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Stiffness of Asphalt-Aggregate Mixes

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Abstract

This report presents an evaluation of several test systems for stiffness determination of asphalt-aggregate mixes, including 1) axial resilient stiffness, 2) diametral resilient stiffness, 3) resilient and dynamic flexural stiffness, and 4) dynamic shear stiffness.

All of the stiffness test systems were found to be sensitive to mix and test variables, especially to asphalt source, asphalt content, aggregate type, and air-void content.

Temperature had the greatest effect on stiffness for axial, diametral, and flexural stiffnesses. On the basis of the data presented it is recommended that the use of diametral stiffness measurements be limited to temperatures equal to or less than 20°C.

Models are presented to permit estimation of flexural stiffness (and loss-stiffness) from shear stiffness (and loss-stiffness in shear) at 20°C and 10 Hz frequency.

Executive Summary

The stiffness of asphalt-aggregate mixes is of paramount importance in determining how well a pavement performs and is fundamental to the analysis of pavement response to traffic loading. Although stiffness testing of asphalt-aggregate mixes was not part of the original objective of the A-003A contract, an independent study was conducted using the following candidate test methods: 1) axial resilient stiffness; 2) diametral resilient stiffness; 3) flexural dynamic stiffness; and 4) shear dynamic stiffness. This report includes an evaluation of candidate stiffness test methods and development of flexural and shear stiffness databases essential for analytically based surrogate fatigue modeling activities.

Two measurement programs were conducted. The first involved mixes containing two aggregates, RB and RL; two asphalts, AAG-1 and AAK-1; two asphalt contents; and two degrees of compaction. Methods of testing were 1) axial resilient stiffness, 2) diametral resilient stiffness, and 3) flexural resilient stiffness. Mixes were tested in the temperature range 0°C to 60°C, although not all tests could be performed at the higher temperatures. The second program included flexural and shear stiffness measurements on mixes containing two aggregates, RD and RH, and light MRL asphalt (core materials). The flexural stiffness measurements were obtained at 20°C, while the shear stiffness tests were conducted at 4°, 20°, and 40°C.

All stiffness test systems were found to be sensitive to mix and test variables, especially to asphalt type (source), asphalt content, aggregate type (source), and air-void content. Each of these variables had either a direct effect on stiffness or an indirect effect through interactions with other variables.

As expected, temperature had by far the most influence on axial, diametral, and flexural stiffnesses. Although the effects on shear stiffness of temperature and load frequency were not discussed, results (Appendix F) are expected to show shear stiffness sensitivity to both these variables.

Major findings from this study are summarized as follows:

- Axial, diametral, flexural, and shear stiffnesses are all sensitive to the mix and test variables — asphalt type, aggregate type, air-void content, and temperature.
- In general, the axial, diametral, and flexure testing of asphalt-aggregate mixes

will yield different estimates for their resilient stiffnesses.

- Diametral stiffnesses computed assuming a Poisson's ratio of 0.35 generally exceed both axial and flexural stiffnesses by approximately 35 to 45 percent.
- Poisson's ratio, necessary for determination of resilient stiffness in diametral testing, cannot be accurately determined in the diametral test and must be assumed based on measurements obtained with other test systems. Because Poisson's ratios must be assumed, diametral stiffnesses are likely to be less reliable than axial stiffnesses.
- Diametral stiffnesses cannot be accurately measured at high temperatures and are not reliable at even moderately high temperatures (40°C). The SHRP A-003A laboratory experience suggests that weak specimens cannot be tested at temperatures as high as 60°C. Large permanent deformations observed in testing at higher temperatures cast serious doubt on the reliability of measurements at those temperatures. It is recommended that indirect tension testing for resilient stiffness measurements be limited to temperatures not exceeding about 20°C.
- Mix and testing effects on resilient stiffness may differ depending on whether loading is in axial compression, indirect tension, or flexure. By inference, the different testing systems may result in differences in structural pavement design.
- The following models can be used to estimate flexural stiffness (and loss-stiffness) on the basis of shear stiffness (and loss-stiffness) at 20°C and 10 Hz frequency:

$$S_o = 8.560\,(G_o)^{0.913}$$

$$S_o'' = 81.125\,(G_o'')^{0.725}$$

where:
S_o = initial flexural stiffness, psi
S_o'' = initial flexural loss-stiffness, psi
G_o = initial shear stiffness, psi
G_o'' = initial shear loss-stiffness, psi.

1

Introduction

1.1 Background

The primary objectives of this research contract were to develop a series of accelerated performance tests for asphalt-aggregate mixes and methods for analyzing asphalt-aggregate interactions that significantly affect pavement performance.

The stiffness of asphalt-aggregate mixes is of paramount importance in determining how well a pavement performs and is essential for the analysis of pavement response to traffic loading. Although fatigue tests and many of the permanent deformation tests can be used to measure stiffness under conditions similar to those experienced by paving mixes in service, there is no assurance that the best system for fatigue testing, for example, is also best for stiffness testing. Although not part of the original objective of the A-003A contract, an independent study for stiffness testing of asphalt-aggregate mixes was conducted under Task C.6, Complementary Investigations. Candidate testing methods included 1) axial resilient stiffness, 2) diametral resilient stiffness, 3) flexural dynamic stiffness, and 4) shear dynamic stiffness.

This report details the complementary laboratory studies conducted as part of SHRP Project A-003A in support of the following:

- evaluation of candidate stiffness test methods, and
- development of flexural and shear stiffness databases essential for analytically based surrogate fatigue modeling activities.

1.2 Objective

The objective of this report is to document the results of various phases of the stiffness test program and the analysis of these test results under the A-003A contract. The flexural stiffness results obtained from the fatigue testing of asphalt-aggregate mixes are also included.

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2×2 Pilot Test Program

2.1 Testing Program

The SHRP A-003A study of stiffness measures was primarily a laboratory investigation. The pilot test program, referred to as the 2×2 study, included evaluation of two Materials Reference Library (MRL) core asphalts (AAG-1 and AAK-1), two MRL aggregates (RL and RB), two asphalt contents (optimum and high), and two levels of compaction (4 and 8 percent air voids), for a total of 16 different mixes. Table 2.1 summarizes the significant variables considered in this study. Methods of testing were 1) axial resilient stiffness, 2) diametral resilient stiffness, and 3) flexural resilient stiffness.

Table 2.1. Significant mix and test variables for stiffness study

Variable	Levels of Treatment				No. of Levels
	1	2	3	4	
Aggregate					
Stripping potential[a]	Low		High		2
Gradation		Medium			1
Asphalt					
Temperature susceptibility[a]	Low		High		2
Content		Optimum	High		2
Compaction					
Air voids - percent	4±1		8±1		2
Test Conditions					
Temperature					
Axial stiffness tests	0°C	20°C	40°C	60°C	4
Diametral stiffness tests	0°C	20°C	40°C		3
Flexural stiffness tests	0°C	20°C			2
Stress Level	Low[b]		High[b]		

[a] Based on the information from MRL

[b] Varies with temperature

Specifically, mix variables included the following:

Aggregates. Two aggregate types — RB and RL — were used in this study. The RB aggregate exhibits a low level of stripping potential; the RL aggregate exhibits a relatively high level of stripping potential. Table 2.2 and Figure 2.1 show the State of California ¾ in. (1.9 mm) medium gradation used in this study.

Table 2.2. Aggregate gradation used

Sieve Size	Percent Passing by Weight	Percent Retained on Each Sieve by Weight
1 in.	100	0
¾ in.	95	5
½ in.	80	15
⅜ in.	68	12
No. 4	48	20
No. 8	35	13
No. 16	25	10
No. 30	17	8
No. 50	12	5
No. 100	8	4
No. 200	5.5	2.5

1 in. = 25.40 mm

Asphalt. Two asphalts were used: AAK-1 (an AC-30), with relatively lower temperature susceptibility (Penetration Index = -0.5), and AAG-1 (an AR-4000), with relatively higher temperature susceptibility (Penetration Index = -1.5). Table 2.3 contains a summary of MRL asphalt properties.

Asphalt Content. Two asphalt contents were used. For each asphalt-aggregate mix, the lower (optimum) asphalt content was determined using standard Hveem procedure. The second asphalt content was set 0.6 percent higher, corresponding approximately to the optimum asphalt content using the Corps of Engineers (Marshall) design procedure[1]. Table 2.4 shows the asphalt contents used for various mixes considered.

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[1] Design criteria for 200 psi tires.

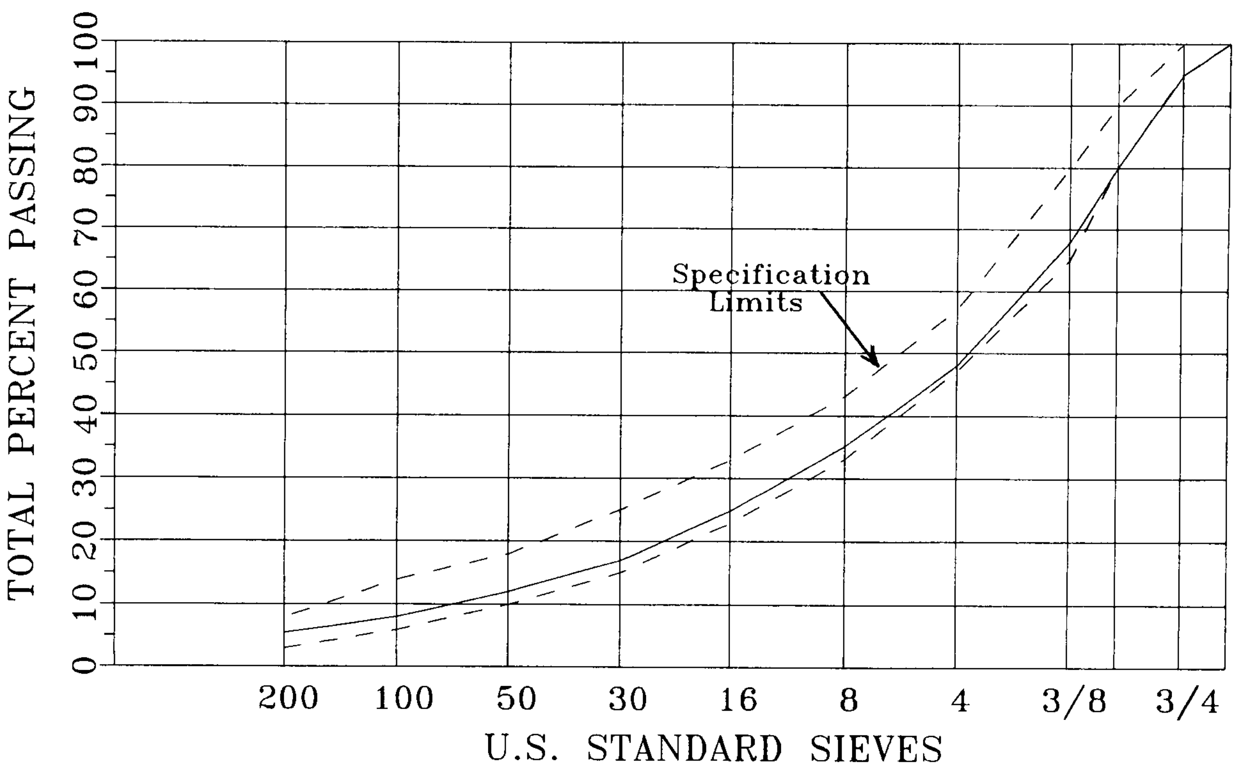

Figure 2.1. Aggregate gradation used

Table 2.3. MRL asphalt properties

	AAA-1	AAB-1	AAC-1	AAD-1	AAF-1	AAG-1	AAK-1	AAM-1
Original Asphalt								
Penetration o dm @25°C, 100g, 5s	160	98	133	135	55	53	70	64
o dm @46°C, 100 g, 5s	15	6	7	9	0	2	2	4
Viscosity o poise, 60°C	864	1029	419	1055	1872	1862	3256	1992
o cSt, 135°C	283	289	179	309	327	243	562	569
After TFOT								
Viscosity o poise, 60°C	1901	2380	1014	3420	4579	3253	9708	3947
o cSt, 135°C	393	393	239	511	472	304	930	744

Table 2.4. Asphalt content used for various mixes

Aggregate Stripping Potential[a]	Temperature Susceptibility[a]			
	Low (AAK, PI=-0.5)		High (AAG, PI=-1.5)	
	Asphalt Content[b]		Asphalt Content[b]	
	Optimum	High	Optimum	High
Low (RB)	5.1	5.7	4.9	5.5
High (RL)	4.3	5.0	4.1	4.8

[a]Based on information from the MRL
[b]Asphalt content by weight of aggregate

Compaction and Air-Void Contents. Two levels of compactive effort were used. The low level of compactive effort was adjusted to provide a target air-void content of 8 percent in the specimen. The high level of compactive effort was adjusted to produce a target air-void content of 4 percent. A Triaxial Institute Kneading Compactor was used to fabricate all specimens.

Test Conditions. For axial resilient stiffness tests, four temperatures — 32°, 68°, 104°, and 140°F (0°, 20°, 40°, and 60°C) — were used. For diametral resilient stiffness tests, three temperatures — 32°, 68°, and 104°F (0°, 20°, and 40°C) — were used. For flexural stiffness tests, two temperatures — 32° and 68°F (0° and 20°C) — were used. Two stress levels (high and low) were used for all the tests. It should be noted that the target stress levels were adjusted for different temperatures to ensure a reasonable strain reading. For all tests, unconditioned specimens (no aging or moisture conditioning) were used. For the axial and diametral tests, two frequencies — 1 Hz (0.1 second loading followed by 0.9 seconds rest period) and 0.5 Hz (0.1 seconds loading followed by 1.9 seconds rest period) — were used. For the flexural stiffness test, a 1.67 Hz frequency (0.1 seconds loading followed by 0.5 seconds rest period) was used.

A full factorial experimental design was used in this study for the axial and diametral resilient stiffness tests. The experimental design used for flexural stiffness was the smallest fractional factorial design that permitted the estimation of all two-factor interactions as well as the main effects of the variables being used. It should be noted that the flexural stiffness tests were part of a larger experiment for the evaluation of fatigue response of mixes (Tayebali et al. 1994) for which it was determined that a ½ fraction of the full factorial would be necessary to estimate the main effects and interactions. Table 2.5 shows the experiment design used for the flexural stiffness test program. Test results for the axial, diametral, and flexural stiffness are Appendixes A, B, and C, respectively.

Table 2.5. Experiment design for flexural stiffness
Experiment Design: $2^{5-1}*2$ Fractional Factorials in 32 Runs

A	B	C	D	E	F	A	B	C	D	E	F
0	0	0	0	0	0	0	0	0	0	0	1
1	0	0	0	1	0	1	0	0	0	1	1
0	1	0	0	1	0	0	1	0	0	1	1
1	1	0	0	0	0	1	1	0	0	0	1
0	0	1	0	1	0	0	0	1	0	1	1
1	0	1	0	0	0	1	0	1	0	0	1
0	1	1	0	0	0	0	1	1	0	0	1
1	1	1	0	1	0	1	1	1	0	1	1
0	0	0	1	1	0	0	0	0	1	1	1
1	0	0	1	0	0	1	0	0	1	0	1
0	1	0	1	0	0	0	1	0	1	0	1
1	1	0	1	1	0	1	1	0	1	1	1
0	0	1	1	0	0	0	0	1	1	0	1
1	0	1	1	1	0	1	0	1	1	1	1
0	1	1	1	1	0	0	1	1	1	1	1
1	1	1	1	0	0	1	1	1	1	0	1

A = Aggregate stripping potential (0=Low, 1=High)
B = Asphalt temperature susceptibility (0=Low, 1=High)
C = Asphalt content (0=Optimum, 1=High)
D = Compaction (air-void) content (0=Low, 1=High)
E = Temperature (0=Low, 1=High)
F = Stress (0=Low, 1=High)

2.2 Axial and Diametral Resilient Stiffness

Results for the axial and diametral stiffness experiments are treated separately from the flexural stiffness experiment results, since the first two are full factorial design, while the latter is a half factorial design. All testing for the axial and diametral stiffness tests were done in accordance with appropriate ASTM test standards[2]. Only total resilient stiffness (M_R) is reported here.

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[2] D 3497, Dynamic Modulus of Asphalt Mixtures, and D 4123, Indirect Tension Test for Resilient Modulus of Bituminous Mixtures.

Because resilient stiffness testing is considered to be "nondestructive," each specimen was subjected to a full range of loading conditions at each of the test temperatures, i.e., two stress levels and two loading frequencies. The average stress levels varied depending on temperature and type of test as follows:

Temperature	**Axial**		**Diametral**	
	Low Stress, psi	**High Stress, psi**	**Low Stress, psi**	**High Stress, psi**
32°F (0°C)	30.6	60.7	26.9	51.8
68°F (20°C)	15.6	30.9	14.1	27.2
104°F (40°C)	8.1	15.8	6.8	13.8
140°F (60°C)	4.2	10.3	-	-

1 psi = 6.89 kPa

The two test frequencies included 0.5 and 1 Hz with load duration of 0.1 seconds for each test method. Using each test method (axial and diametral), a total of 32 specimens were evaluated (16 mixes with full replication), and 384 tests were performed (32 specimens with 12 testing conditions each).

2.2.1 Test Results

Tables 2.6 and 2.7 summarize the average axial and diametral resilient stiffnesses, respectively, for the various materials and test conditions, while Figures 2.2 through 2.8 illustrate the influence of temperature and various mix and loading conditions on the average axial and diametral resilient stiffnesses.

Comparison of axial and diametral stiffnesses indicates that on average the diametral modulus is about 35 to 45 percent larger than the axial stiffness. Table 2.8 shows the ratio of the average resilient stiffnesses from axial and diametral tests for the various mix and testing variables. These same values are illustrated in Figures 2.9 and 2.10. The following observations are noteworthy:

1. At lower temperatures specimens containing AAK-1 asphalt exhibit less axial and diametral stiffness than specimens containing AAG-1 asphalt. At higher temperatures, the axial stiffnesses for AAK-1 specimens are greater, whereas the diametral stiffnesses are still less than those of specimens with AAG-1 asphalt.

2. Specimens containing aggregate RB show greater axial stiffnesses than those containing aggregate RL, except at 32°F (0°C) where the stiffnesses are about the same. On the other hand, diametral stiffnesses for specimens with RB are less than for those containing RL, except at 32°F (0°C).

3. Axial stiffness is more sensitive to air-void content than diametral stiffness.

Table 2.6. Effect of mix and testing variables on average axial resilient stiffness

Variable	Level	Average Axial Resilient Stiffness, psi		
		32°F (0°C)	68°F (20°C)	104°F (40°C)
Asphalt Type	AAK-1	1,720,000	483,000	79,000
	AAG-1	2,600,000	902,000	76,300
Asphalt Content	Optimum	2,130,000	663,000	78,100
	High	2,190,000	722,000	77,200
Aggregate Type	Granite (RB)	2,190,000	757,000	85,300
	Chert (RL)	2,130,000	628,000	70,000
Air Voids	Low	2,570,000	876,000	102,000
	High	1,750,000	509,000	52,900
Stress Level	Low	2,160,000	698,000	78,600
	High	2,160,000	687,000	76,700
Frequency	Low	2,150,000	679,000	75,800
	High	2,170,000	706,000	79,500
Repeats	First	2,180,000	683,000	77,000
	Second	2,140,000	702,000	78,300
Average of Repeats		2,160,000	692,000	77,700

1 psi = 6.89 kPa.

Table 2.7. Effect of mix and testing variables on average diametral resilient stiffness

Variable	Level	Average Diametral Resilient Stiffness, psi		
		32°F (0°C)	68°F (20°C)	104°F (40°C)
Asphalt Type	AAK-1	2,350,000	612,000	96,700
	AAG-1	3,550,000	1,240,000	127,000
Asphalt Content	Optimum	3,100,000	1,040,000	123,000
	High	2,800,000	804,000	101,000
Aggregate Type	Granite (RB)	3,130,000	883,000	104,000
	Chert (RL)	2,770,000	964,000	120,000
Air Voids	Low	3,360,000	1,060,000	138,000
	High	2,530,000	786,000	85,700
Stress Level	Low	2,950,000	948,000	118,000
	High	2,950,000	900,000	106,000
Frequency	Low	2,930,000	916,000	117,000
	High	2,970,000	931,000	107,000
Repeats	First	2,890,000	876,000	112,000
	Second	3,010,000	971,000	112,000
Average of Repeats		2,950,000	923,500	112,000

Table 2.8. Ratio of resilient stiffnesses for axial and diametral tests

Variable	Ratio	32°F (0°C)		68°F (20°C)		104°F (40°C)	
		Axial	Diametral	Axial	Diametral	Axial	Diametral
Asphalt Type	AAK-1 /AAG-1	0.66	0.66	0.54	0.49	1.03	0.76
Asphalt Content	Low/High	0.97	1.11	0.92	1.29	1.01	1.22
Aggregate	RB/RL	1.03	1.13	1.21	0.91	1.22	0.87
Air Voids	Low/High	1.47	1.32	1.72	1.34	1.93	1.61
Stress	Low/High	1.00	1.00	1.02	1.05	1.03	1.11
Frequency	Low/High	0.99	0.99	0.96	0.98	0.95	1.09
Repeats	First/Second	1.02	0.96	0.97	0.90	0.98	1.00
Ratio of average diametral to axial resilient stiffness		1.37		1.35		1.45	
Percent difference		37		35		45	

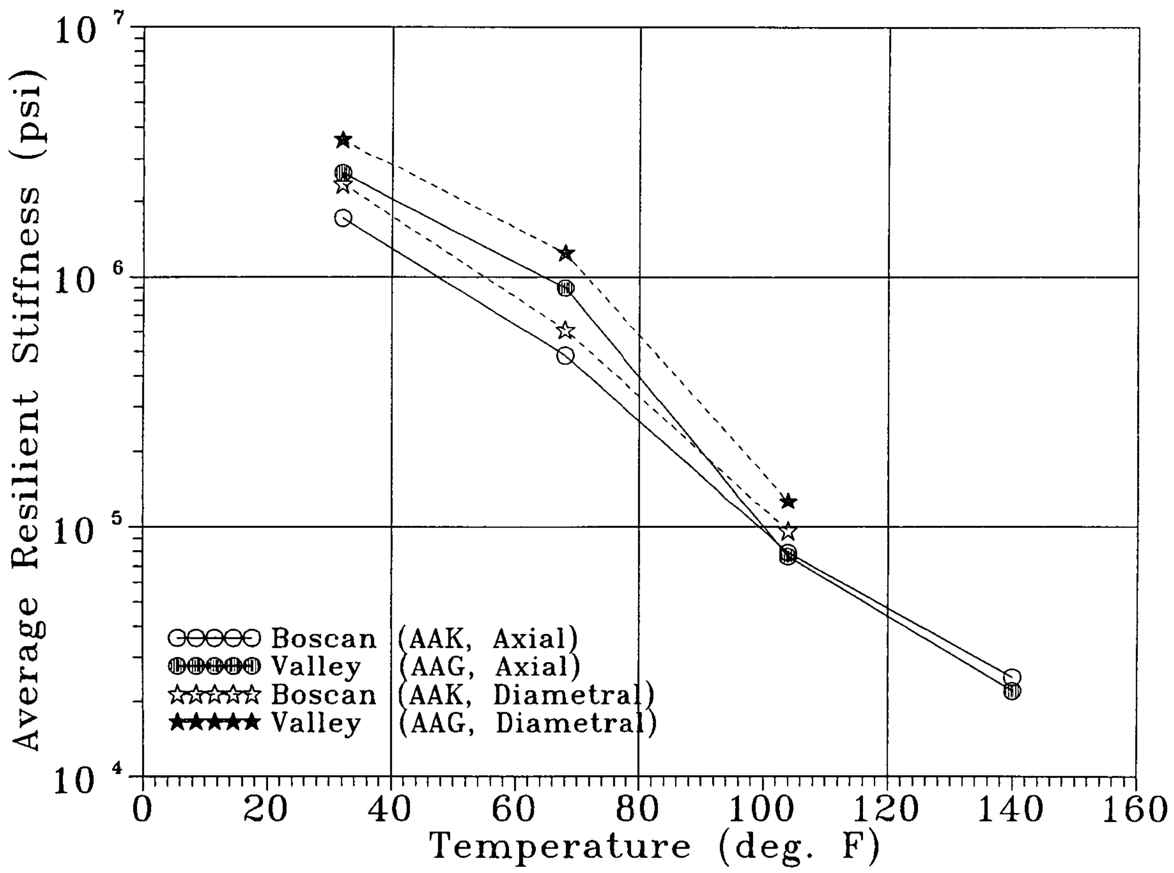

Figure 2.2. Effect of asphalt type on average resilient stiffness

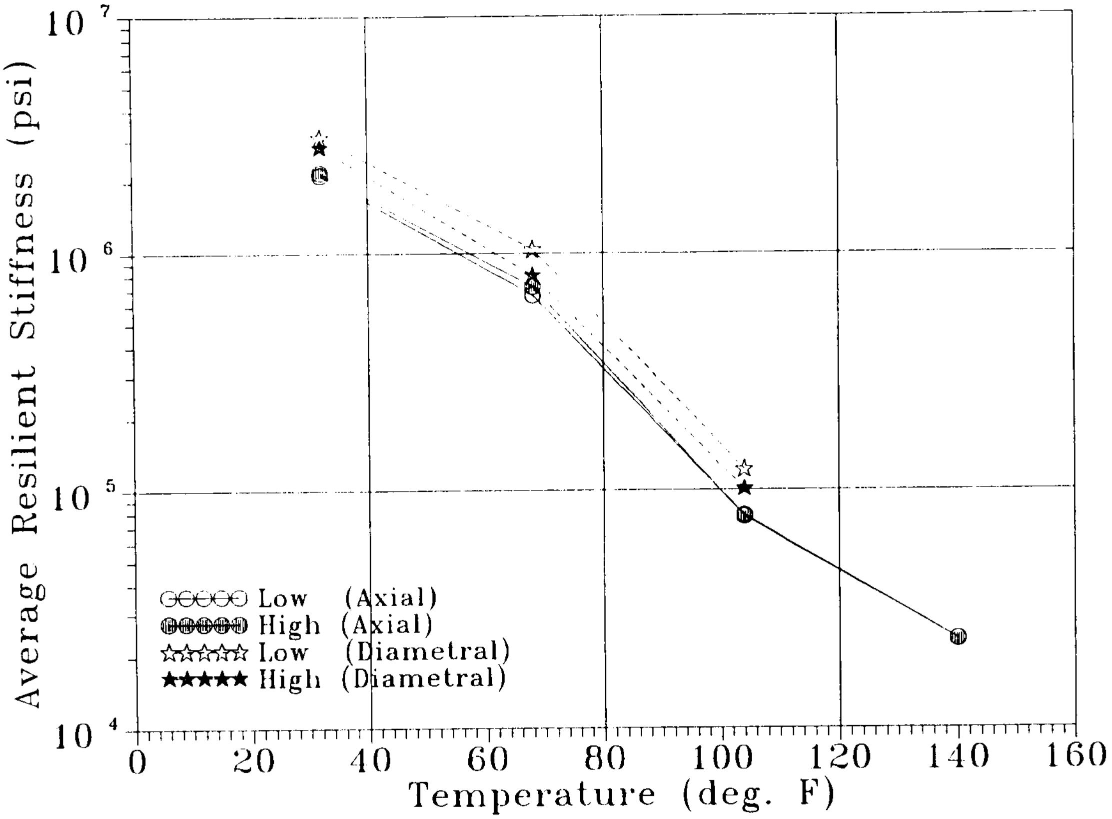

Figure 2.3. Effect of asphalt content on average resilient stiffness

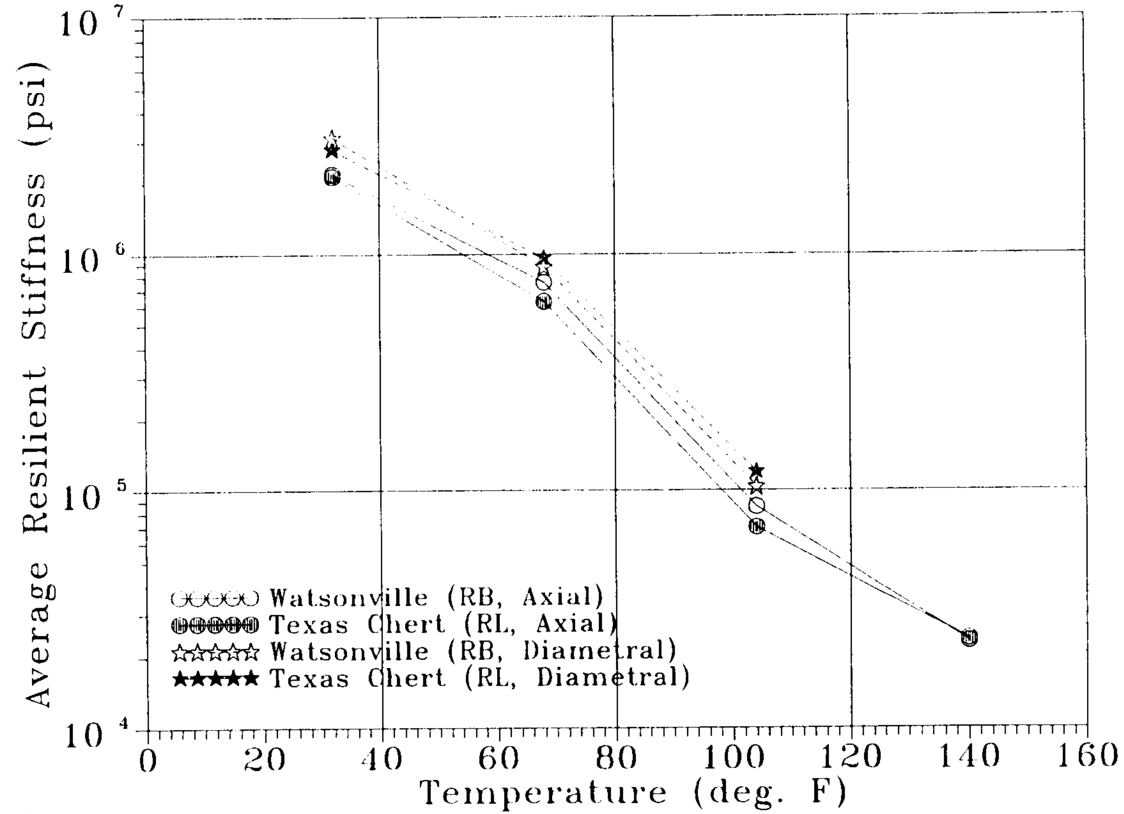

Figure 2.4. Effect of aggregate type on average resilient stiffness

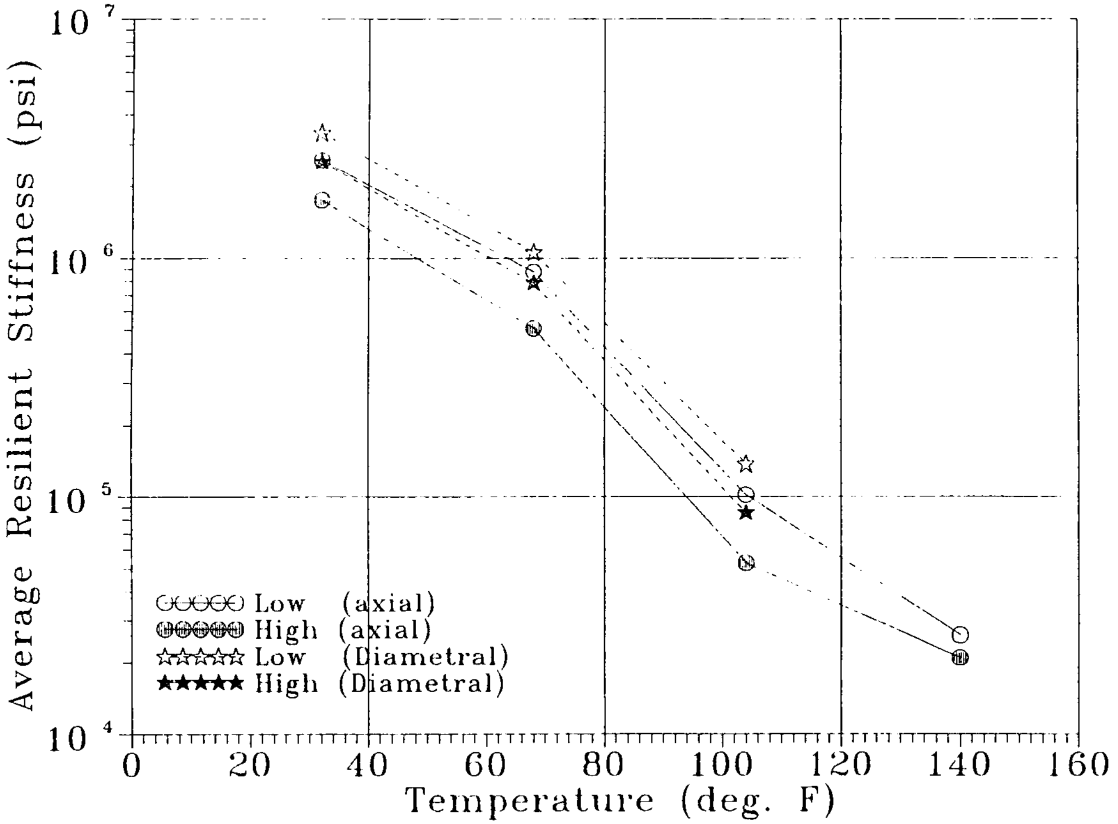

Figure 2.5. Effect of air voids on average resilient stiffness

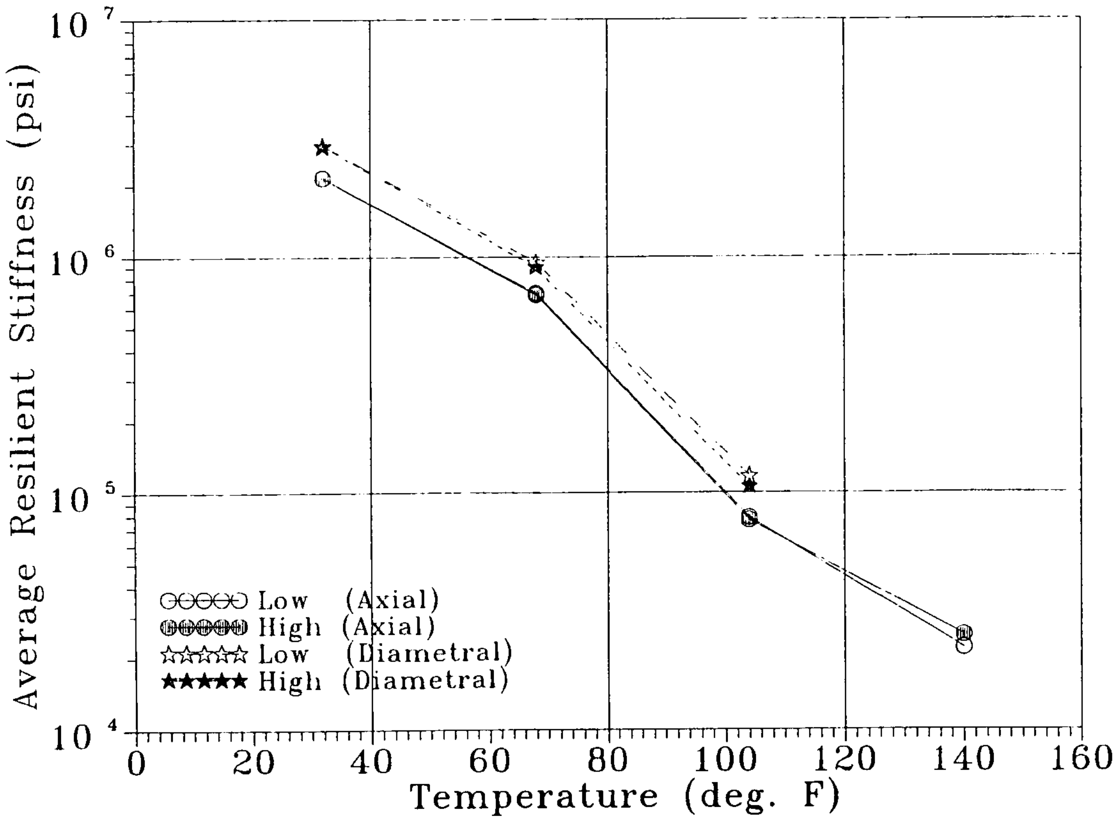

Figure 2.6. Effect of stress level on average resilient stiffness

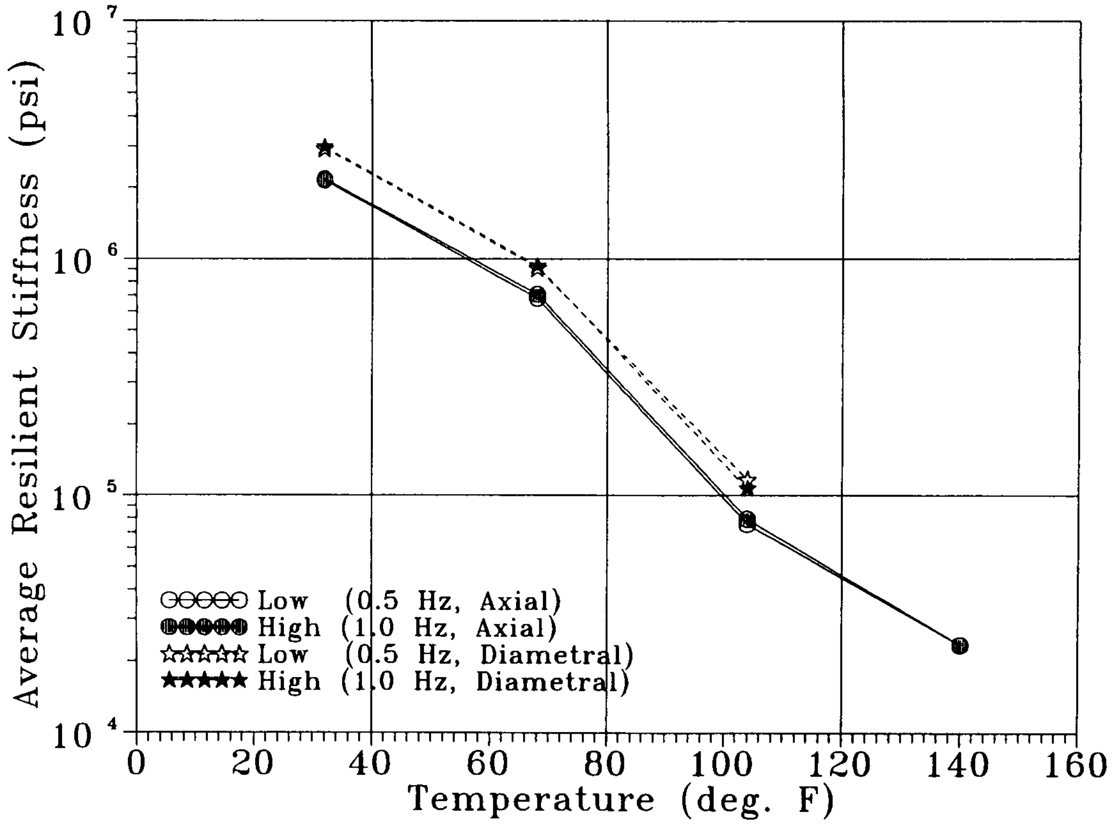

Figure 2.7. Effect of loading frequency on average resilient stiffness

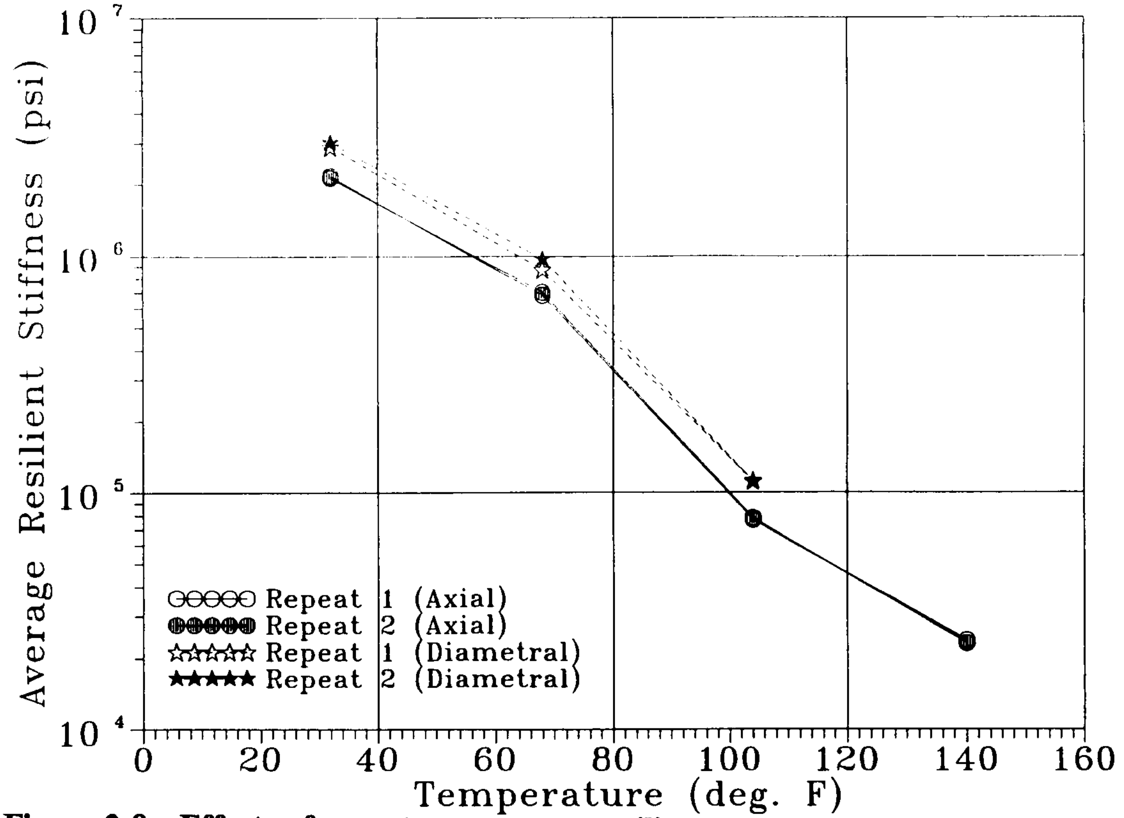

Figure 2.8. Effects of repeats on average resilient stiffness

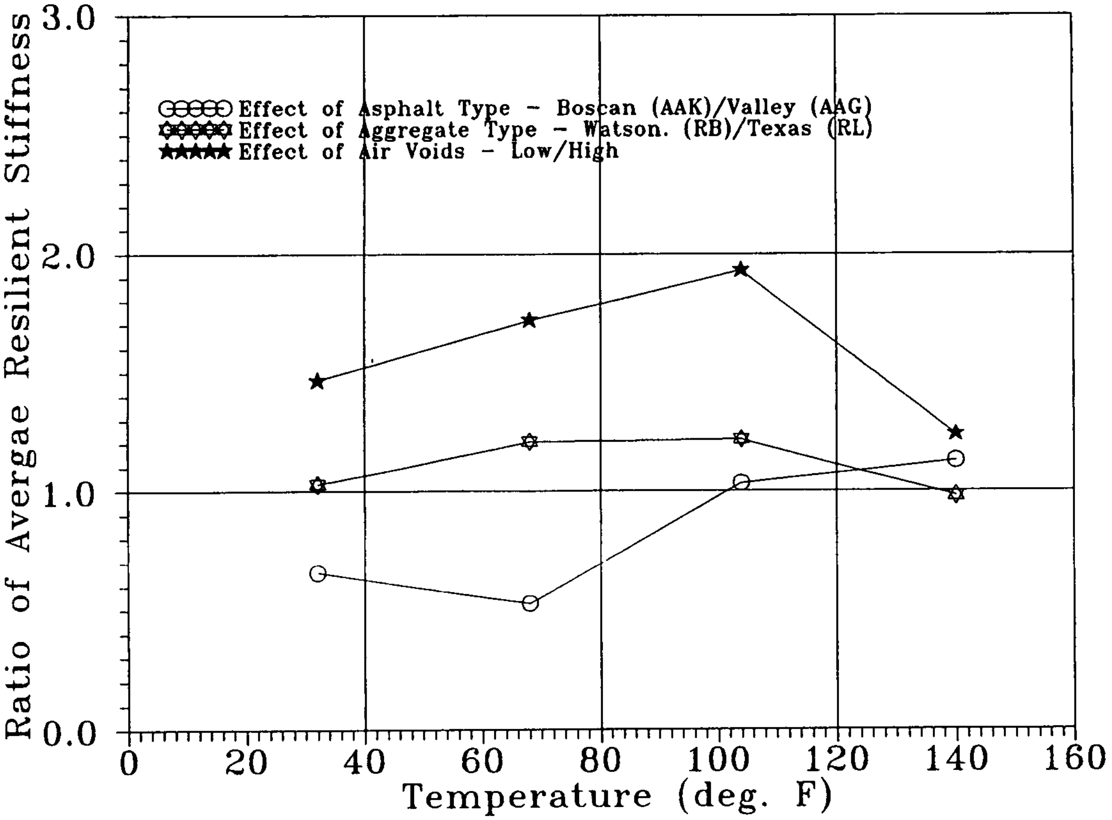

Figure 2.9. Ratio of average axial resilient stiffness versus temperature

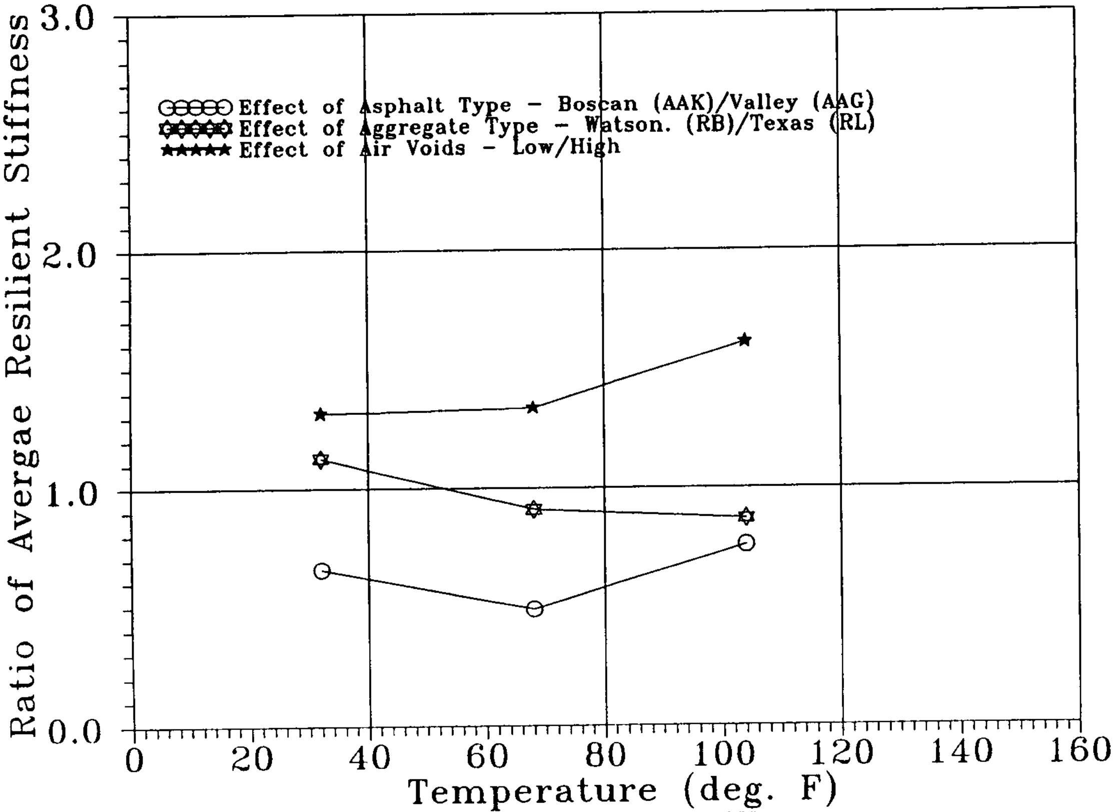

Figure 2.10. Ratio of average diametral resilient stiffness versus temperature

The axial and diametral stiffnesses were also analyzed statistically with a general linear model (GLM), the formulation of which is summarized below.

Statistical Analysis of Test Results

The main purpose of the statistical analysis was to determine the sensitivity of the stiffness to mix and test variables. One of the assumptions necessary for analysis of variance (ANOVA) and general linear modeling is that the dependent and independent variables are normally distributed. Distributions for stiffness and stress/strain were reviewed and found to be log-normally distributed; therefore log transformations were used for ANOVA and general linear modeling using regression analysis.

Two responses were examined: 1) the logarithm of the resilient stiffness and 2) the ratio of the diametral stiffness to the axial stiffness. Independent variables in the GLMs included all seven of the mix and testing variables together with all two-factor interactions among them. Accordingly, for the GLM, a log-linear model of the following type was used:

$$\begin{aligned} Y_i = \mu & + \alpha_0*\text{Asph} + \alpha_1*\text{Aggr} + \alpha_2*\%\text{Asph} + \alpha_3*\text{Voids} + \alpha_4*\text{Temp} + \alpha_5*\text{Stress} + \alpha_6*\text{Freq} \\ & + \alpha_7*\text{Asph}*\text{Aggr} + \alpha_8*\text{Asph}*\%\text{Asph} + \alpha_9*\text{Asph}*\text{Voids} + \alpha_{10}*\text{Asph}*\text{Temp} \\ & + \alpha_{11}*\text{Asph}*\text{Freq} + \alpha_{12}*\text{Asph}*\text{Stress} + \alpha_{13}*\text{Aggr}*\%\text{Asph} + \alpha_{14}*\text{Aggr}*\text{Voids} \\ & + \alpha_{15}*\text{Aggr}*\text{Temp} + \alpha_{16}*\text{Aggr}*\text{Stress} + \alpha_{17}*\text{Aggr}*\text{Freq} + \alpha_{18}*\%\text{Asph}*\text{Voids} \\ & + \alpha_{19}*\%\text{Asph}*\text{Temp} + \alpha_{20}*\%\text{Asph}*\text{Stress} + \alpha_{21}*\%\text{Asph}*\text{Freq} + \alpha_{22}*\text{Voids}*\text{Temp} \\ & + \alpha_{23}*\text{Voids}*\text{Stress} + \alpha_{24}*\text{Voids}*\text{Freq} + \alpha_{25}*\text{Temp}*\text{Stress} + \alpha_{26}*\text{Temp}*\text{Freq} \\ & + \alpha_{27}*\text{Stress}*\text{Freq} \end{aligned} \tag{2.1}$$

where:

Y_i = response variable;
Y_1 = response variable — log-stiffness;
Y_2 = ratio of the diametral stiffness to axial stiffness;
μ = constant (grand mean);
α_i = model coefficients;
Asph = asphalt type;
Aggr = aggregate type;
%Asph = asphalt content;
Voids = percent air voids;
Temp = temperature;
Stress = stress; and
Freq = frequency.

The test method itself (axial or diametral), together with its interactions with the other factors, was added to the GLM for the logarithm of the resilient stiffness. All independent variables were represented as discrete, binary quantities except for temperature, which was treated as a continuous variable. Summary statistics from this modeling are as follows:

Statistic	Resilient Stiffness (Ln psi)	Ratio of Diametral Stiffness to Axial Stiffness
Coefficient of Determination (R^2)	0.962	0.587
Root Mean Square Error	0.281	0.281
Coefficient of Variation (%)	28.7	19.4

1 psi = 6.89 kPa.

Table 2.9 indicates which effects are statistically significant at the 95 percent ($\underline{P} < .05$) probability level. That is, there is a 5 percent or smaller chance that the observed effect could have resulted from a situation in which there is really no effect. As indicated by the coefficient of determination, the fit of the GLM to the resilient stiffness data was good. The coefficient of variation of 28.7 percent compares favorably with the 16.7 to 36.6 percent range of stiffness measurements taken during the A-003A compaction study (Sousa et al. 1991). Although the fit of the GLM to the ratio data was not as good, numerous one-factor and two-factor effects were statistically significant. This means that some of the effects measured by axial test are quite different from the effects measured by diametral test. *Such differences could have serious implications for the evaluation of mix effects in a comprehensive asphalt-aggregate mix design and analysis system (AAMAS).*

The effects of asphalt type and air-void content on resilient stiffness are illustrated in figures 2.11 through 2.13. For the high-temperature testing (Figure 2.11), there appears to be little distinction between asphalt AAK-1 and AAG-1 based on axial resilient stiffness. At the same time, the diametral to axial stiffness ratio seems quite different for the two asphalts. This indicates that the effect of asphalt type on diametral stiffness might be considerably different than its effect on axial modulus. Table 2.10 confirms that the effect of asphalt type on average axial stiffness at 104°F (40°C) is small and statistically insignificant at the $\underline{P} < .05$ level, but the effect on diametral stiffness is much larger and statistically significant. Different results are obtained at lower temperatures (Figure 2.12 and 2.13). Here it appears that the combination of asphalt type AAK-1 with low air voids is similar to the combination of asphalt type AAG-1 with high voids in axial stiffness but not in diametral stiffness. The statistical comparisons in Table 2.10 confirm this finding for 32°F (0°C) but not for 68°F (0°C).

Mix stiffness is an important feature of the mix analysis and design system, and the above illustration simply underscores the fact that mix-design decisions involving fundamental mix properties might well be influenced by stiffness test method.

2.2.2 *Effect of Poisson's Ratio*

As reported earlier, diametral stiffnesses are about 35 to 45 percent greater than corresponding axial stiffnesses. Diametral resilient stiffnesses were computed using the following expression:

$$M_R = P\,(0.27 + \nu)/(Ht) \tag{2.2}$$

where P is the load in pounds, H is the total resilient horizontal deformation in inches, t is the specimen height in inches, and ν is the resilient Poisson's ratio.

Because it is difficult to accurately measure the resilient vertical deformation from which Poisson's ratio is calculated, it is often assumed to be 0.35. This convention has been adopted for most of the diametral stiffnesses reported here. However, a few computations of diametral stiffness were made using values for Poisson's ratio of 0.1 and 0.2, representative of behavior reported at higher frequencies and lower temperatures. The diametral stiffness based on a Poisson's ratio of 0.1 is about 60 percent of the stiffness obtained using a Poisson's ratio of 0.35 (Table 2.11).

Because it was clear that diametral resilient stiffness was sensitive to the assumed value of Poisson's ratio, it was of interest to learn whether axial and diametral results might converge if Poisson's ratios other than 0.35 were used in the computations. Through a trial-and-error process, Poisson's ratios were found for which average axial and diametral stiffnesses were identical. These ratios are summarized as follows:

Frequency (Hz)		**Temperature**	
	32°F (0°C)	68°F (20°C)	104°F (40°C)
0.5	0.19	0.16	0.13
1.0	0.18	0.17	0.19

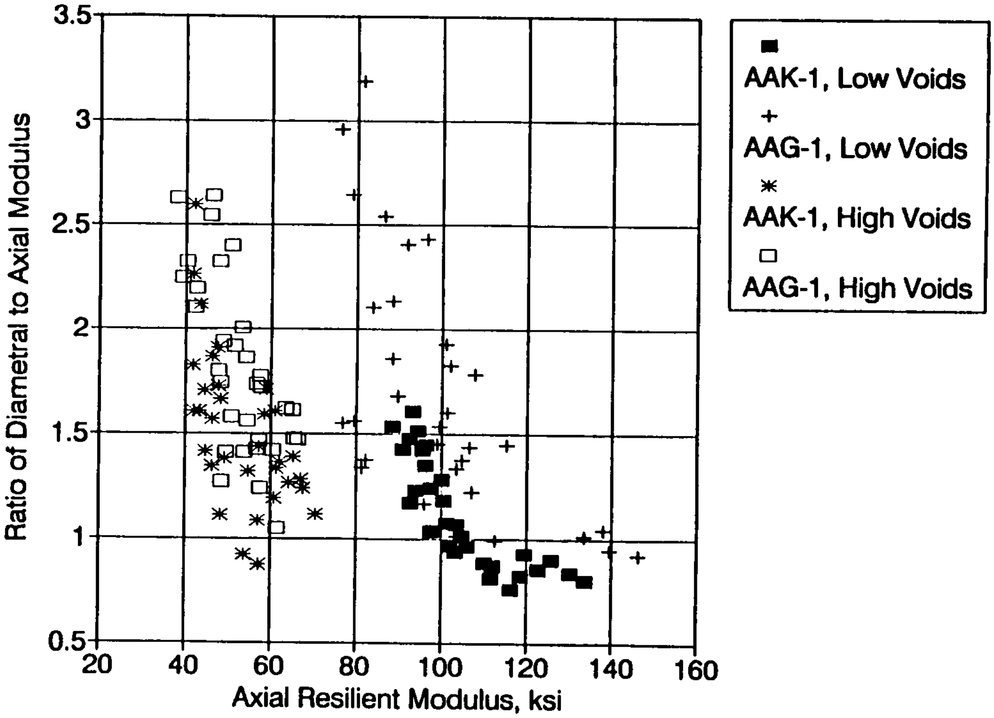

Figure 2.11. Effect of asphalt type and air-void content on resilient stiffnesses measurements at 104°F (40°C)

Table 2.9. Statistically significant effects in stiffness testing

Effect	Resilient Stiffness	Ratio of Diametral Stiffness to Axial Stiffness
Asphalt Type (Asph)	Yes[a]	No
Asphalt Content (%Asph)	No	Yes
Aggregate Type (Aggr)	No	No
Air Voids (%Voids)	Yes	Yes
Stress Level (Stress)	No	No
Loading Frequency (Freq)	No	No
Temperature (Temp)	Yes	No
Type of Test (Test)	Yes	N/A[b]
Asph × % Asph	No	Yes
Asph × Aggr	No	No
Asph × % Voids	No	Yes
Asph × Stress	No	No
Asph × Freq	No	No
Asph × Temp	Yes	Yes
Asph × Test	Yes	N/A
% Asph × Aggr	No	No
% Asph × % Voids	No	No
% Asph × Stress	No	No
% Asph × Freq	No	No
% Asph × Temp	Yes	No
% Asph × Test	No	N/A
Aggr × % Voids	No	Yes
Aggr × Stress	No	No
Aggr × Freq	No	No
Aggr × Temp	Yes	Yes
Aggr × Test	Yes	N/A
% Voids × Stress	No	Yes
% Voids × Freq	No	No
% Voids × Temp	Yes	Yes
% Voids × Test	Yes	N/A
Stress × Freq	No	No
Stress × Temp	Yes	No
Stress × Test	No	N/A
Freq × Temp	No	Yes
Freq × Test	No	N/A
Temp × Test	No	N/A

[a] Yes= significant at $P < .05$ level

[b] N/A =

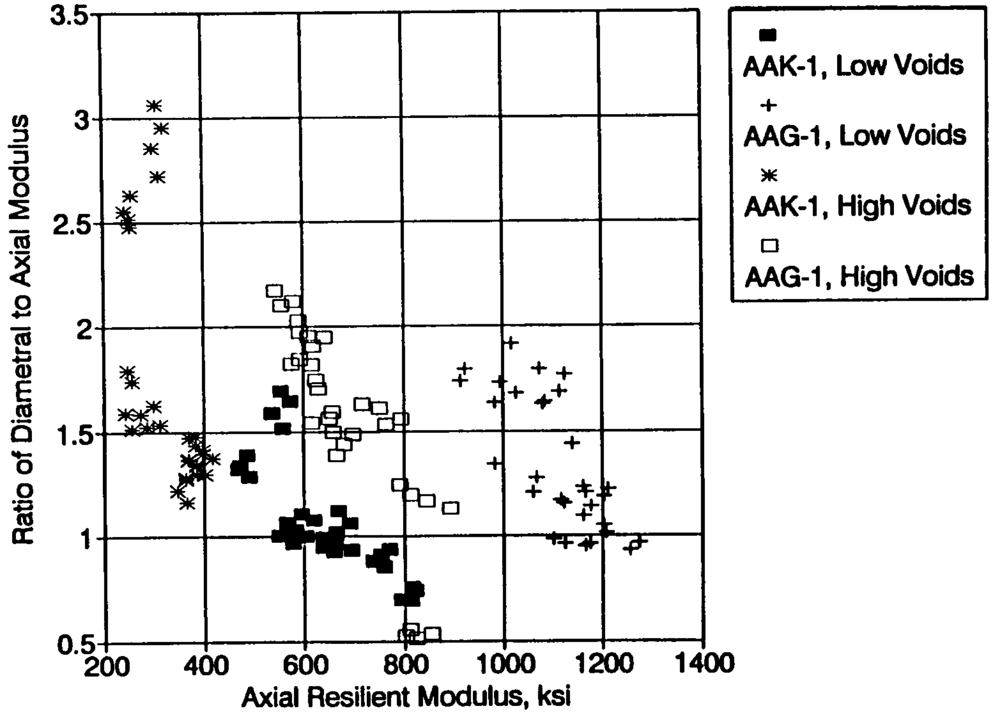

Figure 2.12. Effect of asphalt type and air-void content on resilient stiffnesses measurements at 68°F (20°C)

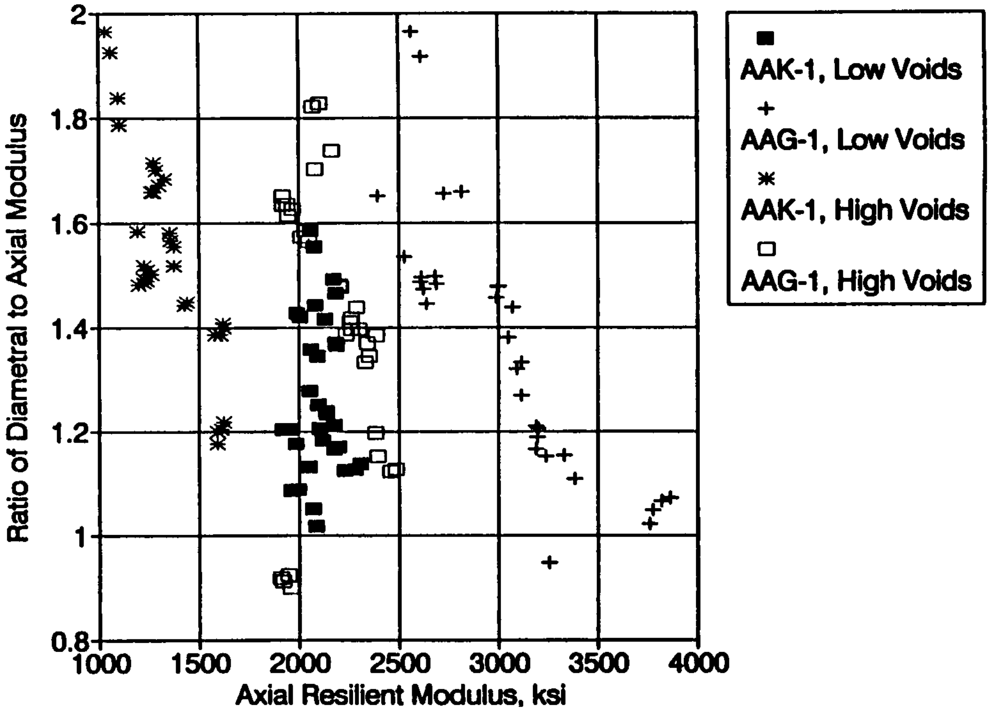

Figure 2.13. Effect of asphalt type and air-void content on resilient stiffnesses measurements at 32°F (0°C)

Table 2.10. Illustrative effect of test method on mix stiffness

Temperature °F (°C)	Mix	Axial Testing		Diametral Testing	
		Average Resilient Stiffness (ksi)	Statistically Significant Difference?	Average Resilient Stiffness (ksi)	Statistically Significant Difference?
104 (40)	AAK-1, Low Voids	104.7	No	114.9	Yes
	AAG-1, Low Voids	100.1		161.1	
	AAK-1, High Voids	53.3	No	78.6	Yes
	AAG-1, High Voids	52.6		92.6	
68 (20)	AAK-1, Low Voids	637.2	Yes	666.3	Yes
	AAG-1, High Voids	690.7		1,013	
32 (0)	AAK-1, Low Voids	2,100	No	2,659	Yes
	AAG-1, High Voids	2,159		3,032	

Table 2.11. Example effect of Poisson's ratio on diametral resilient stiffness (ksi) at 32°F (0°C) testing temperature

Test Number	Height (in.)	Load (lbs)	Horizontal Deformation 10^{-5} in.	Poisson's Ratio		
				0.10	0.20	0.35
1	2.61	443	5.02	1,250	1,590	2,100
2	2.61	400	4.44	1,280	1,620	2,140
3	2.61	855	9.85	1,230	1,560	2,060
4	2.61	841	9.52	1,250	1,590	2,100
5	2.56	426	5.62	1,100	1,390	1,840
6	2.56	379	4.87	1,130	1,430	1,890
7	2.56	845	11.4	1,070	1,360	1,790
8	2.56	781	10.3	1,090	1,390	1,830
Average				1,170	1,490	1,970

1 in. = 25.40 mm.
1 lb = .45 kg.

The variation among these ratios is extremely small, and the anticipated patterns — lower ratios at cooler temperatures and higher frequencies — were not demonstrated. Thus the observed differences between axial and diametral stiffnesses cannot be logically explained by assumptions about the values of Poisson's ratio.

Poisson's ratio was also a subject of inquiry in the National Cooperative Highway Research Program (NCHRP) investigation (Von Quintus et al. 1991). When the investigators computed Poisson's ratio on the basis of measurements of resilient deformation, both vertical and horizontal, they found extreme variations and concluded that many of the computed ratios were unrealistic and impractical. They attributed this to the inappropriateness of using linear elastic theory in deriving the expression for Poisson's ratio. The investigators recommended *assuming*, not *measuring*, Poisson's ratio for the purpose of routine mix design.

This limited study indicates that Poisson's ratio cannot be determined from the vertical and horizontal deformations that are measured in indirect tension tests, either because of excessive deformations that occur in the vicinity of the loading platens and influence vertical deformation measurements, or because of the inappropriateness of linear elastic theory. Moreover, it appears that diametral stiffnesses determined at temperatures below 68°F (20°C) should be computed using values of Poisson's ratio somewhat less than the 0.35 that is normally assumed.

2.2.3 High-Temperature Resilient Stiffnesses

Axial testing was also conducted at a fourth temperature, 140°F (60°C). During this testing, specimens containing high air-void contents — especially those with AAG-1 asphalt and aggregate RL — underwent excessive plastic (permanent) deformations. Nevertheless, these specimens exhibited relatively greater resilient stiffnesses than other specimens in which smaller levels of plastic deformation were observed (that is, those with asphalt AAK-1 and aggregate RB). Table 2.12 shows the average axial resilient stiffnesses at 140°F (60°C). The following should be noted at this temperature.

1. AAG-1 specimens containing granite (RB) show lower stiffnesses than those containing chert (RL) aggregate.

2. The axial stiffness is greater at higher than at lower stress levels. It should be noted that higher stress levels result in more plastic (permanent) deformation.

One explanation for these effects is as follows. When a specimen undergoes excessive plastic deformation, the resilient (elastic or recoverable) strain appears to be smaller since the specimen does not fully recover during the unloading period. Since the resilient stiffness is computed as the ratio of the applied stress to resilient strain, a weak specimen (which experiences large plastic strains and thus smaller resilient strain) exhibits an apparently greater stiffness. Figure 2.14 which shows the trace of the deformation versus time (number of repetitions) for a relatively weak specimen, indicates that the specimen does not recover fully during the unloading phase of the cycle. Further, the magnitude of the plastic deformation in just ten cycles is approximately four to five times that of the resilient deformation.

Similar observations were made during diametral testing at 104°F (40°C). At this temperature most of the specimens — especially those with high air-void contents — experienced large plastic deformations at relatively low stress levels (6 to 10 psi [41 to 69 KPa]) and at low numbers of repetitions (less than 25 to 50). Many of these specimens showed extensive cracking and shear failures (punching) near the loading strips. Because of the extensive distress obtained in specimens at this temperature, the diametral testing that had originally been planned for 140°F (60°C) was not performed. At this high temperature, it was expected that specimens containing high air voids, AAG-1 asphalt, and chert (RL) aggregate would fail even before testing could be initiated.

Table 2.12. Effect of mix and testing variables on average axial stiffness at 140°F (60°C)

			Granite (RB)		Chert (RL)	
Variable	Level	Air Voids	Average Stress, psi	Resilient Stiffness, psi	Average Stress, psi	Resilient Stiffness, psi
Asphalt Type	AAK-1	Low	6.7	29,100	7.0	27,500
		High	6.5	21,000	5.4	21,800
	AAG-1	Low	6.5	23,000	4.1	24,300
		High	6.6	19,800	4.3	20,900
Asphalt Content	Optimum	Low	6.6	26,600	5.7	25,500
		High	6.5	21,700	4.0	20,300
	High	Low	6.6	25,500	5.4	26,400
		High	6.6	19,200	5.7	22,400
Stress Level	Low	Low	4.9	24,500	3.9	25,100
		High	4.8	18,400	3.5	20,000
	High	Low	8.3	27,600	7.2	26,800
		High	8.4	22,500	6.3	22,700
Frequency	Low	Low	6.6	26,400	5.5	25,800
		High	6.6	20,600	4.9	21,500
	High	Low	6.6	26,100	5.6	26,100
		High	6.6	20,400	4.8	21,200
Repeats	First	Low	6.7	25,500	5.6	27,600
		High	6.6	19,100	5.0	22,800
	Second	Low	6.5	26,600	5.5	24,200
		High	6.6	21,800	4.7	20,000

1 psi = 6.89 kPa.

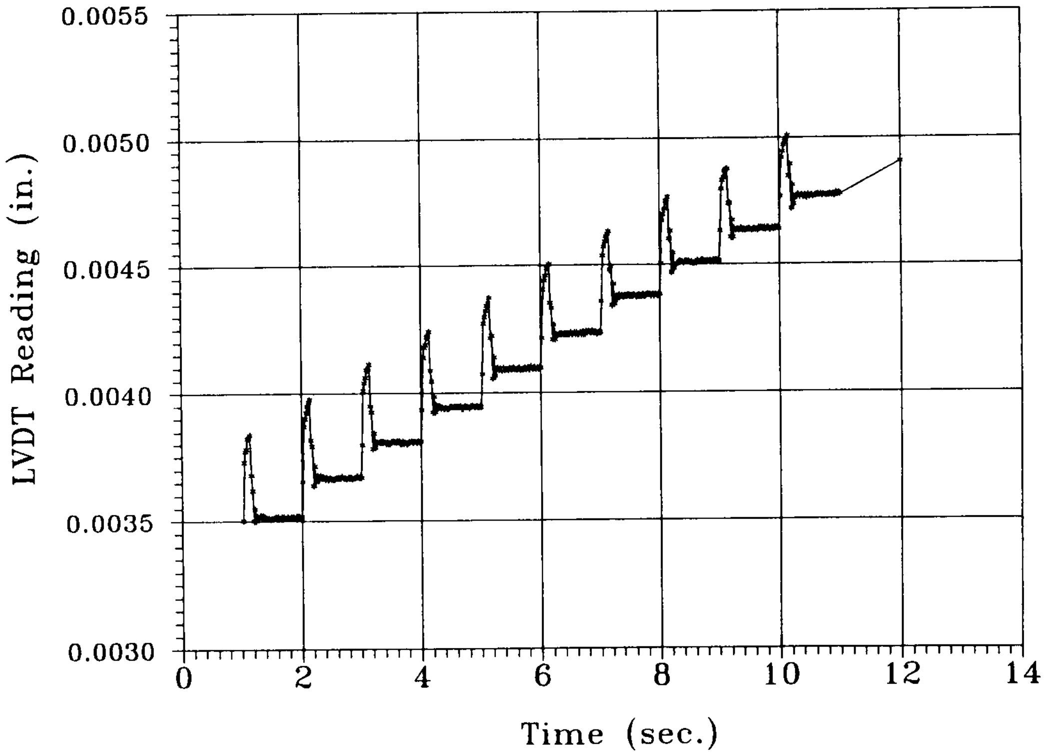

Figure 2.14. Example trace of axial deformation versus time under axial compressive testing

Figures 2.15 and 2.16 show the axial and horizontal deformations in a diametral test, respectively, versus time (number of load repetitions) for a relatively weak specimen tested at 104°F (40°C). It should be noted that both plots show extensive accumulation of permanent strain. It should also be noted that in just eleven load repetitions the axial plastic deformation is about 2.8×10^{-2} in. (7×10^{-1} mm), whereas the horizontal plastic deformation is about 6×10^{-4} in. (1.5×10^{-2} mm). The ratio of axial to horizontal plastic deformation is approximately 50, suggesting extensive localized failure (punching) near the loading strip.

2.3 Flexural Resilient Stiffness

As indicated earlier, evaluation of flexural stiffness was part of a larger experiment for evaluation of fatigue response of mixes (Tayebali et al. 1994a). Stiffness data reported here are those obtained during the controlled-strain flexural fatigue testing for the 2×2 pilot test program. Detailed treatment of the stiffness data has been presented elsewhere (Coplantz and Tayebali 1991; Tayebali et al. 1993) and is summarized in the sections that follow.

Flexural testing was conducted using beam specimens with a 1.5 in. × 1.5 in. (38 mm × 38mm) cross section and 15 in. (381 mm) length, subjected to repeated haversine loading at 1.67 Hz frequency with a load duration of 0.1 seconds. A total of 16 mixes were tested at two temperatures, 32° and 68°F (0° and 20°C).

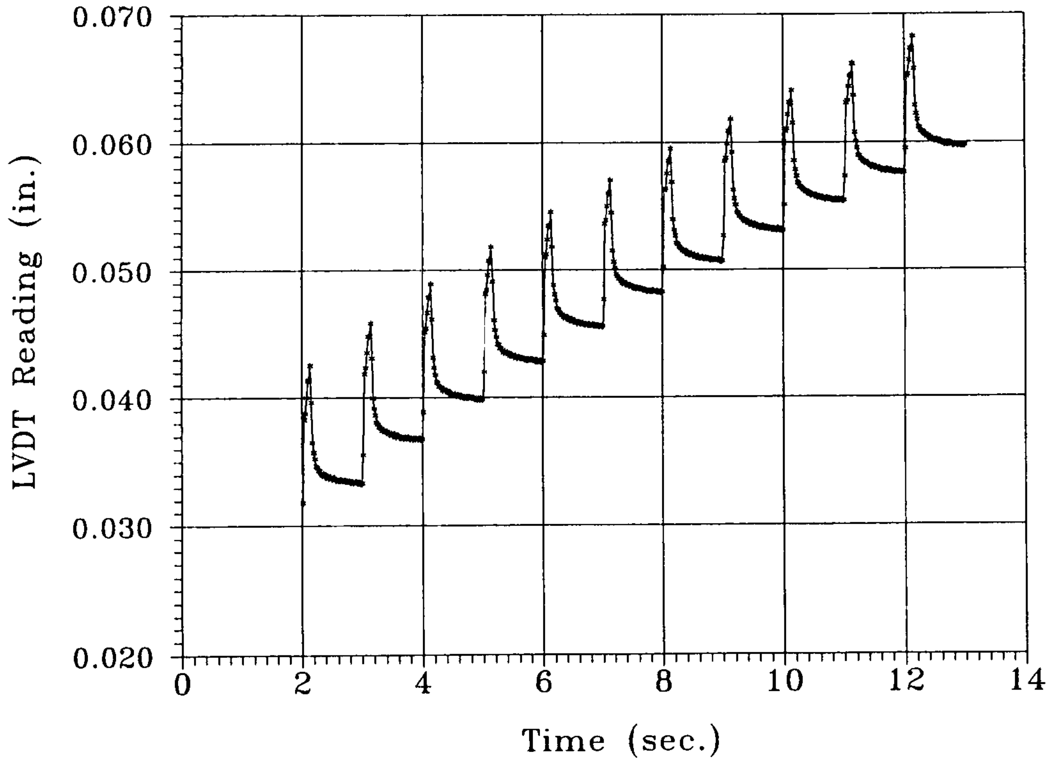

Figure 2.15. Example trace of axial deformation versus time under diametral testing

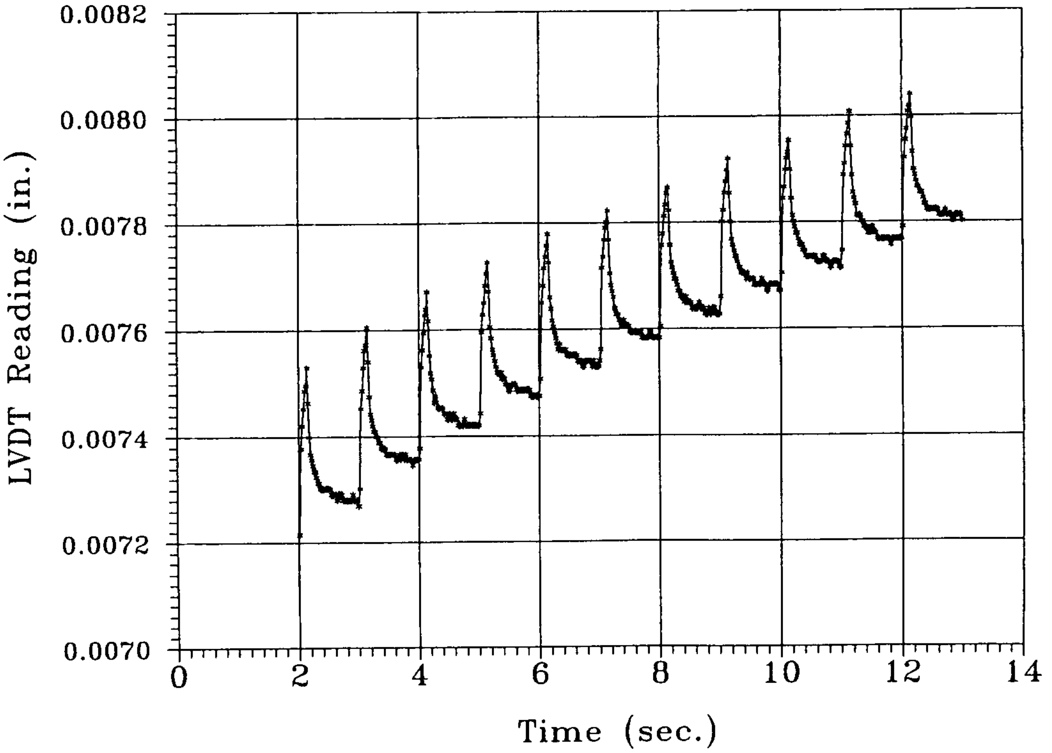

Figure 2.16. Example trace of horizontal deformation versus time under diametral testing

Because a half-factorial experiment design was used, a direct one-on-one comparison of the stiffnesses for different mixes was not possible. The flexural stiffnesses were analyzed statistically using a GLM formulation similar to that described for the axial and diametral stiffnesses. Summary statistics for this modeling are as follows:

Statistic	**Flexural Stiffness**
Coefficient of Determination (R^{2})	0.952
Root Mean Square Error (Ln)	0.158
Coefficient of Variation (%)	15.9

Table 2.13 indicates which main effects and interactions are statistically significant at the $\underline{P} < .05$ confidence level.

As indicated by the coefficient of determination, the fit of the GLM to the flexural stiffness data is good. The coefficient of variation of 15.9 percent compares favorably with the coefficients of variation determined for the axial and diametral stiffness data.

Table 2.14 shows the average values of stiffness, which were computed by first estimating the values for the complete data set using the GLM. The use of these regression models also facilitated corrections for the air-void contents and strain levels to the targeted low and high values for individual test results. The data set was then partitioned according to test temperature and independent variable under consideration, and the logarithmic average was obtained.

Analyses indicate that, for the test type under consideration, stiffness is sensitive to asphalt type, aggregate type, asphalt content, air-void content, and temperature. Strain level was not significant for the GLM, indicating that the stiffness is independent of the strain level, at least within the range evaluated in this study. In addition to the main effects, two-factor interactions between asphalt type and aggregate type, asphalt type and air-void content, asphalt type and temperature, and aggregate type and temperature were noted. Mixes containing asphalt AAG-1 exhibited greater stiffnesses at both temperatures, with the difference being larger at 68°F (20°C) than at 32°F (0°C). For both temperatures, the average stiffness for the optimum asphalt content is higher than that for the high asphalt content; mixes containing aggregate RB exhibit higher average stiffnesses than those containing aggregate RL; and mixes containing low air-void contents exhibit higher average stiffnesses than those containing high air-void contents. The interaction between asphalt type and temperature was anticipated because of the high temperature susceptibility of asphalt AAG-1.

Tables 2.15 and 2.16 compare the flexural, axial, and diametral stiffnesses as a function of mix and testing variables for 32° and 68°F (0° and 20°C), respectively. Average log-transformed stiffness values are also displayed in Figure 2.17 for these two temperatures. Statistical t-test analysis indicates that there is a significant difference among the axial, diametral and flexural stiffnesses at the $\underline{P} < .05$ level, with diametral stiffness exceeding both the axial and the flexural stiffnesses at both temperatures.

2.4 Summary

Comparison of uniaxial compression, indirect tension, and flexure testing of asphalt-aggregate mixes suggests the following:

1. Axial, diametral, and flexural stiffnesses are all sensitive to the mix and test variables, asphalt type, aggregate type, air-void content, and temperature.
2. In general, the axial, diametral, and flexure testing of asphalt-aggregate mixes will yield different estimates of their resilient stiffnesses.
3. Diametral stiffnesses computed using an assumed Poisson's ratio of 0.35 generally exceed both axial and flexural stiffnesses by 35 to 45 percent.

Table 2.13. Statistically significant effects in GLM of 2×2 experiment for flexural stiffness

Effect	Flexural Stiffness
Intercept	Yes[a]
Asphalt Type (Asph)	Yes
Aggregate Type (Aggr)	Yes
Asphalt Content (% Asph)	Yes
Air Voids (% Voids)	Yes
Temperature (Temp)	Yes
Strain	
Asph * Aggr	Yes
Asph * % Asph	
Asph * % Voids	Yes
Asph * Temp	Yes
Asph * Strain	
Aggr * % Asph	
Aggr & % Voids	
Aggr * Temp	Yes
Aggr * Strain	
% Asph * % Voids	
% Asph * Temp	
% Asph * Strain	
% Voids * Temp	
% Voids * Strain	
Temp * Strain	

[a] Yes = significant at $\underline{P} < .05$ level.

Table 2.14. Average results from GLM of 2×2 data for flexural stiffness

Effect	Level	Temperature of 32°F (0°C)	Temperature of 68°F (20°C)
		Stiffness (psi)	Stiffness (psi)
Average		2,048,500	789,100
Asphalt Type	AAK-1	1,824,500	536,500
	AAG-1	2,299,900	1,160,500
	% Difference	21%	54%
Asphalt Content	Optimum	2,166,500	834,500
	High	1,936,900	746,100
	% Difference	-11%	-11%
Aggregate Type	RL	2,003,900	697,000
	RB	2,094,000	893,200
	% Difference	4%	22%
Air Voids	4 %	2,390,300	920,700
	8 %	1,755,500	676,200
	% Difference	-27%	-27%
Strain (micron)	200	2,084,900	803,100
	400	2,012,700	775,300
	% Difference	-3%	-3%

1 psi = 6.89 kPa.

Notes:

1. Air voids normalized to 4 and 8 percent.
2. Strain normalized to 200 and 400 micro in./in. (5,080 and 10,161 micro mm/mm).
3. Averages based on logarithmic means of regressed data.
4. Percentage difference is the difference expressed as a percentage of larger value.

4. Poisson's ratio, necessary in the determination of resilient stiffness in diametral testing, cannot be accurately determined in the diametral test and must be assumed based on measurements obtained with other test systems. Because Poisson's ratios must be assumed, diametral stiffnesses are likely to be less reliable than axial stiffnesses.

5. Diametral stiffnesses cannot be accurately measured at high temperatures and are not reliable at even moderately high temperatures (104°F [40°C]). The SHRP A-003A laboratory experience suggests that weak specimens cannot be tested at temperatures as high as 140°F (60°C). NCHRP investigators also urge caution in "...measuring the resilient modulus of elasticity and other properties at higher test temperatures using indirect tensile testing techniques" (von Quintus et al. 1991). While they include 104°F (40°C) in their recommended test regime, the large permanent deformations observed in the SHRP A-003A testing cast serious doubt on the reliability of measurements at such temperatures. It seems preferable to limit indirect tension testing for resilient stiffness measurements to temperatures not greatly exceeding 68°F (20°C).

6. Mix and testing effects on resilient stiffness may be different depending on whether loading is by axial compression, indirect tension or flexure. By inference, structural pavement design may differ depending on the type of testing system.

Table 2.15. Effect of mix and testing variables on average flexural, axial and diametral stiffness at 32°F (0°C)

Variable	Level	Flexural	Average Resilient Stiffness, psi Axial	Diametral
Asphalt Type	AAK-1	1,825,000	1,720,000	2,350,000
	AAG-1	2,230,000	2,600,000	3,550,000
Asphalt Content	Optimum	2,167,000	2,130,000	3,100,000
	High	1,937,000	2,190,000	2,800,000
Aggregate Type	Granite (RB)	2,094,000	2,190,000	3,130,000
	Chert (RL)	2,004,000	2,130,000	2,770,000
Air Voids	Low	2,390,000	2,570,000	3,360,000
	High	1,756,000	1,750,000	2,530,000
Stress/Strain Level	Low	2,085,000	2,160,000	2,950,000
	High	2,013,000	2,160,000	2,950,000
Average Stress/ Strain Level		2,049,000	2,160,000	2,950,000

1 psi = 6.89 kPa.

Table 2.16. Effect of mix and testing variables on average flexural, axial, and diametral stiffness at 68°F (20°C)

Variable	Level	Flexural	Average Resilient Stiffness, psi Axial	Diametral
Asphalt Type	AAK-1	537,000	483,000	612,000
	AAG-1	1,160,000	902,000	1,240,000
Asphalt Content	Optimum	835,000	663,000	1,040,000
	High	746,000	722,000	804,000
Aggregate Type	Granite (RB)	893,000	757,000	883,000
	Chert (RL)	697,000	628,000	964,000
Air Voids	Low	921,000	876,000	1,060,000
	High	676,000	509,000	786,000
Stress/Strain Level	Low	803,000	698,000	948,000
	High	775,000	687,000	900,000
Average Stress/ Strain Level		789,000	692,000	924,000

1 psi = 6.89 kPa.

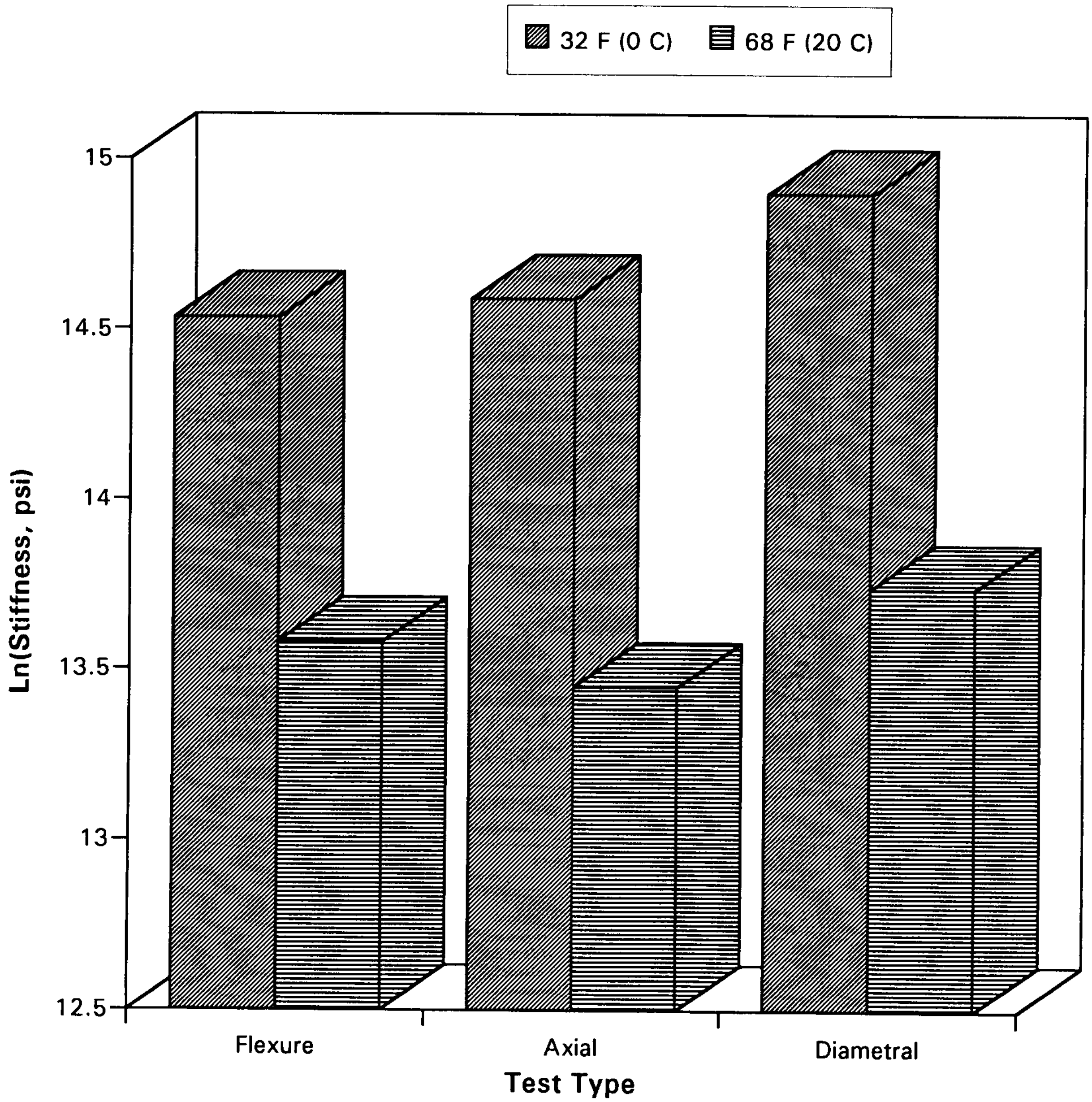

Figure 2.17. Effect of test type on average stiffness at 32° and 68°F (0°and 20°C)

3

8×2 Expanded Test Program

3.1 Introduction

The SHRP materials testing protocol is expected to specify the use of the *shear frequency* sweep test for Level 1 of the abridged mix design and analysis procedure. Level 1 of the abridged procedure for mix design and analysis system for fatigue, as outlined in Part III—Mix Design and Analysis of the fatigue report titled "Fatigue Response of Asphalt-Aggregate Mixes" (Deacon et al. 1994), requires an estimate of the *flexural stiffness* and *flexural loss-stiffness* of the asphalt-aggregate mixes at 68°F (20°C). The flexural stiffness estimate is used in the multilayer elastic analysis to determine the critical level of strain to which the mix is subjected under the traffic load. The flexural loss-stiffness (product of the stiffness and sine of the phase angle between stress and strain) estimate is required to estimate fatigue life of mixes using surrogate fatigue models.

A summary of the flexural stiffness results obtained from the 8×2 expanded fatigue test program is presented here; details are presented elsewhere (Coplantz and Tayebali 1992; Tayebali et al. 1994b). Following this summary, results of the shear frequency sweep tests are presented along with the summary of linear regression calibrations for estimating the flexural stiffness and loss-stiffness based on shear stiffness.

3.2 Mix and Testing Variables

The mix and testing variables included in this expanded testing program were as follows:

Asphalts. Eight MRL asphalts were used: AAA-1, AAB-1, AAC-1, AAD-1, AAF-1, AAG-1, AAK-1, and AAM-1.

Aggregates. Two MRL aggregates were used: RD, a limestone characterized as having low absorption; and RH, a Greywacke gravel. Both materials were 100 percent crushed products with a history of extensive use in their particular place of origin.

Asphalt Content. A single asphalt content for each aggregate combination was incorporated into the mixes 4.3 and 4.9 percent by weight of mix (4.5 and 5.2 percent by weight of aggregate) for RD and RH aggregates, respectively.

Air-Void Contents. Two levels of air-void content, 4 and 7 percent, were selected as targets, with a tolerance of ±1 percent in recognition of the variability expected from slabs prepared with rolling wheel compaction.

Strain Levels. For the flexural test, two strain levels were used: 400 and 700 micro in./in. (10,160 and 17,780 micro mm/mm). For the shear stiffness tests, a 100 micro in./in. (254 micro mm/mm) strain level was used.

Test Frequency. All flexural tests were performed under the controlled-strain mode of loading at a frequency of 10 Hz under sinusoidal loading with no rest periods. For shear stiffness tests, seven frequencies were used: 10, 5, 2, 1, 0.5, 0.2, and 0.1 Hz.

Test Temperature. Flexural tests were performed at 68°F (20°C), while shear stiffness tests were performed at 39°, 68°, and 104°F (4°, 20°, and 40°C).

Conditioning. All mixes were short-term and oven-aged (forced draft oven at 275°F [135°C] for 4 hr).

Compaction Method. All specimens were sawed to the required dimensions from asphalt concrete slabs compacted using the rolling wheel procedure (Harvey 1990).

Features of this experiment, referred to as the 8×2 experiment since it includes eight different asphalts and two different aggregates, are summarized in Tables 3.1 and 3.2. Table 3.3 indicates the asphalt binders[1] and aggregates used. The aggregate gradation is identified in Table 3.4. The experiment design used in this study is a full factorial design consisting of 32 individual mixes.

Testing protocols for flexure and shear stiffness used were similar to those described in SHRP protocols M-009 and M-003.

3.3 Flexural and Shear Stiffness Test Results

The flexural stiffness results for the 8×2 expanded test program are in Appendix D. To model relationships between flexural and shear properties, a shear stiffness test program was conducted on the same 32 mixes tested for the flexural stiffness in the 8×2 expanded test program. Two sets of tests were conducted. The first tests were simple shear tests on prismatic specimens 2.0 in. × 2.5 in. × 6.0 in. (50.8 mm × 63.5 mm × 152.4 mm) at 68°F (20°C) and at 10 Hz frequency (the conditions at which the flexural fatigue tests were conducted) to evaluate mix shear stiffness. The second tests were shear frequency sweep tests on similar prismatic specimens for the same 32 mixes at three different temperatures and seven different frequencies (see table 3.2) to evaluate mix shear stiffness as a function of temperature and frequency. The shear stiffness results are in Appendixes D and E.

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[1] Table 2.3 contains a summary of the properties for the eight MRL core asphalts used here.

Table 3.1. Features of 8×2 flexural fatigue experiment

Number of asphalts	8 — MRL core asphalts (AAA-1, AAB-1, AAC-1, AAD-1, AAF-1, AAG-1, AAK-1, and AAM-1)
Number of aggregates	2 — MRL aggregates (RH and RD)
Asphalt content	1 — Optimum (Hveem) 5.2 percent and 4.5 percent by weight of aggregate for RH and RD aggregate respectively
Air-void levels	2 — 4 ± 1 and 7 ± 1 percent
Strain levels	2 — 400 and 700 micro in./in. (10,160 and 17,780 micro mm/mm)
Replicates at each strain level	2
Temperature	1 — 68°F (20°C)
Frequency	1 — 10 Hz (sinusoidal)
Specimen size	2-in. height, 2.5-in. width, 15-in. length (50.8-mm height, 63.5-mm width, 381-mm length)
Total number of mixes tested	32
Total number of specimens tested	128

Table 3.2. Features of 8×2 shear frequency sweep experiment

Number of asphalts	8 — MRL core asphalts (AAA-1, AAB-1, AAC-1, AAD-1, AAF-1, AAG-1, AAK-1, and AAM-1)
Number of aggregates	2 — MRL aggregates (RH and RD)
Asphalt content	1 — Optimum (Hveem) 5.2 percent and 4.5 percent by weight of aggregate for RH and RD aggregate respectively
Air-void levels	2 — 4 ± 1 and 7 ± 1 percent
Strain levels	1 — 100 micro in./in. (2,540 micro mm/mm)
Temperature	3 — 39°, 68°, and 104°F (4°, 20°, and 40°C)
Frequency	7 — 10, 5, 2, 1, 0.5, 0.2, and 0.1 Hz (sinusoidal)
Specimen size	2-in. height, 2.5-in. width, 6-in. length (50.8-mm height, 63.5-mm width, 381-mm length)
Total number of mixes tested	32
Total number of specimens tested	32

Table 3.3. Asphalt binders and aggregates used in 8×2 experiment

Asphalts (MRL Code)	Grade	Penetration Index (PI)
AAA-1	150/200 Pen Grade	0.7
AAB-1	AC-10	0.0
AAC-1	AC-8	-0.6
AAD-1	AR-4000	1.0
AAF-1	AC-20	-1.0
AAG-1	AR-4000	-1.4
AAK-1	AC-30	-0.5
AAM-1	AC-20	-0.2
Aggregates (MRL Code)	Characteristics	
RB	Watsonville granite, crushed, rough surface texture	
RD	Limestone, low absorption crushed quarry rock	
RH	Greywacke river gravel, partially crushed	
RL	Texas chert, partially crushed, smooth surface texture	

Table 3.4. Aggregate gradation

Sieve Size	Percent Passing by Weight	ASTM Spec. (D 3515)
1 in.	100	100
‹ in.	95	90-100
½ in.	80	—
⅜ in.	68	56-80
No. 4	48	35-65
No. 8	35	23-49
No. 16	25	—
No. 30	17	—
No. 50	12	5-19
No. 100	8	—
No. 200	5.5	2-8
Pan		

1 in. = 25.40 mm

Flexural and shear stiffness results obtained at 68°F (20°C) and 10 Hz frequency were analyzed with a GLM similar to that outlined for the axial and diametral stiffness results. Details of the analysis for the 8×2 flexural stiffness data have been reported by Coplantz and Tayebali (1992), and results are summarized in the following sections.

The results of the ANOVA from the GLM indicate that the dependent (response) variables, flexural stiffness and shear stiffness, can be explained by the main effects of asphalt source, aggregate source, and air voids, and their two-factor interactions (Table 3.5). Note that all main effects are significant above the $\underline{P} < .05$ level. Summary statistics from the GLM for both stiffnesses are presented in Table 3.6. Note that the coefficient of variation and coefficient of determination for the stiffnesses are similar. In addition, these results are similar to those obtained for the 2×2 axial stiffness data (Table 2.12), including asphalt type and aggregate type, and asphalt type and air-void level interactions for flexural stiffness.

Table 3.5. Statistically significant effects in GLM for flexural and shear stiffness (8×2 test program)

Factor/Interaction	Initial Flexural Stiffness	Initial Shear Stiffness
Asphalt Source	H	H
Aggregate Source	H	H
Air Voids	H	H
Strain	H	
Asphalt Source * Aggregate Source	H	
Asphalt Source * Air Voids	H	S
Asphalt Source * Strain		
Aggregate Source * Air Voids		
Aggregate Source * Strain	B	
Air voids * Strain		

H = highly significant (< than 0.01); S = Significant (< 0.01 - 0.05); B = barely significant (< 0.10); Blank = not significant (> 0.10).

Table 3.6. Summary statistics from the GLM for flexural and shear stiffness (8×2 test program)

Statistics	Initial Flexural Stiffness	Initial Shear Stiffness
Coefficient of determination (R^2)	0.960	0.972
Root mean square error (Ln)	0.120	0.114
Coefficient of variation (%)	11.90	11.40

Coefficient of variation = $100 * (e^{MSE} - 1)^{0.5}$. e = base of natural logarithm. MSE = Mean square error.

An overall summary of the response variables is presented in Table 3.7. The effect of asphalt source on mix stiffness is explored in the following sections. Compared to mixes containing the RD aggregate (with all other variables being constant), the average stiffness of mixes containing RH aggregate is lower by approximately 29 percent for flexural stiffness and 32 percent for shear stiffness. Comparing the effect of air voids, increasing air-void content from an average of 4 to 7 percent decreased the overall average stiffness of mixes by approximately 20 percent for both flexure and shear tests. The overall effect of aggregate and air voids is summarized below:

Effect	**Initial Flexural Stiffness**	**Initial Shear Stiffness**
Aggregate Source	29% decrease from RD to RH	32% decrease from RD to RH
Air voids	20% decrease from low to high	19.5% decrease from low to high

Table 3.8 summarizes the performance of two MRL asphalts, AAK-1 and AAG-1, with respect to flexural stiffness in two different experiments (8×2 and 2×2). Although both experiments used third-point flexural beam fatigue tests in controlled-strain mode of loading at 68°F (20°C), all other variables (including aggregate source, strain level, test equipment, specimen size, loading frequency, and pattern) were different for the two experiments. Performance of these two MRL asphalts are identical in both experiments, with mixes containing AAK-1 asphalt showing lower average stiffness moduli than mixes containing AAG-1 asphalt.

Flexural stiffness comparison between mixes containing different asphalts was accomplished through a combination of graphic and statistical analyses. All comparisons were made using response variables adjusted for air voids, and comparison of means was based on log-transformed response variables. The purpose of the comparisons was to 1) classify asphalts into groups of similar performance and 2) distinguish asphalts that perform better than average from those that perform worse than average.

Mixes containing asphalts AAG-1 and AAF-1 were consistently rated the highest, regardless of aggregate source or air-void level. Mixes containing asphalt AAA-1 consistently showed the least stiffness. The Tukey pairwise-comparison matrix across aggregates, air voids, and replicates verified that mixes with asphalt AAA-1 had the least stiffness and that mixes with asphalt AAG-1 had greater stiffness than those with asphalt AAF-1, with a significance of approximately 94 percent. The remaining mixes fell between these two extremes, with mixes containing asphalts AAC-1, AAK-1, and AAM-1 having generally greater stiffness than mixes with asphalts AAB-1 and AAD-1. Based on the graphic results and confirmation with contrast statements, mixes were grouped by flexural stiffness across aggregates, air voids, strain, and replicates as follows:

Lowest Flexural Stiffness Performance Group 1	Group 2	Group 3	**Highest Flexural Stiffness Performance** Group 4
AAA-1	AAB-1	AAC-1	AAF-1
	AAD-1	AAK-1	AAG-1
		AAM-1	

Table 3.7. Average stiffness for 8×2 flexural and shear test program

Effect	Initial Flexural Stiffness (psi)	Initial Shear Stiffness (psi)
Asphalt Source		
AAA-1	295,400	101,900
AAB-1	409,900	141,100
AAC-1	552,700	213,900
AAD-1	386,200	161,000
AAF-1	1,033,000	317,800
AAG-1	1,172,700	357,800
AAK-1	592,800	202,600
AAM-1	604,800	199,900
% Difference[a]	75%	72%
Aggregate Source		
RH	480,900	162,700
RD	676,800	238,900
% Difference	29%	32%
Air Voids		
Low	638,800	219,679
High	509,500	176,911
% Difference	-20%	19.5%

1 psi = 6.89 kPa.

[a] Percentage difference between asphalt source AAA-1 and AAG-1.

Notes:
1. Averages based on the mean of log-transformed data.
2. Percent difference is the expressed as a percentage of the larger value, not the initial value.

Table 3.8. Average flexural stiffness for asphalt source AAK-1 and AAG-1 for the 8×2 and 2×2 test programs

Test Type	Asphalt Source	Flexural Stiffness (psi)
Flexural Fatigue 8×2 Experiment (32°F [0°C])[a]		
Third point sinusoidal loading, 10 Hz frequency, 2 in. × 2.5 in. × 15 in. (51 mm × 64 mm × 381 mm) specimen, RH and RD aggregates, rolling wheel compaction, hydraulic test system	AAK-1 AAG-1	592,800 1,172,700
	% Difference	49%
Flexural Fatigue 2×2 Experiment (68°F [20°C])[b]		
Third point haversine pulse loading, 0.1 sec. loading time, 1.67 Hz frequency, 1.5 in. × 1.5 in × 15 in. (38 mm × 38 mm × 380 mm) specimen, RB and RL aggregates, kneading compaction, pneumatic test system	AAK-1 AAG-1	536,500 1,160,500
	% Difference	54%

1 psi = 6.89 kPa.

[a] Low and high strains correspond to 400 and 700 micro in./in. (10,160 and 17,780 micro mm/mm). Low and high air voids correspond to 4 percent and 7 percent.
[b] Low and high strains correspond to 200 and 400 micro in./in. (5,080 and 10,160 micro mm/mm). Low and high air voids correspond to 4 percent and 8 percent.

Notes:
1. Averages based on the mean of log-transformed data.
2. Percentage difference is the expressed as a percentage of larger value.

3.4 Surrogate Flexural Stiffness Models Based on Shear Stiffness

This section presents regression calibrations for estimating flexural stiffness (and loss-stiffness) and phase angle from the shear stiffness and phase angle, at 68°F (20°C) and 10 Hz frequency. These measures are to be used in Level 1 of the abridged procedure for the mix design and analysis system for fatigue developed as a part of SHRP contract A-003A.

For measurements at 68°F (20°C) and 10 Hz frequency, a linear regression calibration resulted in the following relationships between flexural and shear properties:

$$S_o = 8.560\,(G_o)^{0.913} \qquad R^2=0.712 \tag{3.1}$$

$$S_o'' = 81.125\,(G_o'')^{0.725} \qquad R^2=0.512 \tag{3.2}$$

$$\sin\phi_{S_o} = 1.040\,(\sin\phi_{G_o})^{0.817} \qquad R^2=0.810 \tag{3.3}$$

where:
S_o = initial flexural stiffness, psi;
S_o'' = initial flexural loss-stiffness, psi;
G_o = initial shear stiffness, psi;

G''_o = initial shear loss-stiffness, psi;
ϕ_{So} = initial phase angle between stress and strain in flexure; and
ϕ_{Go} = initial phase angle between stress and strain in shear.

Results of the regression calibrations are presented in Tables 3.9 and 3.10.

Table 3.9. Results of the regression calibration for estimation of flexural stiffness (S_o) based on shear stiffness

Variable	Coefficient	STD Error	STD Coef	Tolerance	T	p (2-tail)
Constant	2.147	0.858	0.000		2.502	0.015
Ln(G_o)	0.913	0.070	0.844	1.000	12.968	0.000

Analysis of Variance

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Regression	12.908	1	12.908	168.168	0.000
Residual	5.129	68	0.077		

Dependent Variable = Ln(S_o); N = 70; Multiple R = 0.844; Squared Multiple R = 0.712; Adjusted Squared Multiple R = 0.708; Standard Error of Estimate = 0.277; STD = Standard; DF= degree of freedom.

Table 3.10. Results of the regression calibrations for estimation sine of phase angle ($\sin\phi_{So}$) in flexure based on sine of phase angle in shear

Variable	Coefficient	STD Error	STD Coef	Tolerance	T	p (2-tail)
Constant	0.039	0.039	0.000		0.981	0.330
Ln($\sin\phi_{Go}$)	0.817	0.049	0.898	1.000	16.825	0.000

Analysis of Variance

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Regression	2.720	1	2.720	283.070	0.000
Residual	0.635	68	0.010		

Dependent Variable = Ln($\sin\phi_{So}$); N = 70; Multiple R = 0.898; Squared Multiple R = 0.806;
Adjusted Squared Multiple R = 0.803; Standard Error of Estimate = 0.098; STD = Standard; DF = Degree of freedom.

3.5 Summary

The SHRP materials testing protocol is expected to specify the use of a shear frequency *sweep test* for Level 1 of the abridged mix design and analysis procedure. Level 1 of the abridged procedure for the mix design and analysis system for fatigue requires an estimate of the *flexural stiffness* and *flexural loss-stiffness* of the asphalt-aggregate mixes at 68°F (20°C) and 10 Hz frequency.

The flexural stiffness estimate is used in the multilayer elastic analysis to determine critical level of strain to which the mix is subjected under traffic load. The flexural loss-stiffness estimate is required to estimate fatigue life of mixes using surrogate fatigue models.

Evaluation of flexural and shear stiffnesses of the 32 mixes containing 8 core MRL asphalt and 2 MRL aggregates at two air-void levels confirmed findings from the earlier 2×2 pilot test program. Major findings include the following:

1. Both flexural and shear stiffnesses are sensitive to mix variables — asphalt type (source), aggregate type (source), and air-void levels.

2. Mix variables seem to have similar effects on both the flexural and shear stiffness with (1) mixes containing asphalt AAA-1 having the lowest stiffness as compared to mixes containing asphalt AAG-1; (2) mixes prepared with RH aggregate having lower stiffness than those containing RD aggregate; and (3) as anticipated, mixes with high voids showing lower stiffness than those with lower voids.

3. Models that can be used to estimate flexural stiffness (and loss-stiffness) based on shear stiffness at 68°F (20°C) and 10 Hz frequency are the following:

$$S_o = 8.560\,(G_o)^{0.913}$$

$$S''_o = 81.125\,(G''_o)^{0.725}$$

where:

S_o = initial flexural stiffness, psi
S''_o = initial flexural loss-stiffness, psi
G_o = initial shear stiffness, psi
G''_o = initial shear loss-stiffness, psi

4

Summary

Several test systems for stiffness determination of asphalt-aggregate mixes were evaluated under SHRP contract A-003A, Task C.6, Complementary Investigations. Included in this evaluation were (1) axial resilient stiffness, (2) diametral resilient stiffness, (3) resilient and dynamic flexural stiffness, and (4) dynamic shear stiffness.

All stiffness test systems were found to be sensitive to mix and test variables, especially to asphalt type (source), asphalt content, aggregate type (source), and air-void content, with each of these variables having either a direct effect on stiffness or an indirect effect through interactions with other variables.

As expected, temperature had by far the most influence on stiffness for axial, diametral, and flexural stiffnesses. Although the effects of temperature and frequency on shear stiffness were not discussed, the results in Appendix F are expected to show shear stiffness sensitivity to both these variables.

Major findings from this study are as follows:

1. Axial, diametral, flexural, and shear stiffnesses are all sensitive to the mix and test variables — asphalt type, aggregate type, air-void content, and temperature.

2. In general, the axial, diametral, and flexure testing of asphalt-aggregate mixes will yield different estimates for their resilient stiffnesses.

3. Diametral stiffnesses computed assuming a Poisson's ratio of 0.35 generally exceed both axial and flexural stiffnesses by approximately 35 to 45 percent.

4. Poisson's ratio, necessary for the determination of resilient stiffness in diametral testing, cannot be accurately determined in the diametral test and must be assumed based on measurements obtained with other test systems. Because Poisson's ratios must be assumed, diametral stiffnesses are likely to be less reliable than axial stiffnesses.

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Appendix A

Axial Resilient Stiffness Test Results

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	T	0	0	0	0	1	.	S	A	R	32 F	4.1	31.8	15.29	2.08E+06
B	0	T	0	0	0	1	1	.	S	A	R	32 F	4.1	30.7	14.46	2.13E+06
B	0	T	0	0	1	0	1	.	S	A	R	32 F	4.1	62.6	28.71	2.18E+06
B	0	T	0	0	1	1	1	.	S	A	R	32 F	4.1	60.1	27.47	2.19E+06
B	0	T	0	0	0	0	2	.	S	A	R	32 F	4.0	32.0	14.67	2.18E+06
B	0	T	0	0	0	1	2	.	S	A	R	32 F	4.0	31.0	14.26	2.17E+06
B	0	T	0	0	1	0	2	.	S	A	R	32 F	4.0	63.4	30.58	2.07E+06
B	0	T	0	0	1	1	2	.	S	A	R	32 F	4.0	60.4	29.34	2.06E+06
B	0	T	1	0	0	0	1	.	S	A	R	32 F	8.1	30.8	27.78	1.24E+06
B	0	T	1	0	0	1	1	.	S	A	R	32 F	8.1	29.5	23.34	1.27E+06
B	0	T	1	0	1	0	1	.	S	A	R	32 F	8.1	61.8	49.78	1.24E+06
B	0	T	1	0	1	1	1	.	S	A	R	32 F	8.1	58.5	47.72	1.23E+06
B	0	T	1	0	0	0	2	.	S	A	R	32 F	8.1	31.7	20.04	1.58E+06
B	0	T	1	0	0	1	2	.	S	A	R	32 F	8.1	30.2	18.80	1.61E+06
B	0	T	1	0	1	0	2	.	S	A	R	32 F	8.1	62.0	38.23	1.62E+06
B	0	T	1	0	1	1	2	.	S	A	R	32 F	8.1	59.0	36.37	1.62E+06
B	1	T	0	0	0	0	1	.	S	A	R	32 F	4.0	30.4	13.85	2.20E+06
B	1	T	0	0	0	1	1	.	S	A	R	32 F	4.0	29.1	13.65	2.13E+06
B	1	T	0	0	1	0	1	.	S	A	R	32 F	4.0	62.4	27.36	2.28E+06
B	1	T	0	0	1	1	1	.	S	A	R	32 F	4.0	58.7	25.39	2.31E+06
B	1	T	0	0	0	0	2	.	S	A	R	32 F	3.6	31.1	14.88	2.09E+06
B	1	T	0	0	0	1	2	.	S	A	R	32 F	3.6	29.9	15.02	1.99E+06
B	1	T	0	0	1	0	2	.	S	A	R	32 F	3.6	60.7	29.52	2.06E+06
B	1	T	0	0	1	1	2	.	S	A	R	32 F	3.6	58.7	29.32	2.00E+06
B	1	T	1	0	0	0	1	.	S	A	R	32 F	8.3	30.7	23.56	1.30E+06
B	1	T	1	0	0	1	1	.	S	A	R	32 F	8.3	29.4	22.11	1.33E+06
B	1	T	1	0	1	0	1	.	S	A	R	32 F	8.3	61.7	45.47	1.36E+06
B	1	T	1	0	1	1	1	.	S	A	R	32 F	8.3	58.5	42.99	1.36E+06
B	1	T	1	0	0	0	2	.	S	A	R	32 F	8.5	31.2	30.17	1.03E+06
B	1	T	1	0	0	1	2	.	S	A	R	32 F	8.5	30.0	28.32	1.06E+06
B	1	T	1	0	1	0	2	.	S	A	R	32 F	8.5	62.6	57.02	1.10E+06
B	1	T	1	0	1	1	2	.	S	A	R	32 F	8.5	59.9	54.34	1.10E+06

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation	Temp. F	Percent Voids	Stress psi.	Strain Micro in./in.	Resilient Modulus psi
AT AC A V TP ST F r . S T M					
V 0 T 0 0 0 1 . S A R	32 F	4.4	32.2	10.33	3.11E+06
V 0 T 0 0 1 1 . S A R	32 F	4.4	31.0	9.95	3.11E+06
V 0 T 0 1 0 1 . S A R	32 F	4.4	63.2	20.45	3.09E+06
V 0 T 0 1 1 1 . S A R	32 F	4.4	60.5	19.83	3.05E+06
V 0 T 0 0 0 2 . S A R	32 F	4.6	32.0	11.36	2.82E+06
V 0 T 0 0 1 2 . S A R	32 F	4.6	31.0	11.36	2.73E+06
V 0 T 0 1 0 2 . S A R	32 F	4.6	63.2	24.60	2.57E+06
V 0 T 0 1 1 2 . S A R	32 F	4.6	60.5	23.14	2.61E+06
V 0 T 1 0 0 0 1 . S A R	32 F	8.4	30.8	13.61	2.26E+06
V 0 T 1 0 0 1 1 . S A R	32 F	8.4	29.5	13.22	2.23E+06
V 0 T 1 0 1 0 1 . S A R	32 F	8.4	61.2	26.23	2.33E+06
V 0 T 1 0 1 1 1 . S A R	32 F	8.4	57.9	24.58	2.35E+06
V 0 T 1 0 0 0 2 . S A R	32 F	8.1	31.4	14.23	2.21E+06
V 0 T 1 0 0 1 2 . S A R	32 F	8.1	30.0	13.63	2.20E+06
V 0 T 1 0 1 0 2 . S A R	32 F	8.1	61.7	26.85	2.30E+06
V 0 T 1 0 1 1 2 . S A R	32 F	8.1	58.6	25.61	2.29E+06
V 1 T 0 0 0 0 1 . S A R	32 F	3.8	31.1	8.27	3.76E+06
V 1 T 0 0 0 1 1 . S A R	32 F	3.8	29.6	7.84	3.78E+06
V 1 T 0 0 1 0 1 . S A R	32 F	3.8	61.6	16.11	3.82E+06
V 1 T 0 0 1 1 1 . S A R	32 F	3.8	58.2	15.08	3.86E+06
V 1 T 0 0 0 0 2 . S A R	32 F	3.6	31.1	11.78	2.64E+06
V 1 T 0 0 0 1 2 . S A R	32 F	3.6	29.6	11.34	2.61E+06
V 1 T 0 0 1 0 2 . S A R	32 F	3.6	61.5	23.53	2.61E+06
V 1 T 0 0 1 1 2 . S A R	32 F	3.6	58.6	21.79	2.69E+06
V 1 T 1 0 0 0 1 . S A R	32 F	8.1	31.8	15.29	2.08E+06
V 1 T 1 0 0 1 1 . S A R	32 F	8.1	30.8	14.25	2.16E+06
V 1 T 1 0 1 0 1 . S A R	32 F	8.1	62.9	30.38	2.07E+06
V 1 T 1 0 1 1 1 . S A R	32 F	8.1	60.4	28.73	2.10E+06
V 1 T 1 0 0 0 2 . S A R	32 F	7.7	31.7	14.05	2.26E+06
V 1 T 1 0 0 1 2 . S A R	32 F	7.7	30.6	12.81	2.39E+06
V 1 T 1 0 1 0 2 . S A R	32 F	7.7	63.1	27.88	2.26E+06
V 1 T 1 0 1 1 2 . S A R	32 F	7.7	60.5	25.82	2.34E+06

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r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	W	0	0	0	0	1	.	S	A	R	32 F	4.2	31.3	14.66	2.14E+06
B	0	W	0	0	0	1	1	.	S	A	R	32 F	4.2	30.1	13.83	2.18E+06
B	0	W	0	0	1	0	1	.	S	A	R	32 F	4.2	62.3	30.35	2.05E+06
B	0	W	0	0	1	1	1	.	S	A	R	32 F	4.2	59.7	28.50	2.09E+06
B	0	W	0	0	0	0	2	.	S	A	R	32 F	4.4	31.8	14.26	2.23E+06
B	0	W	0	0	0	1	2	.	S	A	R	32 F	4.4	30.6	14.05	2.18E+06
B	0	W	0	0	1	0	2	.	S	A	R	32 F	4.4	62.5	29.55	2.12E+06
B	0	W	0	0	1	1	2	.	S	A	R	32 F	4.4	59.4	28.30	2.10E+06
B	0	W	1	0	0	0	1	.	S	A	R	32 F	7.9	30.6	23.94	1.28E+06
B	0	W	1	0	0	1	1	.	S	A	R	32 F	7.9	29.3	22.73	1.29E+06
B	0	W	1	0	1	0	1	.	S	A	R	32 F	7.9	61.7	48.75	1.27E+06
B	0	W	1	0	1	1	1	.	S	A	R	32 F	7.9	58.6	45.86	1.28E+06
B	0	W	1	0	0	0	2	.	S	A	R	32 F	7.7	31.3	19.40	1.61E+06
B	0	W	1	0	0	1	2	.	S	A	R	32 F	7.7	29.9	18.38	1.63E+06
B	0	W	1	0	1	0	2	.	S	A	R	32 F	7.7	62.4	39.24	1.59E+06
B	0	W	1	0	1	1	2	.	S	A	R	32 F	7.7	59.2	37.18	1.59E+06
B	1	W	0	0	0	0	1	.	S	A	R	32 F	4.0	31.2	15.90	1.96E+06
B	1	W	0	0	0	1	1	.	S	A	R	32 F	4.0	29.7	14.89	1.99E+06
B	1	W	0	0	1	0	1	.	S	A	R	32 F	4.0	61.3	29.66	2.07E+06
B	1	W	0	0	1	1	1	.	S	A	R	32 F	4.0	58.5	28.09	2.08E+06
B	1	W	0	0	0	0	2	.	S	A	R	32 F	3.6	30.5	14.88	2.05E+06
B	1	W	0	0	0	1	2	.	S	A	R	32 F	3.6	29.1	14.69	1.98E+06
B	1	W	0	0	1	0	2	.	S	A	R	32 F	3.6	61.5	32.05	1.92E+06
B	1	W	0	0	1	1	2	.	S	A	R	32 F	3.6	58.1	29.74	1.95E+06
B	1	W	1	0	0	0	1	.	S	A	R	32 F	8.2	31.0	22.51	1.38E+06
B	1	W	1	0	0	1	1	.	S	A	R	32 F	8.2	29.3	21.27	1.38E+06
B	1	W	1	0	1	0	1	.	S	A	R	32 F	8.2	60.9	42.61	1.43E+06
B	1	W	1	0	1	1	1	.	S	A	R	32 F	8.2	57.8	40.09	1.44E+06
B	1	W	1	0	0	0	2	.	S	A	R	32 F	8.6	32.2	26.23	1.23E+06
B	1	W	1	0	0	1	2	.	S	A	R	32 F	8.6	30.8	25.81	1.19E+06
B	1	W	1	0	1	0	2	.	S	A	R	32 F	8.6	61.6	51.22	1.20E+06
B	1	W	1	0	1	1	2	.	S	A	R	32 F	8.6	58.9	48.10	1.23E+06

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SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	W	0	0	0	0	1	.	S	A	R	32 F	4.2	31.7	13.23	2.39E+06
V	0	W	0	0	0	1	1	.	S	A	R	32 F	4.2	27.8	10.34	2.68E+06
V	0	W	0	0	1	0	1	.	S	A	R	32 F	4.2	60.6	23.97	2.53E+06
V	0	W	0	0	1	1	1	.	S	A	R	32 F	4.2	63.0	23.97	2.63E+06
V	0	W	0	0	0	0	2	.	S	A	R	32 F	4.5	31.1	10.12	3.07E+06
V	0	W	0	0	0	1	2	.	S	A	R	32 F	4.5	29.8	9.91	3.00E+06
V	0	W	0	0	1	0	2	.	S	A	R	32 F	4.5	61.8	20.65	2.99E+06
V	0	W	0	0	1	1	2	.	S	A	R	32 F	4.5	58.8	19.62	3.00E+06
V	0	W	1	0	0	0	1	.	S	A	R	32 F	8.5	31.7	15.49	2.05E+06
V	0	W	1	0	0	1	1	.	S	A	R	32 F	8.5	30.5	15.49	1.97E+06
V	0	W	1	0	1	0	1	.	S	A	R	32 F	8.5	62.6	31.18	2.01E+06
V	0	W	1	0	1	1	1	.	S	A	R	32 F	8.5	60.0	29.53	2.03E+06
V	0	W	1	0	0	0	2	.	S	A	R	32 F	8.5	32.2	16.74	1.92E+06
V	0	W	1	0	0	1	2	.	S	A	R	32 F	8.5	31.0	16.12	1.92E+06
V	0	W	1	0	1	0	2	.	S	A	R	32 F	8.5	63.1	32.44	1.95E+06
V	0	W	1	0	1	1	2	.	S	A	R	32 F	8.5	60.5	31.20	1.94E+06
V	1	W	0	0	0	0	1	.	S	A	R	32 F	3.6	30.9	9.69	3.19E+06
V	1	W	0	0	0	1	1	.	S	A	R	32 F	3.6	29.5	8.87	3.33E+06
V	1	W	0	0	1	0	1	.	S	A	R	32 F	3.6	62.0	19.40	3.20E+06
V	1	W	0	0	1	1	1	.	S	A	R	32 F	3.6	58.8	18.17	3.24E+06
V	1	W	0	0	0	0	2	.	S	A	R	32 F	3.6	31.1	9.72	3.20E+06
V	1	W	0	0	0	1	2	.	S	A	R	32 F	3.6	29.7	9.30	3.19E+06
V	1	W	0	0	1	0	2	.	S	A	R	32 F	3.6	61.8	19.01	3.25E+06
V	1	W	0	0	1	1	2	.	S	A	R	32 F	3.6	58.7	17.35	3.38E+06
V	1	W	1	0	0	0	1	.	S	A	R	32 F	8.6	32.2	16.52	1.95E+06
V	1	W	1	0	0	1	1	.	S	A	R	32 F	8.6	31.1	15.90	1.95E+06
V	1	W	1	0	1	0	1	.	S	A	R	32 F	8.6	63.0	33.04	1.91E+06
V	1	W	1	0	1	1	1	.	S	A	R	32 F	8.6	60.6	31.59	1.92E+06
V	1	W	1	0	0	0	2	.	S	A	R	32 F	8.0	31.2	13.02	2.40E+06
V	1	W	1	0	0	1	2	.	S	A	R	32 F	8.0	26.9	10.95	2.46E+06
V	1	W	1	0	1	0	2	.	S	A	R	32 F	8.0	63.0	26.44	2.38E+06
V	1	W	1	0	1	1	2	.	S	A	R	32 F	8.0	59.5	23.96	2.49E+06

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Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	T	0	1	0	0	1	.	S	A	R	68 F	4.1	15.9	33.66	4.72E+05
B	0	T	0	1	0	1	1	.	S	A	R	68 F	4.1	15.3	31.39	4.87E+05
B	0	T	0	1	1	0	1	.	S	A	R	68 F	4.1	31.3	66.73	4.69E+05
B	0	T	0	1	1	1	1	.	S	A	R	68 F	4.1	29.9	61.15	4.89E+05
B	0	T	0	1	0	0	2	.	S	A	R	68 F	4.0	16.2	29.12	5.56E+05
B	0	T	0	1	0	1	2	.	S	A	R	68 F	4.0	15.5	27.06	5.74E+05
B	0	T	0	1	1	0	2	.	S	A	R	68 F	4.0	31.2	58.05	5.38E+05
B	0	T	0	1	1	1	2	.	S	A	R	68 F	4.0	29.9	53.50	5.59E+05
B	0	T	1	1	0	0	1	.	S	A	R	68 F	8.1	16.3	64.64	2.52E+05
B	0	T	1	1	0	1	1	.	S	A	R	68 F	8.1	15.7	60.92	2.58E+05
B	0	T	1	1	1	0	1	.	S	A	R	68 F	8.1	31.2	128.48	2.43E+05
B	0	T	1	1	1	1	1	.	S	A	R	68 F	8.1	30.0	117.96	2.54E+05
B	0	T	1	1	0	0	2	.	S	A	R	68 F	8.1	15.9	51.85	3.07E+05
B	0	T	1	1	0	1	2	.	S	A	R	68 F	8.1	15.4	47.90	3.20E+05
B	0	T	1	1	1	0	2	.	S	A	R	68 F	8.1	31.0	103.69	2.99E+05
B	0	T	1	1	1	1	2	.	S	A	R	68 F	8.1	29.6	94.80	3.12E+05
B	1	T	0	1	0	0	1	.	S	A	R	68 F	4.0	13.8	24.38	5.65E+05
B	1	T	0	1	0	1	1	.	S	A	R	68 F	4.0	13.4	23.55	5.68E+05
B	1	T	0	1	1	0	1	.	S	A	R	68 F	4.0	32.0	58.25	5.49E+05
B	1	T	0	1	1	1	1	.	S	A	R	68 F	4.0	30.8	53.30	5.79E+05
B	1	T	0	1	0	0	2	.	S	A	R	68 F	3.6	15.1	25.39	5.96E+05
B	1	T	0	1	0	1	2	.	S	A	R	68 F	3.6	14.7	23.75	6.18E+05
B	1	T	0	1	1	0	2	.	S	A	R	68 F	3.6	30.9	53.07	5.83E+05
B	1	T	0	1	1	1	2	.	S	A	R	68 F	3.6	29.9	49.55	6.04E+05
B	1	T	1	1	0	0	1	.	S	A	R	68 F	8.3	15.6	52.03	2.99E+05
B	1	T	1	1	0	1	1	.	S	A	R	68 F	8.3	15.2	48.54	3.12E+05
B	1	T	1	1	1	0	1	.	S	A	R	68 F	8.3	32.5	118.10	2.75E+05
B	1	T	1	1	1	1	1	.	S	A	R	68 F	8.3	31.3	109.23	2.87E+05
B	1	T	1	1	0	0	2	.	S	A	R	68 F	8.5	16.1	64.64	2.48E+05
B	1	T	1	1	0	1	2	.	S	A	R	68 F	8.5	15.6	60.70	2.57E+05
B	1	T	1	1	1	0	2	.	S	A	R	68 F	8.5	32.4	132.63	2.45E+05
B	1	T	1	1	1	1	2	.	S	A	R	68 F	8.5	31.4	122.47	2.56E+05

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SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	T	0	1	0	0	1	.	S	A	R	68 F	4.4	16.0	17.36	9.24E+05
V	0	T	0	1	0	1	1	.	S	A	R	68 F	4.4	15.4	15.50	9.93E+05
V	0	T	0	1	1	0	1	.	S	A	R	68 F	4.4	31.2	34.10	9.15E+05
V	0	T	0	1	1	1	1	.	S	A	R	68 F	4.4	29.9	30.37	9.83E+05
V	0	T	0	1	0	0	2	.	S	A	R	68 F	4.6	16.0	14.06	1.14E+06
V	0	T	0	1	0	1	2	.	S	A	R	68 F	4.6	15.4	14.25	1.08E+06
V	0	T	0	1	1	0	2	.	S	A	R	68 F	4.6	31.6	30.79	1.03E+06
V	0	T	0	1	1	1	2	.	S	A	R	68 F	4.6	30.0	27.68	1.08E+06
V	0	T	1	1	0	0	1	.	S	A	R	68 F	8.4	15.8	26.64	5.92E+05
V	0	T	1	1	0	1	1	.	S	A	R	68 F	8.4	15.1	24.58	6.16E+05
V	0	T	1	1	1	0	1	.	S	A	R	68 F	8.4	32.3	56.20	5.75E+05
V	0	T	1	1	1	1	1	.	S	A	R	68 F	8.4	31.2	50.00	6.25E+05
V	0	T	1	1	0	0	2	.	S	A	R	68 F	8.1	16.0	25.41	6.29E+05
V	0	T	1	1	0	1	2	.	S	A	R	68 F	8.1	15.4	23.34	6.58E+05
V	0	T	1	1	1	0	2	.	S	A	R	68 F	8.1	32.3	52.46	6.16E+05
V	0	T	1	1	1	1	2	.	S	A	R	68 F	8.1	31.1	46.68	6.67E+05
V	1	T	0	1	0	0	1	.	S	A	R	68 F	3.8	15.0	15.28	9.83E+05
V	1	T	0	1	0	1	1	.	S	A	R	68 F	3.8	14.5	13.63	1.07E+06
V	1	T	0	1	1	0	1	.	S	A	R	68 F	3.8	32.8	30.98	1.06E+06
V	1	T	0	1	1	1	1	.	S	A	R	68 F	3.8	31.8	28.29	1.12E+06
V	1	T	0	1	0	0	2	.	S	A	R	68 F	3.6	15.2	13.63	1.12E+06
V	1	T	0	1	0	1	2	.	S	A	R	68 F	3.6	14.8	12.60	1.18E+06
V	1	T	0	1	1	0	2	.	S	A	R	68 F	3.6	32.6	28.09	1.16E+06
V	1	T	0	1	1	1	2	.	S	A	R	68 F	3.6	31.5	26.22	1.20E+06
V	1	T	1	1	0	0	1	.	S	A	R	68 F	8.1	15.9	29.34	5.43E+05
V	1	T	1	1	0	1	1	.	S	A	R	68 F	8.1	15.5	26.65	5.80E+05
V	1	T	1	1	1	0	1	.	S	A	R	68 F	8.1	32.8	58.88	5.57E+05
V	1	T	1	1	1	1	1	.	S	A	R	68 F	8.1	31.6	53.51	5.91E+05
V	1	T	1	1	0	0	2	.	S	A	R	68 F	7.7	15.8	24.17	6.52E+05
V	1	T	1	1	0	1	2	.	S	A	R	68 F	7.7	15.3	21.90	6.99E+05
V	1	T	1	1	1	0	2	.	S	A	R	68 F	7.7	32.4	49.16	6.60E+05
V	1	T	1	1	1	1	2	.	S	A	R	68 F	7.7	31.2	45.86	6.81E+05

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Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	W	0	1	0	0	1	.	S	A	R	68 F	4.2	16.0	24.16	6.63E+05
B	0	W	0	1	0	1	1	.	S	A	R	68 F	4.2	15.4	22.10	6.95E+05
B	0	W	0	1	1	0	1	.	S	A	R	68 F	4.2	31.0	48.53	6.38E+05
B	0	W	0	1	1	1	1	.	S	A	R	68 F	4.2	29.5	44.81	6.59E+05
B	0	W	0	1	0	0	2	.	S	A	R	68 F	4.4	16.0	23.96	6.68E+05
B	0	W	0	1	0	1	2	.	S	A	R	68 F	4.4	15.3	22.11	6.92E+05
B	0	W	0	1	1	0	2	.	S	A	R	68 F	4.4	30.6	47.92	6.39E+05
B	0	W	0	1	1	1	2	.	S	A	R	68 F	4.4	29.3	44.21	6.62E+05
B	0	W	1	1	0	0	1	.	S	A	R	68 F	7.9	16.6	44.81	3.71E+05
B	0	W	1	1	0	1	1	.	S	A	R	68 F	7.9	16.0	41.72	3.83E+05
B	0	W	1	1	1	0	1	.	S	A	R	68 F	7.9	31.1	84.39	3.69E+05
B	0	W	1	1	1	1	1	.	S	A	R	68 F	7.9	29.5	76.15	3.87E+05
B	0	W	1	1	0	0	2	.	S	A	R	68 F	7.7	15.8	41.23	3.83E+05
B	0	W	1	1	0	1	2	.	S	A	R	68 F	7.7	15.1	38.01	3.98E+05
B	0	W	1	1	1	0	2	.	S	A	R	68 F	7.7	30.9	83.47	3.70E+05
B	0	W	1	1	1	1	2	.	S	A	R	68 F	7.7	29.5	76.65	3.84E+05
B	1	W	0	1	0	0	1	.	S	A	R	68 F	4.0	16.3	19.83	8.22E+05
B	1	W	0	1	0	1	1	.	S	A	R	68 F	4.0	15.7	19.21	8.16E+05
B	1	W	0	1	1	0	1	.	S	A	R	68 F	4.0	32.3	40.69	7.94E+05
B	1	W	0	1	1	1	1	.	S	A	R	68 F	4.0	31.1	38.22	8.14E+05
B	1	W	0	1	0	0	2	.	S	A	R	68 F	3.6	16.3	21.69	7.53E+05
B	1	W	0	1	0	1	2	.	S	A	R	68 F	3.6	15.8	20.45	7.71E+05
B	1	W	0	1	1	0	2	.	S	A	R	68 F	3.6	32.2	43.59	7.38E+05
B	1	W	0	1	1	1	2	.	S	A	R	68 F	3.6	31.0	40.69	7.61E+05
B	1	W	1	1	0	0	1	.	S	A	R	68 F	8.2	16.0	40.24	3.98E+05
B	1	W	1	1	0	1	1	.	S	A	R	68 F	8.2	15.4	36.99	4.17E+05
B	1	W	1	1	1	0	1	.	S	A	R	68 F	8.2	31.0	80.58	3.85E+05
B	1	W	1	1	1	1	1	.	S	A	R	68 F	8.2	29.6	73.54	4.03E+05
B	1	W	1	1	0	0	2	.	S	A	R	68 F	8.6	16.2	44.50	3.64E+05
B	1	W	1	1	0	1	2	.	S	A	R	68 F	8.6	15.5	42.56	3.64E+05
B	1	W	1	1	1	0	2	.	S	A	R	68 F	8.6	31.1	89.85	3.47E+05
B	1	W	1	1	1	1	2	.	S	A	R	68 F	8.6	29.7	81.20	3.66E+05

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	W	0	1	0	0	1	.	S	A	R	68 F	4.2	16.1	13.84	1.16E+06
V	0	W	0	1	0	1	1	.	S	A	R	68 F	4.2	15.5	12.80	1.21E+06
V	0	W	0	1	1	0	1	.	S	A	R	68 F	4.2	31.1	26.64	1.17E+06
V	0	W	0	1	1	1	1	.	S	A	R	68 F	4.2	29.6	24.58	1.20E+06
V	0	W	0	1	0	0	2	.	S	A	R	68 F	4.5	16.1	14.46	1.11E+06
V	0	W	0	1	0	1	2	.	S	A	R	68 F	4.5	15.8	14.04	1.12E+06
V	0	W	0	1	1	0	2	.	S	A	R	68 F	4.5	31.3	30.77	1.02E+06
V	0	W	0	1	1	1	2	.	S	A	R	68 F	4.5	30.0	27.88	1.07E+06
V	0	W	1	1	0	0	1	.	S	A	R	68 F	8.5	16.2	21.48	7.52E+05
V	0	W	1	1	0	1	1	.	S	A	R	68 F	8.5	15.9	20.02	7.94E+05
V	0	W	1	1	1	0	1	.	S	A	R	68 F	8.5	31.0	43.17	7.17E+05
V	0	W	1	1	1	1	1	.	S	A	R	68 F	8.5	29.6	38.79	7.64E+05
V	0	W	1	1	0	0	2	.	S	A	R	68 F	8.5	16.1	26.44	6.10E+05
V	0	W	1	1	0	1	2	.	S	A	R	68 F	8.5	15.7	24.38	6.42E+05
V	0	W	1	1	1	0	2	.	S	A	R	68 F	8.5	31.4	52.90	5.93E+05
V	0	W	1	1	1	1	2	.	S	A	R	68 F	8.5	29.9	48.32	6.19E+05
V	1	W	0	1	0	0	1	.	S	A	R	68 F	3.6	16.1	13.82	1.17E+06
V	1	W	0	1	0	1	1	.	S	A	R	68 F	3.6	15.5	13.21	1.17E+06
V	1	W	0	1	1	0	1	.	S	A	R	68 F	3.6	31.4	28.49	1.10E+06
V	1	W	0	1	1	1	1	.	S	A	R	68 F	3.6	29.9	26.60	1.12E+06
V	1	W	0	1	0	0	2	.	S	A	R	68 F	3.6	16.2	13.44	1.21E+06
V	1	W	0	1	0	1	2	.	S	A	R	68 F	3.6	15.5	12.16	1.28E+06
V	1	W	0	1	1	0	2	.	S	A	R	68 F	3.6	29.5	23.49	1.26E+06
V	1	W	0	1	1	1	2	.	S	A	R	68 F	3.6	31.1	24.74	1.26E+06
V	1	W	1	1	0	0	1	.	S	A	R	68 F	8.6	15.7	19.36	8.11E+05
V	1	W	1	1	0	1	1	.	S	A	R	68 F	8.6	15.2	17.77	8.54E+05
V	1	W	1	1	1	0	1	.	S	A	R	68 F	8.6	32.1	39.89	8.04E+05
V	1	W	1	1	1	1	1	.	S	A	R	68 F	8.6	30.7	37.21	8.26E+05
V	1	W	1	1	0	0	2	.	S	A	R	68 F	8.0	16.3	20.05	8.15E+05
V	1	W	1	1	0	1	2	.	S	A	R	68 F	8.0	15.7	17.58	8.93E+05
V	1	W	1	1	1	0	2	.	S	A	R	68 F	8.0	30.9	39.06	7.92E+05
V	1	W	1	1	1	1	2	.	S	A	R	68 F	8.0	29.6	34.94	8.46E+05

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	T	0	2	0	0	1	.	S	A	R	104 F	4.1	7.7	80.33	9.60E+04
B	0	T	0	2	0	1	1	.	S	A	R	104 F	4.1	7.4	73.61	1.00E+05
B	0	T	0	2	1	0	1	.	S	A	R	104 F	4.1	16.0	175.71	9.12E+04
B	0	T	0	2	1	1	1	.	S	A	R	104 F	4.1	15.7	160.69	9.77E+04
B	0	T	0	2	0	0	2	.	S	A	R	104 F	4.0	8.5	89.67	9.46E+04
B	0	T	0	2	0	1	2	.	S	A	R	104 F	4.0	8.3	85.38	9.67E+04
B	0	T	0	2	1	0	2	.	S	A	R	104 F	4.0	15.6	168.30	9.27E+04
B	0	T	0	2	1	1	2	.	S	A	R	104 F	4.0	15.2	158.32	9.63E+04
B	0	T	1	2	0	0	1	.	S	A	R	104 F	8.1	8.1	169.07	4.77E+04
B	0	T	1	2	0	1	1	.	S	A	R	104 F	8.1	7.8	161.56	4.83E+04
B	0	T	1	2	1	0	1	.	S	A	R	104 F	8.1	15.5	324.17	4.78E+04
B	0	T	1	2	1	1	1	.	S	A	R	104 F	8.1	15.1	305.53	4.93E+04
B	0	T	1	2	0	0	2	.	S	A	R	104 F	8.1	9.2	219.05	4.20E+04
B	0	T	1	2	0	1	2	.	S	A	R	104 F	8.1	8.8	202.30	4.35E+04
B	0	T	1	2	1	0	2	.	S	A	R	104 F	8.1	16.2	387.56	4.18E+04
B	0	T	1	2	1	1	2	.	S	A	R	104 F	8.1	15.7	352.02	4.46E+04
B	1	T	0	2	0	0	1	.	S	A	R	104 F	4.0	8.1	80.44	1.01E+05
B	1	T	0	2	0	1	1	.	S	A	R	104 F	4.0	8.0	78.78	1.01E+05
B	1	T	0	2	1	0	1	.	S	A	R	104 F	4.0	16.2	174.40	9.29E+04
B	1	T	0	2	1	1	1	.	S	A	R	104 F	4.0	15.8	160.13	9.84E+04
B	1	T	0	2	0	0	2	.	S	A	R	104 F	3.6	8.9	95.27	9.34E+04
B	1	T	0	2	0	1	2	.	S	A	R	104 F	3.6	8.5	88.86	9.57E+04
B	1	T	0	2	1	0	2	.	S	A	R	104 F	3.6	16.2	182.00	8.87E+04
B	1	T	0	2	1	1	2	.	S	A	R	104 F	3.6	15.7	166.87	9.42E+04
B	1	T	1	2	0	0	1	.	S	A	R	104 F	8.3	7.2	155.37	4.65E+04
B	1	T	1	2	0	1	1	.	S	A	R	104 F	8.3	7.3	158.67	4.63E+04
B	1	T	1	2	1	0	1	.	S	A	R	104 F	8.3	15.8	340.92	4.65E+04
B	1	T	1	2	1	1	1	.	S	A	R	104 F	8.3	15.4	318.19	4.83E+04
B	1	T	1	2	0	0	2	.	S	A	R	104 F	8.5	8.4	198.85	4.20E+04
B	1	T	1	2	0	1	2	.	S	A	R	104 F	8.5	8.0	190.60	4.21E+04
B	1	T	1	2	1	0	2	.	S	A	R	104 F	8.5	16.1	370.06	4.35E+04
B	1	T	1	2	1	1	2	.	S	A	R	104 F	8.5	15.6	349.04	4.48E+04

AT = Asphalt Type - B=Boscan, V=Valley
AC = Asphalt Content - 0=Low, 1=High
AG = Aggregate Type - W=Watsonville, T=Texas
V = Air Voids - 0=Low, 1=High
TP = Temperature - 0=32 F, 1=68 F, 2=104 F, 3=140 F
ST = Stress Level - 0=Low, 1=High
F = Frequency - 0=0.5 Hz, 1=1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	T	0	2	0	0	1	.	S	A	R	104 F	4.4	6.4	66.50	9.67E+04
V	0	T	0	2	0	1	1	.	S	A	R	104 F	4.4	7.1	70.46	1.01E+05
V	0	T	0	2	1	0	1	.	S	A	R	104 F	4.4	16.3	177.82	9.19E+04
V	0	T	0	2	1	1	1	.	S	A	R	104 F	4.4	16.0	156.71	1.02E+05
V	0	T	0	2	0	0	2	.	S	A	R	104 F	4.6	8.9	109.09	8.16E+04
V	0	T	0	2	0	1	2	.	S	A	R	104 F	4.6	8.7	100.68	8.66E+04
V	0	T	0	2	1	0	2	.	S	A	R	104 F	4.6	16.2	212.42	7.65E+04
V	0	T	0	2	1	1	2	.	S	A	R	104 F	4.6	15.8	199.96	7.91E+04
V	0	T	1	2	0	0	1	.	S	A	R	104 F	8.4	8.5	183.29	4.63E+04
V	0	T	1	2	0	1	1	.	S	A	R	104 F	8.4	8.2	161.45	5.08E+04
V	0	T	1	2	1	0	1	.	S	A	R	104 F	8.4	15.6	365.69	4.27E+04
V	0	T	1	2	1	1	1	.	S	A	R	104 F	8.4	15.2	317.78	4.79E+04
V	0	T	1	2	0	0	2	.	S	A	R	104 F	8.1	6.4	138.31	4.60E+04
V	0	T	1	2	0	1	2	.	S	A	R	104 F	8.1	7.0	144.34	4.88E+04
V	0	T	1	2	1	0	2	.	S	A	R	104 F	8.1	15.8	318.32	4.96E+04
V	0	T	1	2	1	1	2	.	S	A	R	104 F	8.1	15.4	317.07	4.85E+04
V	1	T	0	2	0	0	1	.	S	A	R	104 F	3.8	6.6	73.82	8.87E+04
V	1	T	0	2	0	1	1	.	S	A	R	104 F	3.8	7.3	82.15	8.86E+04
V	1	T	0	2	1	0	1	.	S	A	R	104 F	3.8	16.4	195.24	8.38E+04
V	1	T	0	2	1	1	1	.	S	A	R	104 F	3.8	16.0	177.70	8.99E+04
V	1	T	0	2	0	0	2	.	S	A	R	104 F	3.6	7.4	68.76	1.07E+05
V	1	T	0	2	0	1	2	.	S	A	R	104 F	3.6	7.4	65.42	1.13E+05
V	1	T	0	2	1	0	2	.	S	A	R	104 F	3.6	16.8	174.50	9.61E+04
V	1	T	0	2	1	1	2	.	S	A	R	104 F	3.6	16.3	157.71	1.04E+05
V	1	T	1	2	0	0	1	.	S	A	R	104 F	8.1	8.6	224.97	3.80E+04
V	1	T	1	2	0	1	1	.	S	A	R	104 F	8.1	8.2	208.34	3.94E+04
V	1	T	1	2	1	0	1	.	S	A	R	104 F	8.1	16.1	398.15	4.05E+04
V	1	T	1	2	1	1	1	.	S	A	R	104 F	8.1	15.8	373.02	4.24E+04
V	1	T	1	2	0	0	2	.	S	A	R	104 F	7.7	8.0	166.31	4.82E+04
V	1	T	1	2	0	1	2	.	S	A	R	104 F	7.7	8.0	155.40	5.16E+04
V	1	T	1	2	1	0	2	.	S	A	R	104 F	7.7	16.4	339.81	4.84E+04
V	1	T	1	2	1	1	2	.	S	A	R	104 F	7.7	15.9	312.95	5.08E+04

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	W	0	2	0	0	1	.	S	A	R	104 F	4.2	7.8	61.95	1.26E+05
B	0	W	0	2	0	1	1	.	S	A	R	104 F	4.2	7.6	56.95	1.34E+05
B	0	W	0	2	1	0	1	.	S	A	R	104 F	4.2	16.6	138.25	1.20E+05
B	0	W	0	2	1	1	1	.	S	A	R	104 F	4.2	16.2	124.38	1.30E+05
B	0	W	0	2	0	0	2	.	S	A	R	104 F	4.4	8.4	79.03	1.06E+05
B	0	W	0	2	0	1	2	.	S	A	R	104 F	4.4	8.3	74.00	1.12E+05
B	0	W	0	2	1	0	2	.	S	A	R	104 F	4.4	14.5	142.12	1.02E+05
B	0	W	0	2	1	1	2	.	S	A	R	104 F	4.4	14.6	132.87	1.10E+05
B	0	W	1	2	0	0	1	.	S	A	R	104 F	7.9	9.1	155.75	5.87E+04
B	0	W	1	2	0	1	1	.	S	A	R	104 F	7.9	8.9	143.25	6.21E+04
B	0	W	1	2	1	0	1	.	S	A	R	104 F	7.9	16.3	284.83	5.73E+04
B	0	W	1	2	1	1	1	.	S	A	R	104 F	7.9	15.9	261.32	6.08E+04
B	0	W	1	2	0	0	2	.	S	A	R	104 F	7.7	6.7	102.35	6.55E+04
B	0	W	1	2	0	1	2	.	S	A	R	104 F	7.7	6.7	98.99	6.77E+04
B	0	W	1	2	1	0	2	.	S	A	R	104 F	7.7	16.2	240.75	6.72E+04
B	0	W	1	2	1	1	2	.	S	A	R	104 F	7.7	15.8	223.10	7.07E+04
B	1	W	0	2	0	0	1	.	S	A	R	104 F	4.0	9.1	76.23	1.19E+05
B	1	W	0	2	0	1	1	.	S	A	R	104 F	4.0	8.8	71.25	1.23E+05
B	1	W	0	2	1	0	1	.	S	A	R	104 F	4.0	16.0	143.31	1.12E+05
B	1	W	0	2	1	1	1	.	S	A	R	104 F	4.0	15.6	134.10	1.16E+05
B	1	W	0	2	0	0	2	.	S	A	R	104 F	3.6	8.7	83.98	1.04E+05
B	1	W	0	2	0	1	2	.	S	A	R	104 F	3.6	8.4	79.92	1.05E+05
B	1	W	0	2	1	0	2	.	S	A	R	104 F	3.6	16.3	166.61	9.77E+04
B	1	W	0	2	1	1	2	.	S	A	R	104 F	3.6	15.8	153.13	1.03E+05
B	1	W	1	2	0	0	1	.	S	A	R	104 F	8.2	7.0	118.98	5.91E+04
B	1	W	1	2	0	1	1	.	S	A	R	104 F	8.2	6.9	112.34	6.12E+04
B	1	W	1	2	1	0	1	.	S	A	R	104 F	8.2	16.2	263.34	6.13E+04
B	1	W	1	2	1	1	1	.	S	A	R	104 F	8.2	15.6	242.35	6.45E+04
B	1	W	1	2	0	0	2	.	S	A	R	104 F	8.6	8.8	160.72	5.48E+04
B	1	W	1	2	0	1	2	.	S	A	R	104 F	8.6	8.6	149.85	5.71E+04
B	1	W	1	2	1	0	2	.	S	A	R	104 F	8.6	15.7	290.44	5.39E+04
B	1	W	1	2	1	1	2	.	S	A	R	104 F	8.6	15.3	265.99	5.75E+04

AT = Asphalt Type - B = Boscan, V = Valley
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V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	W	0	2	0	0	1	.	S	A	R	104 F	4.2	9.5	94.82	9.97E+04
V	0	W	0	2	0	1	1	.	S	A	R	104 F	4.2	9.0	85.73	1.05E+05
V	0	W	0	2	1	0	1	.	S	A	R	104 F	4.2	14.7	147.91	9.91E+04
V	0	W	0	2	1	1	1	.	S	A	R	104 F	4.2	14.5	140.24	1.04E+05
V	0	W	0	2	0	0	2	.	S	A	R	104 F	4.5	7.6	70.26	1.08E+05
V	0	W	0	2	0	1	2	.	S	A	R	104 F	4.5	7.4	64.42	1.15E+05
V	0	W	0	2	1	0	2	.	S	A	R	104 F	4.5	15.7	155.00	1.01E+05
V	0	W	0	2	1	1	2	.	S	A	R	104 F	4.5	15.5	144.90	1.07E+05
V	0	W	1	2	0	0	1	.	S	A	R	104 F	8.5	8.3	126.89	6.51E+04
V	0	W	1	2	0	1	1	.	S	A	R	104 F	8.5	8.1	121.91	6.63E+04
V	0	W	1	2	1	0	1	.	S	A	R	104 F	8.5	16.3	256.24	6.35E+04
V	0	W	1	2	1	1	1	.	S	A	R	104 F	8.5	15.9	241.94	6.56E+04
V	0	W	1	2	0	0	2	.	S	A	R	104 F	8.5	8.2	151.29	5.44E+04
V	0	W	1	2	0	1	2	.	S	A	R	104 F	8.5	8.1	141.14	5.77E+04
V	0	W	1	2	1	0	2	.	S	A	R	104 F	8.5	16.5	309.39	5.34E+04
V	0	W	1	2	1	1	2	.	S	A	R	104 F	8.5	16.2	286.14	5.68E+04
V	1	W	0	2	0	0	1	.	S	A	R	104 F	3.6	9.1	114.13	7.96E+04
V	1	W	0	2	0	1	1	.	S	A	R	104 F	3.6	8.7	105.69	8.24E+04
V	1	W	0	2	1	0	1	.	S	A	R	104 F	3.6	15.6	203.13	7.69E+04
V	1	W	0	2	1	1	1	.	S	A	R	104 F	3.6	15.1	185.52	8.14E+04
V	1	W	0	2	0	0	2	.	S	A	R	104 F	3.6	9.2	66.30	1.38E+05
V	1	W	0	2	0	1	2	.	S	A	R	104 F	3.6	8.7	59.55	1.46E+05
V	1	W	0	2	1	0	2	.	S	A	R	104 F	3.6	15.9	119.10	1.34E+05
V	1	W	0	2	1	1	2	.	S	A	R	104 F	3.6	15.5	110.75	1.40E+05
V	1	W	1	2	0	0	1	.	S	A	R	104 F	8.6	9.0	164.72	5.46E+04
V	1	W	1	2	0	1	1	.	S	A	R	104 F	8.6	8.6	151.24	5.68E+04
V	1	W	1	2	1	0	1	.	S	A	R	104 F	8.6	16.1	299.37	5.38E+04
V	1	W	1	2	1	1	1	.	S	A	R	104 F	8.6	15.6	271.03	5.76E+04
V	1	W	1	2	0	0	2	.	S	A	R	104 F	8.0	8.9	153.68	5.79E+04
V	1	W	1	2	0	1	2	.	S	A	R	104 F	8.0	8.6	142.05	6.05E+04
V	1	W	1	2	1	0	2	.	S	A	R	104 F	8.0	16.0	278.30	5.74E+04
V	1	W	1	2	1	1	2	.	S	A	R	104 F	8.0	15.5	252.26	6.16E+04

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	T	0	3	0	0	1	.	S	A	R	140 F	4.1	4.9	201.09	2.43E+04
B	0	T	0	3	0	1	1	.	S	A	R	140 F	4.1	4.9	200.64	2.44E+04
B	0	T	0	3	1	0	1	.	S	A	R	140 F	4.1	10.6	369.96	2.87E+04
B	0	T	0	3	1	1	1	.	S	A	R	140 F	4.1	10.5	358.31	2.93E+04
B	0	T	0	3	0	0	2	.	S	A	R	140 F	4.0	4.8	209.05	2.31E+04
B	0	T	0	3	0	1	2	.	S	A	R	140 F	4.0	4.9	213.21	2.29E+04
B	0	T	0	3	1	0	2	.	S	A	R	140 F	4.0	8.9	337.43	2.64E+04
B	0	T	0	3	1	1	2	.	S	A	R	140 F	4.0	8.9	323.07	2.76E+04
B	0	T	1	3	0	0	1	.	S	A	R	140 F	8.1	3.2	141.04	2.28E+04
B	0	T	1	3	0	1	1	.	S	A	R	140 F	8.1	2.8	129.14	2.13E+04
B	0	T	1	3	1	0	1	.	S	A	R	140 F	8.1	4.9	196.68	2.50E+04
B	0	T	1	3	1	1	1	.	S	A	R	140 F	8.1	4.9	198.35	2.47E+04
B	0	T	1	3	0	0	2	.	S	A	R	140 F	8.1	2.3	139.23	1.64E+04
B	0	T	1	3	0	1	2	.	S	A	R	140 F	8.1	2.3	140.08	1.66E+04
B	0	T	1	3	1	0	2	.	S	A	R	140 F	8.1	4.7	259.68	1.80E+04
B	0	T	1	3	1	1	2	.	S	A	R	140 F	8.1	4.1	238.03	1.72E+04
B	1	T	0	3	0	0	1	.	S	A	R	140 F	4.0	4.8	158.68	3.02E+04
B	1	T	0	3	0	1	1	.	S	A	R	140 F	4.0	5.0	166.21	2.98E+04
B	1	T	0	3	1	0	1	.	S	A	R	140 F	4.0	7.4	232.98	3.19E+04
B	1	T	0	3	1	1	1	.	S	A	R	140 F	4.0	8.2	244.96	3.36E+04
B	1	T	0	3	0	0	2	.	S	A	R	140 F	3.6	4.8	185.67	2.59E+04
B	1	T	0	3	0	1	2	.	S	A	R	140 F	3.6	4.8	186.51	2.59E+04
B	1	T	0	3	1	0	2	.	S	A	R	140 F	3.6	9.5	340.96	2.78E+04
B	1	T	0	3	1	1	2	.	S	A	R	140 F	3.6	9.4	325.79	2.89E+04
B	1	T	1	3	0	0	1	.	S	A	R	140 F	8.3	4.9	218.92	2.24E+04
B	1	T	1	3	0	1	1	.	S	A	R	140 F	8.3	5.0	226.87	2.20E+04
B	1	T	1	3	1	0	1	.	S	A	R	140 F	8.3	9.5	350.01	2.71E+04
B	1	T	1	3	1	1	1	.	S	A	R	140 F	8.3	9.3	355.25	2.62E+04
B	1	T	1	3	0	0	2	.	S	A	R	140 F	8.5	4.8	244.18	1.97E+04
B	1	T	1	3	0	1	2	.	S	A	R	140 F	8.5	5.2	246.94	2.11E+04
B	1	T	1	3	1	0	2	.	S	A	R	140 F	8.5	9.2	374.78	2.45E+04
B	1	T	1	3	1	1	2	.	S	A	R	140 F	8.5	9.0	369.29	2.44E+04

AT = Asphalt Type - B=Boscan, V=Valley
AC = Asphalt Content - 0=Low, 1=High
AG = Aggregate Type - W=Watsonville, T=Texas
V = Air Voids - 0=Low, 1=High
TP = Temperature - 0=32 F, 1=68 F, 2=104 F, 3=140 F
ST = Stress Level - 0=Low, 1=High
F = Frequency - 0=0.5 Hz, 1=1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	T	0	3	0	0	1	.	S	A	R	140 F	4.4	3.4	134.54	2.53E+04
V	0	T	0	3	0	1	1	.	S	A	R	140 F	4.4	3.4	139.87	2.43E+04
V	0	T	0	3	1	0	1	.	S	A	R	140 F	4.4	4.8	188.71	2.53E+04
V	0	T	0	3	1	1	1	.	S	A	R	140 F	4.4	5.0	202.57	2.44E+04
V	0	T	0	3	0	0	2	.	S	A	R	140 F	4.6	2.5	98.54	2.54E+04
V	0	T	0	3	0	1	2	.	S	A	R	140 F	4.6	2.8	111.47	2.51E+04
V	0	T	0	3	1	0	2	.	S	A	R	140 F	4.6	5.5	219.86	2.50E+04
V	0	T	0	3	1	1	2	.	S	A	R	140 F	4.6	5.6	216.43	2.59E+04
V	0	T	1	3	0	0	1	.	S	A	R	140 F	8.4	3.3	169.25	1.95E+04
V	0	T	1	3	0	1	1	.	S	A	R	140 F	8.4	3.2	177.68	1.82E+04
V	0	T	1	3	1	0	1	.	S	A	R	140 F	8.4	5.6	254.53	2.21E+04
V	0	T	1	3	1	1	1	.	S	A	R	140 F	8.4	5.6	271.62	2.07E+04
V	0	T	1	3	0	0	2	.	S	A	R	140 F	8.1	3.5	170.92	2.04E+04
V	0	T	1	3	0	1	2	.	S	A	R	140 F	8.1	3.3	175.18	1.90E+04
V	0	T	1	3	1	0	2	.	S	A	R	140 F	8.1	5.5	251.03	2.20E+04
V	0	T	1	3	1	1	2	.	S	A	R	140 F	8.1	5.5	257.37	2.12E+04
V	1	T	0	3	0	0	1	.	S	A	R	140 F	3.8	3.1	113.98	2.71E+04
V	1	T	0	3	0	1	1	.	S	A	R	140 F	3.8	3.2	111.38	2.86E+04
V	1	T	0	3	1	0	1	.	S	A	R	140 F	3.8	5.5	205.29	2.70E+04
V	1	T	0	3	1	1	1	.	S	A	R	140 F	3.8	5.6	197.64	2.82E+04
V	1	T	0	3	0	0	2	.	S	A	R	140 F	3.6	2.4	121.50	1.96E+04
V	1	T	0	3	0	1	2	.	S	A	R	140 F	3.6	2.3	120.93	1.93E+04
V	1	T	0	3	1	0	2	.	S	A	R	140 F	3.6	5.1	260.89	1.96E+04
V	1	T	0	3	1	1	2	.	S	A	R	140 F	3.6	5.1	259.14	1.96E+04
V	1	T	1	3	0	0	1	.	S	A	R	140 F	8.1	3.6	172.50	2.09E+04
V	1	T	1	3	0	1	1	.	S	A	R	140 F	8.1	3.5	156.39	2.25E+04
V	1	T	1	3	1	0	1	.	S	A	R	140 F	8.1	5.5	239.64	2.31E+04
V	1	T	1	3	1	1	1	.	S	A	R	140 F	8.1	5.7	221.34	2.56E+04
V	1	T	1	3	0	0	2	.	S	A	R	140 F	7.7	2.3	121.62	1.90E+04
V	1	T	1	3	0	1	2	.	S	A	R	140 F	7.7	2.1	113.08	1.81E+04
V	1	T	1	3	1	0	2	.	S	A	R	140 F	7.7	5.7	259.81	2.18E+04
V	1	T	1	3	1	1	2	.	S	A	R	140 F	7.7	5.5	269.24	2.05E+04

AT = Asphalt Type - B=Boscan, V=Valley
AC = Asphalt Content - 0=Low, 1=High
AG = Aggregate Type - W=Watsonville, T=Texas
V = Air Voids - 0=Low, 1=High
TP = Temperature - 0=32 F, 1=68 F, 2=104 F, 3=140 F
ST = Stress Level - 0=Low, 1=High
F = Frequency - 0=0.5 Hz, 1=1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	W	0	3	0	0	1	.	S	A	R	140 F	4.2	5.5	202.20	2.71E+04
B	0	W	0	3	0	1	1	.	S	A	R	140 F	4.2	5.4	201.20	2.66E+04
B	0	W	0	3	1	0	1	.	S	A	R	140 F	4.2	8.4	256.68	3.29E+04
B	0	W	0	3	1	1	1	.	S	A	R	140 F	4.2	8.3	246.66	3.35E+04
B	0	W	0	3	2	0	1	.	S	A	R	140 F	4.2	16.0	419.83	3.82E+04
B	0	W	0	3	2	1	1	.	S	A	R	140 F	4.2	15.6	396.11	3.95E+04
B	0	W	0	3	0	0	2	.	S	A	R	140 F	4.4	4.2	141.90	2.95E+04
B	0	W	0	3	0	1	2	.	S	A	R	140 F	4.4	4.7	160.52	2.93E+04
B	0	W	0	3	1	0	2	.	S	A	R	140 F	4.4	8.9	311.34	2.86E+04
B	0	W	0	3	1	1	2	.	S	A	R	140 F	4.4	8.7	300.86	2.89E+04
B	0	W	0	3	2	0	2	.	S	A	R	140 F	4.4	16.2	510.61	3.16E+04
B	0	W	0	3	2	1	2	.	S	A	R	140 F	4.4	15.8	482.63	3.28E+04
B	0	W	1	3	0	0	1	.	S	A	R	140 F	7.9	4.1	250.39	1.62E+04
B	0	W	1	3	0	1	1	.	S	A	R	140 F	7.9	4.5	283.00	1.59E+04
B	0	W	1	3	1	0	1	.	S	A	R	140 F	7.9	8.8	413.16	2.12E+04
B	0	W	1	3	1	1	1	.	S	A	R	140 F	7.9	8.5	402.83	2.12E+04
B	0	W	1	3	2	0	1	.	S	A	R	140 F	7.9	16.1	632.68	2.54E+04
B	0	W	1	3	2	1	1	.	S	A	R	140 F	7.9	15.7	611.51	2.57E+04
B	0	W	1	3	0	0	2	.	S	A	R	140 F	7.7	4.8	166.52	2.88E+04
B	0	W	1	3	0	1	2	.	S	A	R	140 F	7.7	4.9	174.42	2.79E+04
B	0	W	1	3	1	0	2	.	S	A	R	140 F	7.7	7.0	262.02	2.68E+04
B	0	W	1	3	1	1	2	.	S	A	R	140 F	7.7	7.0	255.79	2.75E+04
B	0	W	1	3	2	0	2	.	S	A	R	140 F	7.7	16.2	498.89	3.25E+04
B	0	W	1	3	2	1	2	.	S	A	R	140 F	7.7	15.8	466.05	3.38E+04
B	1	W	0	3	0	0	1	.	S	A	R	140 F	4.0	4.8	192.31	2.48E+04
B	1	W	0	3	0	1	1	.	S	A	R	140 F	4.0	5.0	193.01	2.58E+04
B	1	W	0	3	1	0	1	.	S	A	R	140 F	4.0	8.0	253.95	3.15E+04
B	1	W	0	3	1	1	1	.	S	A	R	140 F	4.0	7.8	239.95	3.25E+04
B	1	W	0	3	2	0	1	.	S	A	R	140 F	4.0	15.9	502.02	3.16E+04
B	1	W	0	3	2	1	1	.	S	A	R	140 F	4.0	15.4	456.55	3.38E+04
B	1	W	0	3	0	0	2	.	S	A	R	140 F	3.6	4.9	180.05	2.72E+04
B	1	W	0	3	0	1	2	.	S	A	R	140 F	3.6	5.0	181.60	2.73E+04
B	1	W	0	3	1	0	2	.	S	A	R	140 F	3.6	9.0	299.79	3.01E+04
B	1	W	0	3	1	1	2	.	S	A	R	140 F	3.6	8.7	283.61	3.07E+04
B	1	W	0	3	2	0	2	.	S	A	R	140 F	3.6	15.8	488.98	3.22E+04
B	1	W	0	3	2	1	2	.	S	A	R	140 F	3.6	15.2	453.53	3.36E+04
B	1	W	1	3	0	0	1	.	S	A	R	140 F	8.2	4.9	251.88	1.93E+04
B	1	W	1	3	0	1	1	.	S	A	R	140 F	8.2	5.0	257.73	1.92E+04
B	1	W	1	3	1	0	1	.	S	A	R	140 F	8.2	9.1	472.17	1.92E+04
B	1	W	1	3	1	1	1	.	S	A	R	140 F	8.2	8.7	470.49	1.84E+04
B	1	W	1	3	2	0	1	.	S	A	R	140 F	8.2	15.8	649.18	2.44E+04
B	1	W	1	3	2	1	1	.	S	A	R	140 F	8.2	15.4	623.86	2.46E+04
B	1	W	1	3	0	0	2	.	S	A	R	140 F	8.6	4.8	260.31	1.86E+04
B	1	W	1	3	0	1	2	.	S	A	R	140 F	8.6	4.9	261.16	1.87E+04
B	1	W	1	3	1	0	2	.	S	A	R	140 F	8.6	8.8	465.91	1.89E+04

B1W13202.SAR	140 F	8.6	15.6	715.37	2.18E+04
B1W13212.SAR	140 F	8.6	15.2	677.66	2.24E+04

AT = Asphalt Type - B=Boscan, V=Valley
AG = Aggregate Type - W=Watsonville, T=Texas
V = Air Voids - 0=Low, 1=High
TP = Temperature - 0=32 F, 1=68 F, 2=104 F, 3=140 F
ST = Stress Level - 0=Low, 1=Medium, 2=High
F = Frequency - 0=0.5 Hz, 1=1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micro in./in.	Resilient Modulus psi
AT	AC	AG	V	TP	ST	F	r	.	S	T	M					
V	0	W	0	3	0	0	1	.	S	A	R	140 F	4.2	4.8	205.94	2.35E+04
V	0	W	0	3	0	1	1	.	S	A	R	140 F	4.2	4.9	205.43	2.40E+04
V	0	W	0	3	1	0	1	.	S	A	R	140 F	4.2	8.7	396.94	2.18E+04
V	0	W	0	3	1	1	1	.	S	A	R	140 F	4.2	8.4	400.15	2.10E+04
V	0	W	0	3	2	0	1	.	S	A	R	140 F	4.2	16.2	561.45	2.88E+04
V	0	W	0	3	2	1	1	.	S	A	R	140 F	4.2	15.8	556.73	2.84E+04
V	0	W	0	3	0	0	2	.	S	A	R	140 F	4.5	4.8	197.20	2.42E+04
V	0	W	0	3	0	1	2	.	S	A	R	140 F	4.5	4.8	198.02	2.41E+04
V	0	W	0	3	1	0	2	.	S	A	R	140 F	4.5	7.7	302.67	2.56E+04
V	0	W	0	3	1	1	2	.	S	A	R	140 F	4.5	7.9	305.94	2.58E+04
V	0	W	0	3	2	0	2	.	S	A	R	140 F	4.5	15.6	507.30	3.07E+04
V	0	W	0	3	2	1	2	.	S	A	R	140 F	4.5	15.2	481.27	3.16E+04
V	0	W	1	3	0	0	1	.	S	A	R	140 F	8.5	4.8	300.22	1.61E+04
V	0	W	1	3	0	1	1	.	S	A	R	140 F	8.5	4.9	318.77	1.52E+04
V	0	W	1	3	1	0	1	.	S	A	R	140 F	8.5	8.9	361.76	2.45E+04
V	0	W	1	3	1	1	1	.	S	A	R	140 F	8.5	8.5	335.81	2.53E+04
V	0	W	1	3	2	0	1	.	S	A	R	140 F	8.5	16.1	613.77	2.62E+04
V	0	W	1	3	2	1	1	.	S	A	R	140 F	8.5	15.7	582.33	2.70E+04
V	0	W	1	3	0	0	2	.	S	A	R	140 F	8.5	4.7	280.60	1.68E+04
V	0	W	1	3	0	1	2	.	S	A	R	140 F	8.5	4.8	289.30	1.66E+04
V	0	W	1	3	1	0	2	.	S	A	R	140 F	8.5	9.1	384.48	2.36E+04
V	0	W	1	3	1	1	2	.	S	A	R	140 F	8.5	8.9	381.65	2.33E+04
V	0	W	1	3	2	0	2	.	S	A	R	140 F	8.5	16.1	543.96	2.95E+04
V	0	W	1	3	2	1	2	.	S	A	R	140 F	8.5	15.7	533.83	2.93E+04
V	1	W	0	3	0	0	1	.	S	A	R	140 F	3.6	4.8	245.33	1.97E+04
V	1	W	0	3	0	1	1	.	S	A	R	140 F	3.6	4.8	250.08	1.94E+04
V	1	W	0	3	1	0	1	.	S	A	R	140 F	3.6	9.1	403.51	2.26E+04
V	1	W	0	3	1	1	1	.	S	A	R	140 F	3.6	8.9	408.14	2.18E+04
V	1	W	0	3	2	0	1	.	S	A	R	140 F	3.6	16.0	577.20	2.78E+04
V	1	W	0	3	2	1	1	.	S	A	R	140 F	3.6	15.6	561.01	2.78E+04
V	1	W	0	3	0	0	2	.	S	A	R	140 F	3.6	4.8	236.23	2.03E+04
V	1	W	0	3	0	1	2	.	S	A	R	140 F	3.6	4.8	241.28	2.00E+04
V	1	W	0	3	1	0	2	.	S	A	R	140 F	3.6	7.2	263.88	2.71E+04
V	1	W	0	3	1	1	2	.	S	A	R	140 F	3.6	7.5	275.72	2.71E+04
V	1	W	0	3	2	0	2	.	S	A	R	140 F	3.6	15.9	491.54	3.23E+04
V	1	W	0	3	2	1	2	.	S	A	R	140 F	3.6	15.5	474.16	3.26E+04
V	1	W	1	3	0	0	1	.	S	A	R	140 F	8.6	4.8	313.60	1.53E+04
V	1	W	1	3	0	1	1	.	S	A	R	140 F	8.6	4.9	325.26	1.49E+04
V	1	W	1	3	1	0	1	.	S	A	R	140 F	8.6	7.1	334.18	2.13E+04
V	1	W	1	3	1	1	1	.	S	A	R	140 F	8.6	7.9	359.78	2.19E+04
V	1	W	1	3	2	0	1	.	S	A	R	140 F	8.6	16.3	539.49	3.02E+04
V	1	W	1	3	2	1	1	.	S	A	R	140 F	8.6	15.9	531.09	2.99E+04
V	1	W	1	3	0	0	2	.	S	A	R	140 F	8.0	4.8	274.65	1.75E+04
V	1	W	1	3	0	1	2	.	S	A	R	140 F	8.0	4.7	273.89	1.73E+04
V	1	W	1	3	1	0	2	.	S	A	R	140 F	8.0	8.7	368.89	2.36E+04

V1W13112.SAR	140 F	8.0	8.4	356.82	2.37E+04
V1W13202.SAR	140 F	8.0	16.2	509.09	3.19E+04
V1W13212.SAR	140 F	8.0	15.7	493.90	3.18E+04

AT = Asphalt Type - B=Boscan, V=Valley
AC = Asphalt Content - 0=Low, 1=High
AG = Aggregate Type - W=Watsonville, T=Texas
V = Air Voids - 0=Low, 1=High
TP = Temperature - 0=32 F, 1=68 F, 2=104 F, 3=140 F
ST = Stress Level - 0=Low, 1=Medium, 2=High
F = Frequency - 0=0.5 Hz, 1=1 Hz
r = Repeats
SAR = Stiffness-Axial-Repeated Load Test (Controlled Stress)

Appendix B

Diametral Resilient Stiffness Test Results

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micron in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	T	0	0	0	0	1	.	S	D	R	32 F	4.4	28.4	19.20	3.00E+06
B	0	T	0	0	0	1	1	.	S	D	R	32 F	4.4	28.1	18.80	3.01E+06
B	0	T	0	0	1	0	1	.	S	D	R	32 F	4.4	53.7	36.30	2.99E+06
B	0	T	0	0	1	1	1	.	S	D	R	32 F	4.4	52.7	35.60	2.99E+06
B	0	T	0	0	0	0	2	.	S	D	R	32 F	3.6	27.5	17.40	3.20E+06
B	0	T	0	0	0	1	2	.	S	D	R	32 F	3.6	28.6	17.90	3.24E+06
B	0	T	0	0	1	0	2	.	S	D	R	32 F	3.6	50.6	34.10	3.22E+06
B	0	T	0	0	1	1	2	.	S	D	R	32 F	3.6	53.2	33.00	3.26E+06
B	0	T	1	0	0	0	1	.	S	D	R	32 F	8.4	26.6	28.60	1.88E+06
B	0	T	1	0	0	1	1	.	S	D	R	32 F	8.4	26.2	27.80	1.90E+06
B	0	T	1	0	1	0	1	.	S	D	R	32 F	8.4	49.6	54.30	1.85E+06
B	0	T	1	0	1	1	1	.	S	D	R	32 F	8.4	48.7	52.90	1.86E+06
B	0	T	1	0	0	0	2	.	S	D	R	32 F	8.6	25.9	24.30	2.19E+06
B	0	T	1	0	0	1	2	.	S	D	R	32 F	8.6	25.4	23.70	2.23E+06
B	0	T	1	0	1	0	2	.	S	D	R	32 F	8.6	47.5	43.50	2.27E+06
B	0	T	1	0	1	1	2	.	S	D	R	32 F	8.6	46.3	42.30	2.28E+06
B	1	T	0	0	0	0	1	.	S	D	R	32 F	3.7	27.5	21.60	2.57E+06
B	1	T	0	0	0	1	1	.	S	D	R	32 F	3.7	27.1	20.70	2.64E+06
B	1	T	0	0	1	0	1	.	S	D	R	32 F	3.7	52.0	40.80	2.57E+06
B	1	T	0	0	1	1	1	.	S	D	R	32 F	3.7	51.1	39.40	2.63E+06
B	1	T	0	0	0	0	2	.	S	D	R	32 F	4.7	27.5	19.80	2.81E+06
B	1	T	0	0	0	1	2	.	S	D	R	32 F	4.7	27.1	19.30	2.84E+06
B	1	T	0	0	1	0	2	.	S	D	R	32 F	4.7	52.3	37.80	2.79E+06
B	1	T	0	0	1	1	2	.	S	D	R	32 F	4.7	51.4	36.50	2.84E+06
B	1	T	1	0	0	0	1	.	S	D	R	32 F	7.6	26.6	24.63	2.18E+06
B	1	T	1	0	0	1	1	.	S	D	R	32 F	7.6	26.0	23.40	2.24E+06
B	1	T	1	0	1	0	1	.	S	D	R	32 F	7.6	50.3	47.40	2.15E+06
B	1	T	1	0	1	1	1	.	S	D	R	32 F	7.6	49.4	46.80	2.13E+06
B	1	T	1	0	0	0	2	.	S	D	R	32 F	8.5	26.3	26.60	2.03E+06
B	1	T	1	0	0	1	2	.	S	D	R	32 F	8.5	25.9	26.10	2.04E+06
B	1	T	1	0	1	0	2	.	S	D	R	32 F	8.5	49.3	49.70	2.02E+06
B	1	T	1	0	1	1	2	.	S	D	R	32 F	8.5	48.5	50.60	1.97E+06

AT = Asphalt Type - B=Boscan, V=Valley
AC = Asphalt Content - 0=Low, 1=High
AG = Aggregate Type - W=Watsonville, T=Texas
V = Air Voids - 0=Low, 1=High
TP = Temperature - 0=32 F, 1=68 F, 2=104 F, 3=140 F
ST = Stress Level - 0=Low, 1=High
F = Frequency - 0=0.5 Hz, 1=1 Hz
r = Repeats
SDR = Stiffness-Diametral-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micron in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	T	0	0	0	0	1	.	S	D	R	32 F	4.6	28.1	14.40	3.95E+06
V	0	T	0	0	0	1	1	.	S	D	R	32 F	4.6	27.3	13.30	4.15E+06
V	0	T	0	0	1	0	1	.	S	D	R	32 F	4.6	52.7	26.10	4.08E+06
V	0	T	0	0	1	1	1	.	S	D	R	32 F	4.6	51.7	24.80	4.21E+06
V	0	T	0	0	0	0	2	.	S	D	R	32 F	3.6	27.5	11.70	4.68E+06
V	0	T	0	0	0	1	2	.	S	D	R	32 F	3.6	27.0	12.14	4.51E+06
V	0	T	0	0	1	0	2	.	S	D	R	32 F	3.6	52.4	21.00	5.04E+06
V	0	T	0	0	1	1	2	.	S	D	R	32 F	3.6	53.2	21.30	5.01E+06
V	0	T	1	0	0	0	1	.	S	D	R	32 F	8.0	23.5	14.80	3.21E+06
V	0	T	1	0	0	1	1	.	S	D	R	32 F	8.0	26.2	17.10	3.10E+06
V	0	T	1	0	1	0	1	.	S	D	R	32 F	8.0	50.3	32.60	3.11E+06
V	0	T	1	0	1	1	1	.	S	D	R	32 F	8.0	49.4	31.50	3.17E+06
V	0	T	1	0	0	0	2	.	S	D	R	32 F	8.6	27.1	16.80	3.26E+06
V	0	T	1	0	0	1	2	.	S	D	R	32 F	8.6	26.7	16.60	3.26E+06
V	0	T	1	0	1	0	2	.	S	D	R	32 F	8.6	51.6	32.40	3.21E+06
V	0	T	1	0	1	1	2	.	S	D	R	32 F	8.6	50.5	31.00	3.29E+06
V	1	T	0	0	0	0	1	.	S	D	R	32 F	4.1	27.3	14.40	3.84E+06
V	1	T	0	0	0	1	1	.	S	D	R	32 F	4.1	26.9	13.70	3.96E+06
V	1	T	0	0	1	0	1	.	S	D	R	32 F	4.1	51.4	25.50	4.07E+06
V	1	T	0	0	1	1	1	.	S	D	R	32 F	4.1	50.4	24.60	4.14E+06
V	1	T	0	0	0	0	2	.	S	D	R	32 F	4.6	27.1	14.40	3.81E+06
V	1	T	0	0	0	1	2	.	S	D	R	32 F	4.6	26.7	13.90	3.88E+06
V	1	T	0	0	1	0	2	.	S	D	R	32 F	4.6	51.5	26.60	3.91E+06
V	1	T	0	0	1	1	2	.	S	D	R	32 F	4.6	50.6	29.60	3.99E+06
V	1	T	1	0	0	0	1	.	S	D	R	32 F	8.6	27.0	15.20	3.54E+06
V	1	T	1	0	0	1	1	.	S	D	R	32 F	8.6	26.6	14.30	3.76E+06
V	1	T	1	0	1	0	1	.	S	D	R	32 F	8.6	50.8	27.20	3.77E+06
V	1	T	1	0	1	1	1	.	S	D	R	32 F	8.6	49.8	26.20	3.84E+06
V	1	T	1	0	0	0	2	.	S	D	R	32 F	7.4	26.4	16.80	3.18E+06
V	1	T	1	0	0	1	2	.	S	D	R	32 F	7.4	26.1	16.00	3.31E+06
V	1	T	1	0	1	0	2	.	S	D	R	32 F	7.4	50.5	32.20	3.16E+06
V	1	T	1	0	1	1	2	.	S	D	R	32 F	7.4	49.6	31.30	3.21E+06

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SDR = Stiffness-Diametral-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micron in./in	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	W	0	0	0	0	1	.	S	D	R	32 F	3.7	28.8	22.10	2.63E+06
B	0	W	0	0	0	1	1	.	S	D	R	32 F	3.7	28.4	21.80	2.64E+06
B	0	W	0	0	1	0	1	.	S	D	R	32 F	3.7	53.6	41.40	2.62E+06
B	0	W	0	0	1	1	1	.	S	D	R	32 F	3.7	52.6	40.50	2.62E+06
B	0	W	0	0	0	0	2	.	S	D	R	32 F	4.5	29.4	23.60	2.51E+06
B	0	W	0	0	0	1	2	.	S	D	R	32 F	4.5	28.9	23.00	2.54E+06
B	0	W	0	0	1	0	2	.	S	D	R	32 F	4.5	55.9	45.20	2.50E+06
B	0	W	0	0	1	1	2	.	S	D	R	32 F	4.5	54.8	43.70	2.53E+06
B	0	W	1	0	0	0	1	.	S	D	R	32 F	7.4	26.4	24.30	2.19E+06
B	0	W	1	0	0	1	1	.	S	D	R	32 F	7.4	25.0	23.30	2.19E+06
B	0	W	1	0	1	0	1	.	S	D	R	32 F	7.4	53.3	51.20	2.10E+06
B	0	W	1	0	1	1	1	.	S	D	R	32 F	7.4	52.4	50.10	2.12E+06
B	0	W	1	0	0	0	2	.	S	D	R	32 F	7.7	27.5	28.60	1.94E+06
B	0	W	1	0	0	1	2	.	S	D	R	32 F	7.7	25.2	25.70	1.98E+06
B	0	W	1	0	1	0	2	.	S	D	R	32 F	7.7	53.2	57.60	1.87E+06
B	0	W	1	0	1	1	2	.	S	D	R	32 F	7.7	52.3	55.40	1.91E+06
B	1	W	0	0	0	0	1	.	S	D	R	32 F	3.6	29.2	27.80	2.13E+06
B	1	W	0	0	0	1	1	.	S	D	R	32 F	3.6	28.1	26.20	2.17E+06
B	1	W	0	0	1	0	1	.	S	D	R	32 F	3.6	55.3	51.60	2.17E+06
B	1	W	0	0	1	1	1	.	S	D	R	32 F	3.6	54.3	51.80	2.12E+06
B	1	W	0	0	0	0	2	.	S	D	R	32 F	4.2	28.2	24.60	2.32E+06
B	1	W	0	0	0	1	2	.	S	D	R	32 F	4.2	27.8	24.10	2.33E+06
B	1	W	0	0	1	0	2	.	S	D	R	32 F	4.2	53.9	47.20	2.31E+06
B	1	W	0	0	1	1	2	.	S	D	R	32 F	4.2	52.9	45.60	2.35E+06
B	1	W	1	0	0	0	1	.	S	D	R	32 F	7.7	27.0	26.10	2.09E+06
B	1	W	1	0	0	1	1	.	S	D	R	32 F	7.7	24.4	23.10	2.14E+06
B	1	W	1	0	1	0	1	.	S	D	R	32 F	7.7	52.1	51.20	2.06E+06
B	1	W	1	0	1	1	1	.	S	D	R	32 F	7.7	51.3	49.50	2.09E+06
B	1	W	1	0	0	0	2	.	S	D	R	32 F	7.6	26.5	29.20	1.83E+06
B	1	W	1	0	0	1	2	.	S	D	R	32 F	7.6	23.6	25.30	1.89E+06
B	1	W	1	0	1	0	2	.	S	D	R	32 F	7.6	52.6	59.50	1.78E+06
B	1	W	1	0	1	1	2	.	S	D	R	32 F	7.6	48.6	53.80	1.82E+06

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0=Low, 1=High
AG = Aggregate Type - W=Watsonville, T=Texas
V = Air Voids - 0=Low, 1=High
TP = Temperature - 0=32F, 1=68 F, 2=104 F, 3=140 F
ST = Stress Level - 0=Low, 1=High
F = Frequency - 0=0.5 Hz, 1=1 Hz
r = Repeats
SDR = Stiffness-Diametral-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micron	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	W	0	0	0	0	1	.	S	D	R	32 F	3.5	28.1	14.40	3.95E+06
V	0	W	0	0	0	1	1	.	S	D	R	32 F	3.5	25.6	12.90	4.02E+06
V	0	W	0	0	1	0	1	.	S	D	R	32 F	3.5	52.7	27.50	3.88E+06
V	0	W	0	0	1	1	1	.	S	D	R	32 F	3.5	51.9	27.10	3.87E+06
V	0	W	0	0	0	0	2	.	S	D	R	32 F	4.0	27.5	12.60	4.42E+06
V	0	W	0	0	0	1	2	.	S	D	R	32 F	4.0	27.1	12.30	4.44E+06
V	0	W	0	0	1	0	2	.	S	D	R	32 F	4.0	54.3	25.20	4.36E+06
V	0	W	0	0	1	1	2	.	S	D	R	32 F	4.0	53.4	24.30	4.43E+06
V	0	W	1	0	0	0	1	.	S	D	R	32 F	8.4	27.1	17.20	3.20E+06
V	0	W	1	0	0	1	1	.	S	D	R	32 F	8.4	26.6	16.80	3.20E+06
V	0	W	1	0	1	0	1	.	S	D	R	32 F	8.4	52.4	33.50	3.16E+06
V	0	W	1	0	1	1	1	.	S	D	R	32 F	8.4	51.5	32.30	3.22E+06
V	0	W	1	0	0	0	2	.	S	D	R	32 F	8.1	27.5	17.50	3.17E+06
V	0	W	1	0	0	1	2	.	S	D	R	32 F	8.1	27.0	17.40	3.14E+06
V	0	W	1	0	1	0	2	.	S	D	R	32 F	8.1	52.4	33.70	3.14E+06
V	0	W	1	0	1	1	2	.	S	D	R	32 F	8.1	51.3	32.70	3.17E+06
V	1	W	0	0	0	0	1	.	S	D	R	32 F	3.9	27.6	15.00	3.72E+06
V	1	W	0	0	0	1	1	.	S	D	R	32 F	3.9	24.5	12.90	3.84E+06
V	1	W	0	0	1	0	1	.	S	D	R	32 F	3.9	52.9	28.10	3.80E+06
V	1	W	0	0	1	1	1	.	S	D	R	32 F	3.9	52.8	28.60	3.73E+06
V	1	W	0	0	0	0	2	.	S	D	R	32 F	3.6	28.4	14.90	3.86E+06
V	1	W	0	0	0	1	2	.	S	D	R	32 F	3.6	25.5	13.30	3.86E+06
V	1	W	0	0	1	0	2	.	S	D	R	32 F	3.6	55.7	36.60	3.08E+06
V	1	W	0	0	1	1	2	.	S	D	R	32 F	3.6	54.6	29.40	3.75E+06
V	1	W	1	0	0	0	1	.	S	D	R	32 F	8.3	27.2	30.50	1.80E+06
V	1	W	1	0	0	1	1	.	S	D	R	32 F	8.3	26.5	30.40	1.76E+06
V	1	W	1	0	1	0	1	.	S	D	R	32 F	8.3	51.5	59.40	1.75E+06
V	1	W	1	0	1	1	1	.	S	D	R	32 F	8.3	50.6	58.30	1.75E+06
V	1	W	1	0	0	0	2	.	S	D	R	32 F	8.0	27.1	19.90	2.76E+06
V	1	W	1	0	0	1	2	.	S	D	R	32 F	8.0	26.7	19.60	2.76E+06
V	1	W	1	0	1	0	2	.	S	D	R	32 F	8.0	51.8	36.70	2.85E+06
V	1	W	1	0	1	1	2	.	S	D	R	32 F	8.0	50.9	36.80	2.80E+06

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SDR = Stiffness-Diametral-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micron in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	T	0	1	0	0	1	.	S	D	R	68 F	4.4	14.5	46.10	6.33E+05
B	0	T	0	1	0	1	1	.	S	D	R	68 F	4.4	14.2	42.50	6.77E+05
B	0	T	0	1	1	0	1	.	S	D	R	68 F	4.4	28.7	93.60	6.19E+05
B	0	T	0	1	1	1	1	.	S	D	R	68 F	4.4	28.1	90.40	6.29E+05
B	0	T	0	1	0	0	2	.	S	D	R	68 F	3.6	14.3	30.70	9.40E+05
B	0	T	0	1	0	1	2	.	S	D	R	68 F	3.6	14.0	29.80	9.46E+05
B	0	T	0	1	1	0	2	.	S	D	R	68 F	3.6	27.7	65.10	8.54E+05
B	0	T	0	1	1	1	2	.	S	D	R	68 F	3.6	27.1	64.00	8.49E+05
B	0	T	1	1	0	0	1	.	S	D	R	68 F	8.4	13.4	46.10	6.33E+05
B	0	T	1	1	0	1	1	.	S	D	R	68 F	8.4	13.2	42.50	6.77E+05
B	0	T	1	1	1	0	1	.	S	D	R	68 F	8.4	26.6	93.60	6.19E+05
B	0	T	1	1	1	1	1	.	S	D	R	68 F	8.4	26.1	90.40	6.29E+05
B	0	T	1	1	0	0	2	.	S	D	R	68 F	8.6	13.3	30.70	9.40E+05
B	0	T	1	1	0	1	2	.	S	D	R	68 F	8.6	13.0	29.80	9.46E+05
B	0	T	1	1	1	0	2	.	S	D	R	68 F	8.6	25.6	65.10	8.54E+05
B	0	T	1	1	1	1	2	.	S	D	R	68 F	8.6	25.1	64.00	8.49E+05
B	1	T	0	1	0	0	1	.	S	D	R	68 F	3.7	14.1	47.40	6.00E+05
B	1	T	0	1	0	1	1	.	S	D	R	68 F	3.7	13.8	46.50	6.01E+05
B	1	T	0	1	1	0	1	.	S	D	R	68 F	3.7	27.1	99.80	5.50E+05
B	1	T	0	1	1	1	1	.	S	D	R	68 F	3.7	26.6	96.40	5.58E+05
B	1	T	0	1	0	0	2	.	S	D	R	68 F	4.7	14.1	43.20	6.60E+05
B	1	T	0	1	0	1	2	.	S	D	R	68 F	4.7	13.8	42.00	6.64E+05
B	1	T	0	1	1	0	2	.	S	D	R	68 F	4.7	27.3	91.90	6.00E+05
B	1	T	0	1	1	1	2	.	S	D	R	68 F	4.7	26.6	89.30	6.03E+05
B	1	T	1	1	0	0	1	.	S	D	R	68 F	7.6	13.3	57.40	4.86E+05
B	1	T	1	1	0	1	1	.	S	D	R	68 F	7.6	13.0	56.80	4.79E+05
B	1	T	1	1	1	0	1	.	S	D	R	68 F	7.6	26.5	127.00	4.35E+05
B	1	T	1	1	1	1	1	.	S	D	R	68 F	7.6	26.0	124.00	4.37E+05
B	1	T	1	1	0	0	2	.	S	D	R	68 F	8.5	12.9	53.80	4.45E+05
B	1	T	1	1	0	1	2	.	S	D	R	68 F	8.5	12.6	57.10	4.48E+05
B	1	T	1	1	1	0	2	.	S	D	R	68 F	8.5	25.8	134.00	3.89E+05
B	1	T	1	1	1	1	2	.	S	D	R	68 F	8.5	25.3	132.00	3.88E+05

AT = Asphalt Type - B=Boscan, V=Valley
AC = Asphalt Content - 0=Low, 1=High
AG = Aggregate Type - W=Watsonville, T=Texas
V = Air Voids - 0=Low, 1=High
TP = Temperature - 0=32 F, 1=68 F, 2=104 F, 3=140 F
ST = Stress Level - 0=Low, 1=High
F = Frequency - 0=0.5 Hz, 1=1 Hz
r = Repeats
SDR = Stiffness-Diametral-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micron in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	T	0	1	0	0	1	.	S	D	R	68 F	4.6	14.4	17.60	1.66E+06
V	0	T	0	1	0	1	1	.	S	D	R	68 F	4.6	14.1	16.50	1.72E+06
V	0	T	0	1	1	0	1	.	S	D	R	68 F	4.6	27.4	34.80	1.59E+06
V	0	T	0	1	1	1	1	.	S	D	R	68 F	4.6	26.9	33.60	1.61E+06
V	0	T	0	1	0	0	2	.	S	D	R	68 F	3.6	14.2	17.50	1.64E+06
V	0	T	0	1	0	1	2	.	S	D	R	68 F	3.6	13.9	15.90	1.76E+06
V	0	T	0	1	1	0	2	.	S	D	R	68 F	3.6	27.6	32.30	1.73E+06
V	0	T	0	1	1	1	2	.	S	D	R	68 F	3.6	27.1	30.80	1.78E+06
V	0	T	1	1	0	0	1	.	S	D	R	68 F	8.0	14.1	26.00	1.09E+06
V	0	T	1	1	0	1	1	.	S	D	R	68 F	8.0	13.7	24.80	1.12E+06
V	0	T	1	1	1	0	1	.	S	D	R	68 F	8.0	26.5	50.90	1.05E+06
V	0	T	1	1	1	1	1	.	S	D	R	68 F	8.0	25.9	49.60	1.09E+06
V	0	T	1	1	0	0	2	.	S	D	R	68 F	8.6	13.8	26.10	1.07E+06
V	0	T	1	1	0	1	2	.	S	D	R	68 F	8.6	13.9	26.70	1.05E+06
V	0	T	1	1	1	0	2	.	S	D	R	68 F	8.6	26.4	56.20	9.50E+05
V	0	T	1	1	1	1	2	.	S	D	R	68 F	8.6	25.8	56.50	9.25E+05
V	1	T	0	1	0	0	1	.	S	D	R	68 F	4.1	13.8	21.10	1.32E+06
V	1	T	0	1	0	1	1	.	S	D	R	68 F	4.1	13.5	20.00	1.36E+06
V	1	T	0	1	1	0	1	.	S	D	R	68 F	4.1	27.4	43.10	1.28E+06
V	1	T	0	1	1	1	1	.	S	D	R	68 F	4.1	26.8	41.90	1.30E+06
V	1	T	0	1	0	0	2	.	S	D	R	68 F	4.6	13.9	21.50	1.31E+06
V	1	T	0	1	0	1	2	.	S	D	R	68 F	4.6	13.6	20.60	1.34E+06
V	1	T	0	1	1	0	2	.	S	D	R	68 F	4.6	27.2	43.40	1.27E+06
V	1	T	0	1	1	1	2	.	S	D	R	68 F	4.6	26.7	43.00	1.26E+06
V	1	T	1	1	0	0	1	.	S	D	R	68 F	8.6	13.7	23.40	1.18E+06
V	1	T	1	1	0	1	1	.	S	D	R	68 F	8.6	13.4	22.10	1.23E+06
V	1	T	1	1	1	0	1	.	S	D	R	68 F	8.6	27.0	46.50	1.17E+06
V	1	T	1	1	1	1	1	.	S	D	R	68 F	8.6	26.4	44.40	1.20E+06
V	1	T	1	1	0	0	2	.	S	D	R	68 F	7.4	13.5	26.80	1.02E+06
V	1	T	1	1	0	1	2	.	S	D	R	68 F	7.4	13.3	25.80	1.04E+06
V	1	T	1	1	1	0	2	.	S	D	R	68 F	7.4	26.4	54.30	9.87E+05
V	1	T	1	1	1	1	2	.	S	D	R	68 F	7.4	25.9	53.30	9.81E+05

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SDR = Stiffness-Diametral-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micron in./in	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	W	0	1	0	0	1	.	S	D	R	68 F	3.7	14.9	44.70	6.74E+05
B	0	W	0	1	0	1	1	.	S	D	R	68 F	3.7	13.2	41.10	6.47E+05
B	0	W	0	1	1	0	1	.	S	D	R	68 F	3.7	28.2	94.80	6.02E+05
B	0	W	0	1	1	1	1	.	S	D	R	68 F	3.7	27.6	91.50	6.10E+05
B	0	W	0	1	0	0	2	.	S	D	R	68 F	4.5	14.9	40.30	7.50E+05
B	0	W	0	1	0	1	2	.	S	D	R	68 F	4.5	14.6	40.40	7.32E+05
B	0	W	0	1	1	0	2	.	S	D	R	68 F	4.5	28.8	91.80	6.34E+05
B	0	W	0	1	1	1	2	.	S	D	R	68 F	4.5	28.2	89.20	6.39E+05
B	0	W	1	1	0	0	1	.	S	D	R	68 F	7.4	14.1	52.30	5.46E+05
B	0	W	1	1	0	1	1	.	S	D	R	68 F	7.4	13.9	51.20	5.49E+05
B	0	W	1	1	1	0	1	.	S	D	R	68 F	7.4	27.4	110.00	5.03E+05
B	0	W	1	1	1	1	1	.	S	D	R	68 F	7.4	26.7	107.00	5.03E+05
B	0	W	1	1	0	0	2	.	S	D	R	68 F	7.7	14.0	50.20	5.66E+05
B	0	W	1	1	0	1	2	.	S	D	R	68 F	7.7	13.7	49.30	5.63E+05
B	0	W	1	1	1	0	2	.	S	D	R	68 F	7.7	26.9	108.00	5.06E+05
B	0	W	1	1	1	1	2	.	S	D	R	68 F	7.7	26.4	103.00	5.16E+05
B	1	W	0	1	0	0	1	.	S	D	R	68 F	3.6	15.0	49.70	6.09E+05
B	1	W	0	1	0	1	1	.	S	D	R	68 F	3.6	17.8	47.90	6.15E+05
B	1	W	0	1	1	0	1	.	S	D	R	68 F	3.6	29.0	105.00	5.56E+05
B	1	W	0	1	1	1	1	.	S	D	R	68 F	3.6	28.5	102.00	5.66E+05
B	1	W	0	1	0	0	2	.	S	D	R	68 F	4.2	14.5	43.00	6.85E+05
B	1	W	0	1	0	1	2	.	S	D	R	68 F	4.2	14.3	40.00	7.22E+05
B	1	W	0	1	1	0	2	.	S	D	R	68 F	4.2	28.0	87.20	6.48E+05
B	1	W	0	1	1	1	2	.	S	D	R	68 F	4.2	27.4	85.50	6.48E+05
B	1	W	1	1	0	0	1	.	S	D	R	68 F	7.7	14.3	52.00	5.55E+05
B	1	W	1	1	0	1	1	.	S	D	R	68 F	7.7	13.9	49.10	5.72E+05
B	1	W	1	1	1	0	1	.	S	D	R	68 F	7.7	27.5	108.00	5.14E+05
B	1	W	1	1	1	1	1	.	S	D	R	68 F	7.7	27.0	105.00	5.22E+05
B	1	W	1	1	0	0	2	.	S	D	R	68 F	7.6	13.4	58.60	4.62E+05
B	1	W	1	1	0	1	2	.	S	D	R	68 F	7.6	13.2	57.00	4.66E+05
B	1	W	1	1	1	0	2	.	S	D	R	68 F	7.6	27.6	132.00	4.22E+05
B	1	W	1	1	1	1	2	.	S	D	R	68 F	7.6	26.9	129.00	4.24E+05

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SDR = Stiffness-Diametral-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micron in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
V	0	W	0	1	0	0	1	.	S	D	R	68 F	3.5	14.6	20.60	1.43E+06
V	0	W	0	1	0	1	1	.	S	D	R	68 F	3.5	14.3	19.50	1.48E+06
V	0	W	0	1	1	0	1	.	S	D	R	68 F	3.5	28.2	40.60	1.41E+06
V	0	W	0	1	1	1	1	.	S	D	R	68 F	3.5	27.7	39.10	1.43E+06
V	0	W	0	1	0	0	2	.	S	D	R	68 F	4.0	15.2	16.40	1.88E+06
V	0	W	0	1	0	1	2	.	S	D	R	68 F	4.0	14.9	15.10	1.99E+06
V	0	W	0	1	1	0	2	.	S	D	R	68 F	4.0	28.8	29.90	1.95E+06
V	0	W	0	1	1	1	2	.	S	D	R	68 F	4.0	28.2	29.70	1.93E+06
V	0	W	1	1	0	0	1	.	S	D	R	68 F	8.4	18.1	30.40	1.21E+06
V	0	W	1	1	0	1	1	.	S	D	R	68 F	8.4	17.8	29.10	1.24E+06
V	0	W	1	1	1	0	1	.	S	D	R	68 F	8.4	26.9	46.30	1.17E+06
V	0	W	1	1	1	1	1	.	S	D	R	68 F	8.4	26.2	45.10	1.17E+06
V	0	W	1	1	0	0	2	.	S	D	R	68 F	8.1	14.2	24.00	1.19E+06
V	0	W	1	1	0	1	2	.	S	D	R	68 F	8.1	13.8	22.40	1.25E+06
V	0	W	1	1	1	0	2	.	S	D	R	68 F	8.1	27.1	46.70	1.17E+06
V	0	W	1	1	1	1	2	.	S	D	R	68 F	8.1	26.6	45.40	1.18E+06
V	1	W	0	1	0	0	1	.	S	D	R	68 F	3.9	14.8	26.50	1.11E+06
V	1	W	0	1	0	1	1	.	S	D	R	68 F	3.9	14.6	26.10	1.13E+06
V	1	W	0	1	1	0	1	.	S	D	R	68 F	3.9	29.1	54.40	1.08E+06
V	1	W	0	1	1	1	1	.	S	D	R	68 F	3.9	28.6	53.30	1.08E+06
V	1	W	0	1	0	0	2	.	S	D	R	68 F	3.6	15.7	26.10	1.22E+06
V	1	W	0	1	0	1	2	.	S	D	R	68 F	3.6	15.4	25.30	1.23E+06
V	1	W	0	1	1	0	2	.	S	D	R	68 F	3.6	29.3	50.70	1.17E+06
V	1	W	0	1	1	1	2	.	S	D	R	68 F	3.6	28.7	49.50	1.17E+06
V	1	W	1	1	0	0	1	.	S	D	R	68 F	8.3	13.7	61.20	4.51E+05
V	1	W	1	1	0	1	1	.	S	D	R	68 F	8.3	13.4	59.00	4.57E+05
V	1	W	1	1	1	0	1	.	S	D	R	68 F	8.3	27.2	13.10	4.20E+05
V	1	W	1	1	1	1	1	.	S	D	R	68 F	8.3	26.8	12.80	4.22E+05
V	1	W	1	1	0	0	2	.	S	D	R	68 F	8.0	12.9	26.80	9.77E+05
V	1	W	1	1	0	1	2	.	S	D	R	68 F	8.0	12.8	25.60	1.01E+06
V	1	W	1	1	1	0	2	.	S	D	R	68 F	8.0	27.2	55.60	9.87E+05
V	1	W	1	1	1	1	2	.	S	D	R	68 F	8.0	27.4	54.80	9.88E+05

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SDR = Stiffness-Diametral-Repeated Load Test (Controlled Stress)

Specimen Designation												Temp. F	Percent Voids	Stress psi.	Strain Micron in./in.	Resilient Modulus psi
AT	AC	A	V	TP	ST	F	r	.	S	T	M					
B	0	T	0	2	0	0	1	.	S	D	R	104 F	4.4	7.7	113	1.38E+05
B	0	T	0	2	0	1	1	.	S	D	R	104 F	4.4	6.9	109	1.28E+05
B	0	T	0	2	1	0	1	.	S	D	R	104 F	4.4	14.3	223	1.30E+05
B	0	T	0	2	1	1	1	.	S	D	R	104 F	4.4	14.2	237	1.21E+05
B	0	T	0	2	0	0	2	.	S	D	R	104 F	3.6	7.2	102	1.43E+05
B	0	T	0	2	0	1	2	.	S	D	R	104 F	3.6	6.9	100	1.40E+05
B	0	T	0	2	1	0	2	.	S	D	R	104 F	3.6	14.4	214	1.37E+05
B	0	T	0	2	1	1	2	.	S	D	R	104 F	3.6	14.2	222	1.30E+05
B	0	T	1	2	0	0	1	.	S	D	R	104 F	8.4	6.9	156	9.09E+04
B	0	T	1	2	0	1	1	.	S	D	R	104 F	8.4	6.4	161	8.02E+04
B	0	T	1	2	1	0	1	.	S	D	R	104 F	8.4	13.1	323	8.26E+04
B	0	T	1	2	1	1	1	.	S	D	R	104 F	8.4	13.0	388	6.78E+04
B	0	T	1	2	0	0	2	.	S	D	R	104 F	8.6	6.4	120	1.09E+05
B	0	T	1	2	0	1	2	.	S	D	R	104 F	8.6	6.3	139	9.20E+04
B	0	T	1	2	1	0	2	.	S	D	R	104 F	8.6	12.9	278	9.45E+04
B	0	T	1	2	1	1	2	.	S	D	R	104 F	8.6	12.8	341	7.59E+04
B	1	T	0	2	0	0	1	.	S	D	R	104 F	3.7	7.2	123	1.19E+05
B	1	T	0	2	0	1	1	.	S	D	R	104 F	3.7	6.6	123	1.09E+05
B	1	T	0	2	1	0	1	.	S	D	R	104 F	3.7	13.9	256	1.09E+05
B	1	T	0	2	1	1	1	.	S	D	R	104 F	3.7	13.7	272	1.02E+05
B	1	T	0	2	0	0	2	.	S	D	R	104 F	4.7	6.9	93	1.50E+05
B	1	T	0	2	0	1	2	.	S	D	R	104 F	4.7	6.7	100	1.36E+05
B	1	T	0	2	1	0	2	.	S	D	R	104 F	4.7	13.9	207	1.36E+05
B	1	T	0	2	1	1	2	.	S	D	R	104 F	4.7	13.8	241	1.16E+05
B	1	T	1	2	0	0	1	.	S	D	R	104 F	7.6	6.8	158	8.65E+04
B	1	T	1	2	0	1	1	.	S	D	R	104 F	7.6	6.6	184	7.26E+04
B	1	T	1	2	1	0	1	.	S	D	R	104 F	7.6	13.0	420	6.25E+04
B	1	T	1	2	1	1	1	.	S	D	R	104 F	7.6	12.7	478	5.37E+04
B	1	T	1	2	0	0	2	.	S	D	R	104 F	8.5	6.4	170	7.65E+04
B	1	T	1	2	0	1	2	.	S	D	R	104 F	8.5	6.4	191	6.75E+04
B	1	T	1	2	1	0	2	.	S	D	R	104 F	8.5	13.1	380	6.98E+04
B	1	T	1	2	1	1	2	.	S	D	R	104 F	8.5	13.0	414	6.33E+04

AT = Asphalt Type - B = Boscan, V = Valley
AC = Asphalt Content - 0 = Low, 1 = High
AG = Aggregate Type - W = Watsonville, T = Texas
V = Air Voids - 0 = Low, 1 = High
TP = Temperature - 0 = 32 F, 1 = 68 F, 2 = 104 F, 3 = 140 F
ST = Stress Level - 0 = Low, 1 = High
F = Frequency - 0 = 0.5 Hz, 1 = 1 Hz
r = Repeats
SDR = Stiffness-Diametral-Repeated Load Test (Controlled Stress)

Appendix C

Flexural Stiffness Test Results

SPECIMEN DESIGNATION												TEMP F	PERCENT VOIDS	STRAIN Micron	STRESS psi	STIFF. psi
AT	AC	AG	G	V	TP	ST	r		S	T	M					
B	0	T	M	0	1	0	1	.	F	F	S	68	4.0	231	127.4	553000
B	0	T	M	0	1	0	2	.	F	F	S	68	5.4	275	160.2	584000
B	0	T	M	0	1	1	1	.	F	F	S	68	4.5	501	243.0	485000
B	0	T	M	0	1	1	2	.	F	F	S	68	4.6	474	238.0	503000
B	1	T	M	1	1	0	1	.	F	F	S	68	7.6	225	103.6	464000
B	1	T	M	1	1	0	2	.	F	F	S	68	7.8	231	84.4	367000
B	1	T	M	1	1	1	1	.	F	F	S	68	7.5	432	141.6	332000
B	1	T	M	1	1	1	2	.	F	F	S	68	7.5	463	142.6	308000
B	0	W	M	1	1	0	1	.	F	F	S	68	8.6	240	128.3	535000
B	0	W	M	1	1	0	2	.	F	F	S	68	7.7	233	165.0	708000
B	0	W	M	1	1	1	1	.	F	F	S	68	8.0	457	257.9	567000
B	0	W	M	1	1	1	2	.	F	F	S	68	8.3	432	211.0	489000
B	1	W	M	0	1	0	1	.	F	F	S	68	3.1	294	156.8	573000
B	1	W	M	0	1	1	1	.	F	F	S	68	3.6	523	167.4	320000
B	1	W	M	0	1	1	2	.	F	F	S	68	3.6	481	282.0	588000
V	0	T	M	1	1	0	1	.	F	F	S	68	8.3	272	183.1	674000
V	0	T	M	1	1	0	2	.	F	F	S	68	8.6	252	202.8	804000
V	0	T	M	1	1	1	1	.	F	F	S	68	7.4	484	334.3	691000
V	0	T	M	1	1	1	2	.	F	F	S	68	7.5	455	314.5	692000
V	1	T	M	0	1	0	1	.	F	F	S	68	3.8	251	319.1	1270000
V	1	T	M	0	1	0	2	.	F	F	S	68	4.4	213	248.3	1170000
V	1	T	M	0	1	1	1	.	F	F	S	68	3.6	510	496.0	1030000
V	1	T	M	0	1	1	2	.	F	F	S	68	4.7	429	419.0	1020000
V	0	W	M	0	1	0	1	.	F	F	S	68	4.0	252	398.1	1580000
V	0	W	M	0	1	0	2	.	F	F	S	68	3.5	219	314.5	1440000
V	0	W	M	0	1	1	1	.	F	F	S	68	4.5	457	577.2	1520000
V	0	W	M	0	1	1	2	.	F	F	S	68	4.3	509	601.0	1470000
V	1	W	M	1	1	0	1	.	F	F	S	68	7.7	205	248.8	1220000
V	1	W	M	1	1	0	2	.	F	F	S	68	8.0	240	243.3	1020000
V	1	W	M	1	1	1	1	.	F	F	S	68	7.7	488	420.6	862000
V	1	W	M	1	1	1	2	.	F	F	S	68	8.0	476	340.2	950000
B	0	T	M	1	0	0	1	.	F	F	S	32	7.8	193	370.6	1920000
B	0	T	M	1	0	0	2	.	F	F	S	32	7.7	163	252.7	1550000
B	0	T	M	1	0	1	1	.	F	F	S	32	7.9	436	797.9	1830000
B	0	T	M	1	0	1	2	.	F	F	S	32	7.5	408	603.8	1480000
B	1	T	M	0	0	0	1	.	F	F	S	32	3.5	191	449.8	2355000
B	1	T	M	0	0	1	1	.	F	F	S	32	4.5	316	606.7	1920000
B	1	T	M	0	0	1	2	.	F	F	S	32	4.6	303	633.3	2090000
B	0	W	M	0	0	0	1	.	F	F	S	32	4.1	290	498.8	1720000
B	0	W	M	0	0	0	2	.	F	F	S	32	3.7	259	507.6	1960000
B	0	W	M	0	0	1	1	.	F	F	S	32	3.5	417	813.2	1950000
B	1	W	M	1	0	0	1	.	F	F	S	32	8.4	274	345.2	1260000
B	1	W	M	1	0	0	2	.	F	F	S	32	7.4	315	409.5	1300000
B	1	W	M	1	0	1	1	.	F	F	S	32	7.7	426	560.2	1315000

V0TM0001.FFS	32	4.1	83	284.5	3430000
V0TM0002.FFS	32	4.5	128	371.2	2900000
V0TM0011.FFS	32	3.5	194	537.4	2770000
V1TM1001.FFS	32	7.4	202	474.7	2350000
V1TM1011.FFS	32	6.6	278	317.0	1140000
V0WM1001.FFS	32	7.9	193	413.0	2140000
V0WM1011.FFS	32	8.4	300	621.0	2070000
V0WM1012.FFS	32	8.3	294	564.5	1920000
V1WM0001.FFS	32	4.3	190	566.2	2980000
V1WM0011.FFS	32	4.6	295	772.9	2620000
V1WM0012.FFS	32	4.1	282	879.8	3120000

Appendix D

Flexural Stiffness Test Results — 10 Hz, 68°F (20°C)

Dynamic Flexural Fatigue, Controlled-strain Tests
20 C, 10 Hz Frequency
8x2 Expanded Test Program

Specimen Designation					STRAIN in./in.	STRESS psi	STIFF psi	PHASE ANGLE	VOIDS %	VFB %
AT	AG	VO	ST	RP						
AAA	RH	0	0	0	0.0004	112.0	280000	50	3.4	77.8
AAA	RH	0	0	1	0.0004	102.5	256300	48	4.3	73.3
AAA	RH	0	1	0	0.0007	196.7	281000	52	3.3	78.3
AAA	RH	0	1	1	0.0007	212.7	303903	51	2.9	80.5
AAA	RH	1	0	0	0.0004	92.2	230586	48	7.4	60.7
AAA	RH	1	0	1	0.0004	103.7	259305	47	6.5	64.0
AAA	RH	1	1	0	0.0007	132.1	188702	52	8.0	58.7
AAA	RH	1	1	1	0.0007	159.1	227334	49	7.1	61.8
AAB	RH	0	0	0	0.0004	203.0	507619	36	3.4	77.7
AAB	RH	0	0	1	0.0004	167.9	419727	38	4.9	70.4
AAB	RH	0	1	0	0.0007	337.3	481812	39	3.0	79.8
AAB	RH	0	1	1	0.0007	396.4	566296	38	3.3	78.2
AAB	RH	1	0	0	0.0004	104.3	260759	42	7.0	61.9
AAB	RH	1	0	1	0.0004	123.5	308749	40	6.2	64.9
AAB	RH	1	1	0	0.0007	172.4	246346	42	7.4	60.5
AAB	RH	1	1	1	0.0007	202.8	289686	41	7.2	61.2
AAC	RH	0	0	0	0.0004	192.5	481278	41	4.4	72.8
AAC	RH	0	0	1	0.0004	201.5	503664	39	5.0	70.0
AAC	RH	0	1	0	0.0007	303.2	433204	43	4.1	74.2
AAC	RH	0	1	1	0.0007	341.0	487116	41	4.9	70.5
AAC	RH	1	0	0	0.0004	171.0	427567	37	7.3	61.0
AAC	RH	1	0	1	0.0004	157.6	394031	37	7.4	60.6
AAC	RH	1	1	0	0.0007	318.5	455067	39	8.0	58.6
AAC	RH	1	1	1	0.0007	261.3	373261	41	6.8	62.8
AAD	RH	0	0	0	0.0004	112.1	280138	47	5.0	69.9
AAD	RH	0	0	1	0.0004	104.5	261154	46	4.7	71.3
AAD	RH	0	1	0	0.0007	226.4	323421	43	3.2	78.7
AAD	RH	0	1	1	0.0007	189.9	271282	46	4.5	72.2
AAD	RH	1	0	0	0.0004	99.9	249680	44	7.1	61.5
AAD	RH	1	0	1	0.0004	104.7	261827	44	6.6	63.4
AAD	RH	1	1	0	0.0007	209.6	299443	43	7.3	60.8
AAD	RH	1	1	1	0.0007	197.7	282460	44	6.1	65.3
AAF	RH	0	0	0	0.0004	380.6	951616	22	5.0	70.0
AAF	RH	0	0	1	0.0004	393.5	983642	23	4.4	72.8
AAF	RH	0	1	0	0.0007	674.7	963905	23	4.6	71.8
AAF	RH	0	1	1	0.0007	677.1	967305	23	3.7	76.2
AAF	RH	1	0	0	0.0004	278.4	696083	23	7.8	59.2
AAF	RH	1	0	1	0.0004	292.9	732152	24	6.1	65.4
AAF	RH	1	1	0	0.0007	613.2	875958	25	7.5	60.2
AAF	RH	1	1	1	0.0007	486.3	694703	26	7.1	61.7
AAG	RH	0	0	0	0.0004	524.2	1310386	27	3.0	80.0
AAG	RH	0	0	1	0.0004	501.6	1254039	28	4.3	73.4

AAG	RH	0	1	0	0.0007	697.4	996218	30	4.9	70.6
AAG	RH	0	1	1	0.0007	773.2	1104506	31	4.6	72.0
AAG	RH	1	0	0	0.0004	412.4	1031115	25	7.3	61.1
AAG	RH	1	0	1	0.0004	346.3	865633	27	8.0	58.8
AAG	RH	1	1	0	0.0007	644.3	920395	27	8.0	58.8
AAG	RH	1	1	1	0.0007	705.2	1007440	28	7.0	62.2
AAK	RH	0	0	0	0.0004	235.0	587528	33	3.7	76.1
AAK	RH	0	0	1	0.0004	197.8	494481	36	3.3	78.2
AAK	RH	0	1	0	0.0007	441.9	631334	32	4.9	70.4
AAK	RH	0	1	1	0.0007	331.0	472869	37	4.9	70.4
AAK	RH	1	0	0	0.0004	198.7	496642	36	6.3	64.5
AAK	RH	1	0	1	0.0004	231.9	579684	31	6.8	62.7
AAK	RH	1	1	0	0.0007	300.0	428538	35	6.5	63.8
AAK	RH	1	1	1	0.0007	402.3	574656	30	6.4	64.2
AAM	RH	0	0	0	0.0004	216.5	541269	30	4.7	71.4
AAM	RH	0	0	1	0.0004	235.6	589103	28	4.4	72.8
AAM	RH	0	1	0	0.0007	366.7	523793	31	5.0	70.0
AAM	RH	0	1	1	0.0007	383.3	547619	30	4.0	74.7
AAM	RH	1	0	0	0.0004	172.4	430974	32	6.7	63.1
AAM	RH	1	0	1	0.0004	209.3	523354	30	6.6	63.5
AAM	RH	1	1	0	0.0007	272.4	389168	33	7.2	61.3
AAM	RH	1	1	1	0.0007	287.9	411262	35	6.7	63.1
AAA	RD	0	0	0	0.0004	166.2	415618	45	4.1	71.9
AAA	RD	0	0	1	0.0004	203.0	507463	43	3.1	77.3
AAA	RD	0	1	0	0.0007	264.3	377607	39	4.4	70.3
AAA	RD	0	1	1	0.0007	275.6	393676	45	5.1	67.0
AAA	RD	1	0	0	0.0004	129.2	323089	44	6.6	60.7
AAA	RD	1	0	1	0.0004	138.9	347197	45	6.6	60.7
AAA	RD	1	1	0	0.0007	186.4	266311	50	6.8	59.9
AAA	RD	1	1	1	0.0007	170.7	243852	51	7.4	57.7
AAB	RD	0	0	0	0.0004	217.5	543824	39	4.3	70.7
AAB	RD	0	0	1	0.0004	203.4	508482	37	5.1	66.8
AAB	RD	0	1	0	0.0007	428.8	612567	36	3.3	76.0
AAB	RD	0	1	1	0.0007	349.8	499714	37	4.4	70.2
AAB	RD	1	0	0	0.0004	158.0	395042	40	7.9	55.8
AAB	RD	1	0	1	0.0004	158.0	395042	40	7.9	55.8
AAB	RD	1	1	0	0.0007	240.9	344118	43	6.7	60.1
AAB	RD	1	1	1	0.0007	259.0	370023	43	6.0	62.9
AAC	RD	0	0	0	0.0004	363.6	909111	29	3.6	74.5
AAC	RD	0	0	1	0.0004	335.9	839788	33	2.9	78.5
AAC	RD	0	1	0	0.0007	609.6	870873	33	4.4	70.3
AAC	RD	0	1	1	0.0007	615.1	878704	33	3.7	73.9
AAC	RD	1	0	0	0.0004	190.2	475605	39	6.6	60.6
AAC	RD	1	0	1	0.0004	206.0	515054	37	7.1	58.8
AAC	RD	1	1	0	0.0007	410.3	586150	36	7.3	58.0
AAC	RD	1	1	1	0.0007	381.7	545290	37	6.9	59.5
AAD	RD	0	0	0	0.0004	281.1	702675	34	4.3	70.9
AAD	RD	0	0	1	0.0004	246.9	617258	36	3.7	74.0
AAD	RD	0	1	0	0.0007	469.9	671325	36	4.8	68.4

AAD	RD	0	1	1	0.0007	444.3	634694	36	4.5	69.9
AAD	RD	1	0	0	0.0004	210.5	526142	36	6.1	62.7
AAD	RD	1	0	1	0.0004	163.0	407570	41	7.0	59.2
AAD	RD	1	1	0	0.0007	287.4	410614	42	7.0	59.2
AAD	RD	1	1	1	0.0007	278.8	398256	42	6.9	59.6
AAF	RD	0	0	0	0.0004	541.6	1354033	23	3.1	77.4
AAF	RD	0	0	1	0.0004	541.6	1354033	23	3.1	77.4
AAF	RD	0	1	0	0.0007	917.2	1310302	23	4.4	70.4
AAF	RD	0	1	1	0.0007	766.5	1094966	24	4.0	72.4
AAF	RD	1	0	0	0.0004	465.8	1164535	20	7.3	58.1
AAF	RD	1	0	1	0.0004	502.9	1257144	21	7.6	57.1
AAF	RD	1	1	0	0.0007	842.0	1202883	24	6.8	60.0
AAF	RD	1	1	1	0.0007	869.9	1242772	22	6.0	63.1
AAG	RD	0	0	0	0.0004	658.4	1645964	18	4.4	70.4
AAG	RD	0	0	1	0.0004	441.1	1102628	34	3.1	77.3
AAG	RD	0	1	0	0.0007	833.5	1190716	31	3.6	74.5
AAG	RD	0	1	1	0.0007	818.9	1169842	33	3.7	74.0
AAG	RD	1	0	0	0.0004	556.2	1390451	22	7.9	56.0
AAG	RD	1	0	1	0.0004	554.1	1385351	21	8.1	55.3
AAG	RD	1	1	0	0.0007	784.2	1120251	26	7.4	57.8
AAG	RD	1	1	1	0.0007	845.6	1207954	22	7.8	56.4
AAK	RD	0	0	0	0.0004	266.3	665762	35	4.8	68.0
AAK	RD	0	0	1	0.0004	313.9	784823	31	4.2	71.0
AAK	RD	0	1	0	0.0007	489.0	698510	34	4.0	72.0
AAK	RD	0	1	1	0.0007	450.1	642944	34	3.2	76.4
AAK	RD	1	0	0	0.0004	254.6	636436	35	6.4	61.1
AAK	RD	1	0	1	0.0004	286.3	715710	32	6.1	62.3
AAK	RD	1	1	0	0.0007	415.5	593598	36	6.1	62.3
AAK	RD	1	1	1	0.0007	397.8	568229	36	6.9	59.1
AAM	RD	0	0	0	0.0004	291.2	728105	29	4.2	71.2
AAM	RD	0	0	1	0.0004	288.1	720310	30	4.1	71.8
AAM	RD	0	1	0	0.0007	510.7	729574	31	3.9	72.8
AAM	RD	0	1	1	0.0007	471.1	672964	32	4.0	72.3
AAM	RD	1	0	0	0.0004	376.4	941019	24	6.1	62.6
AAM	RD	1	0	1	0.0004	355.2	888063	25	6.7	60.2
AAM	RD	1	1	0	0.0007	435.7	622358	30	7.7	56.6
AAM	RD	1	1	1	0.0007	496.7	709638	30	6.0	63.0

Appendix E

Shear Stiffness Test Results — 10 Hz, 68°F (20°C)

Specimen Designation	Shear Stiffness (psi)	Shear Phase Angle	Voids %	VFB %
AAARH011	109200	43	2.9	80.5
AAARH110	63642	38	8.0	58.7
AABRH011	127490	29	3.3	78.2
AABRH110	98022	27	7.4	60.5
AACRH001	188845	27	5.0	70.0
AACRH111	201755	27	6.8	62.8
AADRH010	158084	30	3.2	78.7
AADRH100	129422	35	7.1	61.5
AAFRH001	222269	18	4.4	72.8
AAFRH111	310157	18	7.1	61.7
AAGRH000	306830	22	3.0	80.0
AAGRH101	251426	21	8.0	58.8
AAKRH011	188585	29	4.9	70.4
AAKRH110	144878	25	6.5	63.8
AAMRH001	185809	24	4.4	72.8
AAMRH110	132065	25	7.2	61.3
AAARD001	161836	36	3.1	77.3
AAARD101	95994	41	6.6	60.7
AABRD010	195195	26	3.3	76.0
AABRD110	162592	28	6.7	60.1
AACRD000	247035	25	3.6	74.5
AACRD100	222357	27	6.6	60.6
AADRD000	206752	34	4.3	70.9
AADRD111	158678	37	6.9	59.6
AAFRD000	400018	17	3.1	77.4
AAFRD100	369987	18	7.3	58.1
AAGRD000	520149	18	4.4	70.4
AAGRD110	408234	19	7.4	57.8
AAKRD001	258925	27	4.2	71.0
AAKRD111	238221	28	6.9	59.1
AAMRD010	340757	21	3.9	72.8
AAMRD110	191167	20	7.7	56.6

Appendix F

Shear Stiffness Frequency Sweep Test Results

Shear Frequency Sweep Results for the 8x2 Expanded Test Program

MIXTURE DESIGNATION	FREQUENCY	TEST TEMP.	4 DEGREES	TEST TEMP.	20 DEGREES	TEST TEMP.	40 DEGREES
		COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE
AAARH000	10	319339	23.2	87817	45.7	15138	60.2
	5	272020	26.0	63216	50.3	10431	56.7
	2	213261	30.6	38575	54.9	6725	51.6
	1	171863	34.3	26584	56.0	4872	47.2
	0.5	135119	38.2	17577	56.6	3933	41.0
	0.2	93924	43.1	10095	55.9	2572	37.8
	0.1	68665	47.1	7480	52.1	2750	36.9
AABRH010	10	460412	16.4	145347	38.5	18938	50.9
	5	409025	18.0	112655	43.7	12361	51.3
	2	348895	20.0	79246	44.8	7509	53.1
	1	305084	22.4	57480	47.5	5358	47.6
	0.5	259120	25.0	41301	49.5	4386	43.3
	0.2	203974	28.8	27172	51.6	3517	40.2
	0.1	166291	32.2	19643	50.2	3263	32.3
AACRH000	10	414565	17.4	182024	33.4	30870	54.5
	5	365141	19.2	143658	37.3	17960	56.7
	2	301873	22.6	98903	42.9	10939	54.6
	1	257437	25.6	72124	46.6	7627	51.0
	0.5	214388	28.8	51582	49.9	5908	43.3
	0.2	160957	33.3	31991	54.5	4042	39.1
	0.1	126941	37.3	21782	55.8	3596	30.5
AADRH000	10	382719	19.7	98576	43.8	11868	65.7
	5	326663	22.6	73823	47.3	8454	58.3
	2	260122	26.7	49051	50.3	5318	53.2
	1	215375	29.4	34614	51.2	3911	46.6
	0.5	173893	32.7	24123	53.3	3054	35.5
	0.2	127002	36.9	15074	52.0	2506	33.9
	0.1	97607	40.4	11406	51.5	2628	27.1

MIXTURE DESIGNATION	FREQUENCY	TEST TEMP.	4 DEGREES	TEST TEMP.	20 DEGREES	TEST TEMP.	40 DEGREES
		COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE
AAFRHO11	10	370921	11.7	205665	18.9	62664	52.5
	5	349883	11.6	183646	20.9	40982	48.6
	2	321552	12.5	153816	23.5	27467	50.8
	1	298936	13.4	131561	26.3	19865	51.4
	0.5	275472	14.7	110518	29.4	13761	50.0
	0.2	243033	16.7	83876	33.2	8843	50.3
	0.1	217622	18.6	67131	37.2	6821	43.7
AAGRHO11	10	896328	13.0	213137	32.3	33983	68.8
	5	836546	14.5	155447	37.6	21199	71.3
	2	748977	16.2	89891	53.4	11264	69.4
	1	677378	18.0	59669	59.7	7130	64.0
	0.5	604356	20.1	37658	63.8	5072	58.4
	0.2	501754	24.4	20040	66.2	3536	40.9
	0.1	422503	28.1	13560	65.1	3251	36.8
AAKRHO11	10	410895	16.6	141366	36.0	23710	54.8
	5	368806	17.7	101264	42.0	16848	55.1
	2	312712	20.5	70799	45.1	10203	52.4
	1	268490	23.0	51284	47.8	7558	50.2
	0.5	228369	25.7	37466	49.8	5587	44.3
	0.2	179510	30.1	24033	52.4	4202	42.3
	0.1	144453	32.9	17651	52.6	2989	29.4
AAMRHO11	10	489845	13.5	200445	27.1	33409	48.1
	5	451470	14.3	168267	28.2	24591	48.8
	2	400833	15.1	130493	30.6	15818	49.3
	1	366341	15.7	105733	32.4	11482	48.7
	0.5	332143	16.8	84787	34.2	8669	48.3
	0.2	286950	18.1	62435	36.9	6207	41.9
	0.1	254579	19.7	48935	38.3	4827	39.2

MIXTURE DESIGNATION	FREQUENCY	TEST TEMP.	4 DEGREES	TEST TEMP.	20 DEGREES	TEST TEMP.	40 DEGREES
		COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE
AAARH111	10	228309	25.1	118137	38.6	18190	51.0
	5	193917	28.2	91346	40.8	12473	50.4
	2	148435	32.2	63215	43.8	8219	47.2
	1	118901	35.7	47732	46.1	6207	41.6
	0.5	92182	38.6	35521	47.5	5289	39.1
	0.2	64125	42.6	24185	48.1	3877	29.1
	0.1	48436	43.8	17911	48.5	3485	30.6
AABRH111	10	323213	11.2	68464	39.6	18616	52.1
	5	289554	11.4	51699	41.8	13840	51.0
	2	238366	13.4	34264	44.8	9670	48.4
	1	203235	15.5	24606	46.0	7481	45.8
	0.5	170308	18.1	17476	46.9	5964	42.5
	0.2	133114	21.9	11492	46.9	4655	38.1
	0.1	109194	25.0	8577	45.9	4053	35.7
AACRH100	10	429836	11.3	115469	34.5	20396	57.1
	5	380760	12.6	87846	38.2	14370	56.3
	2	332671	14.9	60549	42.6	9234	53.2
	1	295247	16.1	44589	46.2	6806	49.7
	0.5	261051	18.3	32290	48.9	5318	45.7
	0.2	214863	21.1	20614	52.2	4122	39.7
	0.1	182093	23.8	14595	52.6	3595	36.7
AADRH101	10	325323	13.5	84858	36.7	16304	51.3
	5	287670	16.4	65035	39.4	12497	48.5
	2	240562	19.7	44245	43.2	8858	44.5
	1	207798	22.3	32845	44.7	6969	41.8
	0.5	176194	24.7	24251	45.9	5757	38.1
	0.2	138260	28.2	16201	46.9	4730	34.6
	0.1	112338	30.9	12079	45.6	4203	31.0

MIXTURE DESIGNATION	FREQUENCY	TEST TEMP. 4 DEGREES		TEST TEMP. 20 DEGREES		TEST TEMP. 40 DEGREES	
		COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE
AAFRH101	10	473866	9.9	240651	21.0	52251	45.1
	5	447150	9.3	201751	25.4	35661	48.9
	2	407915	9.7	157563	27.6	22769	51.7
	1	377392	10.4	129450	30.9	15956	51.7
	0.5	348050	11.8	105215	34.0	11325	51.2
	0.2	309488	13.7	75706	39.2	7420	47.2
	0.1	277743	15.4	57472	43.0	5830	42.7
AAGRH110	10	692021	11.8	460019	18.6	46173	64.5
	5	636244	11.3	386884	21.1	29239	67.4
	2	577181	12.7	307454	27.4	15697	65.4
	1	528224	14.6	249061	32.7	10137	61.7
	0.5	481872	16.2	196112	38.5	6988	55.3
	0.2	415253	19.9	131287	47.7	4773	45.4
	0.1	360575	23.4	90673	54.6	4083	39.9
AAKRH100	10	443828	16.8	230870	27.5	48785	50.2
	5	396097	17.3	178368	30.7	35711	50.6
	2	337328	18.9	131114	35.2	23378	49.5
	1	296298	20.8	101365	38.1	17169	47.7
	0.5	253559	23.2	76425	41.5	12901	46.4
	0.2	203223	26.4	51308	45.4	9035	43.0
	0.1	166718	29.5	37426	47.1	7288	40.2
AAMRH100	10	436482	13.9	221422	29.7	27671	49.0
	5	388249	14.9	179656	29.0	21738	48.2
	2	332077	16.4	139650	29.8	15606	44.8
	1	293070	17.5	113750	31.6	12020	42.8
	0.5	255211	19.2	91534	33.0	9531	40.5
	0.2	208263	20.9	68239	35.9	7307	36.2
	0.1	175684	23.1	53160	37.6	6126	32.9

MIXTURE DESIGNATION	FREQUENCY	TEST TEMP.	4 DEGREES	TEST TEMP.	20 DEGREES	TEST TEMP.	40 DEGREES
		COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE
AAARD000	10	597332	22.0	222323	36.5	23540	56.2
	5	517109	21.8	167119	40.1	17474	52.8
	2	422594	24.9	113463	44.5	12045	47.2
	1	350720	27.5	82743	47.5	9464	42.4
	0.5	286177	30.9	59420	50.0	7774	39.1
	0.2	211361	35.0	37365	52.3	6290	34.3
	0.1	163017	38.4	26488	52.7	5543	31.2
AABRD000	10	511505	14.8	224618	27.7	30155	55.2
	5	455429	15.5	178646	30.9	21403	55.6
	2	392383	18.0	131581	35.5	13754	54.1
	1	344426	19.6	101594	38.9	10065	51.8
	0.5	300470	22.1	76691	42.0	7498	48.9
	0.2	244809	25.6	51037	45.9	5560	43.3
	0.1	204194	28.4	37545	47.7	4536	39.0
AACRD010	10	617414	14.0	237372	29.9	32056	60.4
	5	555543	13.4	192774	31.7	22958	61.0
	2	485810	14.4	146770	34.3	14243	57.9
	1	442664	15.6	116407	37.4	10071	54.0
	0.5	398184	17.2	89963	40.5	7596	49.2
	0.2	342262	19.5	61340	44.8	5454	43.4
	0.1	300661	21.5	44805	48.0	4589	38.6
AADRD010	10	271299	25.3	131339	37.0	26700	57.9
	5	239772	25.9	102425	40.0	19196	56.3
	2	195018	27.3	71316	43.5	12352	52.7
	1	162682	28.9	52443	46.2	9177	49.0
	0.5	134905	31.6	38025	47.8	7073	45.5
	0.2	101901	34.8	24722	49.8	5507	39.8
	0.1	81359	37.7	17757	50.1	4662	36.8

MIXTURE DESIGNATION	FREQUENCY	TEST TEMP.	4 DEGREES	TEST TEMP.	20 DEGREES	TEST TEMP.	40 DEGREES
		COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE
AAFRD010	10	716398	14.0	404247	19.7	81697	48.6
	5	667956	12.0	351443	20.3	57521	52.3
	2	614519	11.6	293912	22.3	36943	56.1
	1	576142	12.1	251914	24.9	25341	57.8
	0.5	536791	12.9	211349	28.2	17555	58.1
	0.2	481096	14.7	162558	32.9	11018	55.0
	0.1	441599	15.9	129258	36.6	8441	51.1
AAGRD010	10	539256	11.6	342395	27.6	47971	65.5
	5	544649	7.1	301667	26.7	30552	67.9
	2	516837	8.4	241310	31.2	16503	65.6
	1	487920	9.6	195940	36.9	10639	60.7
	0.5	463290	10.5	150253	43.5	7422	54.4
	0.2	420596	12.3	97676	53.2	5459	45.2
	0.1	394816	13.8	64977	60.0	4587	41.4
AAKRD010	10	467991	14.2	195348	27.8	37178	52.2
	5	414629	14.7	154366	31.3	26678	52.8
	2	362235	17.6	112563	36.4	17038	51.7
	1	323599	19.4	86610	40.0	12494	49.9
	0.5	2824733	21.4	64792	43.0	9236	46.9
	0.2	233944	24.8	43120	46.3	6549	42.7
	0.1	197822	26.9	31541	48.0	5407	38.7
AAMRD001	10	833751	12.3	361333	24.5	52683	52.8
	5	736792	11.3	291653	25.6	36727	54.4
	2	662418	12.3	226665	29.7	23448	54.4
	1	610793	13.2	182222	33.1	16699	53.8
	0.5	554862	14.6	144047	36.0	12245	52.1
	0.2	490930	16.4	102301	40.0	8589	48.6
	0.1	440202	17.9	77572	43.2	6733	44.8

MIXTURE DESIGNATION	FREQUENCY	TEST TEMP.	4 DEGREES	TEST TEMP.	20 DEGREES	TEST TEMP.	40 DEGREES
		COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE
AAARD111	10	303639	21.8	72382	43.2	12461	54.8
	5	259202	23.5	53832	46.0	9232	49.5
	2	208469	25.8	35112	48.7	6505	44.5
	1	173320	28.2	25238	49.9	5294	39.9
	0.5	142260	30.7	17995	49.4	4544	36.0
	0.2	106071	34.5	11825	47.5	3874	31.2
	0.1	83194	36.9	8916	45.2	3462	26.6
AABRD111	10	813523	13.3	243672	34.9	26684	59.6
	5	703794	14.2	183056	38.0	18401	57.3
	2	604480	16.2	130208	42.2	11752	53.3
	1	534102	18.0	97703	44.9	8821	48.9
	0.5	467977	19.5	72229	47.5	6768	45.4
	0.2	386007	22.4	47331	49.3	5459	39.0
	0.1	328804	25.0	34574	50.2	4692	35.4
AACRD111	10	257263	12.1	174772	26.2	27016	56.2
	5	224686	12.7	138557	29.5	18687	55.9
	2	197627	15.8	103526	34.7	11648	53.2
	1	175467	17.8	80918	38.1	8479	49.7
	0.5	156021	19.4	61537	41.8	6568	44.5
	0.2	129415	21.8	41549	45.8	4968	38.5
	0.1	111759	23.9	30199	48.5	4151	33.7
AADRD110	10	599989	15.3	155231	35.7	21913	55.2
	5	525486	16.9	120827	38.7	15631	53.9
	2	439811	19.0	84954	42.4	10392	49.6
	1	378471	21.7	63258	45.1	7997	45.8
	0.5	321061	24.3	46246	46.8	6409	41.3
	0.2	250461	27.9	30340	48.4	5153	36.2
	0.1	205074	30.7	22313	49.1	4556	32.5

MIXTURE DESIGNATION	FREQUENCY	TEST TEMP.	4 DEGREES	TEST TEMP.	20 DEGREES	TEST TEMP.	40 DEGREES
		COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE	COMP. SHEAR MODULUS (psi)	PHASE ANGLE
AAFRD110	10	1035150	5.9	410433	20.1	75657	48.0
	5	968926	7.1	351810	20.7	50038	53.0
	2	898681	8.4	289007	23.7	30707	56.4
	1	843227	9.1	241769	27.2	20754	57.1
	0.5	793384	9.8	202143	30.6	14324	55.7
	0.2	720153	11.6	150487	35.8	8835	52.5
	0.1	662532	12.9	117084	39.5	6551	46.3
AAGRD101	10	307414	8.0	246552	21.2	45208	61.3
	5	278807	9.0	203359	26.1	28724	64.0
	2	255306	11.3	156058	31.7	15729	62.7
	1	235294	12.5	125008	36.3	10328	58.1
	0.5	215587	14.2	97316	41.7	7147	51.6
	0.2	189869	16.9	65270	48.9	5050	42.6
	0.1	168953	18.9	46127	53.5	4297	38.5
AAKRD100	10	410826	16.8	162248	28.9	30382	52.2
	5	363012	18.0	132730	30.1	21416	51.9
	2	309879	19.0	100962	34.6	13831	49.2
	1	269987	21.0	78750	38.6	10254	46.8
	0.5	236803	22.7	60032	41.7	7850	43.4
	0.2	189876	25.8	40504	44.9	5994	38.4
	0.1	158889	27.9	30014	47.0	5087	34.6
AAMRD111	10	403302	11.5	142149	24.6	33515	48.4
	5	355547	11.9	118222	26.5	24642	48.7
	2	312682	13.7	93638	29.0	16695	48.7
	1	283770	14.7	77502	30.6	12515	47.3
	0.5	256045	15.5	63883	32.2	9572	45.4
	0.2	221310	17.1	48601	34.1	7020	42.4
	0.1	196781	18.5	38924	35.6	5707	39.4