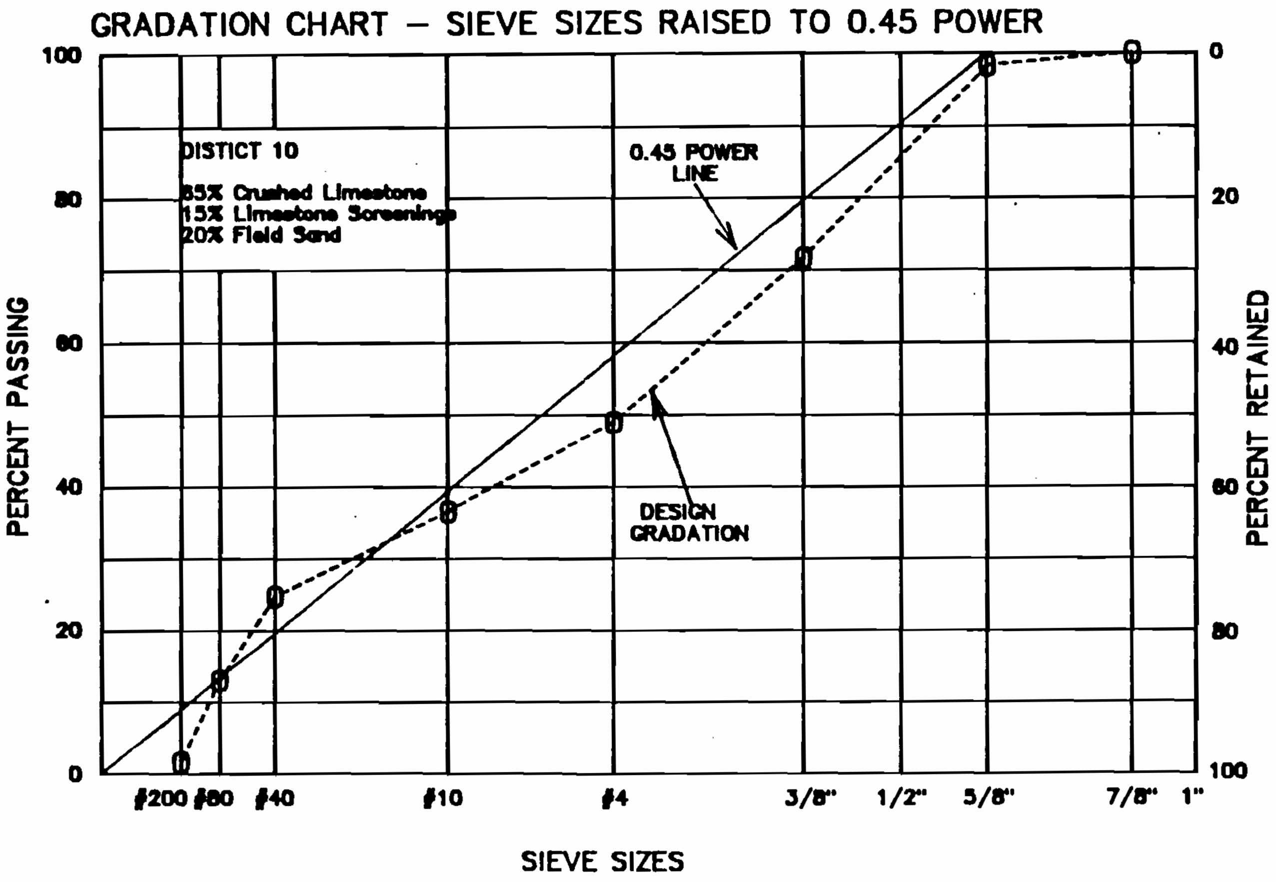


Fig. D-2 Aggregate Gradation Chart.

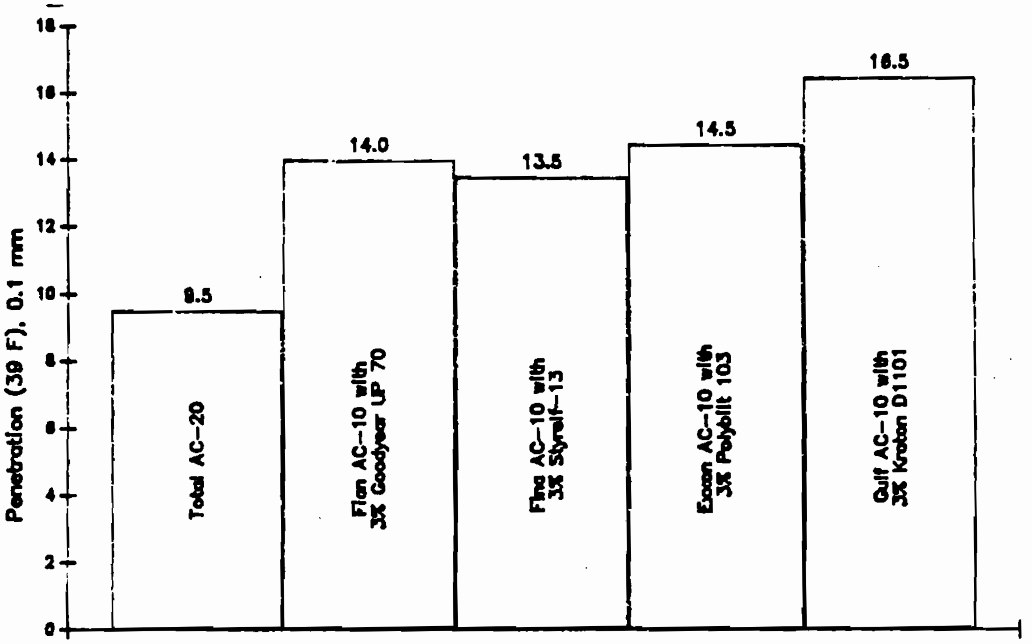


Fig. D-3 Penetration at 39F for Unmodified and Modified Binders. (District 10)

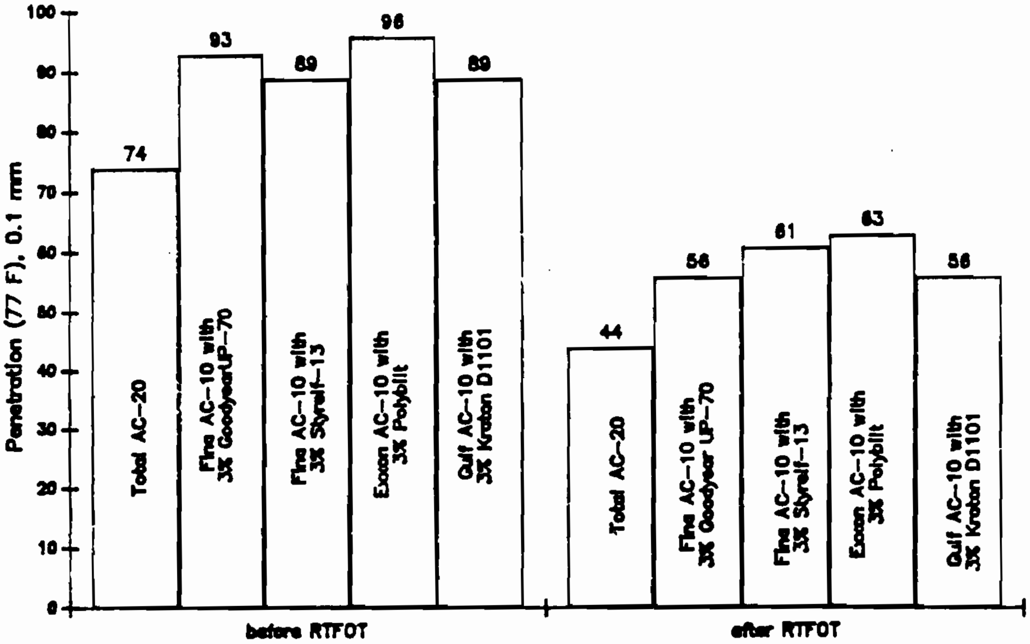


Fig. D-4 Penetration at 77F for Unmodified and Modified Binders. (District 10)

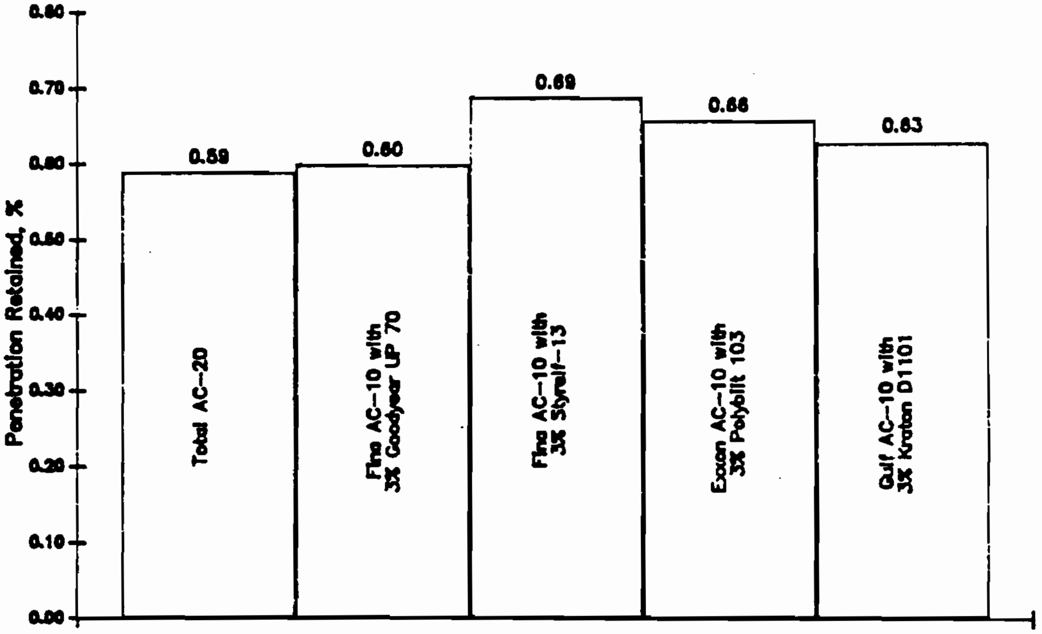


Fig. D-5 Penetration Retained at 77F for Unmodified and Modified Binders. (District 10)

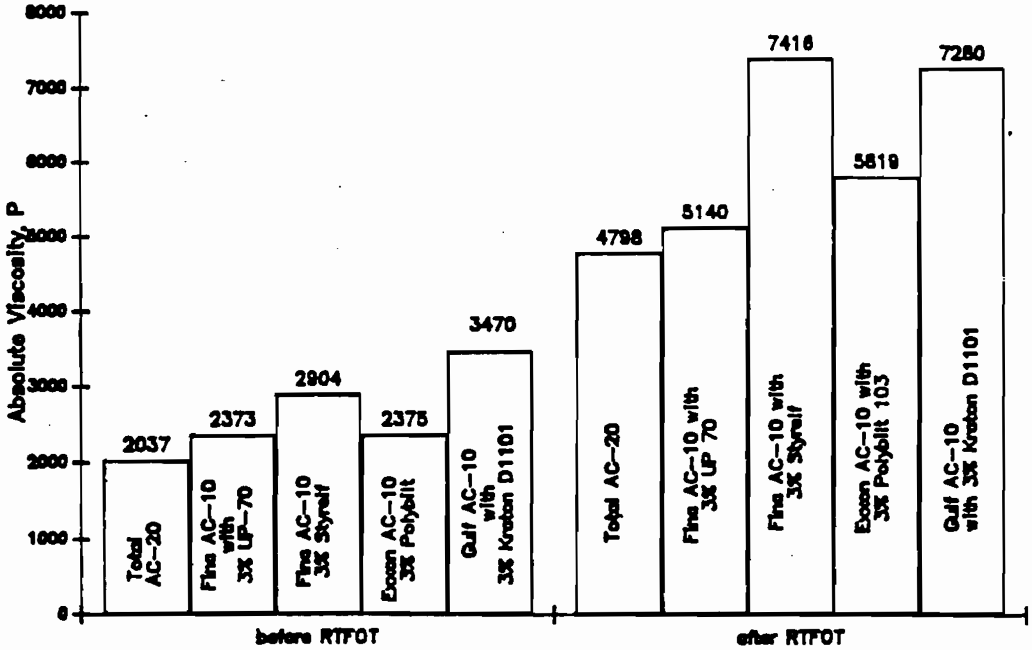


Fig. D-6 Viscosity at 140F for Unmodified and Modified Binders. (District 10)

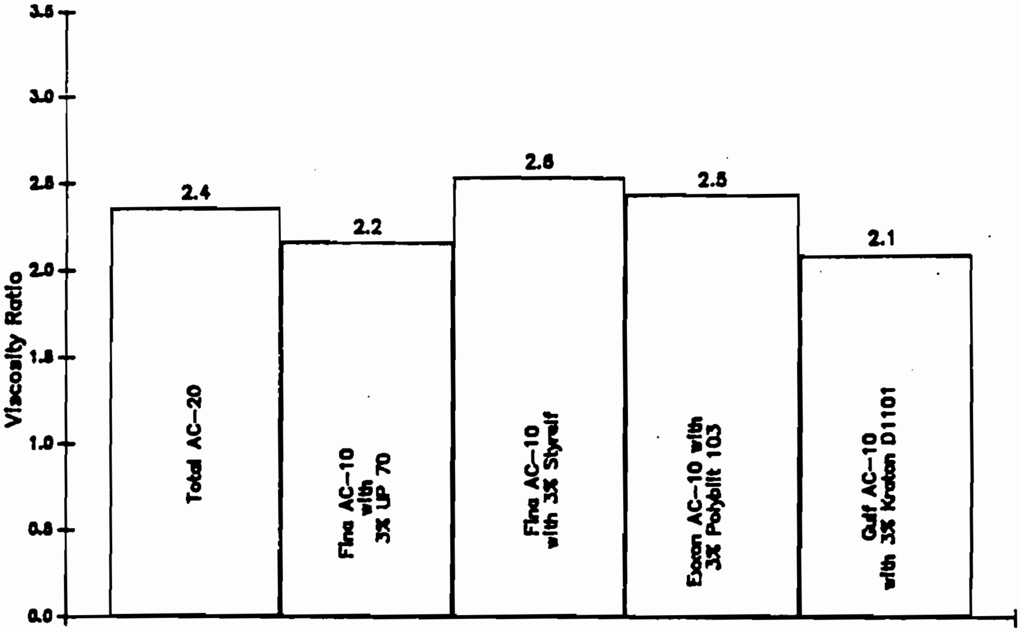


Fig. D-7 Viscosity Ratio at 140F for Unmodified and Modified Binders. (District 10)

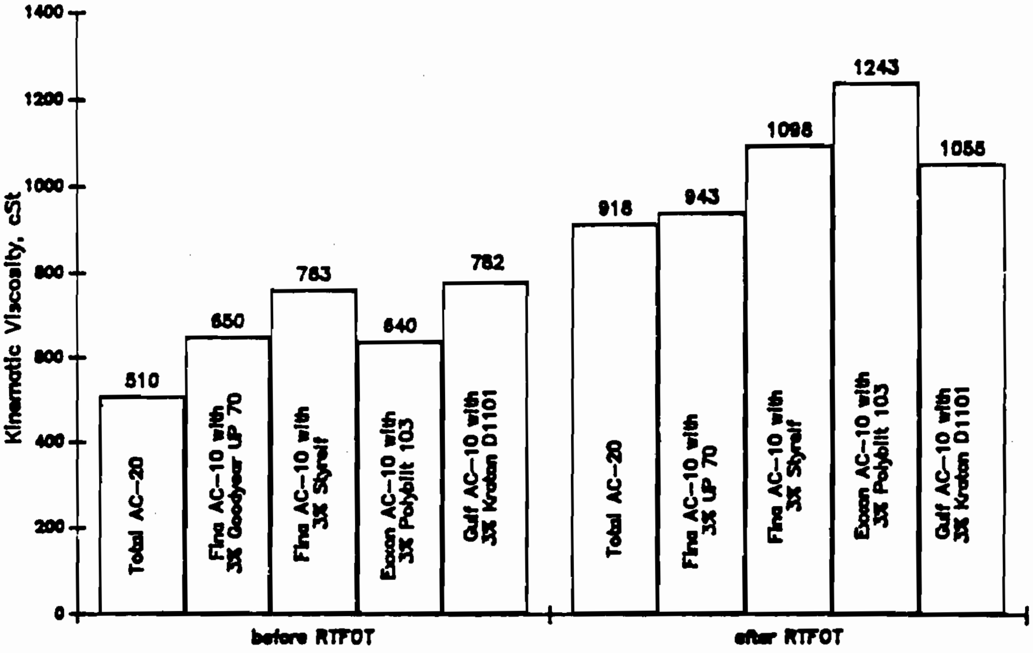


Fig. D-8 Kinematic Viscosity at 275F for Unmodified and Modified Binders. (District 10)

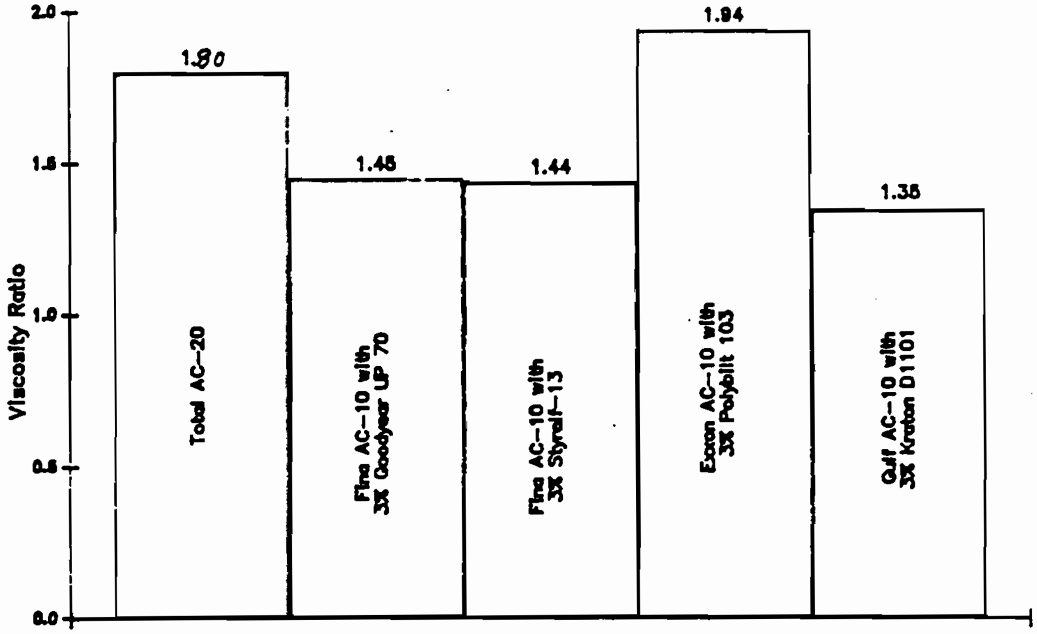


Fig. D-9 Viscosity Ratio at 275F for Unmodified and Modified Binders. (District 10)

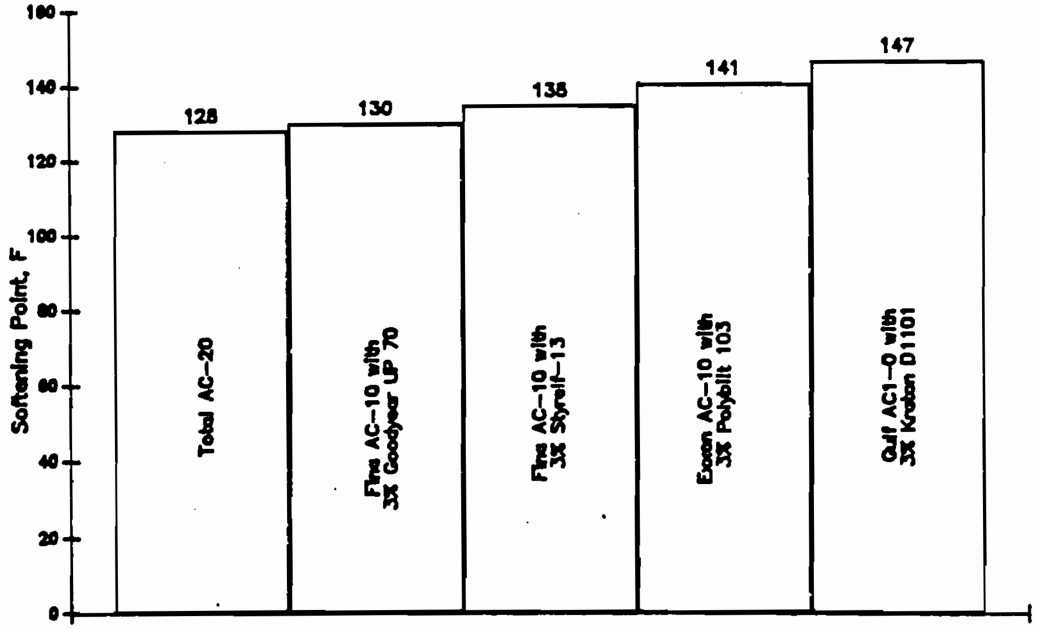


Fig. D-10 Softening point for Unmodified and Modified Binders. (District 10)

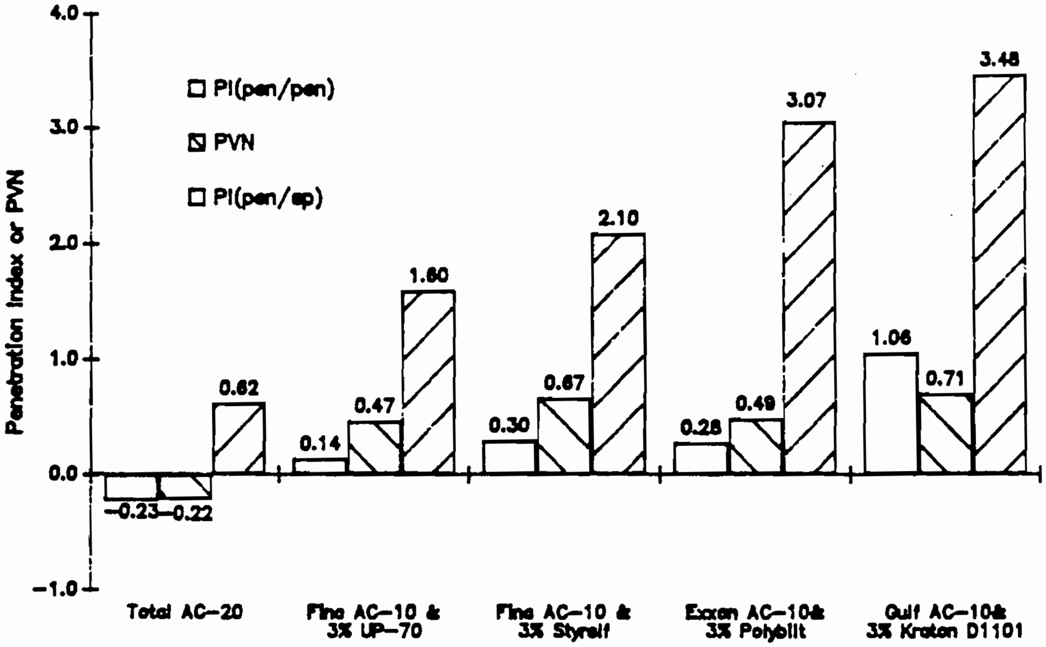


Fig. D-11 Penetration Index and PVN for Unmodified and Modified Binders. (District 10)

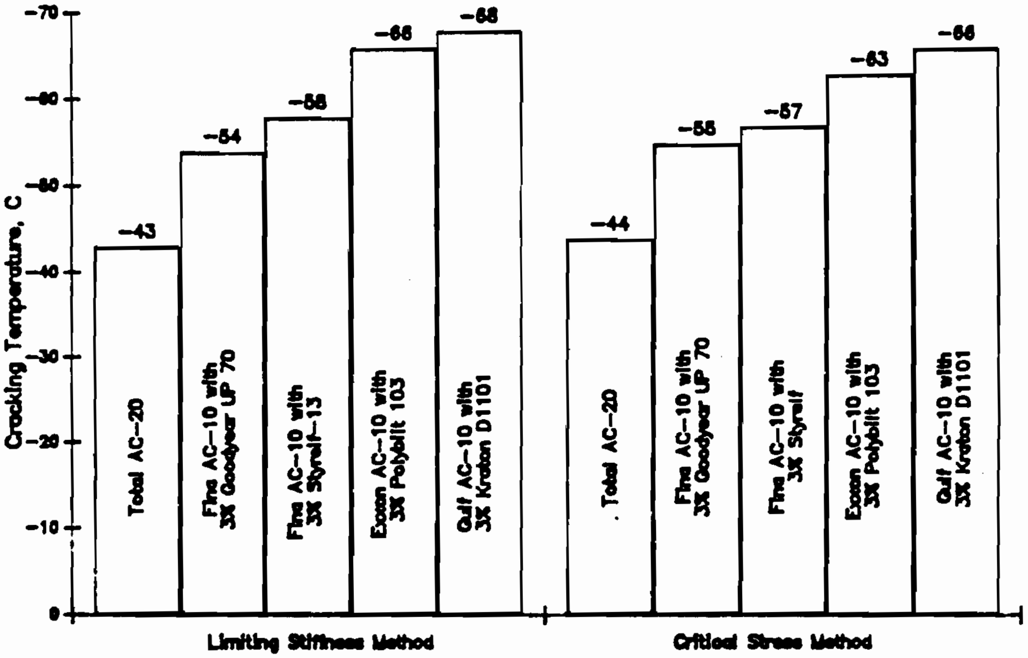


Fig. D-12 Cracking Temperature for Unmodified and Modified Binders. (District 10)

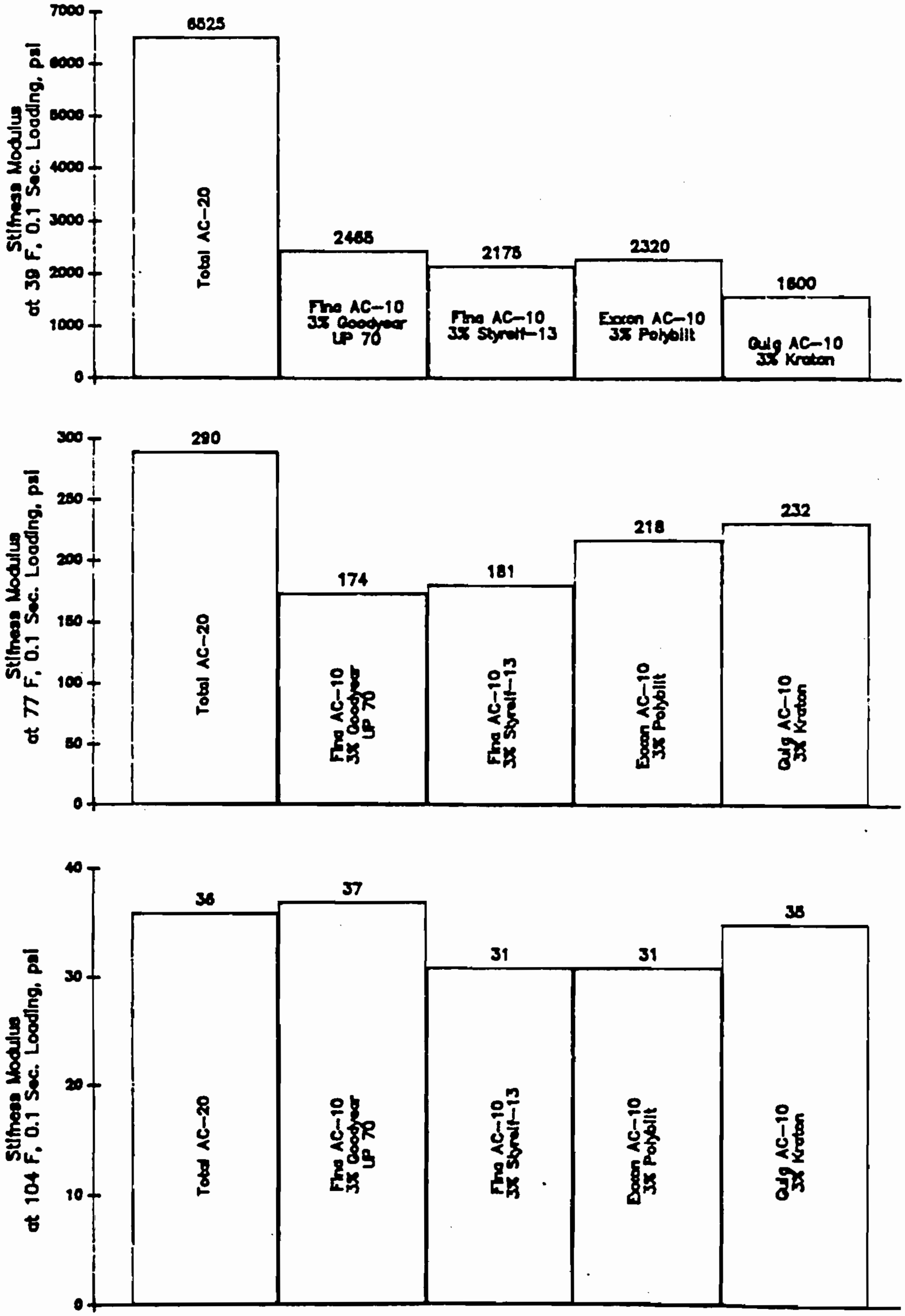


Fig. D-13 Stiffness Modulus at Different Test Temperatures for Unmodified and Modified Binders. (District 10)

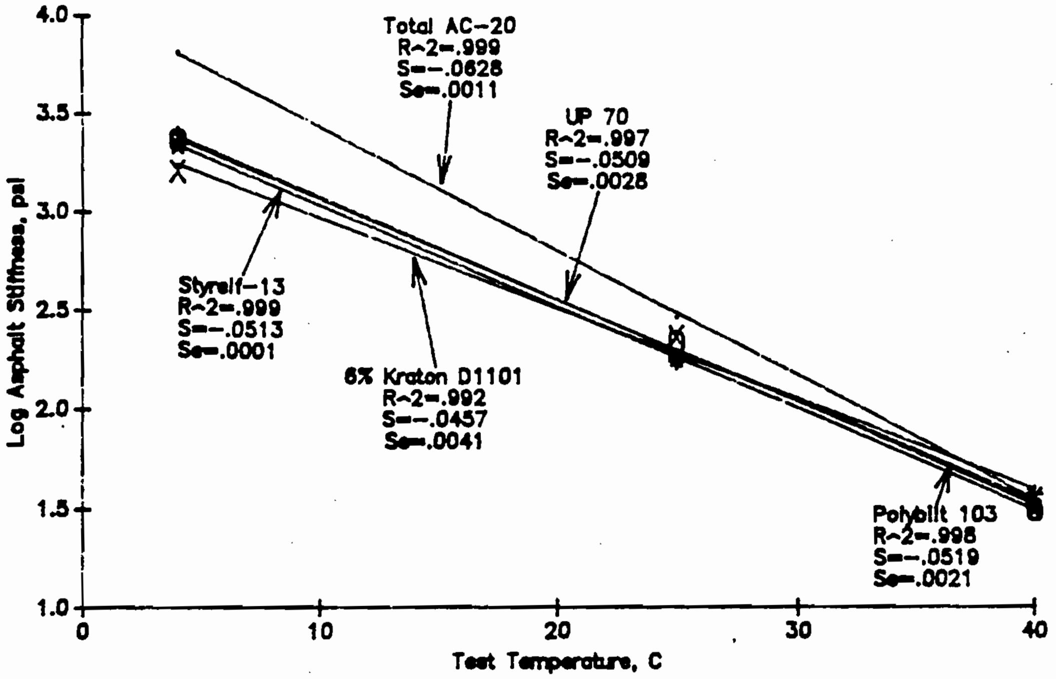


Fig. D-14 Asphalt Stiffness vs. Test Temperature for Unmodified and Modified Binders. (District 10)

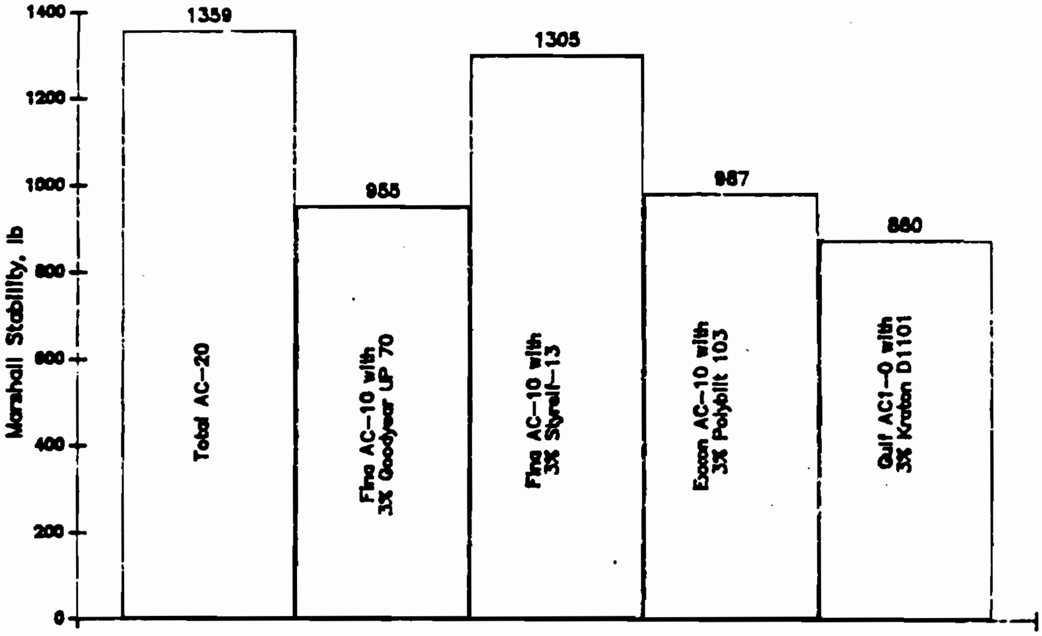


Fig. D-15 Marshall Stability for Laboratory Mixtures Using Standard Compaction.

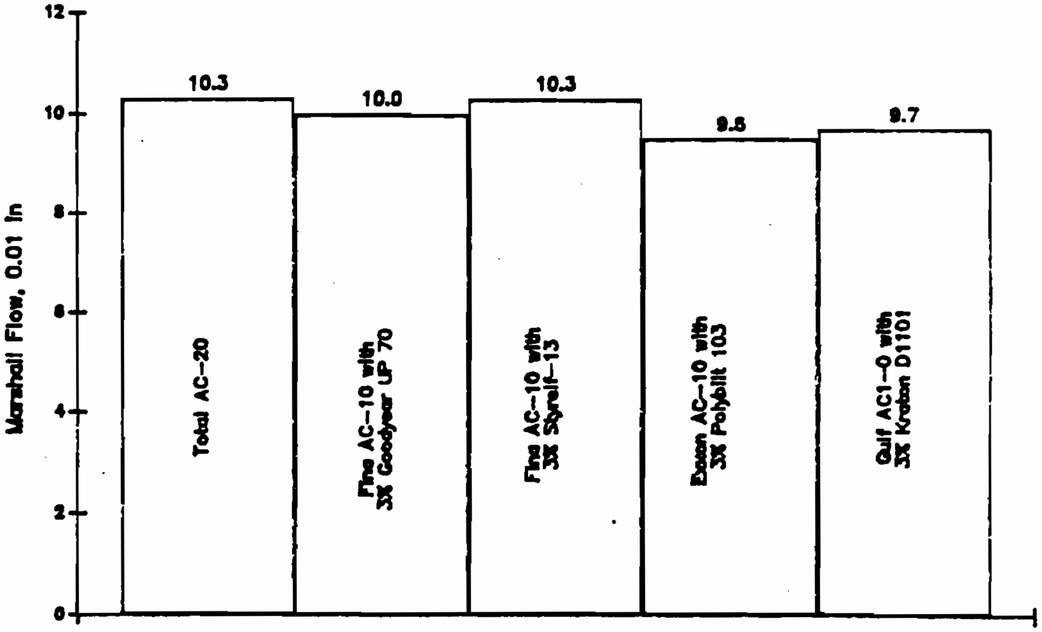


Fig. D-16 Marshall flow for Laboratory Mixtures Using Standard Compaction.

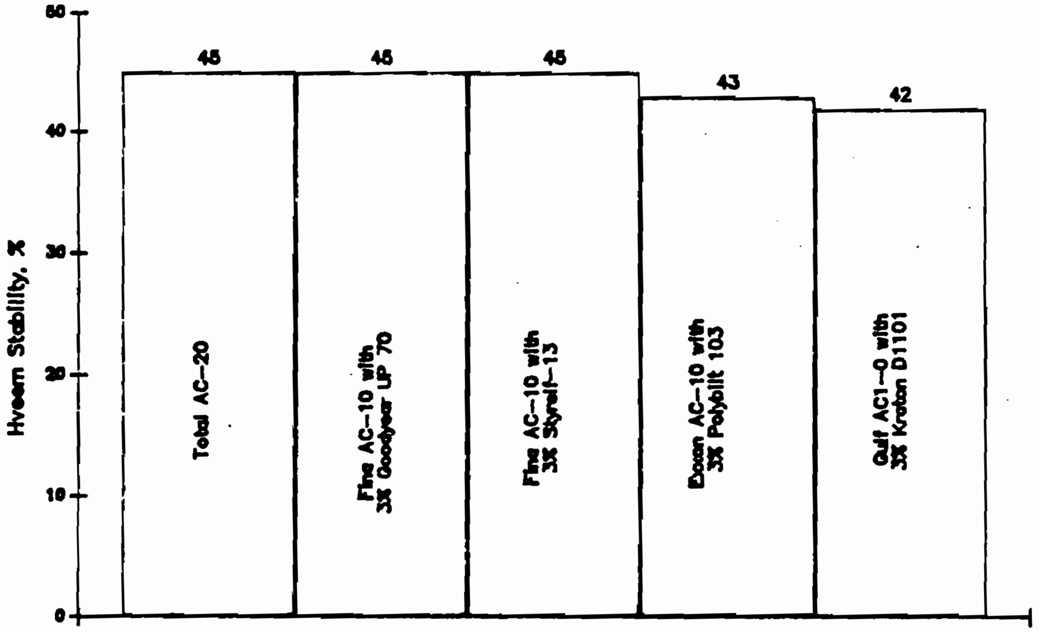


Fig. D-17 Hveem Stability for Laboratory Mixtures Using Standard Compaction.

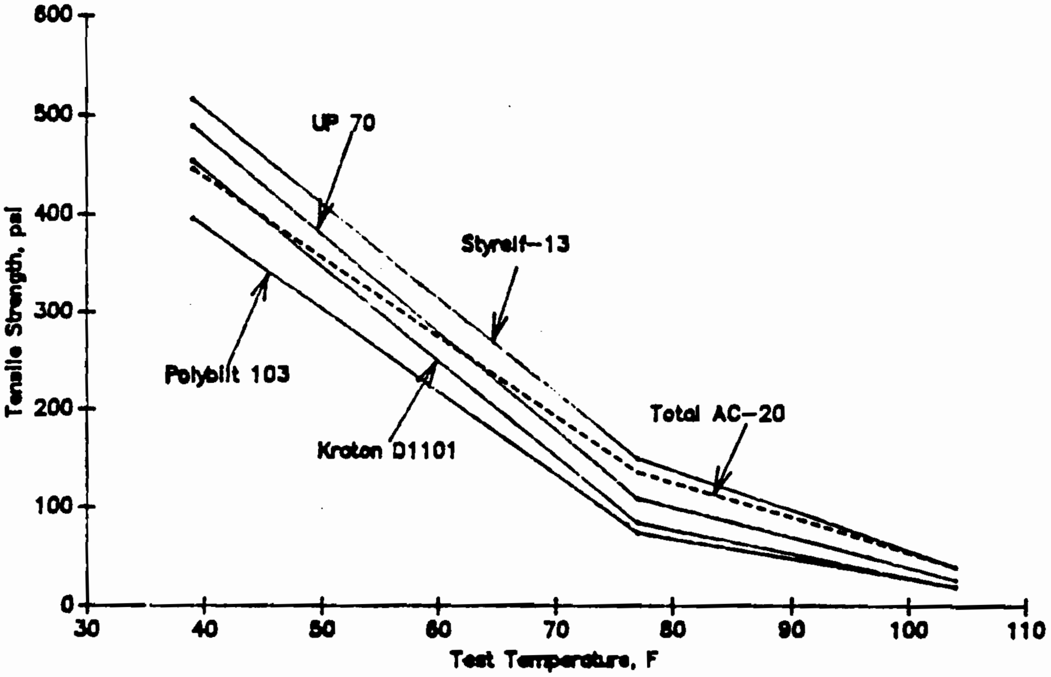


Fig. D-18 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

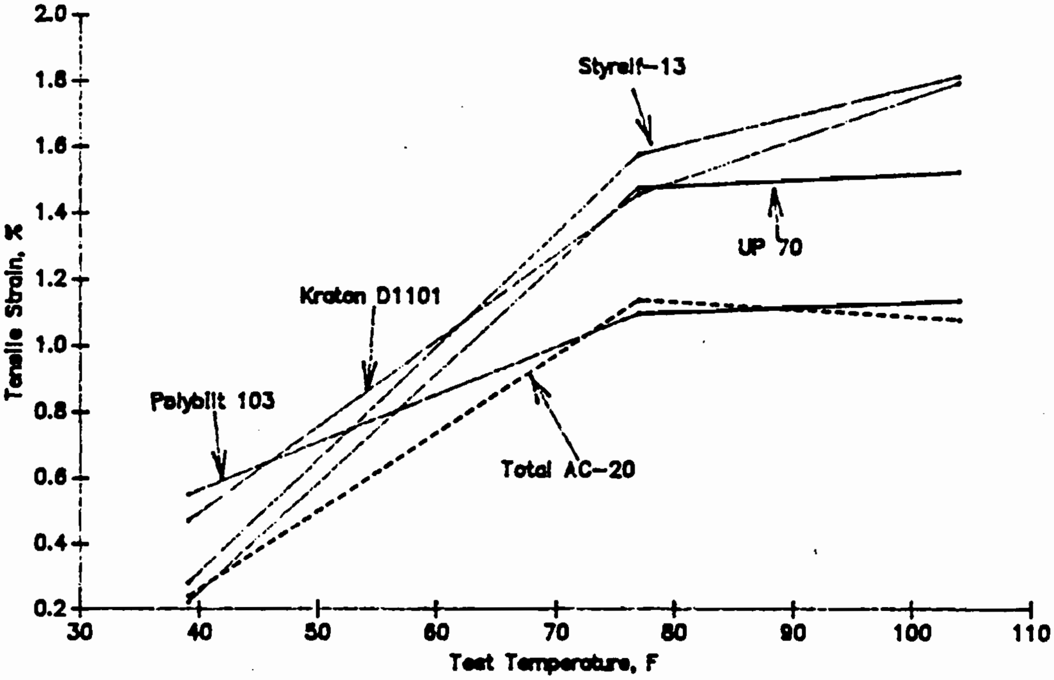


Fig. D-19 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

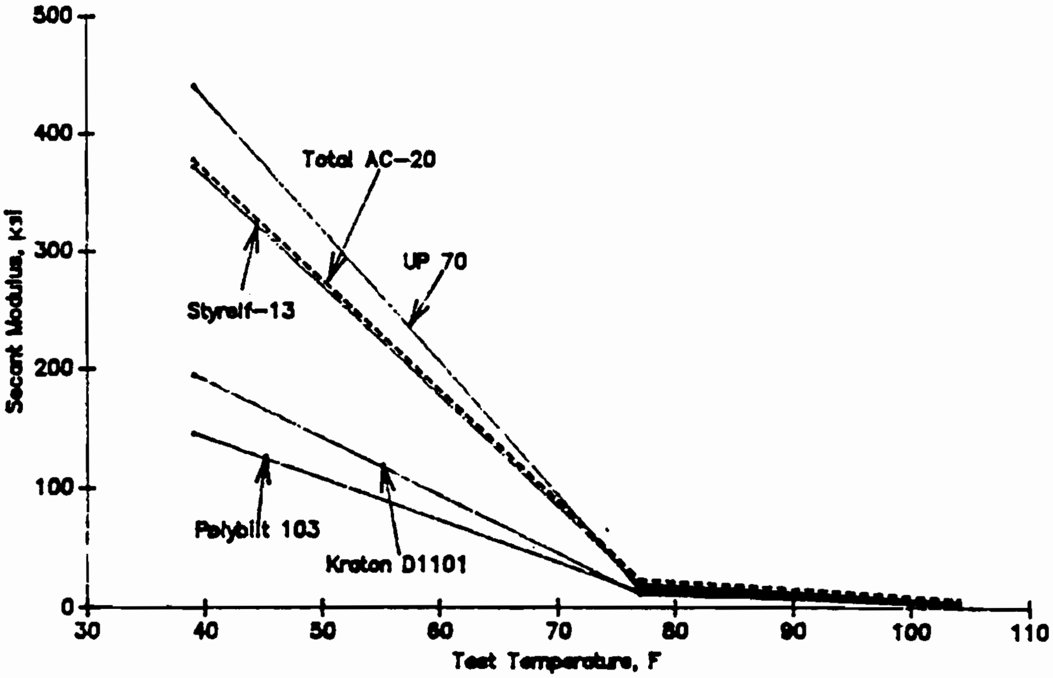


Fig. D-20 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

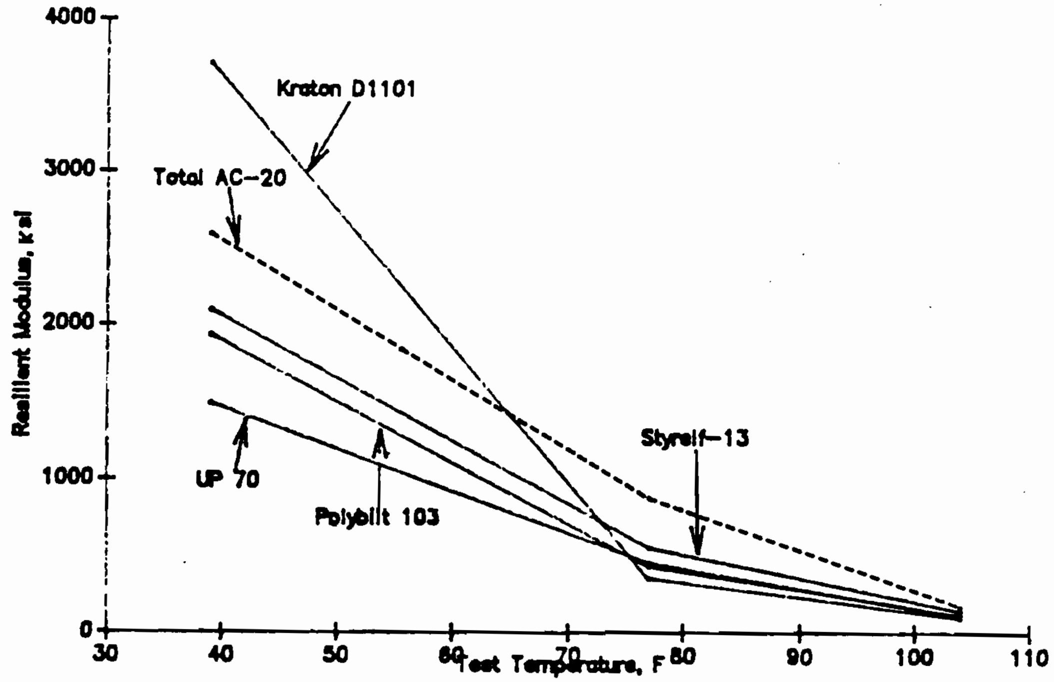


Fig. D-21 Resilient Modulus vs, Test Temperature for Laboratory Mixtures Using Standard Compaction.

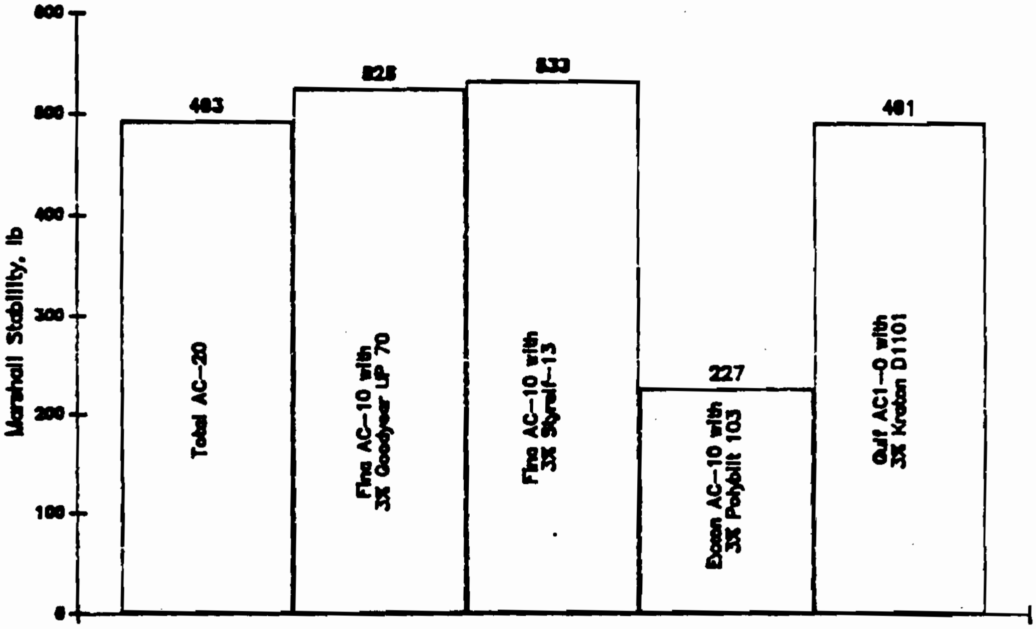


Fig. D-22 Marshall Stability for Laboratory Mixtures Using Modified Compaction.

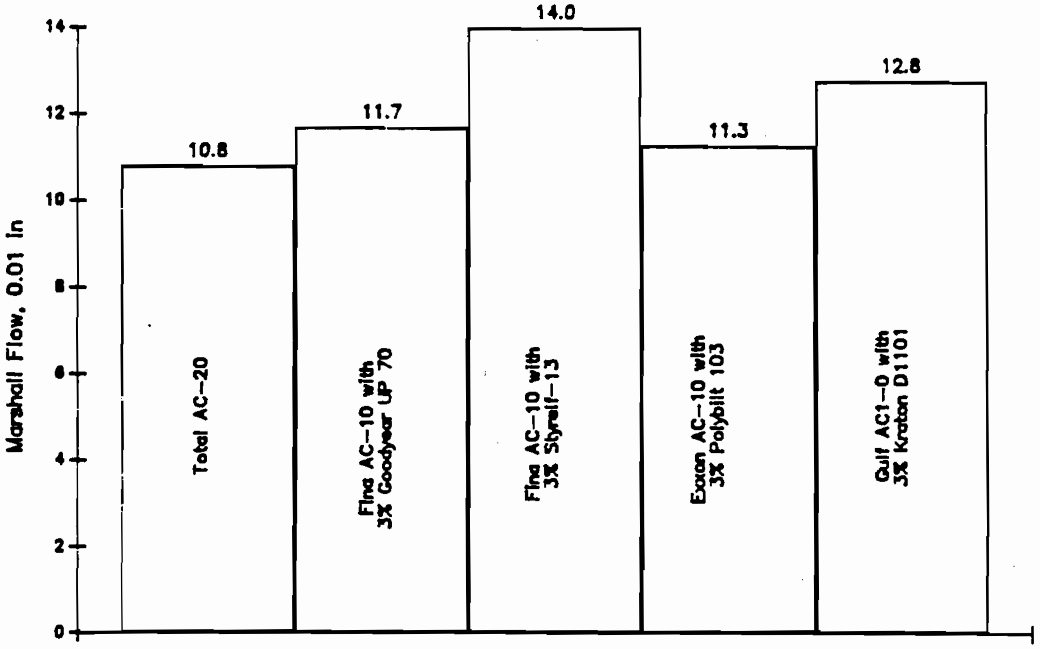


Fig. D-23 Marshall Flow for Laboratory Mixtures Using Modified Compaction.

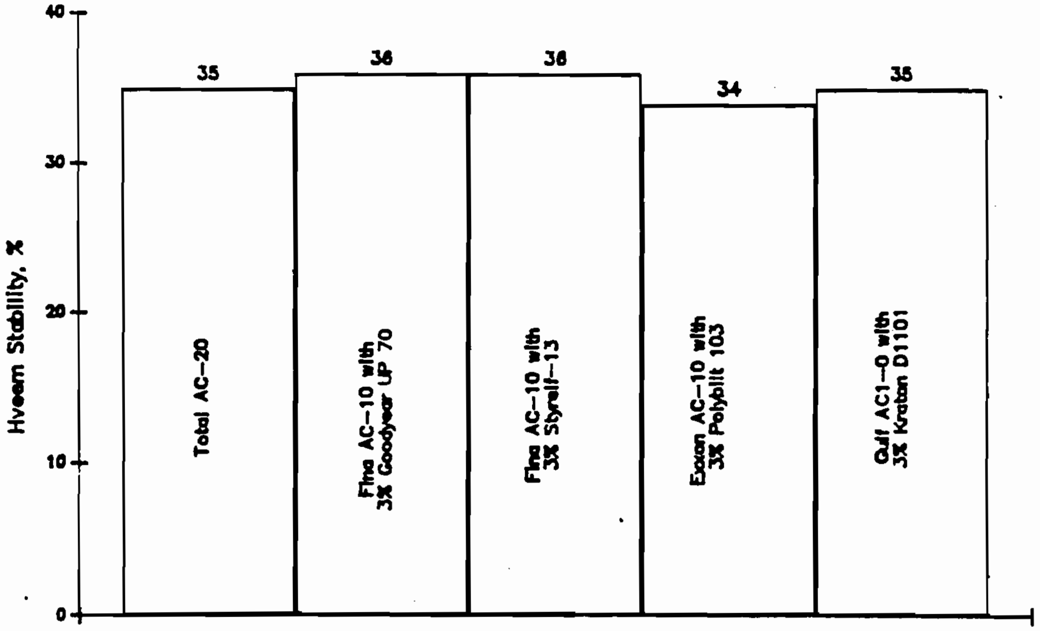


Fig. D-24 Hveem Stability for Laboratory Mixtures Using Modified Compaction.

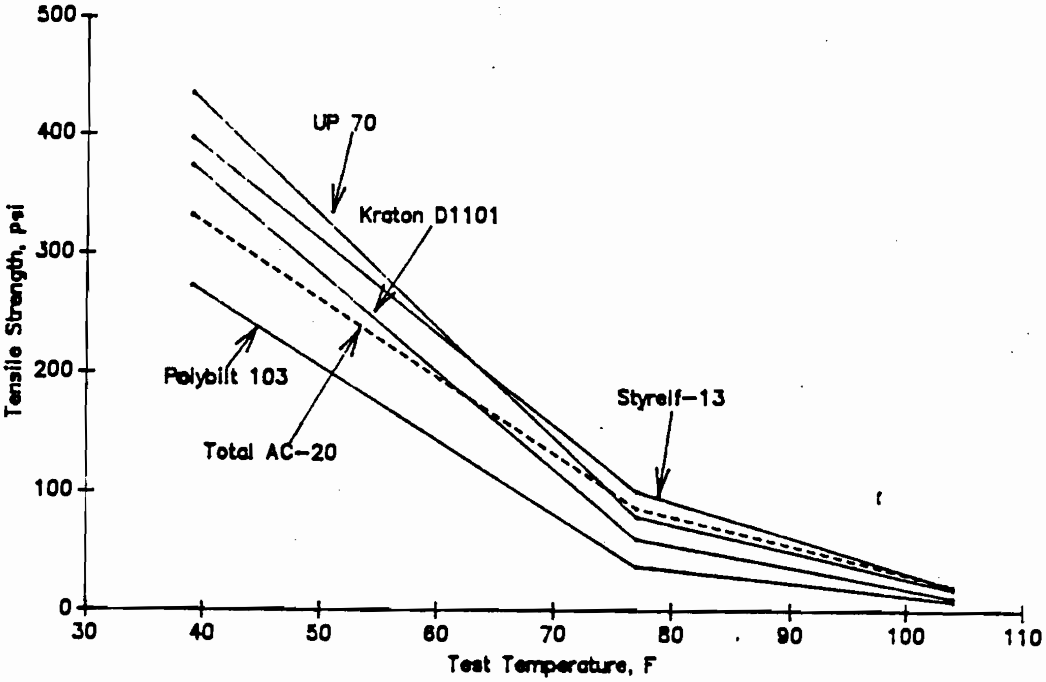


Fig. D-25 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

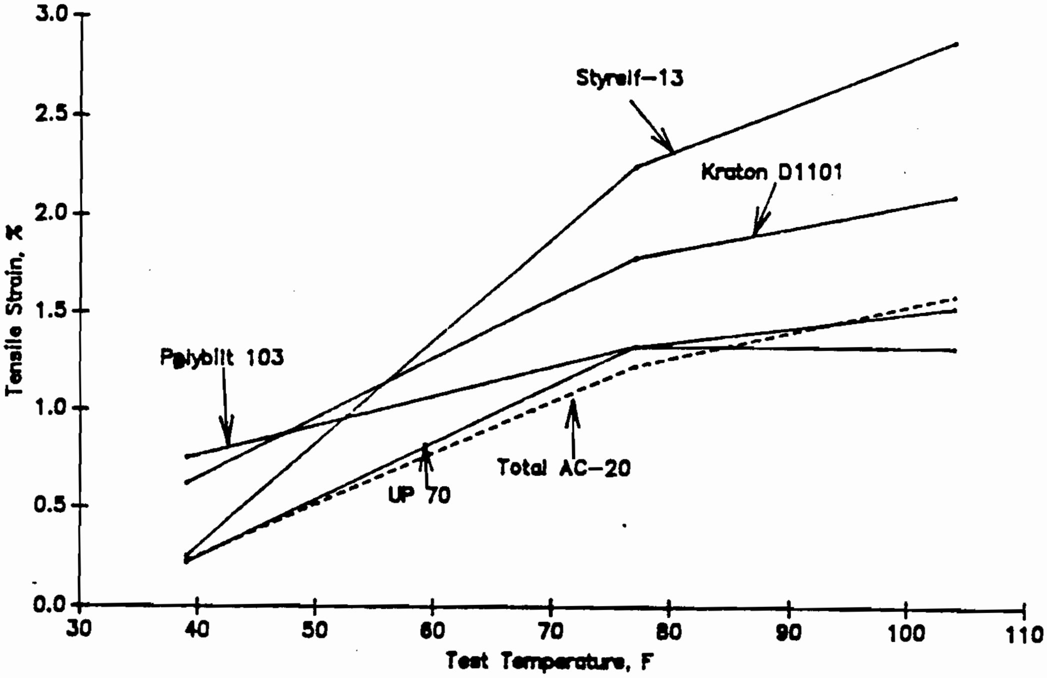


Fig. D-26 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

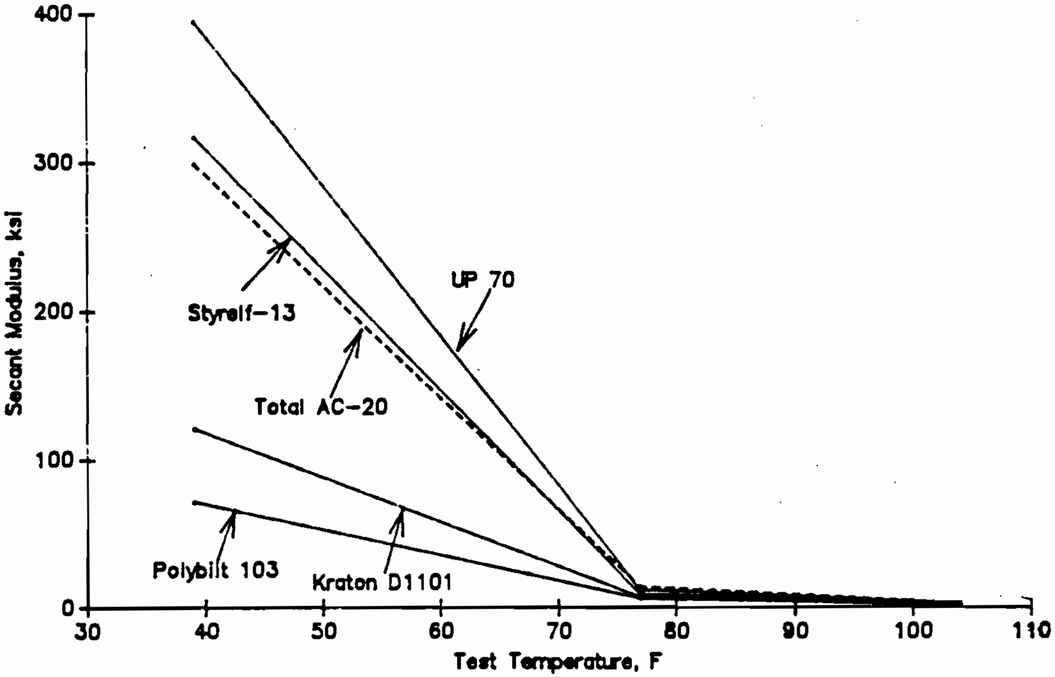


Fig. D-27 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

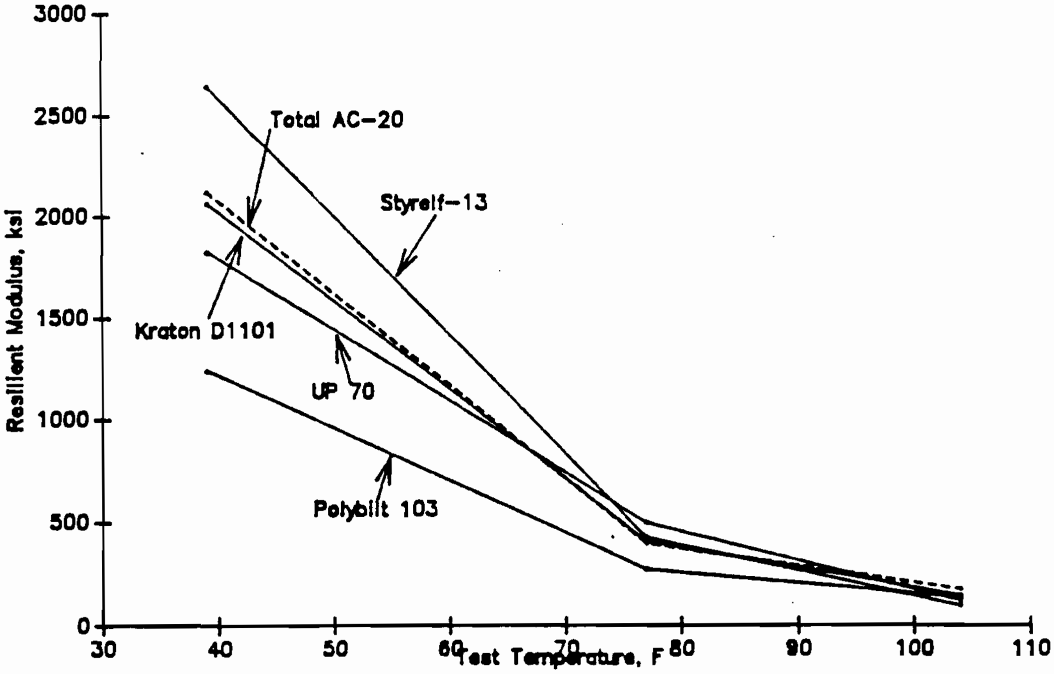


Fig. D-28 Resilient Modulus vs. Test Temperatures for Laboratory Mixtures Using Modified Compaction.

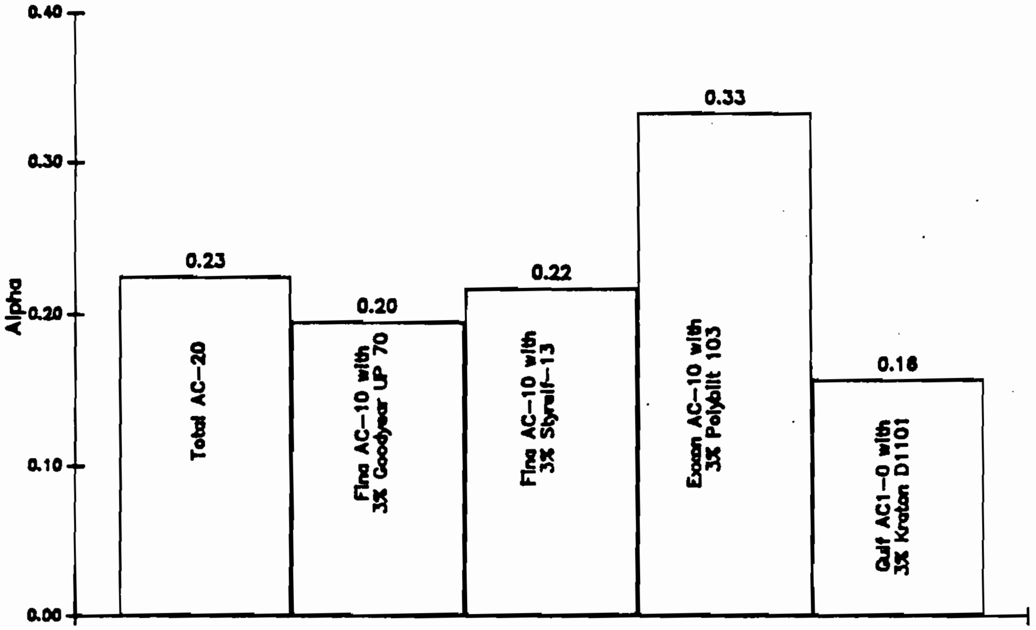


Fig. D-29 Alpha Values for Laboratory Mixtures Using Modified Compaction.

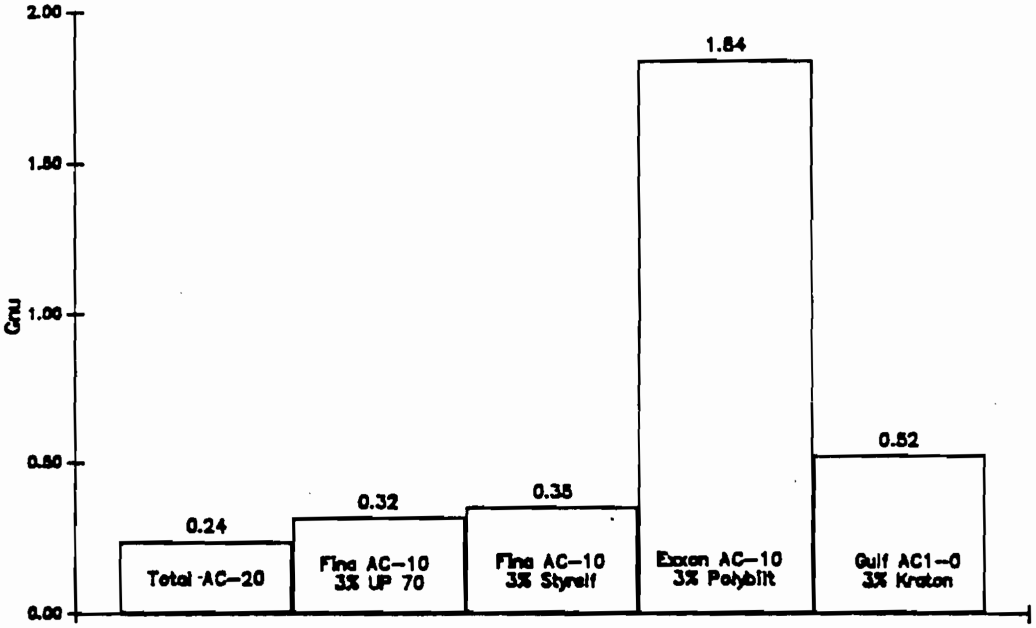


Fig. D-30 Gnu Values for Laboratory Mixtures Using Modified Compaction.

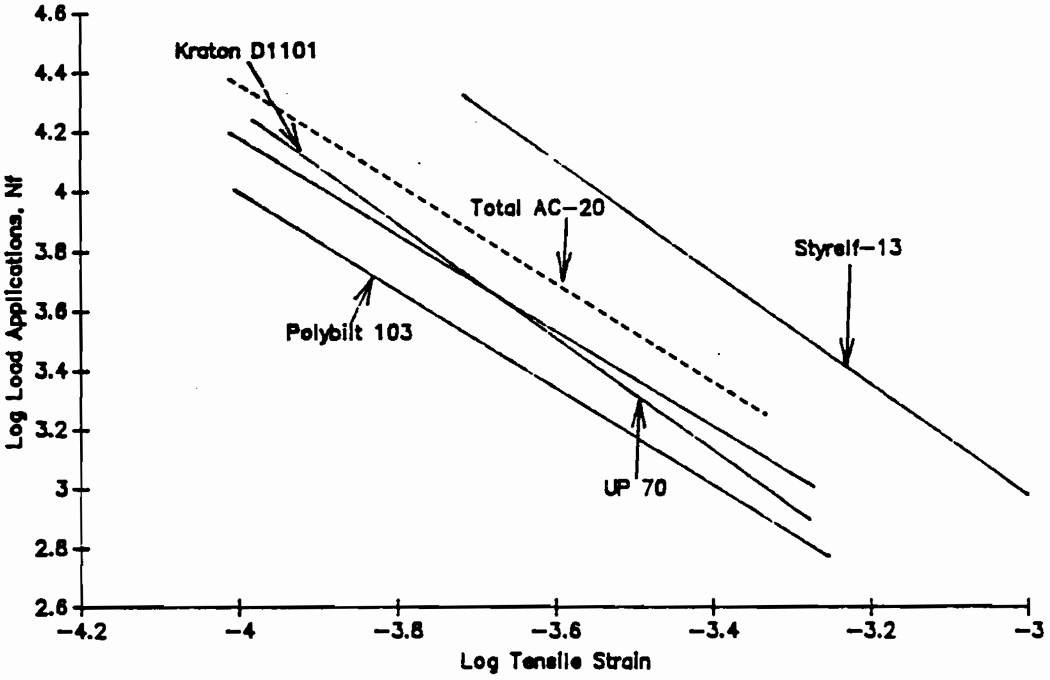


Fig. D-31 Relationship between Fatigue Life and Applied Strain for Laboratory Mixtures Using Modified Compaction.

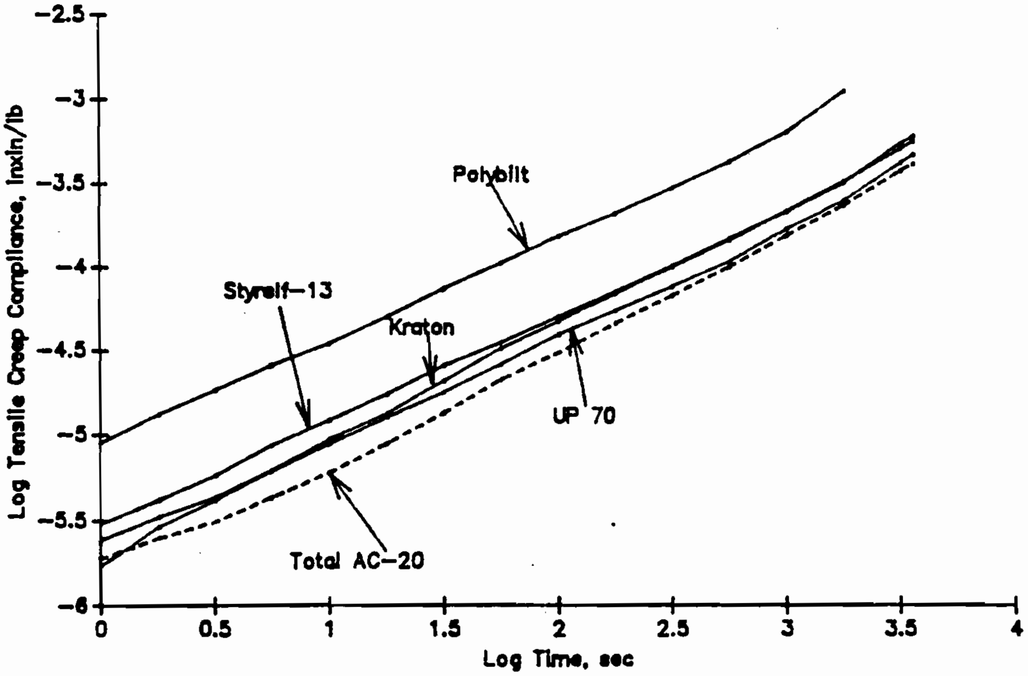


Fig. D-32 Creep Compliance Curves at 60F for Laboratory Mixtures Using Modified Compaction.

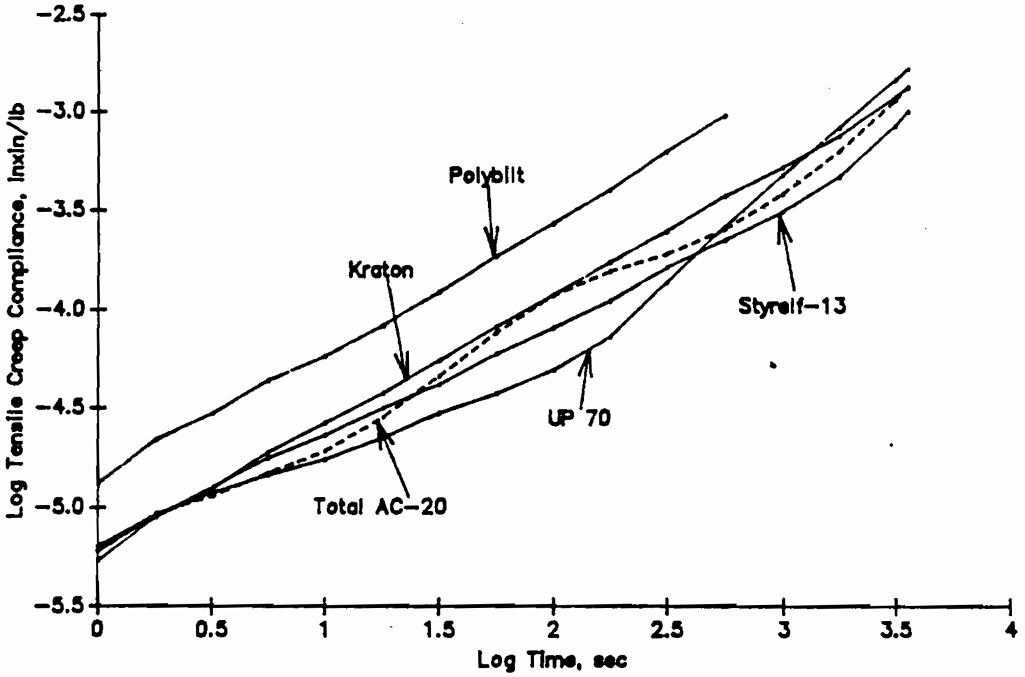


Fig. D-33 Creep Compliance Curves at 77F for Laboratory Mixtures Using Modified Compaction.

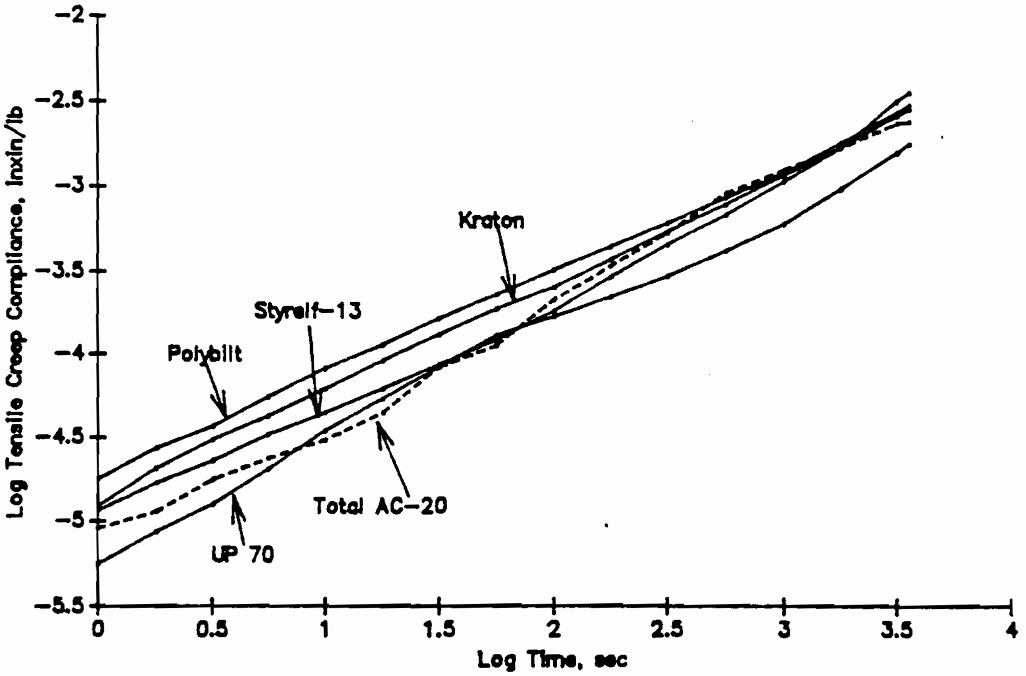


Fig. D-34 Creep Compliance Curves at 90F for Laboratory Mixtures Using Modified Compaction.

District 10 Field Test Sections
US69 – Smith County
Date Placed: July 1990

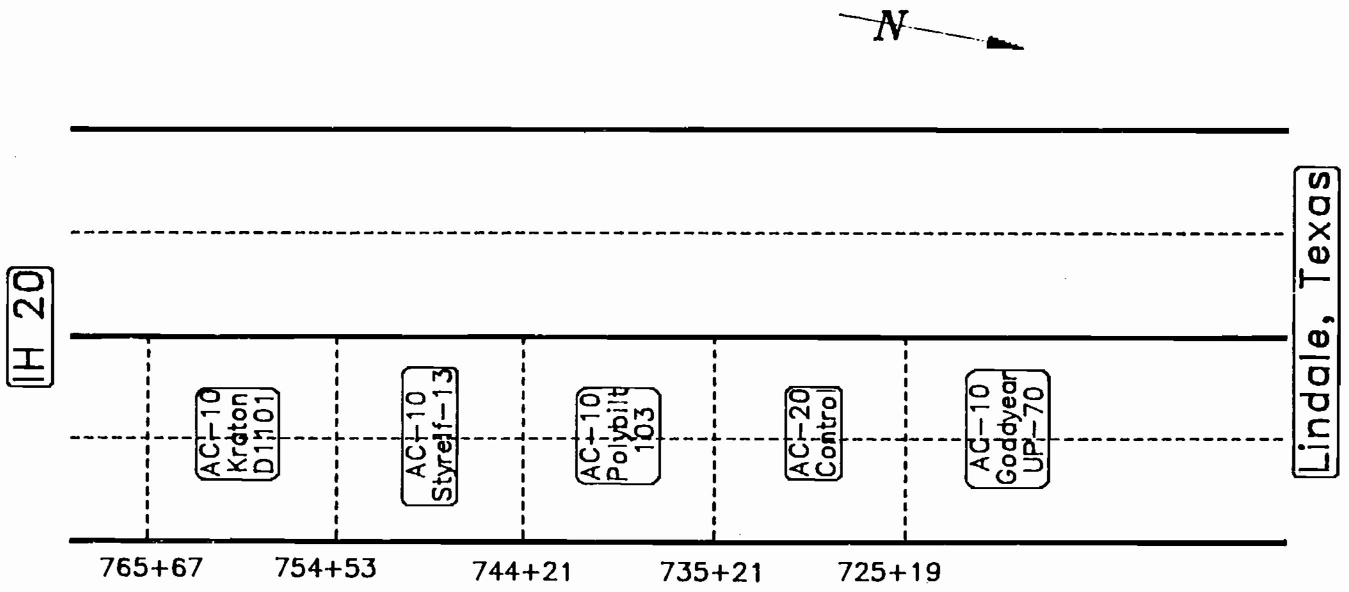


Fig. D-1 Schematic Illustration of Field Test Section.

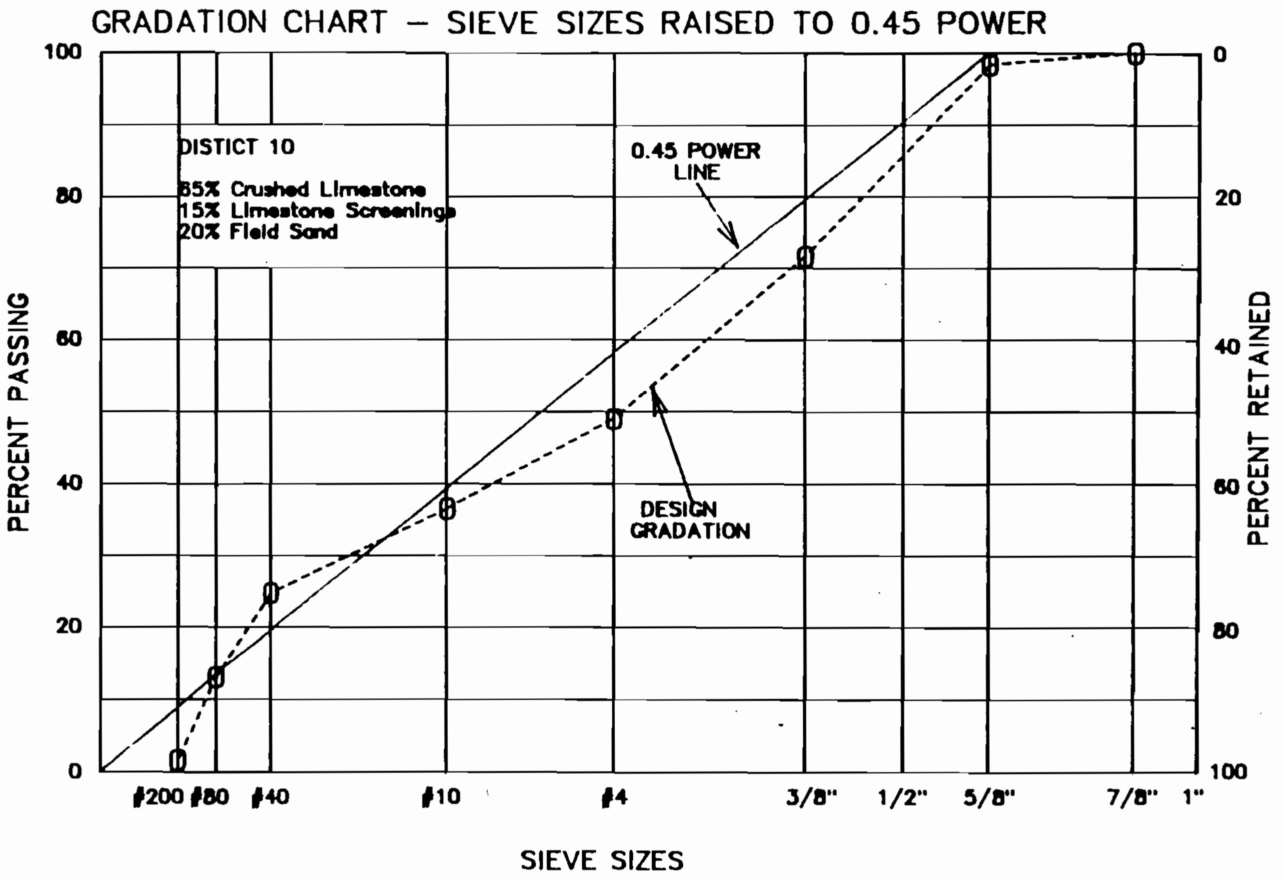


Fig. D-2 Aggregate Gradation Chart.

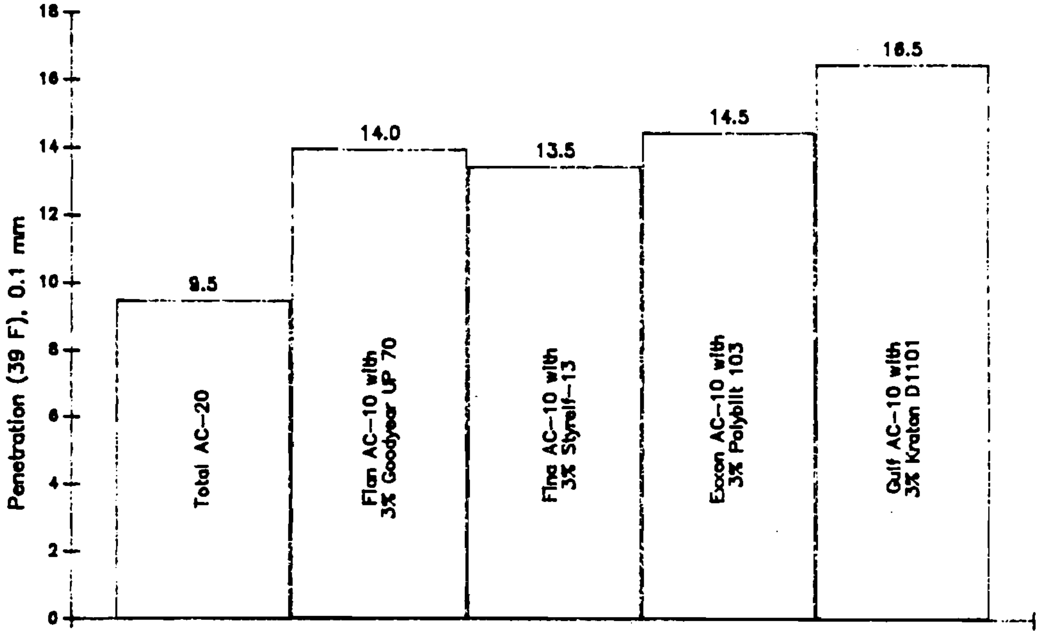


Fig. D-3 Penetration at 39F for Unmodified and Modified Binders. (District 10)

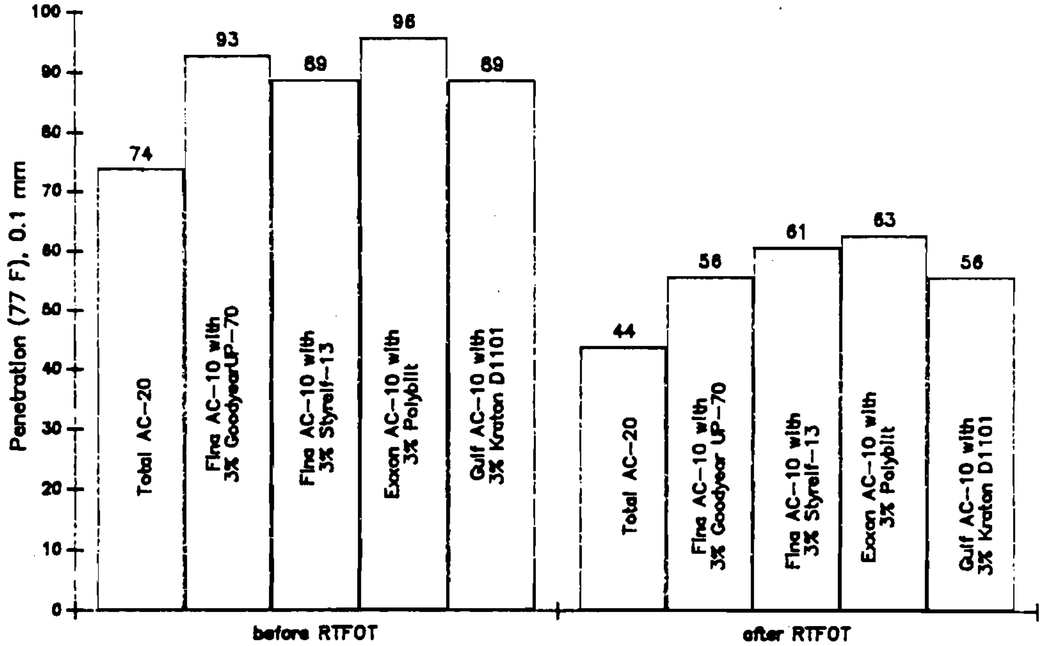


Fig. D-4 Penetration at 77F for Unmodified and Modified Binders. (District 10)

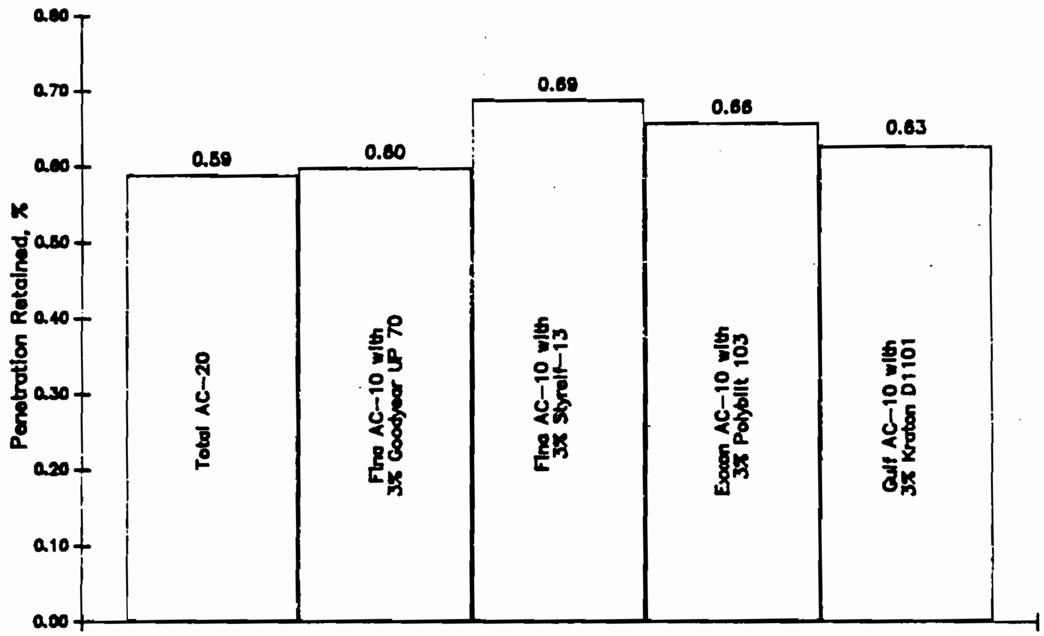


Fig. D-5 Penetration Retained at 77F for Unmodified and Modified Binders. (District 10)

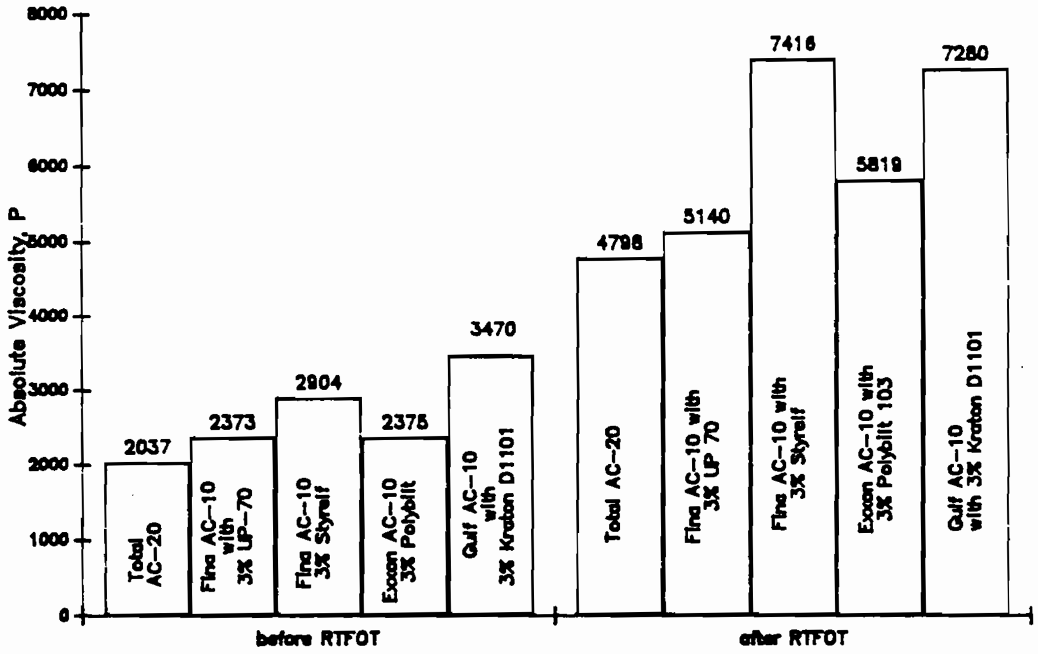


Fig. D-6 Viscosity at 140F for Unmodified and Modified Binders. (District 10)

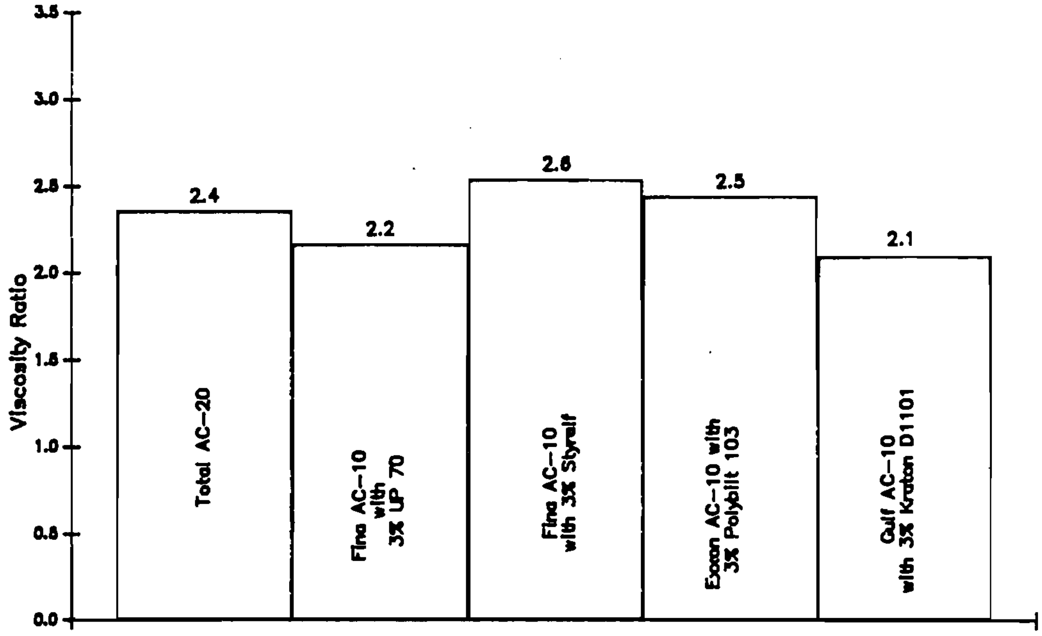


Fig. D-7 Viscosity Ratio at 140F for Unmodified and Modified Binders. (District 10)

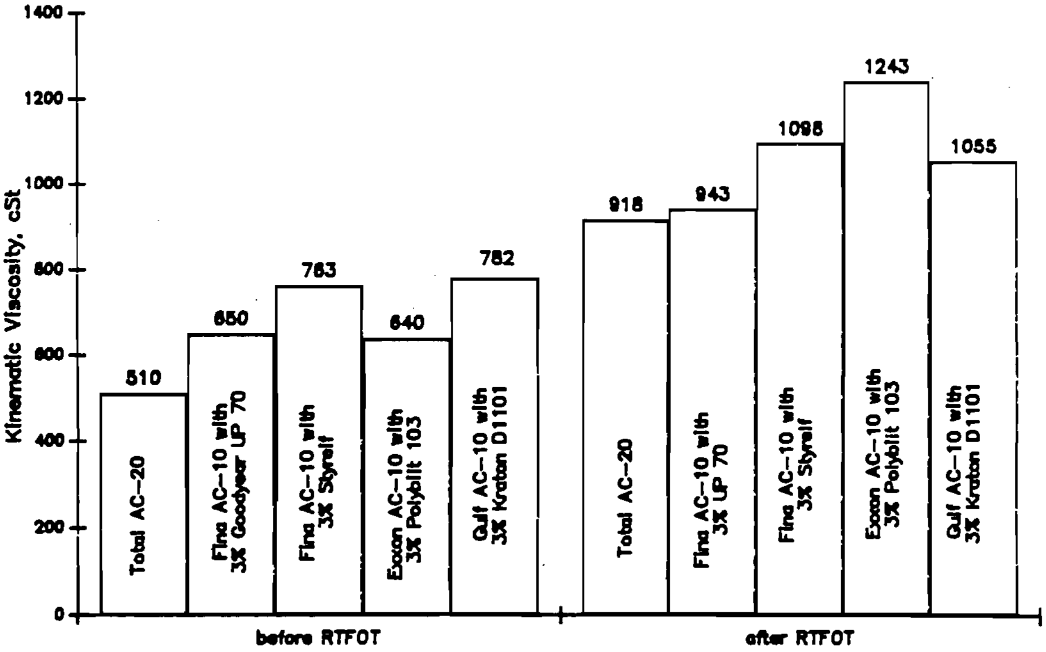


Fig. D-8 Kinematic Viscosity at 275F for Unmodified and Modified Binders. (District 10)

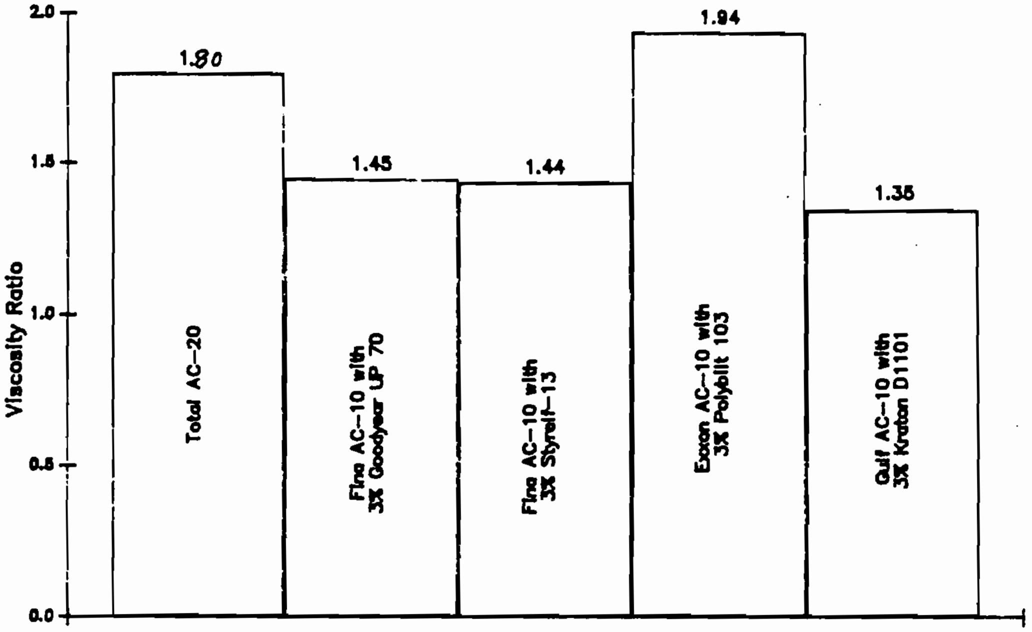


Fig. D-9 Viscosity Ratio at 275F for Unmodified and Modified Binders. (District 10)

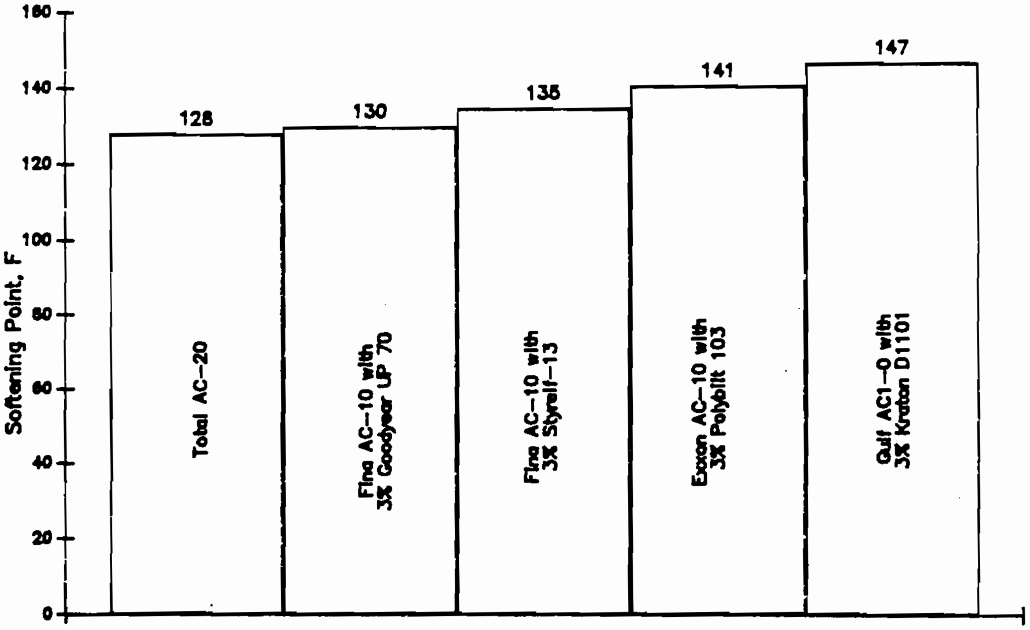


Fig. D-10 Softening point for Unmodified and Modified Binders. (District 10)

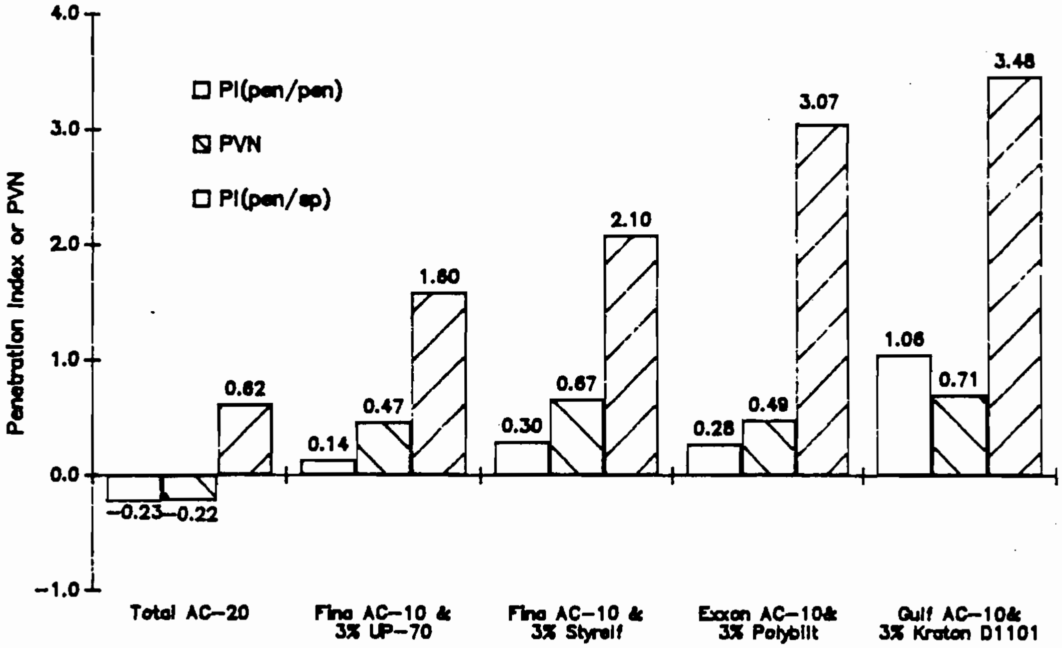


Fig. D-11 Penetration Index and PVN for Unmodified and Modified Binders. (District 10)

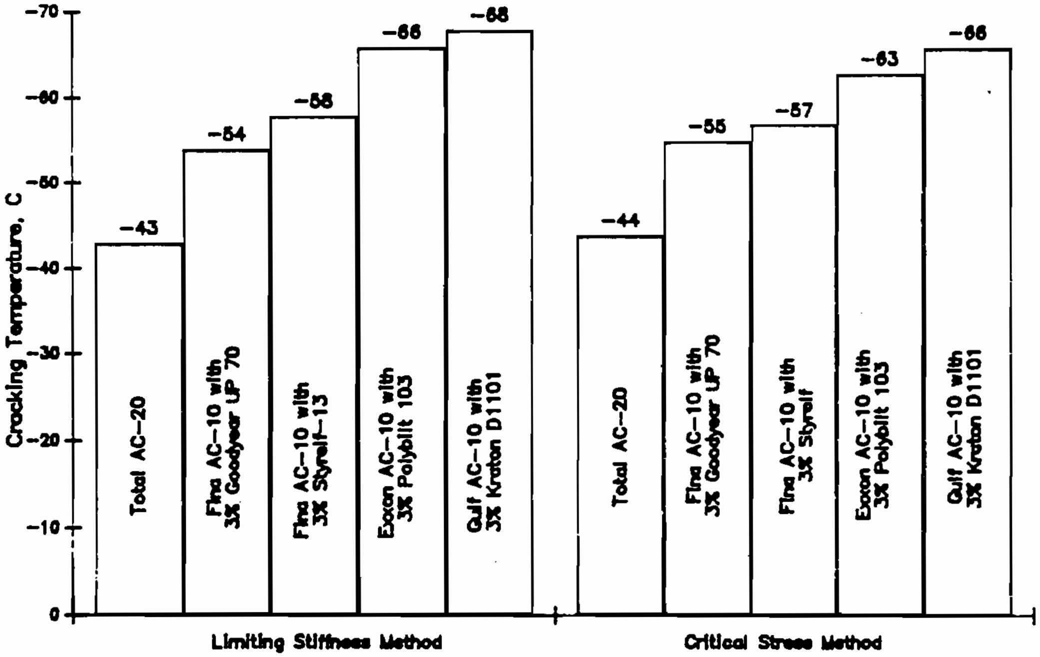


Fig. D-12 Cracking Temperature for Unmodified and Modified Binders. (District 10)

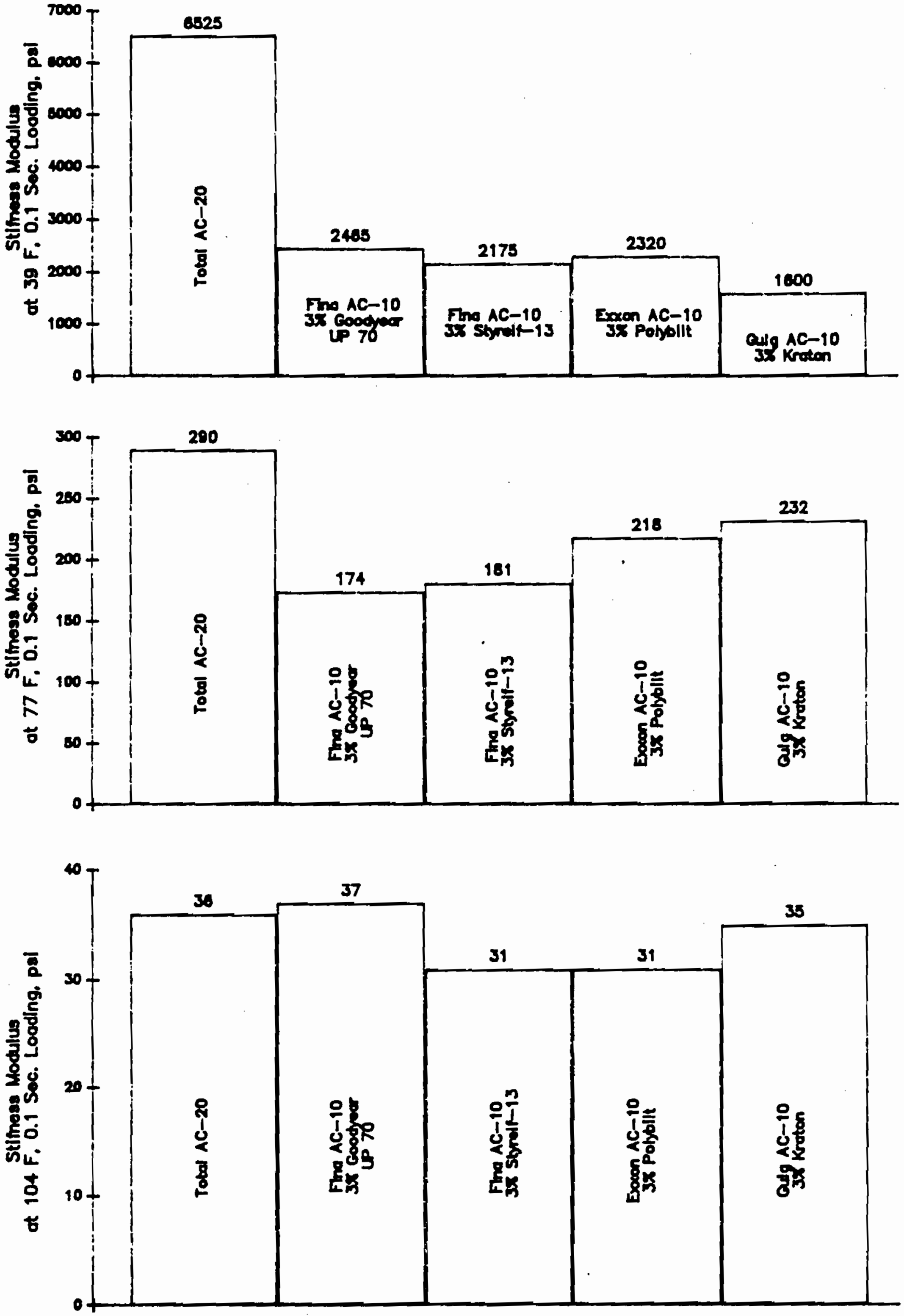


Fig. D-13 Stiffness Modulus at Different Test Temperatures for Unmodified and Modified Binders. (District 10)

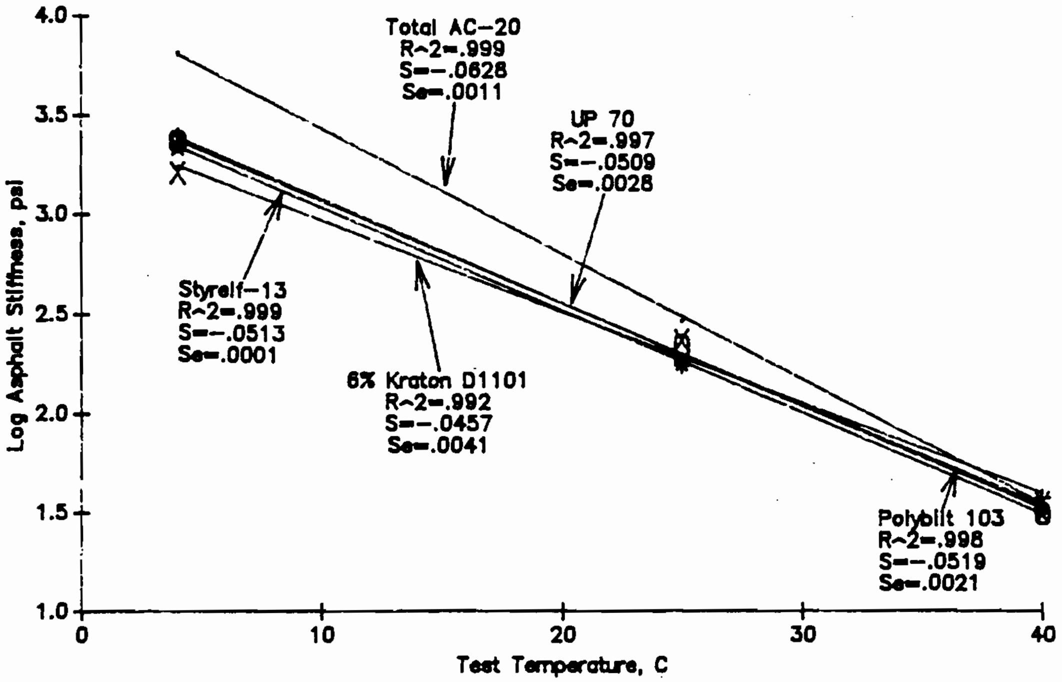


Fig. D-14 Asphalt Stiffness vs. Test Temperature for Unmodified and Modified Binders. (District 10)

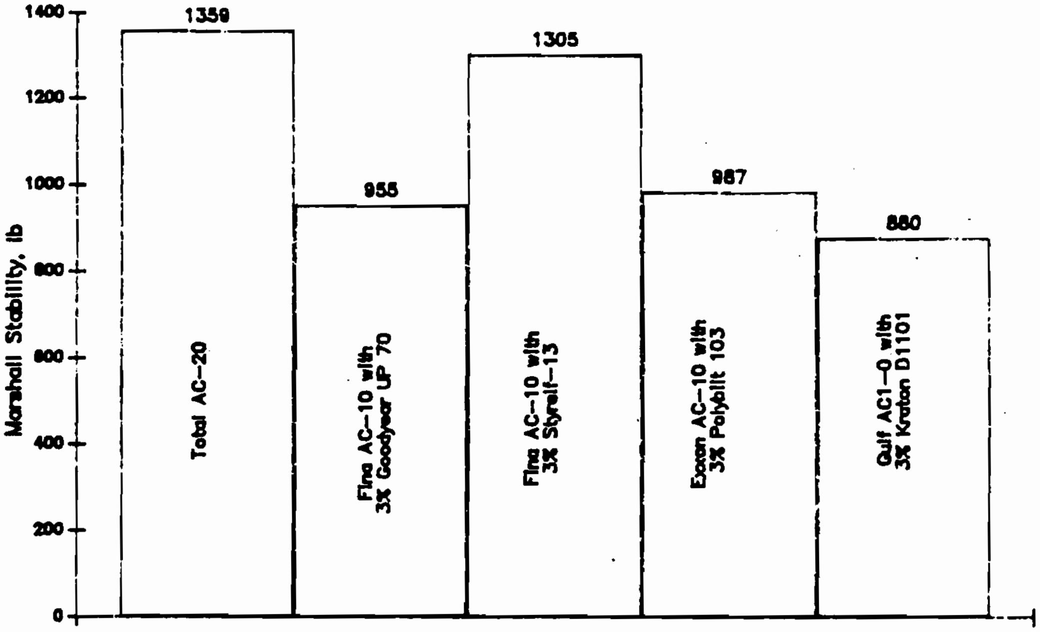


Fig. D-15 Marshall Stability for Laboratory Mixtures Using Standard Compaction.

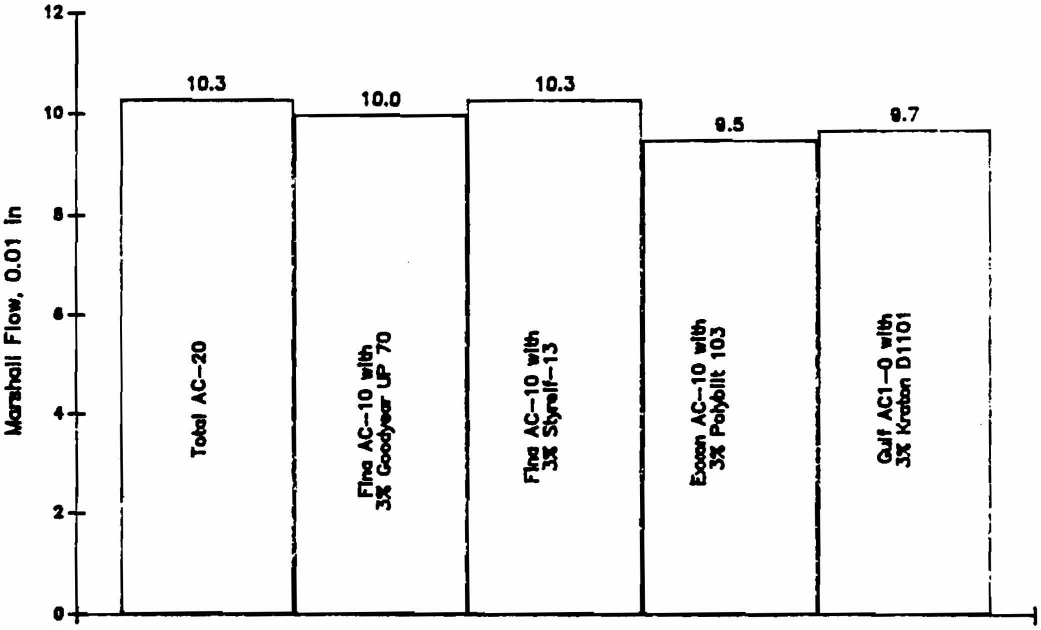


Fig. D-16 Marshall flow for Laboratory Mixtures Using Standard Compaction.

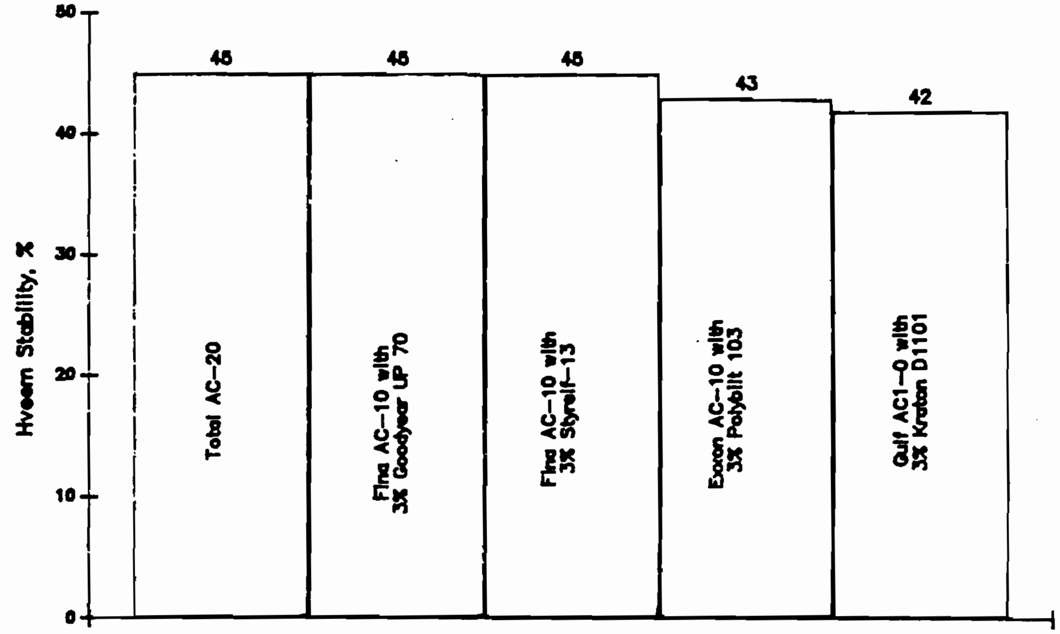


Fig. D-17 Hveem Stability for Laboratory Mixtures Using Standard Compaction.

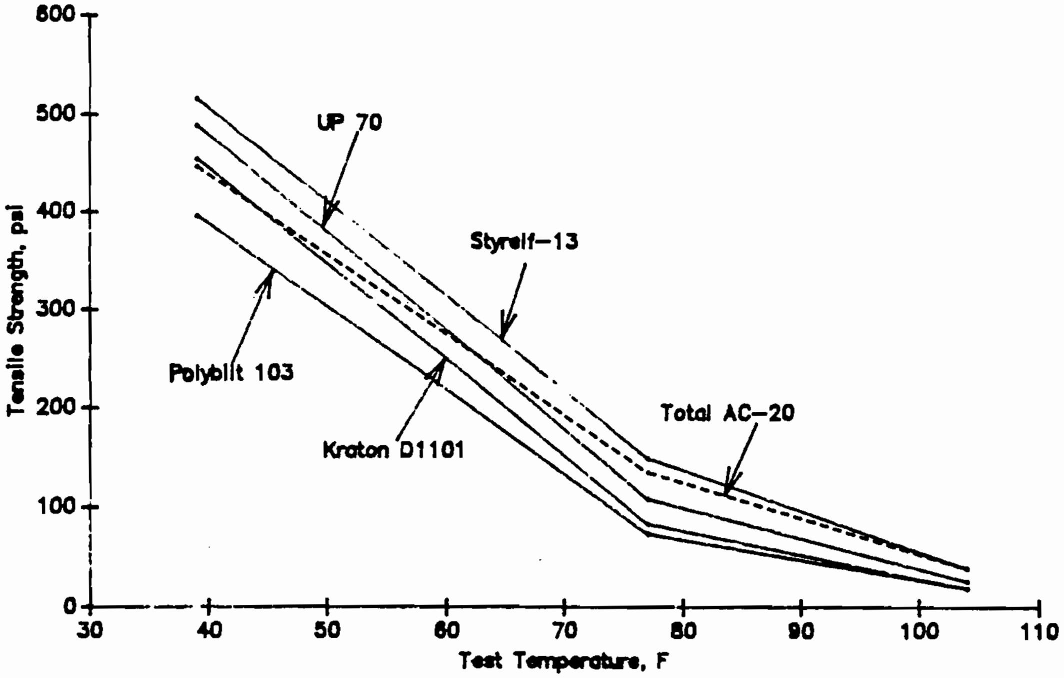


Fig. D-18 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

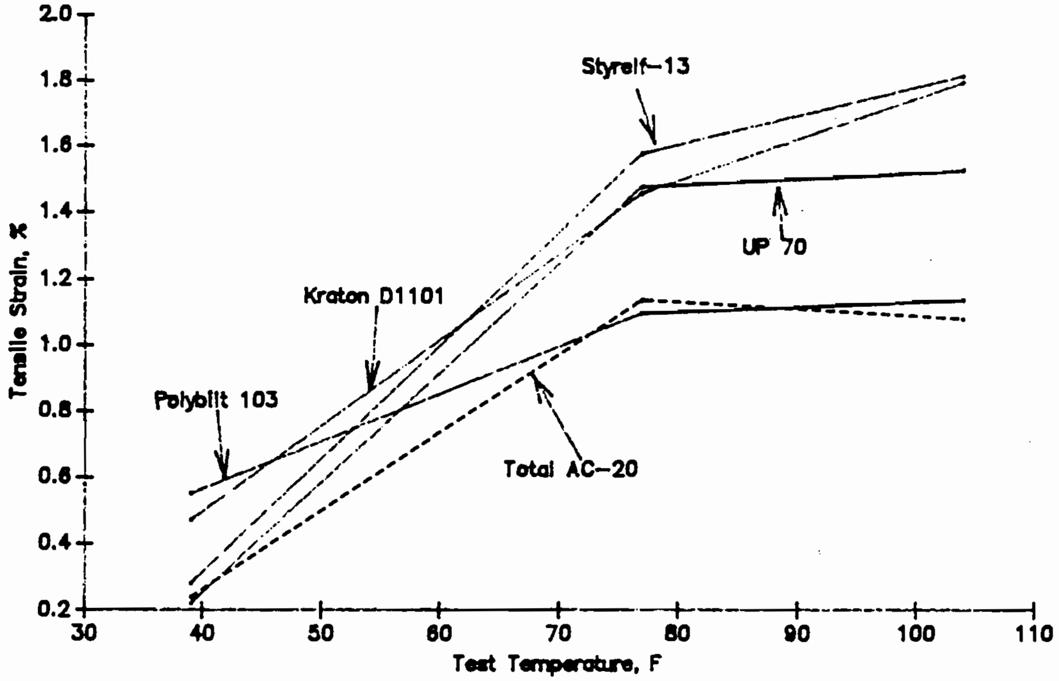


Fig. D-19 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

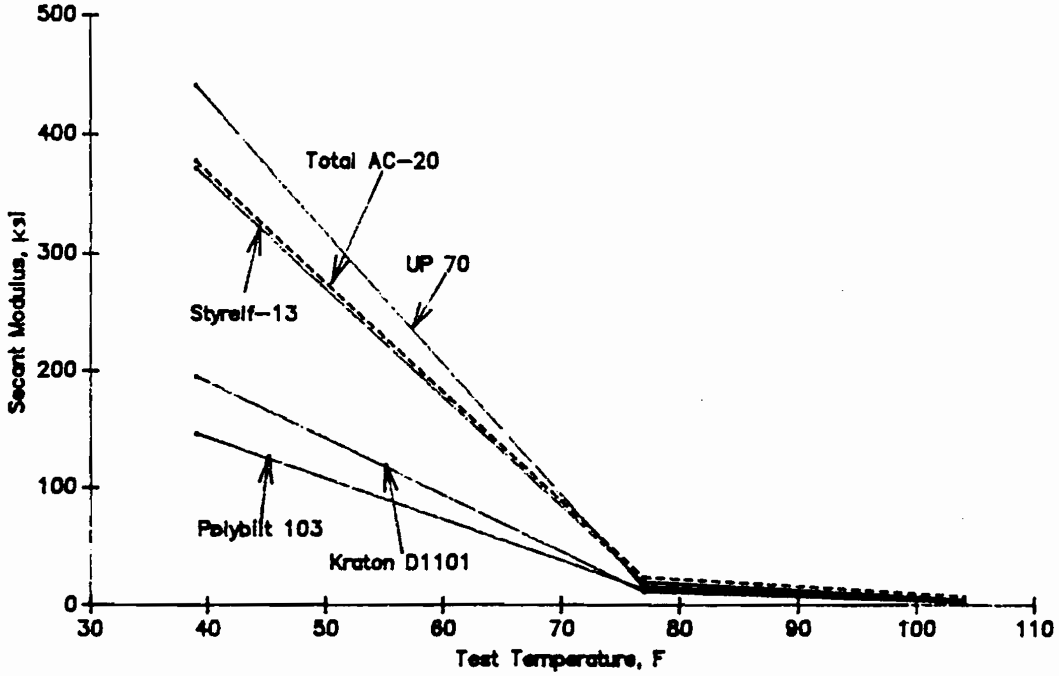


Fig. D-20 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Standard Compaction.

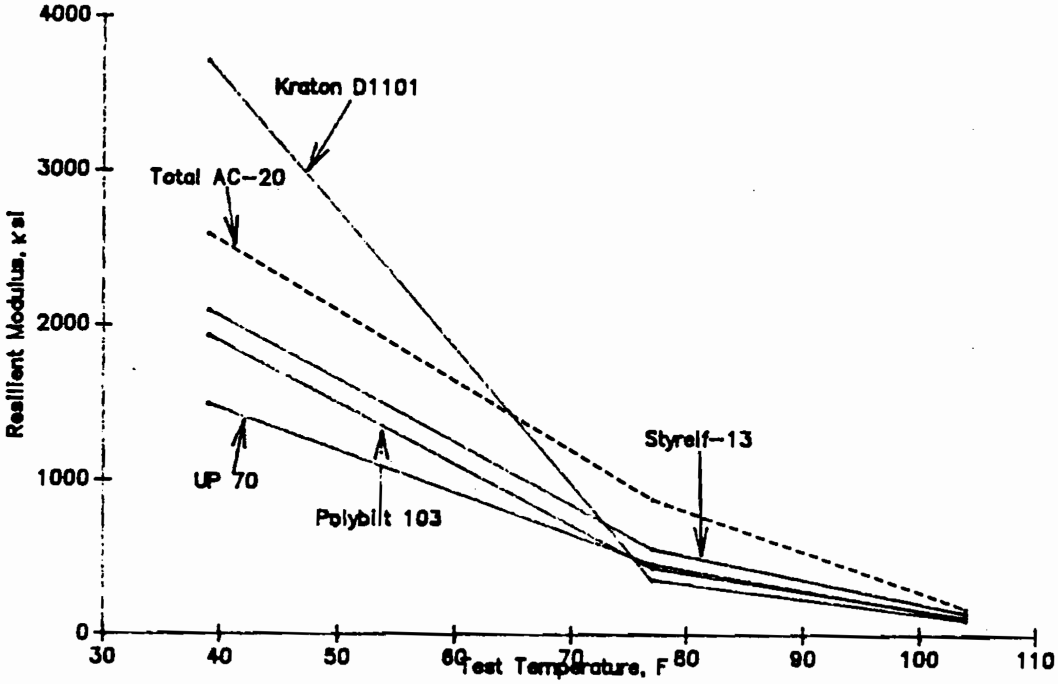


Fig. D-21 Resilient Modulus vs, Test Temperature for Laboratory Mixtures Using Standard Compaction.

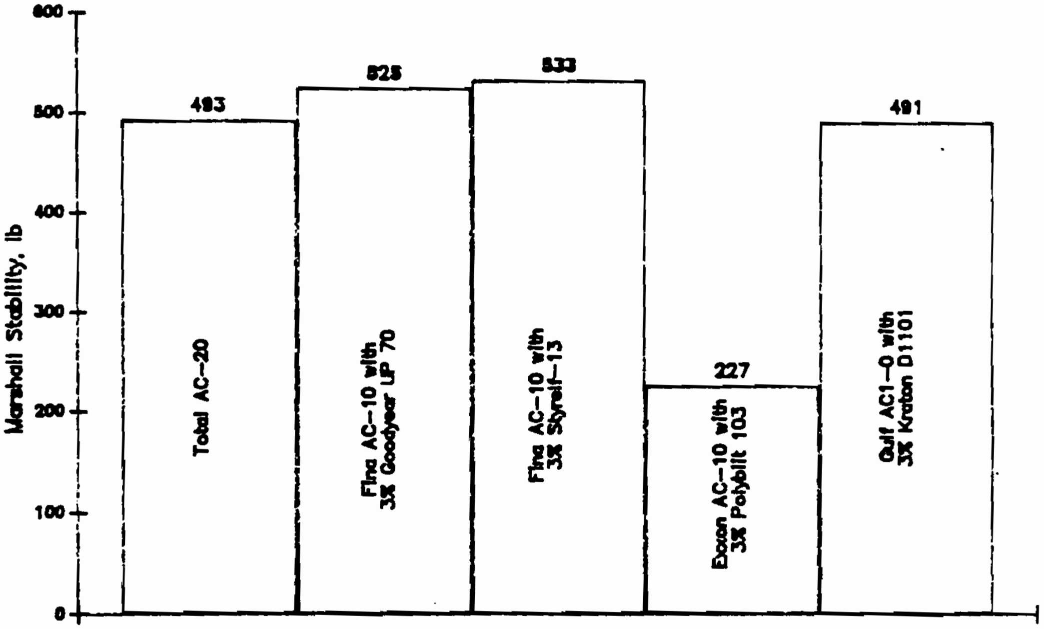


Fig. D-22 Marshall Stability for Laboratory Mixtures Using Modified Compaction.

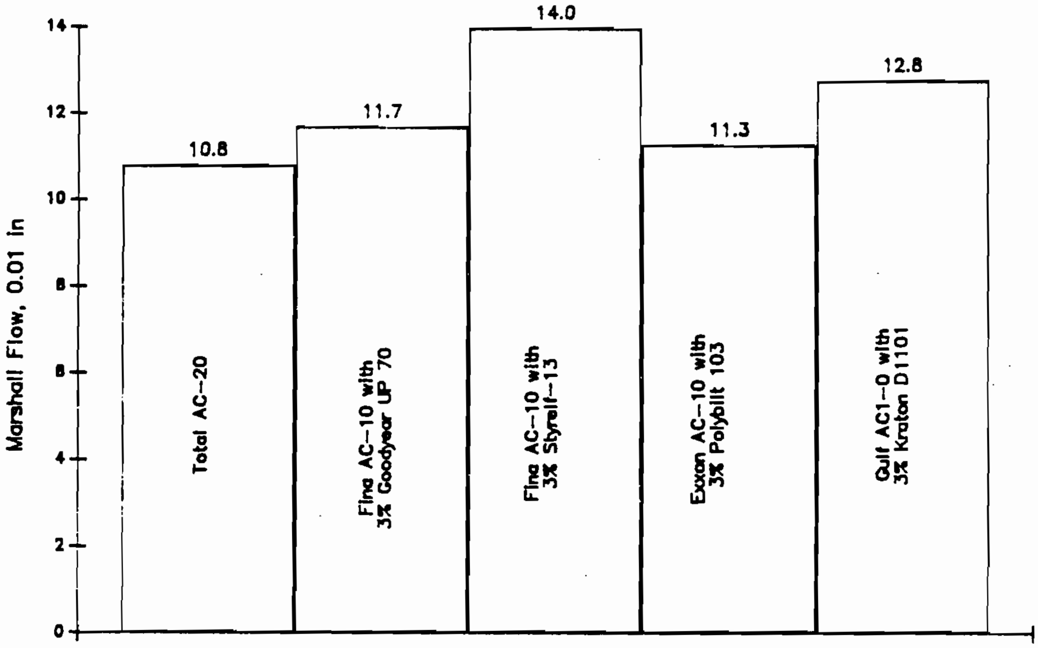


Fig. D-23 Marshall Flow for Laboratory Mixtures Using Modified Compaction.

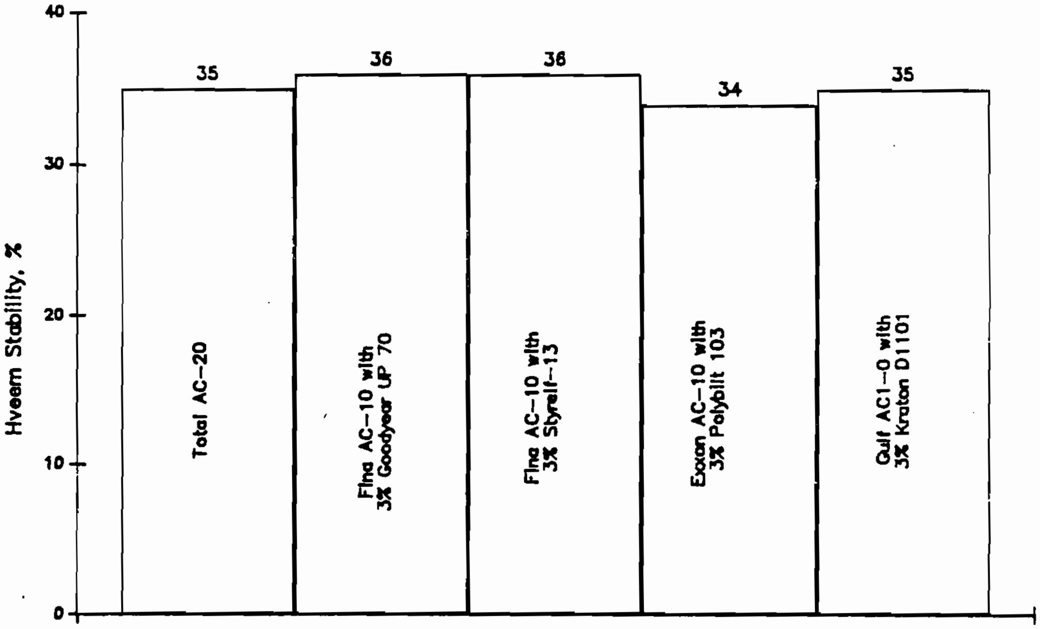


Fig. D-24 Hveem Stability for Laboratory Mixtures Using Modified Compaction.

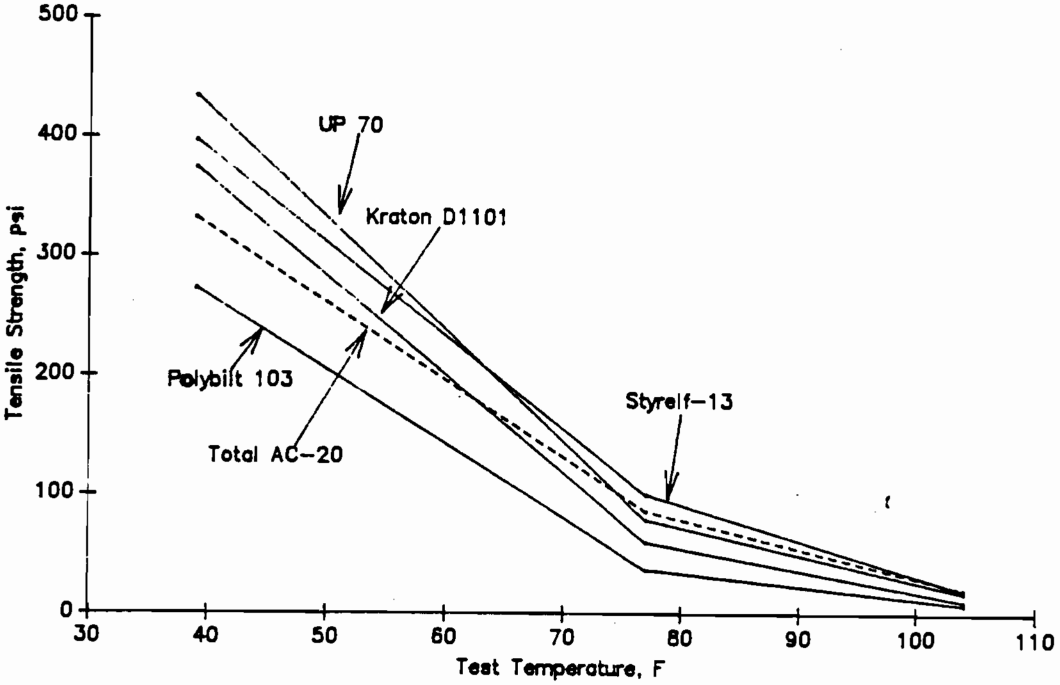


Fig. D-25 Tensile Strength vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

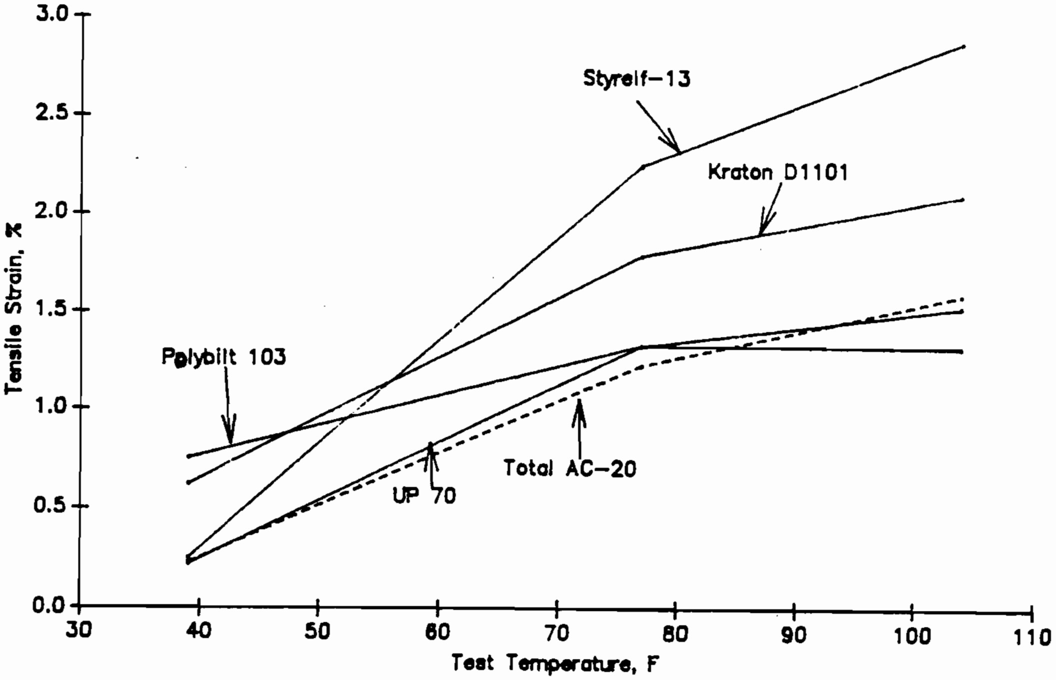


Fig. D-26 Tensile Strain at Failure vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

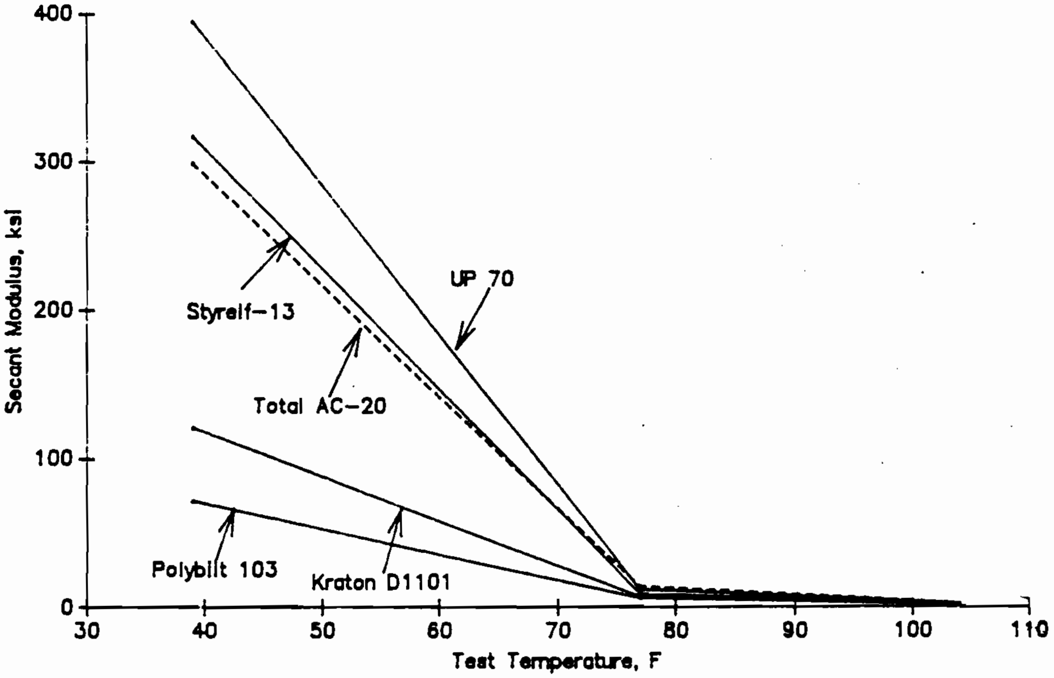


Fig. D-27 Secant Modulus vs. Test Temperature for Laboratory Mixtures Using Modified Compaction.

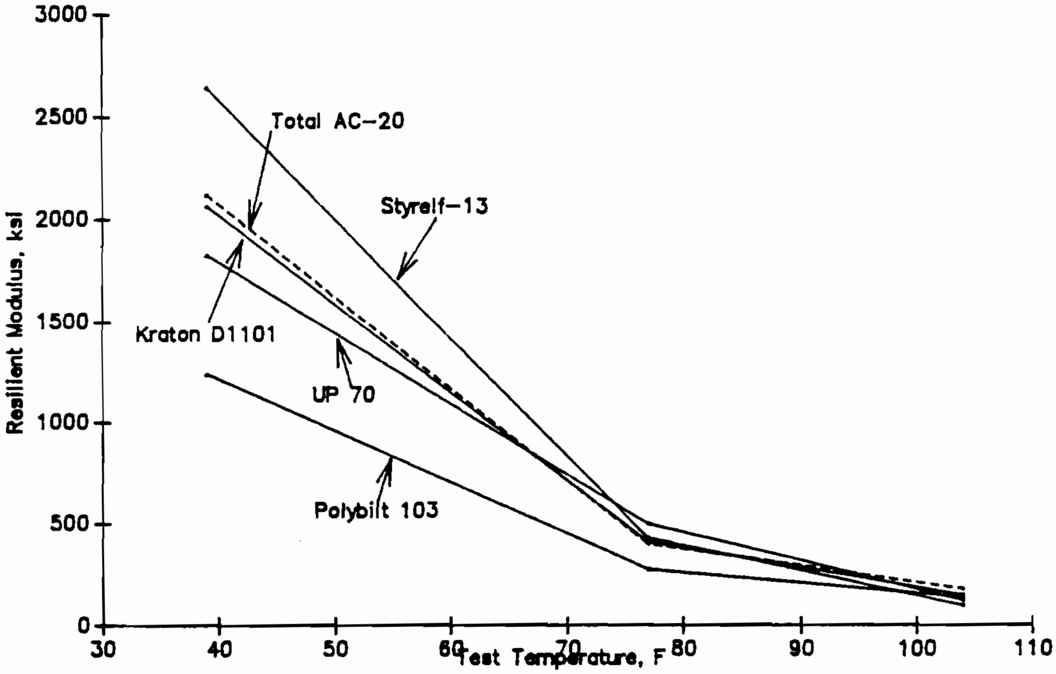


Fig. D-28 Resilient Modulus vs. Test Temperatures for Laboratory Mixtures Using Modified Compaction.

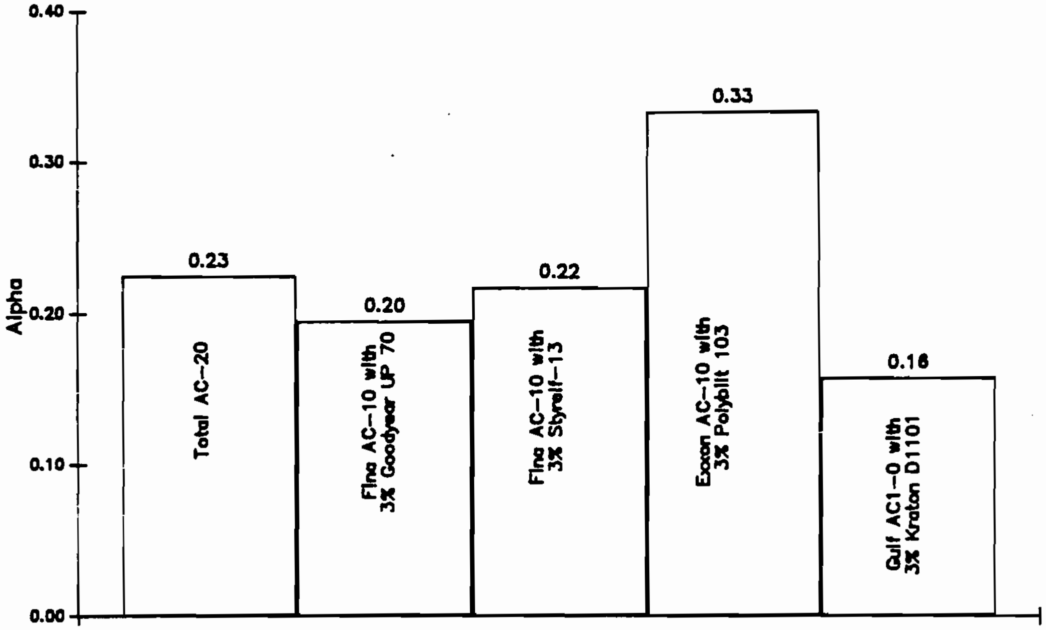


Fig. D-29 Alpha Values for Laboratory Mixtures Using Modified Compaction.

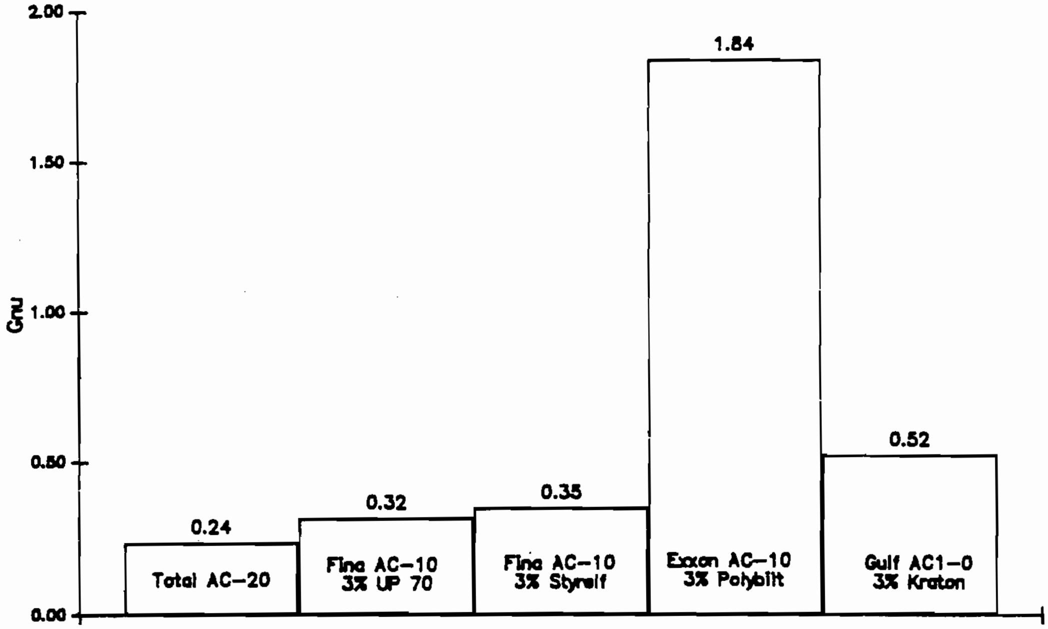


Fig. D-30 Gnu Values for Laboratory Mixtures Using Modified Compaction.

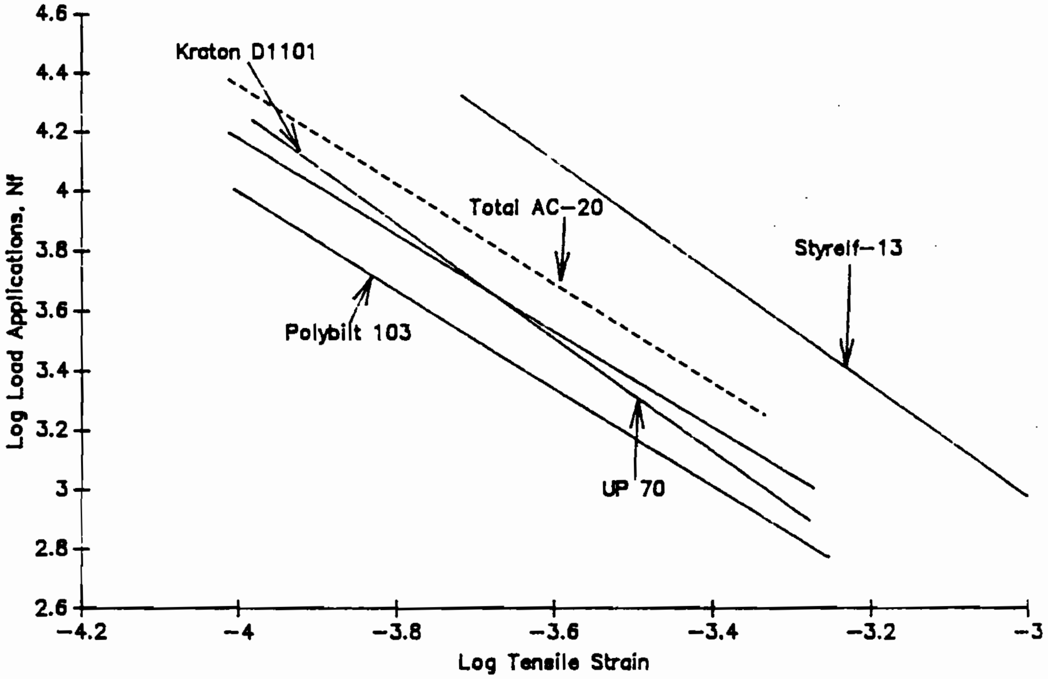


Fig. D-31 Relationship between Fatigue Life and Applied Strain for Laboratory Mixtures Using Modified Compaction.

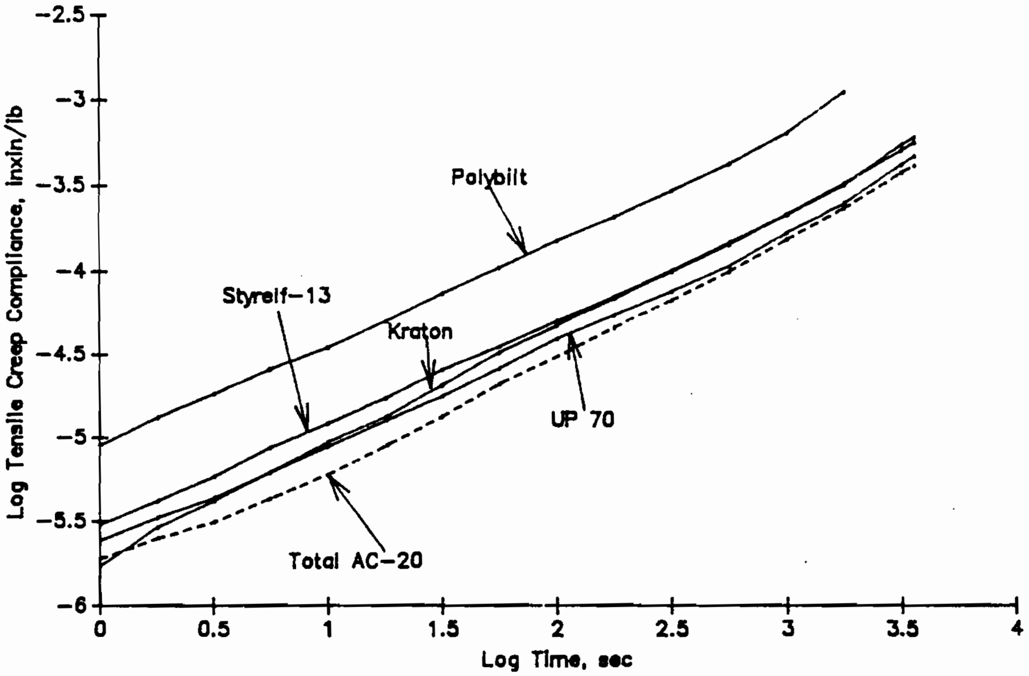


Fig. D-32 Creep Compliance Curves at 60F for Laboratory Mixtures Using Modified Compaction.

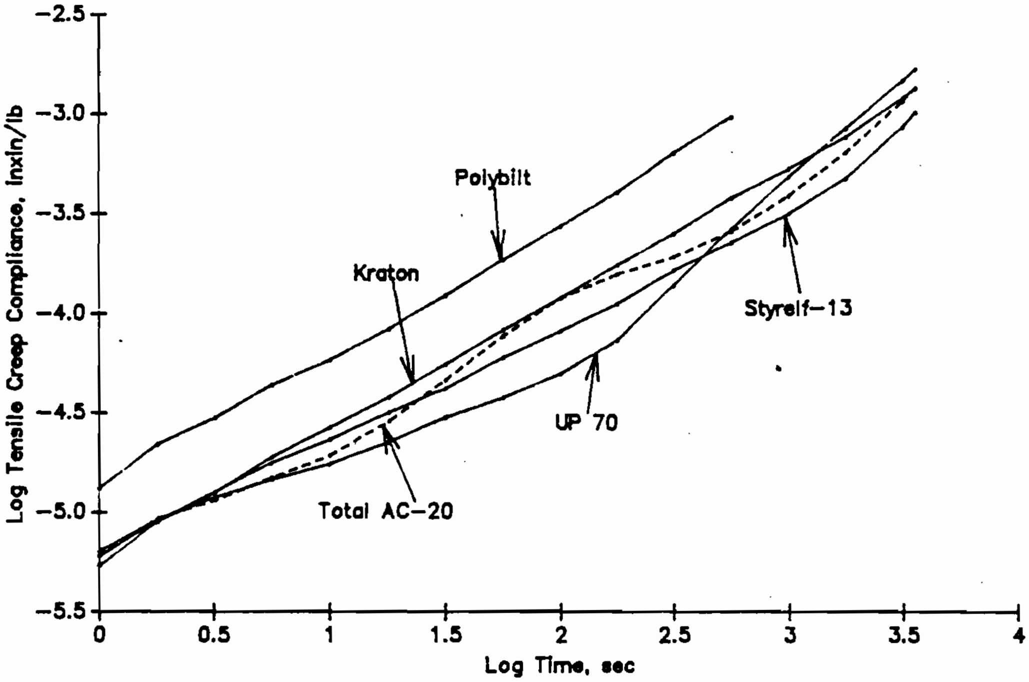


Fig. D-33 Creep Compliance Curves at 77F for Laboratory Mixtures Using Modified Compaction.

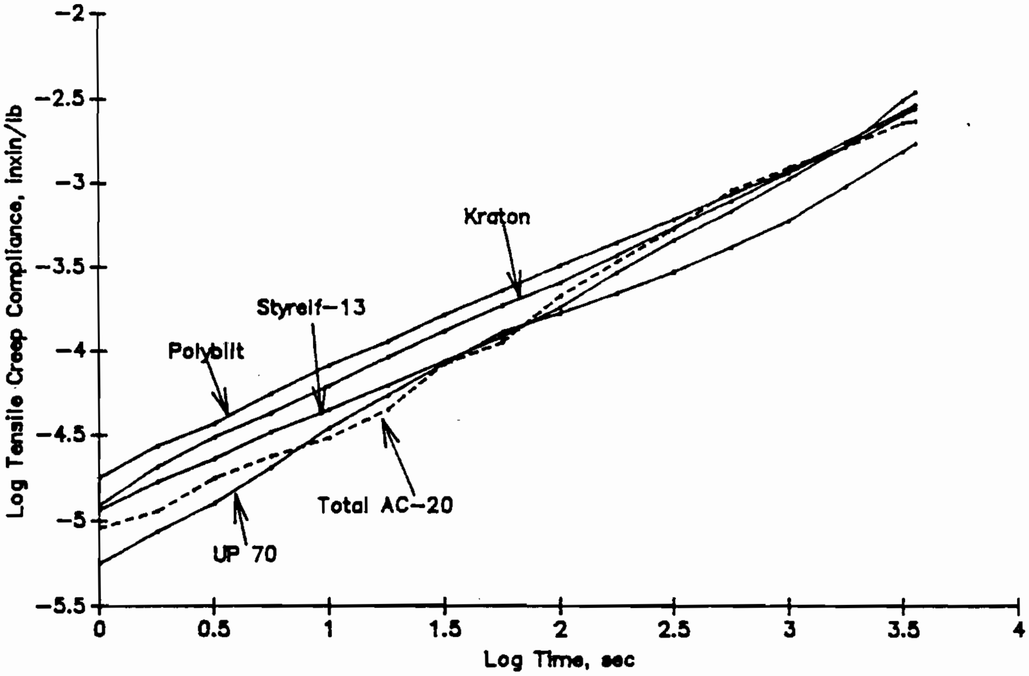


Fig. D-34 Creep Compliance Curves at 90F for Laboratory Mixtures Using Modified Compaction.

APPENDIX E

SEAL COAT TEST SECTIONS (Districts 17, 6)

APPENDIX E

SEAL COAT TEST SECTIONS (Districts 17, 6)

Polymer modified asphalts are used in seal coats primarily where a high volume of traffic is anticipated because it holds the aggregates quicker and longer. In addition to better and longer aggregate retention, the polymer modification will reduce bleeding and shelling.

To evaluate the effectiveness of polymers on seal coat field performance, two seal coat projects involving a total of eight test sections (including controls) were constructed on U.S. 79 (District 17) and S.H. 18 (District 6) in August 1990 and September 1990 respectively. The test sections are shown schematically in Figures E-1 and E-2. Aggregates, asphalts and polymers utilized in the two projects are identified in Table 2.1. Identical pre-coated aggregates were utilized for all test sections in a given district.

The aggregate rates were one cubic yard per 100 and 120 square yards for Districts 17 and 6, respectively. The asphalt application rate was 0.35 gallons per square yard for both the projects. Specifics of each job are shown in Tables E-1 and E-2. Field construction was conducted by Districts 17 and 6 of the TxDOT and assisted by the Center for Transportation Research, The University of Texas at Austin. Condition surveys after construction are being obtained to determine whether use of the polymer modified binders will be beneficial in terms of long term pavement performances.

District 17 Field Test Sections
US79 – Robertson County, Beginning East Of Duck Creek
Date Placed: AUGUST 1990

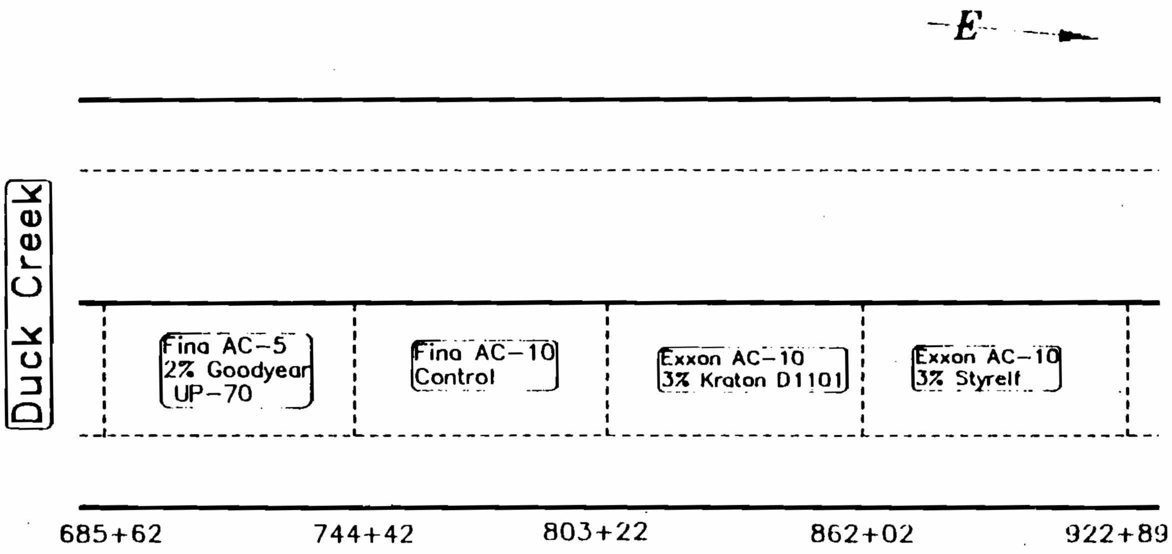


Fig E-1 Schematic Illustration of Seal Coat Test Sections (District 17).

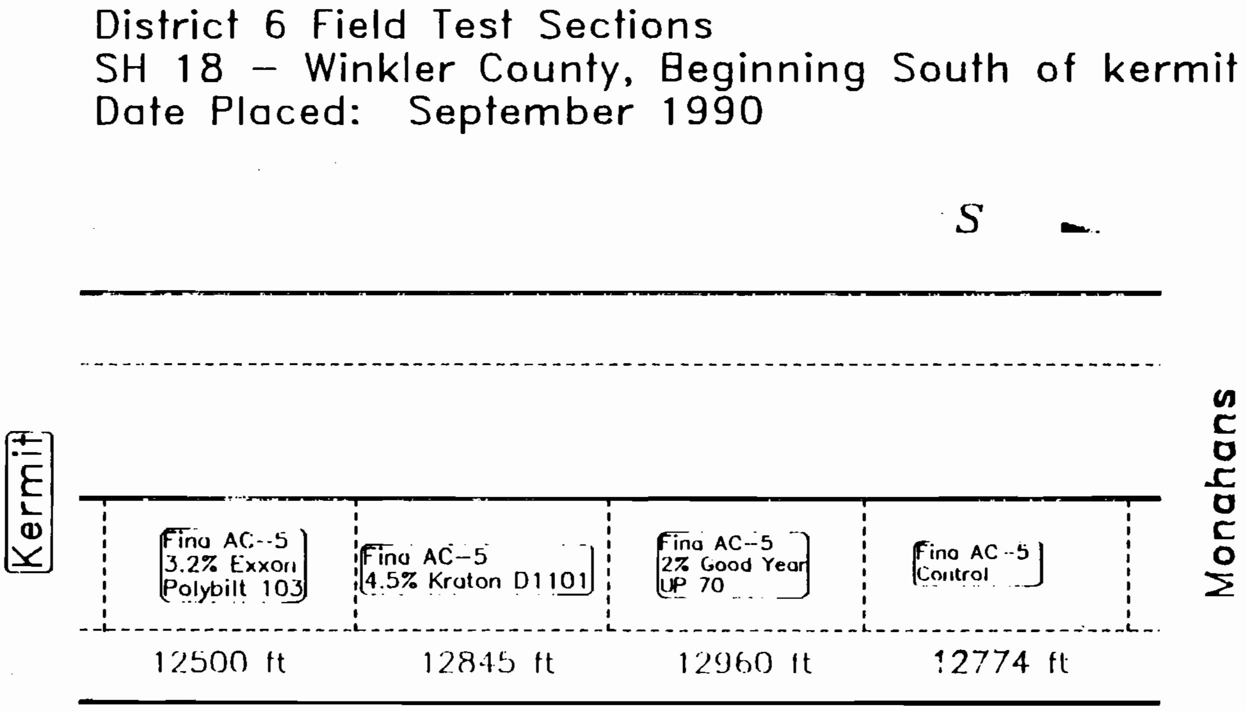


Fig E-2 Schematic Illustration of Seal Coat Test Sections (District 6).

Table E-1 Chip Seal Conditions (District 6)
Winkler County, SH18
Date of Application: 9-7-90 Weather: Clear
Contractor: Wagner & Sons
Control #292-2-31

Material	AC5/3.2% EVA	AC5/4.5% Kraton	AC5/2% Latex	AC5/Control (FINA)
Rate (gal/yd^2)	.367	.375	.351	.354
Aggregate	CSA GR4 TY PB	CSA GR4 TY PB	CSA GR4 TY PB	CSA GR4 TY PB
Rate	1:116	1:119	1:120	1:119
Station #'s	1510+47 to 1635+44	1635+44 to 1763+89	1763+89 to 1893+49	1893+49 to 2021+23

Field notes indicate good aggregate retention in all test sections.
Some rutting was noted in the existing roadway.

Table E-2 Chip Seal Conditions (District 17)
Robertson County, US79
Date of Application: 8/10/90 Weather: Clear
Contractor: Joe Richards, Inc.
Control #186-6-40

Material	Fina AC5 2% UP-70	Fina AC-10	Exxon AC-10 3% Kraton	Exxon AC-10 3% Styrelf
Rate (gal/yd^2)	.348	.352	.357	.359
Aggregate	---------Grade 4---Precoated---Type PB-----(Southwest Materials)--------			
Rate	1:100	1:100	1:100	1:100
Station #'s	685+62 to 744+42	744+42 to 803+22	803+22 to 862+02	862+02 to 922+89

APPENDIX F

DEVELOPMENT OF CREEP COMPLIANCE FORMULA USING THE INDIRECT TENSILE TEST

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DEVELOPMENT OF CREEP COMPLIANCE FORMULA USING THE INDIRECT TENSILE TEST

The indirect tensile test involves loading of a circular element with a compressive load acting along the vertical plane. Hondros (Ref. 35) developed equations for stresses created in a circular element subject to a strip loading (Fig. E.1), assuming the body forces are negligible. Later, Kennedy (Ref. 21) developed equations for estimating the modulus of elasticity, Poisson's ratio, and strain in terms of applied load and deformations (horizontal and vertical). In order to obtain creep compliance, it is necessary to develop elastic relationships based upon deformations and material properties. These elastic relationships can be transformed to a viscoelastic solution by utilizing the correspondence principle which will be described in later sections.

It should be noted that the equation of creep compliance

$$D(t) = \frac{\epsilon(t)}{\sigma_0}$$

cannot be used in indirect tensile creep test analysis since the state of stress is not uniaxial.

EQUATIONS FOR COMPUTING STRESS AND DEFORMATIONS

Two analytical functions, $\phi(Z)$ and $\varphi(Z)$, for the concentrated forces (0,-P) and (0,P) acting at the points $Z_0 = Re^{i\alpha}$ and $\overline{Z_0} = Re^{-i\alpha}$ of the edge of the circular disc (Fig. E.2) were extracted from reference 36. These functions are as follows:

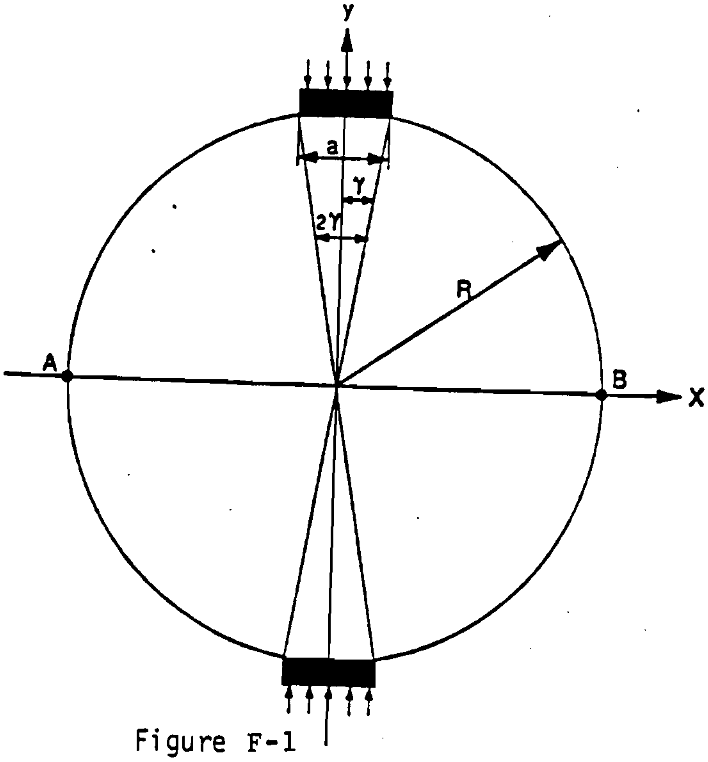

Figure F-1

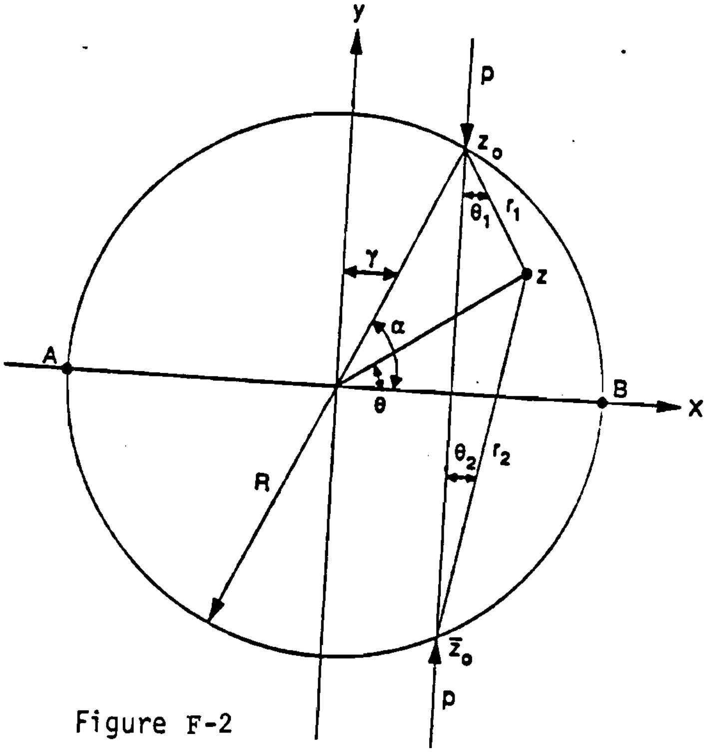

Figure F-2

$$\varphi(Z) = \frac{Pi}{2\pi}\left(\log\frac{Z_o-Z}{\overline{Z_0}-Z}-\log\frac{Z_0-\overline{Z_0}}{2R^2}Z\right)$$

$$\psi(Z) = \frac{Pi}{2\pi}\left(\log\frac{Z_0-Z}{\overline{Z_0}-Z}+\frac{\overline{Z_0}}{Z_0-Z}-\frac{Z_0}{\overline{Z_0}-Z}\right) \tag{E.1}$$

Formulas for displacement and stresses on the circular disc at any arbitrary point Z can be expressed in the terms of the analytical functions $\varphi(Z)$ and $\Psi(Z)$ (Ref. 37) as follows

$$\sigma_{xx}+\sigma_{yy} = 4R[\varphi'(Z)]$$

$$\sigma_{yy}-\sigma_{xx}+2i\sigma_{xy}=2[\overline{Z}\varphi''(Z)+\psi'(Z)] \tag{E.2}$$

$$2\mu(U_x+iU_y)=\chi\varphi(Z)-Z\,\overline{\varphi'(Z)}+\overline{\psi(Z)}$$

where

$$\chi=\frac{\lambda+3\mu}{\lambda+\mu}$$

$$\mu = \textit{Shear modulus}$$

$$\lambda = \frac{2\mu\nu}{1-2\nu} = \textit{Lame's constant}$$

$$\nu = \textit{Poisson's ratio}$$

The substitution of $\varphi'(Z)$, $\varphi''(Z)$, $\Psi'(Z)$, $\varphi(Z)$ and the conjugates of $\varphi'(Z)$ and $\Psi(Z)$ (which can be obtained from Equations E.1) in the right-hand member of Equations E.2 yield

$$\sigma_{yy}+\sigma XX = 2\frac{P}{\pi}\left(-\frac{Cos\theta_1}{r_1}-\frac{Cos\theta_2}{r_2}+\frac{Sin\alpha}{R}\right)$$

$$\sigma_{yy}-\sigma_{xx}+2i\sigma_{xy}=\frac{-2P}{\pi}\left(\frac{Cos2\theta_1 Cos\theta_1}{r_1}+\frac{Cos2\theta_2 Cos\theta_2}{r_2}\right)+$$

$$\frac{2Pi}{\pi}\left(\frac{Sin2\theta_1 Cos\theta_1}{r_1}+\frac{Sin2\theta_2 Cos\theta_2}{r_2}\right) \qquad \text{(E.3)}$$

$$2\mu(U_x+iU_y)=\frac{Pi}{2\pi}\left(\chi\log\frac{r_1}{r_2}+\log\frac{r_1}{r_2}+Cos2\theta_2-Cos2\theta_1-\frac{(1-\chi)\,rSin\alpha Sin\theta}{R}\right)$$

$$-\frac{P}{2\pi}\left((\chi-1)\,(\theta_1+\theta_2+\pi)-(Sin2\theta_2+Sin2\theta_1)+\frac{(1-\chi)\,rSin\alpha Cos\theta}{R}\right)$$

Equation E-3 is used for plane-strain problems.

In the generalized plane-stress problems $\bar{\lambda}$ must be used instead of λ and P must be conceived as the quantity P/h (h is the thickness of the disc).

$$\bar{\lambda}=\frac{2\lambda\mu}{\lambda+2\mu}$$

Solving the equations E.3 for plane-stress problem we get:

$$\sigma_{xx}=-\frac{2P}{\pi h}\left(\frac{Sin^2\theta_1 Cos\theta_1}{r_1}+\frac{Sin^2\theta_2 Cos\theta_2}{r_2}\right)+\frac{PSin\alpha}{\pi hR}$$

$$\sigma_{yy}=-\frac{2P}{\pi h}\left(\frac{Cos^3\theta_1}{r_1}+\frac{Cos^3\theta_2}{r_2}\right)+\frac{PSin\alpha}{\pi R}$$

$$\sigma_{xy}=\frac{2P}{\pi h}\left(\frac{Sin\theta_1 Cos^2\theta_1}{r_1}-\frac{Sin\theta_2 Cos^2\theta_2}{r_2}\right) \qquad (E.4)$$

$$U_x=-\frac{P}{4\pi h\mu}\left(\frac{2(1-\nu)(\theta_1+\theta_2)}{(1+\nu)}-Sin2\theta_1-Sin2\theta_2-\frac{2(1-\nu)xSin\alpha}{(1+\nu)R}\right)$$

$$U_y=\frac{P}{4\pi h\mu}\left(\frac{4}{1+\nu}\log\frac{r_2}{r_1}+Cos2\theta_1-Cos2\theta_2-\frac{2(1-\nu)ySin\alpha}{(1+\nu)R}\right)$$

Deformations in the x and y directions (U_x and U_y) and stresses (σ_x, σ_y and σ_{xy}) for strip loading (Fig. E.1) at any point can be easily computed by integrating equation E.4. For example, the deformations and stresses on the horizontal plane passing through the origin ($r_1=r_2$ $\theta_1=\theta_2$) for uniformly distributed load with intensity P/ha are as follows:

$$\sigma_{xx}=-\int_{-\gamma}^{+\gamma}\frac{P}{ah\pi Cos\gamma}\left[\frac{4Cos^2\gamma\left(\frac{x}{R}-Sin\gamma\right)^2}{\left[\left(\frac{x}{R}-Sin\gamma\right)^2+Cos^2\gamma\right]^2}-Cos^2\gamma\right]d\gamma$$

$$\sigma_{yy}=-\int_{-\gamma}^{\gamma}\frac{P}{ah\pi Cos\gamma}\left[\frac{4Cos^{4}\gamma}{[(\frac{X}{R}-Sin\gamma)^{2}+Cos^{2}\gamma]^{2}}-Cos^{2}\gamma\right]d\gamma$$

$$\sigma_{xy}=0 \tag{E.5}$$

$$U_{x}=-\int_{-\gamma}^{\gamma}\frac{PR}{4\pi\mu ha}\left[\frac{2(1-\nu)}{1+\nu}Tan^{-1}\ 2\ (X/R-Sin\gamma)/Cos\gamma\right]$$

$$-\left[\frac{4(X/R-Sin\gamma)Cos\gamma}{[(X/R-Sin\gamma)^{2}+Cos^{2}\gamma]}-\frac{2(1-\nu)XCos\gamma}{(1+\nu)R}\right]d\gamma$$

Stresses at the center of the specimen (X=0) and displacement at point B (X=R) can be obtained by performing the integration of Equation E.5.

$$\sigma_{xx}=-\frac{2P}{\pi ha}(4/3\ Sin^{3}\gamma-Sin\gamma)$$

$$\sigma_{yy}=-\frac{2P}{\pi ha}\left(\frac{Sin3\gamma}{3}+2Sin\gamma\right) \tag{E.6}$$

$$U_{x}(at\ point\ B)=-\frac{PR}{4\pi\mu ha}\left[\frac{2(1-\nu)}{(1+\nu)}(\pi\gamma-2Sin\gamma)-4Sin\gamma\right]$$

$$U_{y}=0$$

For a 4-inch diameter specimen and half inch curved loading strip the stresses at the center of specimen are:

$$\sigma_{xx} = .1555\frac{P}{h}$$

$$\sigma_{yy} = -.4729\frac{P}{h} \qquad \text{(E.7)}$$

$$\sigma_{xy} = 0$$

Creep Compliance Equation

The correspondence principle (Ref. 37) states that if a viscoelastic material is subjected to a load function, $P=P_0g(t)$, the resulting stresses at time $t = t_1$ are the same as those in elastic material under the load $P = P_0g(t_1)$. The strain and displacements are derived from those of the elastic solution by replacing the material properties (Poisson's ratio and modulus) with S times their Laplace transforms and by substituting the displacement and load function with their Laplace transforms. If it is considered that asphalt concrete mixtures are isochronal in shear (ν is constant with time), then the displacement equation in E.6 for a viscoelastic material and load function $P(t) = P_0g(t)$ can be written as follows:

$$\overline{U}(S) = +\frac{P_o\overline{g}(S)}{S\overline{\mu}(S)}K \qquad \text{(E.8)}$$

where

$$K = -\frac{R}{4\pi ah}\left[\frac{2(1-\nu)}{(1+\nu)}(\pi\gamma - 2Sin\gamma) - 4Sin\gamma\right]$$

$\bar{g}(S)$ *-Laplace transform of* $g(t)$

$\bar{\mu}(S)$ *-Laplace transform of* $\mu(t)$

Having $J(S)\mu(S)-\frac{1}{S}$, *the convolusion of equation E-8 is as follows*

$$U(t)-P_0K\int_0^t J(\tau)\,\frac{dg(t-\tau)}{d\tau}\,d\tau \qquad \text{(E.9)}$$

where

$P_0g(t)$ = load function

$J(t)$ = shear creep compliance

Shear creep compliance can be computed from E.9 by knowing the values of displacement and load functions which are recorded during indirect creep test.

Several assumptions should be recognized when the creep compliance formula, E.9, is utilized. The most important of these are as follows:

1. The mathematical analysis assumes that the material is isotropic and homogenous.
2. The state of plane stress exists in the specimen; but it does not occur in the practical situation.
3. Materials are isochronal in shear, which means the Poisson's ratio is not a function of stress or time.
4. Materials have Newtonian behavior.
5. The effect of heterogeneity on the general distribution of stress has not been determined but is probably quite small for steel loading strip.

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