TYPICAL DYNAMIC MODULI FOR NORTH CAROLINA ASPHALT CONCRETE MIXTURES

FINAL REPORT

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16. Abstract

This report presents results from an experimental study on the dynamic modulus testing of hot mix asphalts (HMAs) in uniaxial compression and indirect tension (IDT) modes. The study includes forty-two mixtures that are commonly used in North Carolina and have varying aggregate sources, aggregate gradations, asphalt sources, asphalt grades, and asphalt contents. The procedures outlined in the AASHTO TP 62-03 *Standard Method of Test for Determining Dynamic Modulus of Hot-Mix Asphalt Concrete Mixtures* have been modified in this study by reducing the number of test temperatures from five to four and by increasing the number of loading frequencies. This modified four-temperature protocol resulted in a reduction of the testing time.

The dynamic modulus database developed from the axial compression testing was used to evaluate the prediction accuracy of the two dynamic modulus predictive models that are currently available, i.e., the Witczak and Hirsch models. A case study was conducted to determine the effects of predictive errors on the fatigue cracking and rutting performance of HMA pavements. The database was also used to investigate the effects of different mixture variables on the dynamic modulus. It was found that the binder variables (i.e., the source, performance grade, and content) have a much more significant effect on the dynamic modulus than the aggregate variables (i.e., source and gradation).

An analytical solution to determine the dynamic modulus, phase angle, and Poisson's ratio using the IDT test was developed using the theory of linear viscoelasticity. The resulting IDT dynamic modulus was found to be statistically the same as the dynamic modulus determined from the axial compression testing about 80% of the time. It was found that the amount of variability between replicates increases as the nominal maximum aggregate size (NMAS) increases. The digital image correlation (DIC) method, a noncontact, full-field displacement measurement technique, was employed to investigate the relationship between the displacement gauge length in the IDT test and the NMAS.

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1. INTRODUCTION

1.1 Research Needs and Significance

The design methods adopted in the 2004 NCHRP 1-37A Guide for Design of New and Rehabilitated Pavement Structures (hereafter referred to as the *Guide*) are based on mechanistic-empirical principles in which the prediction of pavement responses and performance requires the inclusion of the fundamental properties of layer materials. The significance of this Guide is its incorporation of the most important property among those fundamental properties of layer materials, the dynamic modulus of asphalt concrete. This single property, which is relatively new to state highway agencies, is used as the key parameter in the Guide as well as in the Superpave simple performance test protocol that will be used to complement the volumetric mix design.

The dynamic modulus is one of the two material properties that are determined from complex modulus testing, the other being the phase angle, ϕ. The complex modulus, E*, is defined as a complex number that relates stress to strain for a linear viscoelastic material subjected to a sinusoidal loading. The absolute value of the complex modulus, |E*|, is commonly referred to as the dynamic modulus and is determined by dividing the peak-to-peak stress by the peak-to-peak strain under a sinusoidal loading. This property represents the frequency- (and therefore time-) dependent stiffness characteristic of the material.

As a mechanistic-empirical design procedure, the Guide requires the modulus of each layer material to determine stresses and strains (i.e., responses) in pavement structures. For asphalt concrete layers, the dynamic modulus was selected due to its

fundamental nature and its ability to represent the stress-strain behavior of the material as a function of temperature and loading rate. Also, recent findings from the NCHRP 9-19 project (Superpave Support and Performance Models Management) suggest that the dynamic modulus is one of the best indicators for the rutting and fatigue cracking of asphalt mixtures (Pellinen, 2001). Therefore, the complex modulus test has been selected as the simple performance test method to complement the Superpave volumetric mix design using the Superpave Gyratory Compactor. The fact that the same material property can be used in both pavement response and performance prediction implies a significant advantage to state highway agencies because only a single piece of equipment and test method is necessary for both pavement thickness design and asphalt mixture design. Also, this advantage allows both the thickness design and the mixture design to be implemented for the same theoretical framework. This capability has long been regarded as one of the major goals in developing these new design methods.

Although the dynamic modulus has been known to some researchers since the 1960s (Shook et al., 1969; Kallas, 1970; Bohn et al., 1970; Cragg and Pell, 1971; Yeager and Wood, 1975; Majidzadeh et al., 1979; Akhter and Witczak, 1985; Miller et al., 1983; Witczak and Fonseca, 1996), the use of the dynamic modulus by state highway agencies has not been widespread. This is also true for North Carolina; indeed, there is little information on dynamic moduli for the asphalt concrete mixes used in North Carolina. The Guide includes default values for the dynamic modulus; however, there are insufficient data with which to judge how well the default values represent local materials. This lack of experience in testing coupled with inadequate knowledge of

dynamic moduli values of local materials constitute major obstacles for the North Carolina Department of Transportation's (NCDOT's) implementation of the Guide.

Another issue related to the dynamic modulus is its use in forensic studies and pavement rehabilitation design. The current dynamic modulus protocol calls for the uniaxial compression testing of 100 mm diameter and 150 mm tall asphalt concrete specimens. It is often impossible to obtain this size of specimen from actual pavements. Given that a typical asphalt layer thickness is less than a few inches and that coring is the most effective method of obtaining specimens from actual pavements, the indirect tensile (IDT) testing of cores seems to be more appropriate for the evaluation of existing pavements. Theoretically, the dynamic moduli values determined from the IDT test should be the same as the ones determined from the uniaxial compression test. However, various issues involved in specimen fabrication, testing details, and analysis methods warrant the evaluation of the relationship between these values. Understanding the relationship between these values is essential in order to use the dynamic modulus in both the new design and rehabilitation of asphalt pavements and to maintain consistency in pavement management as a whole.

1.2 Research Objectives

The primary objectives of the research are:

1. to develop a database for typical dynamic moduli values and their variability for asphalt concrete mixes used in North Carolina, using both the uniaxial compression test and the IDT test; and

2. to evaluate dynamic modulus predictive models currently available, i.e., the Witczak and Hirsch models.

1.3 Report Organization

This report is composed of five chapters. Chapter 1 presents the research needs and objectives. Chapter 2 introduces the complex modulus and presents the analytical solutions for the complex modulus in the axial compression and the IDT modes. Chapter 2 also presents the Witczak and Hirsch models for predicting the dynamic modulus of HMA from the mix design information. In Chapter 3, the materials, specimen fabrication, and the experimental program are discussed. Chapter 4 presents the axial compression complex modulus data and proposes the modified test protocol for the determination of the complex modulus. A discussion follows on the predictive errors derived from the Witczak and Hirsch models and their effects on pavement performance. Lastly in Chapter 4, the effects of mixture variables and permanent strain accumulated during the dynamic modulus testing on the dynamic modulus are investigated. Chapter 5 presents the complex modulus data obtained from the IDT test. These moduli are compared against those determined from the axial compression test. Chapter 6 investigates the aggregate size effect on the dynamic modulus determined from the IDT test using the Digital Image Correlation (DIC) technique. Conclusions from this research and future research recommendations are given in Chapter 7.

2. COMPLEX MODULUS

2.1 Complex Modulus Determination in Axial Compression

Stiffness is an important property to consider for the design of any structure. In the case of asphalt concrete the stiffness changes with temperature and frequency. Thus, when designing a pavement structure, the stiffness (moduli) values must be accurately represented at any and all desired temperature-frequency combinations. The development of a mastercurve allows the modulus to be determined at any reasonable temperature-frequency combination.

For viscoelastic materials, such as asphalt concrete, the complex modulus, (E*), is often used to represent the stiffness of the material. The complex modulus has an elastic or storage component and a viscous or loss component. The storage (elastic) component is related to the material's ability to store energy, whereas the loss (viscous) component is responsible for the loss of damping and energy in the system. As is true for the overall modulus, the storage modulus, (E'), and the loss modulus, (E"), change with the temperature and rate of loading. For purely elastic materials, there is no damping loss and, thus, the elastic component is equal to the overall modulus. The complex modulus is related to loss and storage moduli via Eq. (2-1):

$$E^* = E' + iE'' \tag{2-1}$$

where E' = the storage modulus;

E" = the loss modulus; and

i = $\sqrt{-1}$.

The magnitude of E*, the so-called dynamic modulus, is represented by |E*| and can be obtained from:

$$|E^*| = \sqrt{(E')^2 + (E'')^2} \tag{2-2}$$

The phase angle, f, is defined as:

$$\tan f = \frac{E''}{E'} \tag{2-3}$$

These relationships can be shown graphically, as in Figure 2.1.

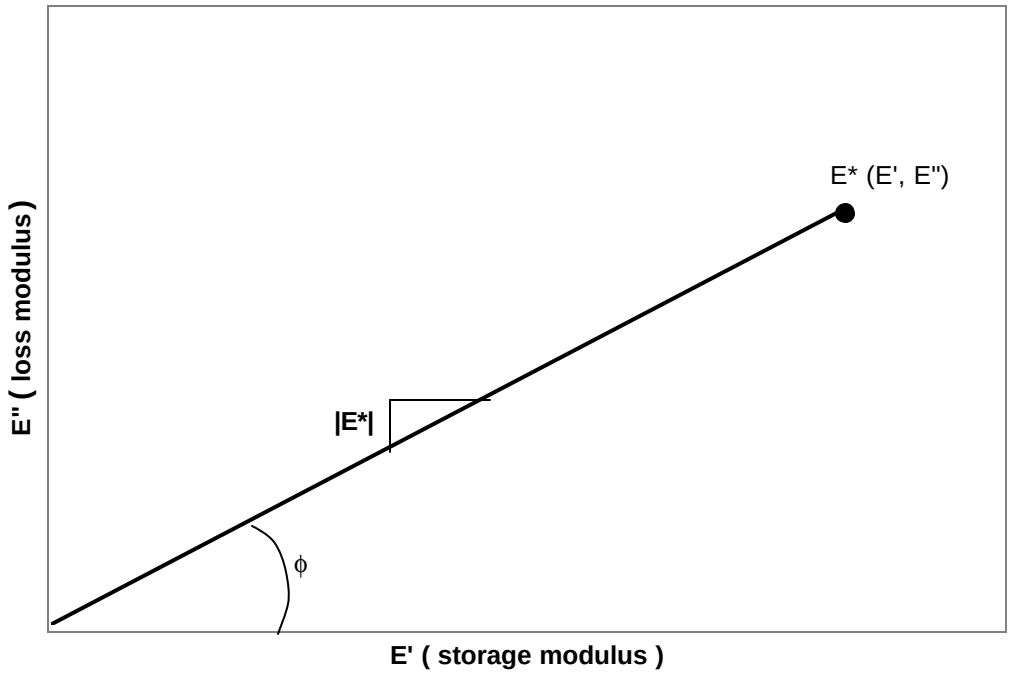


Figure 2.1 Complex modulus relationship

The dynamic modulus and phase angle are determined using a sinusoidal loading history. In uniaxial compression, the axial stress, (s), and axial strain, (e), are determined from:

$$s = \frac{P}{A} \tag{2-4}$$

where P = load; and

A = cross-sectional area of the specimen.

$$e = \frac{\Delta}{GL} \tag{2-5}$$

where Δ = change in displacement; and

GL = gauge length.

Figure 2.2 shows typical load and displacement data from uniaxial compression dynamic modulus testing. Figure 2.3 shows the stress and strain data converted from Figure 2.2. The dynamic modulus is determined from:

$$|E^*| = \frac{s_0}{e_0} \tag{2-6}$$

where s_0 = stress amplitude; and

e_0 = strain amplitude.

The phase angle is determined from:

$$f = 2pf\Delta t \tag{2-7}$$

where f = loading frequency in Hz; and

Δt = the time delay between the stress and strain cycles.

Although the dynamic modulus is only a part of the information to be obtained from the complex modulus test, the pavement community often refers to the complex modulus test as the dynamic modulus test because of the important role of the dynamic modulus in pavement and mix designs. For the rest of this report, the term *dynamic modulus test* will be used whenever the complex modulus test is referred.

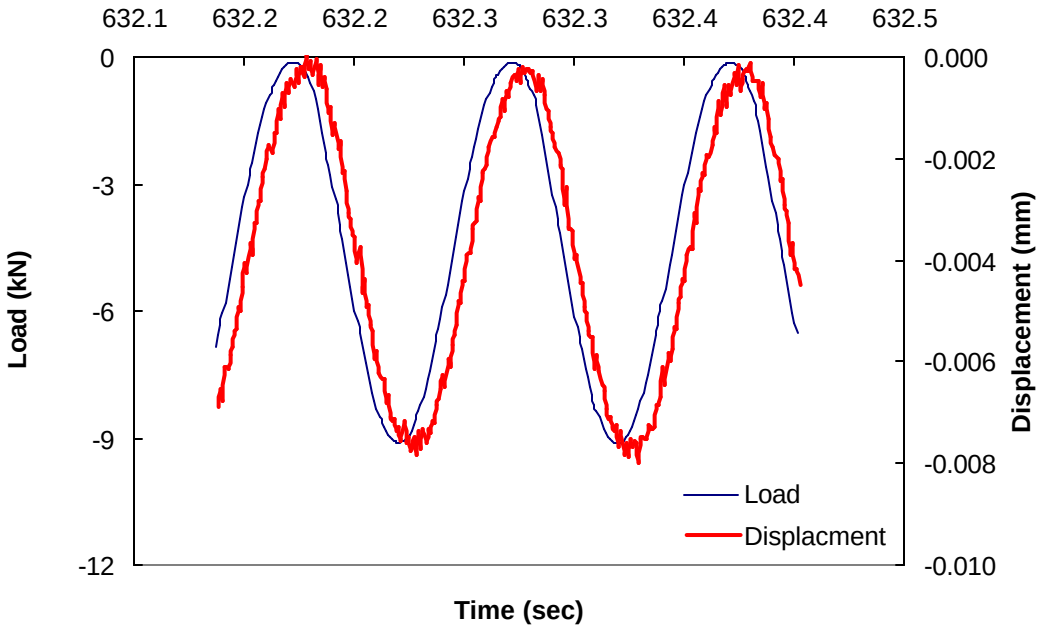


Figure 2.2 Load and displacement curves from sinusoidal loading

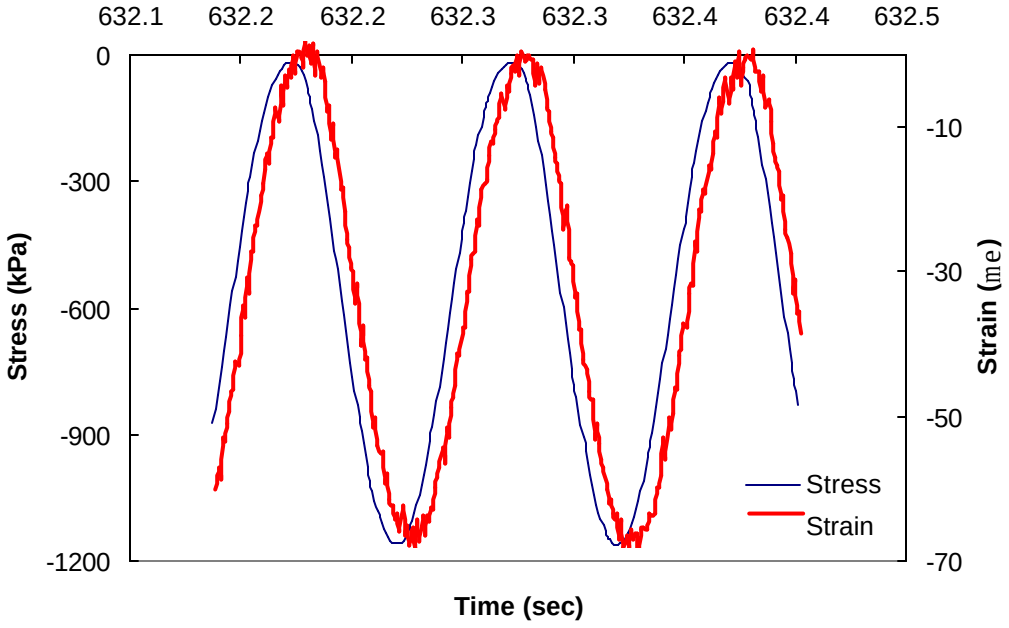


Figure 2.3 Stress and strain curves from sinusoidal loading

2.2 Dynamic Modulus Mastercurve

2.2.1 Mastercurve Construction

In the Guide, dynamic modulus data at various temperature-frequency combinations are used to develop a mastercurve. The dynamic modulus mastercurve is based on the concept of the time-temperature superposition (or time-temperature equivalence) principle; that is, the same modulus value of a material can be obtained either at low test temperatures and long times or at high test temperatures but short times. In other words, the behavior of a material at high temperatures is the same as that under long loading times or slow loading rates, and the material behavior at low temperatures is the same as that under short loading times or fast loading rates. The material that exhibits this type of behavior is called *thermorheologically simple (TRS).*

The time-temperature superposition of a material can be checked by performing dynamic modulus tests at varying temperatures and frequencies on the same specimen. Although the dynamic modulus test is supposed to be nondestructive, the stress-controlled mode used in the compression dynamic modulus test causes an increase in the mean strain as the test proceeds. Therefore, the testing method needs to be designed so that the testing at the temperature and frequency used in the early sequence of the temperature-frequency sweep has the least effect on the subsequent testing temperatures and frequencies. This consideration is reflected in the AASHTO's protocol for dynamic modulus testing, TP62-03 *Standard Method of Test for Determining Dynamic Modulus of Hot-Mix Asphalt Concrete Mixtures* (2003), by beginning the test at the lowest temperature and proceeding to the highest temperature. Also, at a given temperature, testing begins at the highest frequency and goes to the lowest frequency. This sequence

is intuitive because asphalt concrete becomes stiffer at low temperatures and high frequencies.

Figure 2.4(a) shows the dynamic modulus data obtained from a 9.5 mm Superpave mix. As expected, the dynamic modulus increases as the loading frequency increases and the temperature decreases. The simplifying feature of these data is that all of the curves can be superimposed to form a single continuous curve by means of horizontal translations only. For example, the dynamic modulus curves at –10°, 35°, and 54°C in Figure 2.4(a) are shifted horizontally to the 10°C curve to form the mastercurve, as shown in Figure 2.4(b). Once the horizontal shift is made, the effect of temperature and loading frequency is represented by reduced frequency. The relationships among the amount of horizontal shift, temperature, loading frequency, and the reduced frequency is defined as follows:

$$a_T = \frac{f_{T_0}}{f_T} \tag{2-8}$$

where a_T = frequency-temperature shift factor for temperature T;

f_{T_0} = reduced frequency at the reference temperature (T_0); and

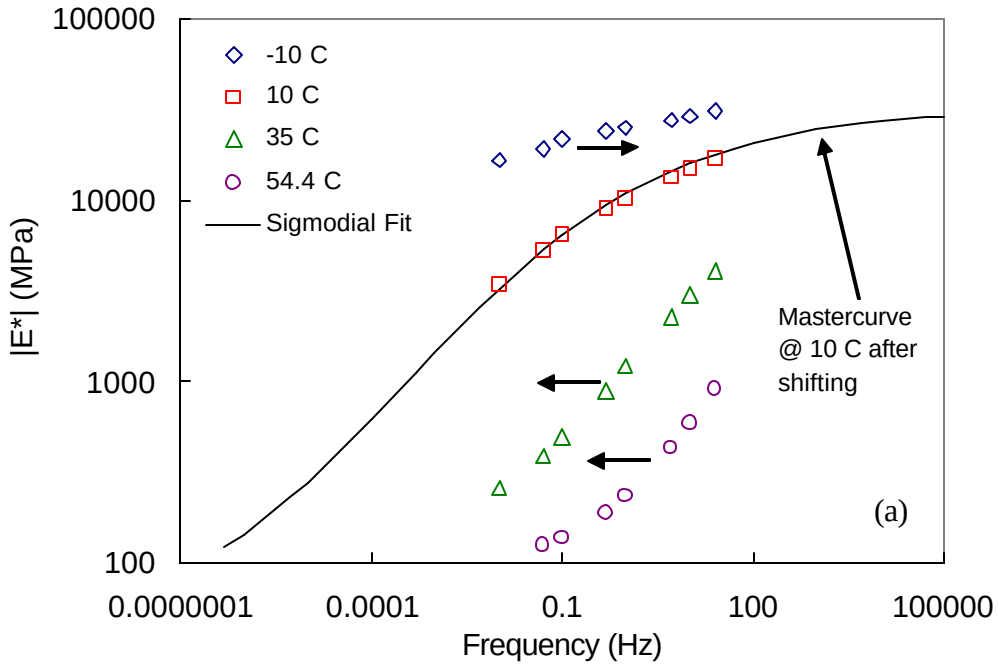
f_T = frequency at temperature T.

2.2.2 Sigmoidal Function

The dynamic modulus mastercurve is represented in the Guide by a sigmoidal function, shown below:

$$\log|E^*| = a + \frac{b}{1+\frac{1}{\exp^{d+e(\log f_R)}}} \quad (2\text{-}9)$$

In order to accomplish the horizontal shift automatically, an error minimization technique was used. This method minimizes the amount of error between the sigmoidal function and the shifted data. The minimization of error was accomplished using the Solver module in Excel using the coefficients (a, b, d, and e), presented in Eq. (2-9), and the shift factors for all the temperatures except the reference temperature. Since the error is calculated using log(|E*|) values, the resulting sigmoidal function produces larger errors in high reduced frequencies than in low reduced frequencies. In order to correct this problem, different weight factors were applied to data obtained from different temperatures in the error minimization process. The magnitudes of weight factors at different temperatures were determined to obtain the same order of error in |E*| among the different temperatures. It was found that a typical weight factor varies between 3 and 10, and that the weight factors of 5 and 3 (i.e., multiplying the error in log(|E*|) by 5 and 3) for -10° and 10°C result in the best fit for the entire region of the |E*| mastercurve. An example of the fit between the shifted data and the sigmoidal function with and without weight factors is shown in Figure 2.5, and the shift factor versus temperature relationship is shown in Figure 2.6, which is represented analytically using the quadratic function.



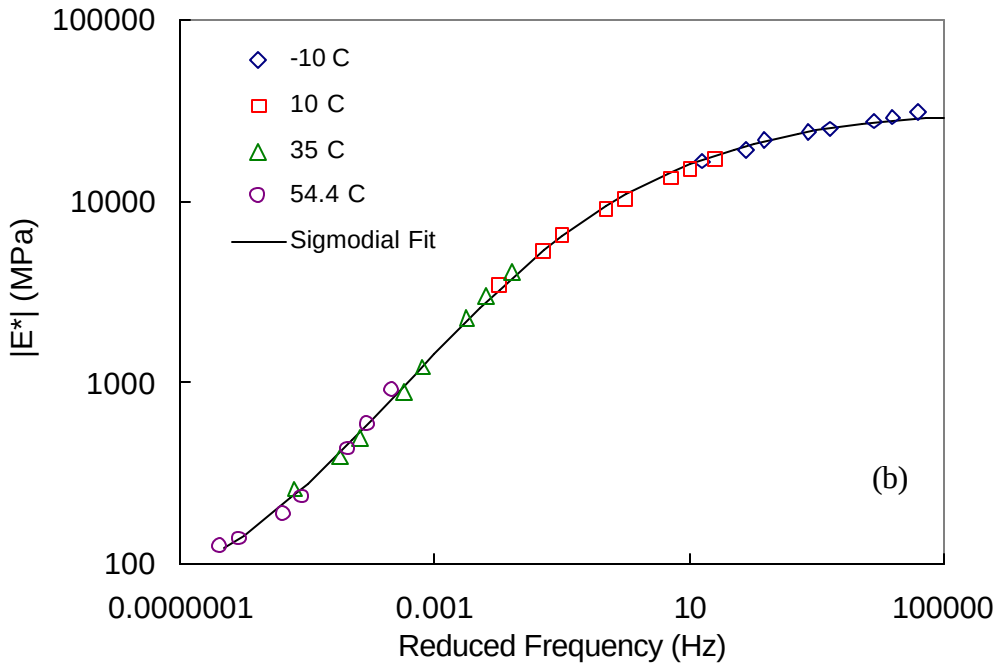


Figure 2.4 (a) Dynamic modulus as a function of loading frequency and temperature;

(b) Dynamic modulus mastercurve after horizontal shifting

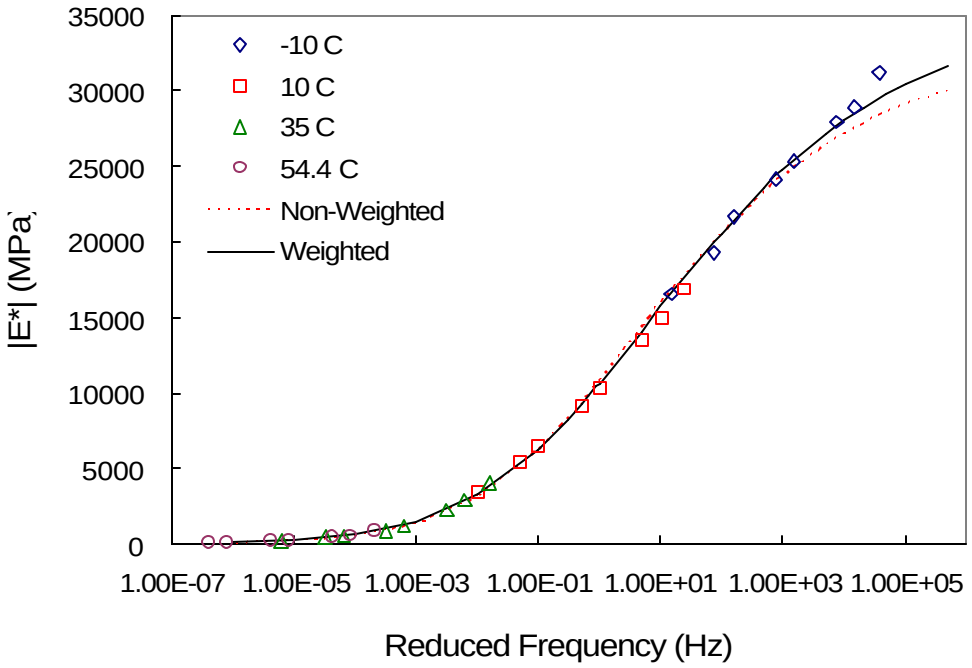


Figure 2.5 Effect of weight factors in sigmoidal fitting

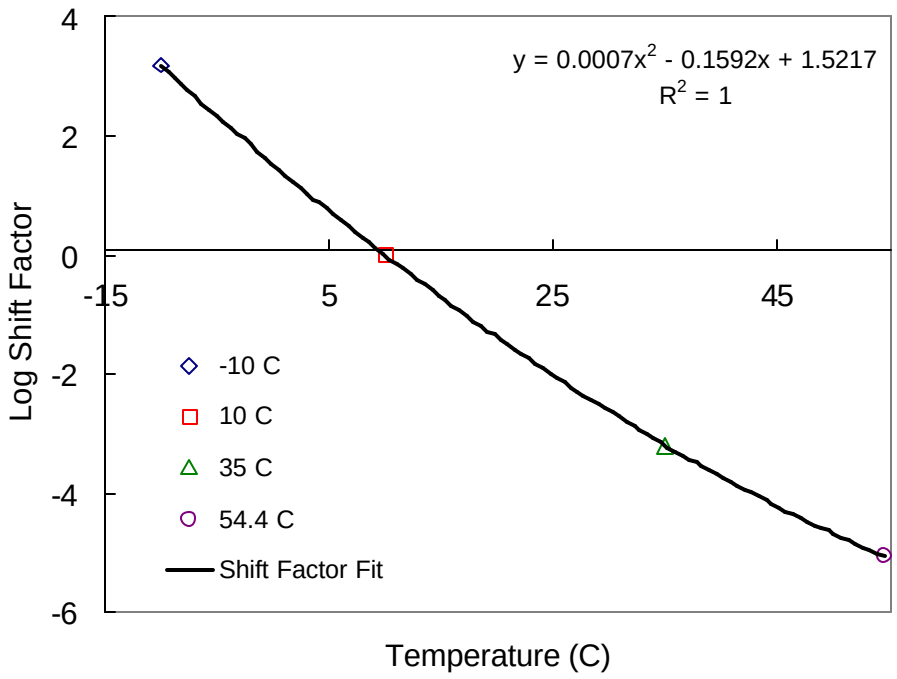


Figure 2.6 Shift factor versus temperature

2.3 Complex Modulus Determination in IDT

2.3.1 Linear Elastic Solution

Historically, the pavement community utilized the elastic solutions for IDT testing that Hondros (1959) derived using the plane stress assumption until Roque and Buttlar (1992) introduced correction factors that accounted for the bulging effect of the specimen. Later, Kim et al. (2001) introduced viscoelastic solutions for the IDT creep test using the theory of linear viscoelasticity.

Unlike those of the uniaxial test specimens, the stress and strain distributions in IDT specimens are biaxial. This biaxial state of stress and strain can cause errors in determining the material properties obtained from the IDT test unless the derivation of the properties is carefully handled. These errors may cause enough of a difference between the dynamic modulus determined from the IDT test and the dynamic modulus determined from the axial compression test that the criteria and design methods that are based on the dynamic modulus determined from the axial compression test cannot be used in forensic studies where the asphalt layer is not thick enough to yield 150 mm tall specimens needed for axial compression testing.

To illustrate this point more clearly, Hooke's Law, the governing equation for elastic materials, is presented below for both uniaxial and biaxial cases:

Uniaxial case: $s_y = E \times e_y$ or $e_y = \frac{s_y}{E}$ (2-10)

Biaxial case: $e_x = \frac{1}{E}(s_x - n s_y)$ (2-11)

where *x* and *y* denote the loading direction (i.e., the vertical direction) and the direction perpendicular to the loading direction (i.e., the horizontal direction), respectively.

In the uniaxial case (i.e., the axial compression dynamic modulus test) in Eq. (2-10), one can divide the axial stress (s_y) by the axial strain (e_y) to obtain the modulus. However, in the biaxial case (i.e., the IDT dynamic modulus test) in Eq. (2-11), one cannot obtain the modulus by dividing the horizontal stress (s_x) by the horizontal strain (e_x). Rather, the correct way to determine the modulus of the material is to divide the biaxial stress (i.e., s_x-?s_y) by the horizontal strain (e_x). If the incorrect solution (i.e., s_x/e_x) is used to represent the modulus of the material, then that modulus should not be considered the same as the modulus determined from the axial test.

2.3.2 Linear Viscoelastic Solution

The linear viscoelastic solution for the complex modulus of HMA under the IDT mode has been developed by Kim et al. (2004), and is presented in this section. This solution will be applied to the IDT test results to evaluate its accuracy against the dynamic modulus determined by the axial compression test. A comparison of both the elastic and viscoelastic solutions in IDT will be presented.

Assuming the plane stress state, Hondros (1959) developed the following expressions for stresses and strains along the horizontal diameter of the IDT specimen subjected to a strip load, shown in Figure 2.7:

$$e_x = \frac{1}{E}(s_x - n s_y) \tag{2-12}$$

with

$$s_x(x) = \frac{2P}{pad}\left[\frac{(1-x^2/R^2)\sin 2a}{1+2x^2/R^2\cos 2a + x^4/R^4} - \tan^{-1}\left\{\frac{1-x^2/R^2}{1+x^2/R^2}\tan a\right\}\right] = \frac{2P}{pad}[f(x)-g(x)] \tag{2-13}$$

$$s_y(x) = -\frac{2P}{pad}\left[\frac{(1-x^2/R^2)\sin 2a}{1+2x^2/R^2\cos 2a + x^4/R^4} + \tan^{-1}\left\{\frac{1-x^2/R^2}{1+x^2/R^2}\tan a\right\}\right] = -\frac{2P}{pad}[f(x)+g(x)] \quad (2\text{-}14)$$

where

P = applied load;

a = loading strip width, m;

d = thickness of specimen, m;

R = radius of specimen, m;

a = radial angle;

E = Young's modulus; and

$?$ = Poisson's ratio.

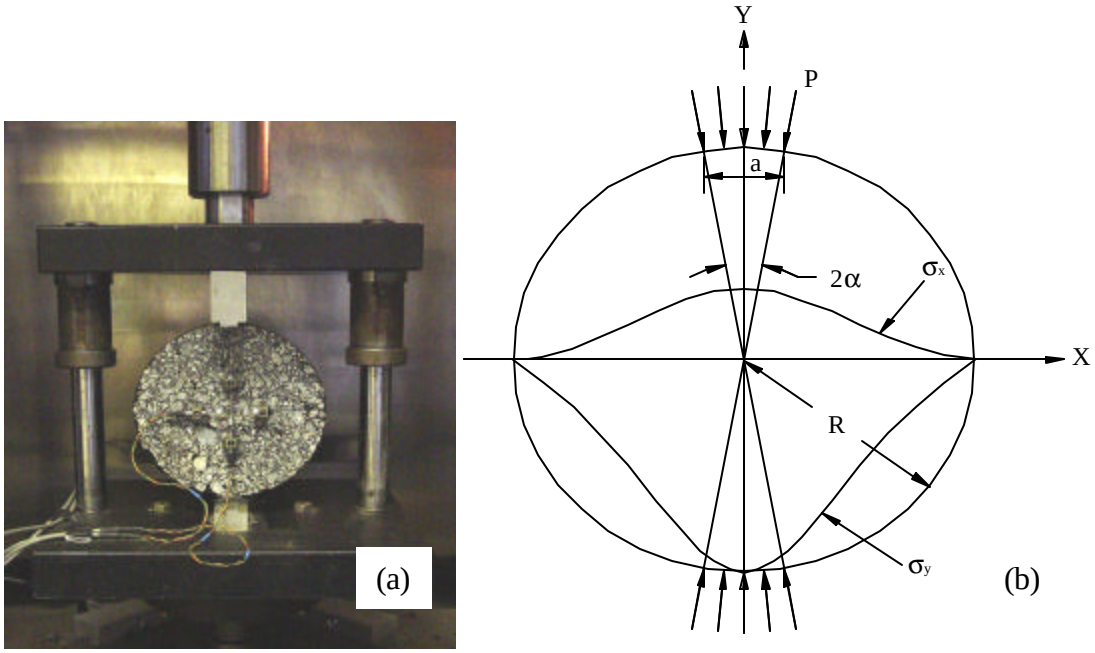


Figure 2.7 (a) IDT test setup; (b) Schematic of the IDT specimen subjected to a strip load

For the viscoelastic materials subjected to the sinusoidal load in a steady state, Eq. (2-12) can be rewritten as:

$$e_x = \frac{1}{E^*}(s_x - n s_y) \tag{2-15}$$

where E^* is the complex modulus. It is often helpful to have E^* in polar form,

$$E^* = \left|E^*\right| \cdot e^{if} \tag{2-16}$$

where $\left|E^*\right|$ is the dynamic modulus and f is the phase angle calculated from the time lag between the load and the displacement. The response to the sinusoidal load applied in the complex modulus test is the imaginary component of the response due to the complex load, *P*, shown below:

$$P = P_0 e^{iwt} = P_0(\cos wt + i \sin wt) \tag{2-17}$$

where P_0 and w are the amplitude and the angular frequency of the sinusoidal load used in the complex modulus test, respectively.

Substituting Eqs. (2-13), (2-14), (2-16), and (2-17) into Eq. (2-15) results in:

$$e_x(x,t) = \frac{2P_0}{\left|E^*\right| pad} e^{i(wt-f)} \left[(1+n) f(x) + (n-1) g(x)\right] \tag{2-18}$$

Integrate Eq. (2-18) over the gauge length to determine the horizontal displacement, *U*(*t*), and obtain:

$$U(t) = \int_{-l}^{l} e_x(x,t)dx = \frac{2P_0}{\left|E^*\right| pad} e^{i(wt-f)} \left[(1+n) \int_{-l}^{l} f(x)dx + (n-1) \int_{-l}^{l} g(x)dx \right] \tag{2-19}$$

where *l* is half of the gauge length. One may extract the response that only occurs due to the sinusoidal input by taking an imaginary part of the total response. Therefore, the dynamic modulus derived can be expressed using the horizontal displacement, *U*(*t*), as follows:

$$\left|E^*\right| = \frac{2P_0 \sin(wt - f)}{pad \cdot U(t)} A \tag{2-20}$$

where

$$A = \left[(1+n) \int_{-l}^{l} f(x)dx + (n-1) \int_{-l}^{l} g(x)dx \right] \tag{2-21}$$

with

$$f(x) = \frac{\left(1 - x^2 / R^2\right) sin\, 2a}{1 + 2x^2 / R^2 \, cos\, 2a + x^4 / R^4} \text{ and} \tag{2-22}$$

$$g(x) = tan^{-1}\left\{ \frac{1 - x^2 / R^2}{1 + x^2 / R^2} tan\, a \right\} \tag{2-23}$$

Similarly, the analogous expression for the dynamic modulus using the vertical displacement, $V(t)$, is:

$$\left|E^*\right| = \frac{2P_0 \sin(wt - f)}{pad \cdot V(t)} B \tag{2-24}$$

where

$$B = \left[(n-1) \int_{-l}^{l} n(y)dy - (1+n) \int_{-l}^{l} m(y)dy \right] \tag{2-25}$$

with

$$m(y) = \frac{\left(1 - y^2 / R^2\right) sin\, 2a}{1 - 2y^2 / R^2 \, cos\, 2a + y^4 / R^4} \text{ and} \tag{2-26}$$

$$n(y) = tan^{-1}\left\{ \frac{1 + y^2 / R^2}{1 - y^2 / R^2} tan\, a \right\} \tag{2-27}$$

By equating Eqs. (2-20) and (2-24), one can obtain

$$A \cdot V(t) = B \cdot U(t) \tag{2-28}$$

Then, one may derive the expression for Poisson's ratio as follows:

$$n = \frac{b_1 U(t) - g_1 V(t)}{-b_2 U(t) + g_2 V(t)} \tag{2-29}$$

where

$$b_1 = -\int_{-l}^{l} n(y)dy - \int_{-l}^{l} m(y)dy,$$

$$b_2 = \int_{-l}^{l} n(y)dy - \int_{-l}^{l} m(y)dy,$$

$$g_1 = \int_{-l}^{l} f(x)dx - \int_{-l}^{l} g(x)dx, \text{ and}$$

$$g_2 = \int_{-l}^{l} f(x)dx + \int_{-l}^{l} g(x)dx \tag{2-30}$$

Combining Eqs. (2-20) and (2-24) yields a single form of the dynamic modulus, as shown below:

$$\left|E^*\right| = \frac{P_0 \sin(wt - f) AV(t) + P_0 \sin(wt - f) BU(t)}{pad \cdot V(t) \cdot U(t)} \tag{2-31}$$

After substituting Eqs. (2-21) and (2-25) into Eq. (2-31), one can obtain:

$$\left|E^*\right| = 2\frac{P_0 \sin(wt - f)}{pad} \frac{b_1 g_2 - b_2 g_1}{g_2 V(t) - b_2 U(t)} \tag{2-32}$$

The vertical and horizontal displacements can be expressed in sine functions as follows:

$$V(t) = V_0 \sin(wt - f) \tag{2-33a}$$

$$U(t) = U_0 \sin(wt - f) \tag{2-33b}$$

where V_0 and U_0 are the constant amplitudes of vertical and horizontal displacements, respectively. Therefore, the final form of the dynamic modulus is:

$$\left|E^*\right| = 2\frac{P_0}{pad}\frac{b_1 g_2 - b_2 g_1}{g_2 V_0 - b_2 U_0} \tag{2-34}$$

Likewise, the expression for Poisson's ratio can be simplified as:

$$n = \frac{b_1 U_0 - g_1 V_0}{-b_2 U_0 + g_2 V_0} \tag{2-35}$$

The coefficients, b_1, b_2, g_1, and g_2, in Eqs. (2-34) and (2-35), are calculated for different specimen diameters and gauge lengths, and are presented in Table 2.1. Eqs. (2-34) and (2-35) are based on the plane stress assumption. Kim et al. (2001) used the three-dimensional finite element analysis to calculate the center strain in the IDT specimen and concluded that the error due to the plane stress assumption is negligible.

Table 2.1 – Coefficients for Poisson's Ratio and Dynamic Modulus

Specimen Diameter (mm)	Gauge Length (mm)	b_1	b_2	g_1	g_2
101.6	25.4	-0.0098	-0.0031	0.0029	0.0091
101.6	38.1	-0.0153	-0.0047	0.0040	0.0128
101.6	50.8	-0.0215	-0.0062	0.0047	0.0157
152.4	25.4	-0.0065	-0.0021	0.0020	0.0062
152.4	38.1	-0.0099	-0.0032	0.0029	0.0091
152.4	50.8	-0.0134	-0.0042	0.0037	0.0116

2.4 Predictive Models

2.4.1 Witczak's Predictive Equation

Witczak's predictive equation is the relationship developed between the dynamic modulus and mixture properties from data accumulated over the last thirty years by Witczak (Akhter and Witczak, 1985; Miller et al., 1983; Witczak and Fonseca, 1996; Witczak 2000). The most recent version of the predictive equation is based on data from

more than 200 different asphalt mixes, including a wide range of modified asphalts. The predictive relationship is:

$$\log|E^*| = -1.249937 + 0.029232 \cdot p_{200} - 0.001767 \cdot (p_{200})^2 - 0.002841 \cdot p_4 - 0.058097 \cdot V_a - 0.802208 \cdot \frac{Vb_{eff}}{(Vb_{eff} + V_a)} + \frac{3.871977 - 0.0021 \cdot p_4 + 0.003958 \cdot p_{38} - 0.000017 \cdot (p_{38})^2 + 0.005470 \cdot p_{34}}{1 + e^{(-0.603313 - 0.313351 \log(f) - 0.393532 \log(\eta))}} \quad (2\text{-}36)$$

where |E*| = the asphalt mix dynamic modulus in 10^5 psi;

η = bitumen viscosity in 10^6 poise (at any temperature, degree of aging);

f = load frequency in Hz;

V_a = % air voids in the mix, by volume;

Vb_{eff} = % effective bitumen content, by volume;

P_{34} = % retained in the ¾ in. sieve, by total aggregate weight (cumulative);

P_{38} = % retained in the 3/8 in. sieve, by total aggregate weight (cumulative);

P_4 = % retained in the No. 4 sieve, by total aggregate weight (cumulative); and

P_{200} = % passing the No. 200 sieve, by total aggregate weight.

2.4.2 The Hirsch Model

The Hirsch Model was developed by Christensen et al. (2003) to estimate the dynamic modulus of asphalt concrete using the binder modulus and volumetric properties of the mixture (VMA and VFA). The model is based upon a widely used model for predicting properties of composite materials, the law of mixtures. The law of mixtures, in its general form, represents the mechanical response of two phases in parallel:

$$E_C = v_1 E_1 + v_2 E_2 \quad (2\text{-}37)$$

where E refers to the material property; ? refers to the volume fraction of a given phase; the subscript c refers to the composite; and the subscripts 1 and 2 refer to different phases present in the composite. Another form of the law of mixtures can be obtained for phases in a series:

$$\frac{1}{E_C} = \frac{n_1}{E_1} + \frac{n_2}{E_2} \tag{2-38}$$

The Hirsch model combines both phases in parallel and in series arrangements:

$$\frac{1}{E_C} = \frac{n_{1s}}{E_1} + \frac{n_{2s}}{E_2} + \frac{(v_{1P} + v_{2P})^2}{v_{1P}E_1 + v_{2P}E_2} \tag{2-39}$$

Christensen et al. (2003) used Eq. (2-39) to develop the following model for predicting the asphalt concrete dynamic modulus from the binder modulus and volumetric properties:

$$E^* = P_c\left[4200000\left(1 - VMA/100\right) + 3|G^*|\left(\frac{VFA \times VMA}{10000}\right)\right] + \left(1 - P_c\right)\left[\frac{1 - VMA/100}{4200000} + \frac{VMA}{3VFA|G^*|}\right]^{-1} \tag{2-40}$$

where

$$P_c = \frac{\left(20 + \frac{VFA \times 3|G^*|}{VMA}\right)^{0.58}}{650 + \left(\frac{VFA \times 3|G^*|}{VMA}\right)^{0.58}} = \text{aggregate contact volume;} \tag{2-41}$$

VFA = voids filled with asphalt;

VMA = voids in mineral aggregate; and

|G*| = dynamic shear modulus of binder.

3. MATERIALS AND TESTING PROGRAM

This chapter presents the materials, the testing equipment and methods used for the testing of HMA and asphalt binders, and the data analysis methods.

3.1 Dynamic Modulus Testing of HMA

Included in this section are the HMAs selected for testing, the procedure for specimen fabrication, and axial compression and IDT dynamic modulus test methods.

3.1.1 Materials

In this project, 42 asphalt mixtures were tested in the axial compression mode, and 24 of these mixtures were tested in the IDT mode. Table 3.1 summarizes the mixture variables for all the mixtures and indicates the mixtures selected for the IDT testing. A wide variety of aggregate sources from the mountains to the coast of North Carolina were utilized. The mixtures included 32 designs using granite and 10 using limestone aggregate sources. In these mixtures, 7 primary aggregate sources were used. Also, 8 binders with performance grades (PG) of 64-22, 70-22, and 76-22 were used in making these mixtures.

Maximum specific gravity (G_{mm}) tests were performed on all the mixtures in accordance with AASHTO T209. Three batches of each mixture were made and tested. If the variation in G_{mm} values between any two test specimens exceeded 0.011, additional replicates were tested. The outlier was easily identified and removed from the average after additional testing was completed.

Table 3.1 – Summary of Mixture Characteristics

Mix Type	Gradation	Aggregate Type	Primary Aggregate Location	Binder Grade	Asphalt Source	% AC Content	IDT Mixture
S[a]9.5[b]A[c]	Coarse	Granite	Morganton, NC	PG 64-22	Inman, SC	5.8	yes
S9.5A	Fine	Granite	Charlotte, NC	PG 64-22	Wilmington, NC	6.4	yes
S9.5A	Fine	Limestone	Castle Hayne, NC	PG 64-22	Wilmington, NC	6.7	-
S9.5B	Coarse	Granite	Haw River, NC	PG 64-22	Wilmington, NC	5.9	yes
S9.5B0[d]	Fine	Granite	Morganton, NC	PG 64-22	Inman, SC	6.3	yes
S9.5B1[d]	Fine	Granite	Charlotte, NC	PG 64-22	Wilmington, NC	5.8	yes
S9.5B2[d]	Fine	Granite	Garner, NC	PG 64-22	Wilmington, NC	5.5	-
S9.5B3[d]	Fine	Granite	Garner, NC	PG 64-22	Wilmington, NC	5.6	-
S9.5B4[d]	Fine	Granite	Garner, NC	PG 64-22	Wilmington, NC	5.7	-
S9.5B	Fine	Limestone	Castle Hayne, NC	PG 64-22	Wilmington, NC	6.2	-
S9.5C	Coarse	Granite	Holly Springs, NC	PG 70-22	Wilmington, NC	5.3	yes
S9.5C0[d]	Fine	Granite	Garner, NC	PG 70-22	Wilmington, NC	5.0	yes
S9.5C1[d]	Fine	Granite	Garner, NC	PG 70-22	Wilmington, NC	5.0	-
S9.5C2[d]	Fine	Granite	Garner, NC	PG 70-22	Wilmington, NC	5.2	-
S9.5C3[d]	Fine	Granite	Garner, NC	PG 64-22	Wilmington, NC	5.9	-
S9.5C	Fine	Limestone	Castle Hayne, NC	PG 70-22	Wilmington, NC	6.7	-
S12.5B	Coarse	Granite	Haw River, NC	PG 64-22	Wilmington, NC	5.5	yes
S12.5B	Fine	Granite	Holly Springs, NC	PG 64-22	Wilmington, NC	5.3	yes
S12.5C	Coarse	Granite	Morganton, NC	PG 70-22	Inman, SC	4.6	yes
S12.5C	Fine	Granite	Concord, NC	PG 70-22	Wilmington, NC	5.0	yes
S12.5C	Fine	Limestone	Castle Hayne, NC	PG 70-22	Wilmington, NC	6.7	-
S12.5D	Coarse	Granite	Concord, NC	PG 70-22	Wilmington, NC	5.0	yes
S12.5D	Fine	Granite	Concord, NC	PG 76-22	Salisbury, NC	4.7	yes
I19.0B	Coarse	Granite	Haw River, NC	PG 64-22	Apex, NC	5.0	yes
I19.0B	Coarse	Limestone	Castle Hayne, NC	PG 64-22	Wilmington, NC	5.2	-
I19.0B0[d]	Fine	Granite	Garner, NC	PG 64-22	Wilmington, NC	5.4	yes
I19.0B1[d]	Fine	Granite	Charlotte, NC	PG 64-22	Wilmington, NC	4.3	yes
I19.0B2[d]	Fine	Granite	Garner, NC	PG 64-22	Wilmington, NC	4.4	-
I19.0B3[d]	Fine	Granite	Garner, NC	PG 64-22	Wilmington, NC	4.5	-
I19.0B	Fine	Limestone	Castle Hayne, NC	PG 64-22	Wilmington, NC	5.1	-
I19.0C	Coarse	Granite	Garner, NC	PG 64-22	Wilmington, NC	4.7	yes
I19.0C	Fine	Granite	Concord, NC	PG 64-22	Charlotte, NC	4.8	yes
I19.0C	Fine	Limestone	Castle Hayne, NC	PG 64-22	Wilmington, NC	4.9	-
I19.0D	Coarse	Granite	Charlotte, NC	PG 70-22	Wilmington, NC	4.3	yes
I19.0D	Fine	Granite	Concord, NC	PG 70-22	Salisbury, NC	4.1	yes
B25.0B	Coarse	Granite	Holly Springs, NC	PG 64-22	Wilmington, NC	4.5	yes
B25.0B	Coarse	Limestone	Castle Hayne, NC	PG 64-22	Wilmington, NC	4.2	-
B25.0B	Fine	Granite	Garner, NC	PG 64-22	Wilmington, NC	4.2	yes
B25.0B	Fine	Limestone	Castle Hayne, NC	PG 64-22	Wilmington, NC	5.0	-
B25.0C	Coarse	Granite	Haw River, NC	PG 64-22	Wilmington, NC	4.0	yes
B25.0C	Fine	Granite	Concord, NC	PG 64-22	Charlotte, NC	4.4	yes
B25.0C	Fine	Limestone	Castle Hayne, NC	PG 64-22	Wilmington, NC	5.1	-

Note: [a]S for surface mix, I for intermediate mix, and B for base mix
[b]Nominal Maximum Aggregate Size (in mm)
[c]Traffic volume indicator
[d]Differentiates mixtures with the same designation

3.1.2 Specimen Fabrication

Asphalt mixtures were mixed and compacted at temperatures that were in accordance with the requirements for each binder. All mixtures were aged at 135°C for four hours (i.e., short-term oven aging) before compaction.

For mixtures tested in the axial compression mode, samples were compacted into gyratory plugs of 150 mm in diameter by 178 mm in height. Later, they were cut and cored to cylindrical specimens with dimensions of 100 mm in diameter and 150 mm in height. For mixtures tested in the IDT mode, samples were compacted into gyratory plugs of 150 mm in diameter by 60 mm in height, and they were cut to 38 mm height. Both ends were cut to ensure a more consistent air void distribution along the height of the test specimens.

The target air voids for the final cut and cored specimen were 4% ± 0.5%. In order to achieve this density, the target air voids for the gyratory plug had to be higher than that of the cut and cored specimen. The different requirements for the different target air voids occurred because of density variations throughout the height and diameter of the compacted specimen. Chehab et al. (2000) found that the center of the gyratory plug is the most dense and that the least dense areas are on the outer surfaces. The difference between the target air voids for the gyratory plug and for the cut and cored specimen typically increased as the NMAS increased with an average being about 1.5% to 2%.

For IDT specimens, a small study was conducted using four mixtures with different NMASs to estimate the reduction in air voids when the specimen is cut from a 60 mm height to 38 mm. The study showed that, in general, the reduction in air voids is

around 1% for 9.5 mm NMAS and the reduction increases by approximately 0.5% increments as the NMAS increases to 12.5, 19, and 25 mm.

Air voids were measured using the Corelok vacuum sealing device. Specifications provided in ASTM D6752-03 were followed in taking these measurements and making the calculations. Appropriate adjustments were made to account for the density of water when measurements were taken at temperatures other than 25°C.

For each of the 42 mixtures there were 3 replicates of each tested. During fabrication or testing, if errors were made or densities were not met, then the specimen was discarded and an additional specimen was manufactured and tested.

3.1.3 Testing Systems

3.1.3.1 Test Setup

Testing was performed using a closed-loop servo-hydraulic machine, manufactured by Material Testing System (MTS). This machine is capable of applying loads up to 20 kips over a wide range of frequencies (25 to 0.01 Hz). For all the testing conducted in this project, a 5 kip load cell was utilized, as the maximum applied load was about 4 kip.

A temperature chamber, cooled by liquid nitrogen, was used to control the test temperature. Dummy specimens with thermocouples embedded in the middle of the specimen were used to monitor the temperatures to which the specimens were subjected.

For axial compression testing, 100 mm diameter metal end plates attached to the top and bottom rams were used to apply the compressive load to the specimen. Friction-reducing end treatments were used to lessen the confinement that occurs as a result of the friction against the specimen and the metal end plates. The end treatments were made of

two latex membranes, each 0.0125 in. thick. A very small amount of silicon grease was smeared between the latex membranes to allow the specimen to move (dilate) with respect to the metal end plates. Caution was used to apply only the minimum amount of grease necessary because excess grease creates a slick interface that causes the specimen to slip out of the test setup under high load and high frequency combinations. Also, an approximate 25 mm diameter hole was introduced in the center of the membrane to allow a small amount of contact between the metal plate and the specimen, thereby increasing the friction and reducing the movement of the specimen during testing.

The axial compression test setup is shown in Figure 3.1. For the IDT test, the Load Guide Device (LGD), developed from the Strategic Highway Research Program (SHRP), was used as the loading apparatus. This device is shown in Figure 3.2(a). From the NCHRP 1-28 study, it was found that when compared against other loading devices with no column or four columns, the SHRP LGD with two guide columns resulted in the least amount of "rocking" of the IDT specimen without causing significant friction between the upper loading plate and guide columns under repetitive loading (Barksdale et al., 1997).

For axial compression testing, vertical deformations were measured using four loose-core, CD type LVDTs (linear variable differential transducers) at 90° radial intervals. Targets were glued to the specimen face in the middle two-thirds of the specimen (100 mm), and the LVDTs were mounted to the targets. A gluing device was used to maintain consistent spacing between the LVDT targets. The LVDT setup is shown in Figure 3.1.

Figure 3.1 LVDT mounting and spacing

For IDT specimens, the vertical and horizontal deformations were measured using loose-core type miniature XSB LVDTs. These were mounted on each of the specimen faces using a 50.8 mm gauge length, as shown in Figure 3.2(b).

3.1.3.2 Data Acquisition System

The data acquisition system used in this project is composed of LabView software and a 16-bit data acquisition board by National Instruments. It is capable of acquiring signals from up to 16 channels simultaneously. Of these 16 channels, only 6 were used in the testing described herein. One channel was dedicated to the load cell on the machine, one to the actuator LVDT, and four to the on-specimen LVDTs. The data acquisition rate was 100 points per cycle.

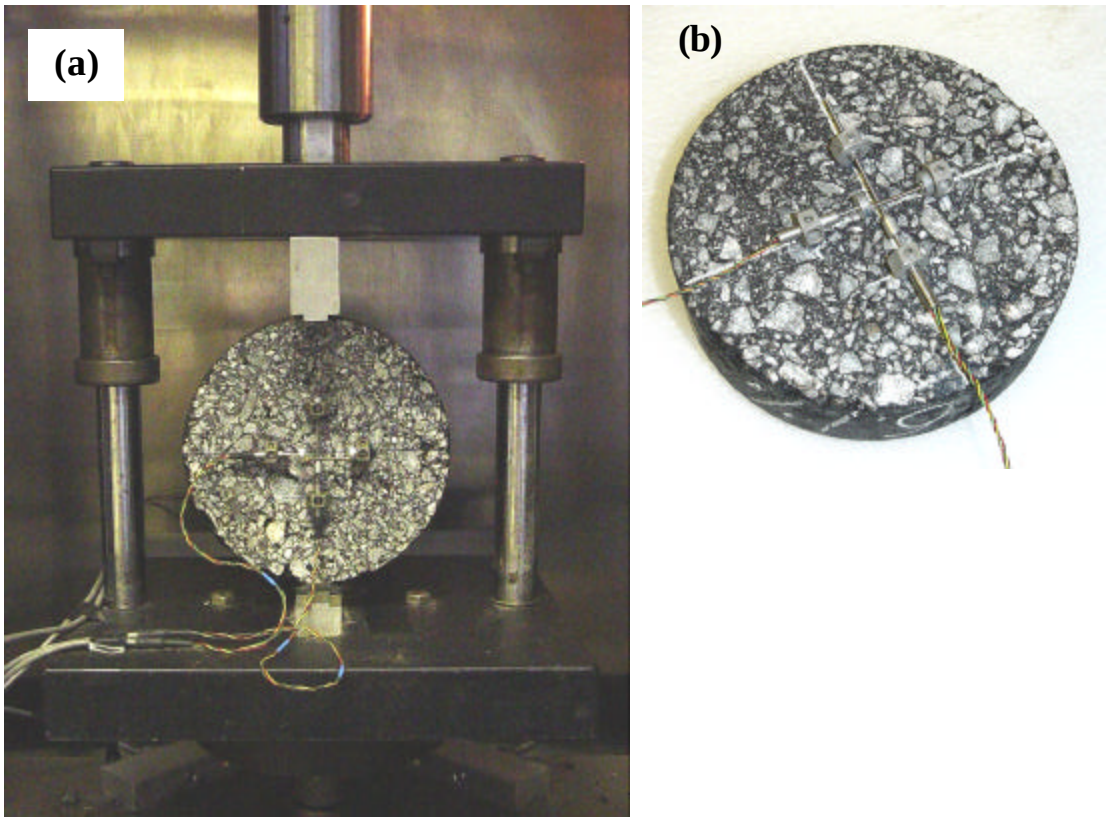


Figure 3.2 (a) IDT test setup with SHRP LGD; (b) Surface-Mounted LVDTs

3.1.4 Test Methods

Complex modulus testing was performed in this project in both uniaxial compression and IDT modes. These tests were performed in a stress-controlled mode and were designed to measure the linear viscoelastic property of asphalt concrete. In this research, 75 microstrain was used as the limit of the linear viscoelastic behavior. Since the material is temperature and frequency dependent, the load applied was adjusted at each combination of frequency and temperature to ensure that the axial and horizontal strains did not exceed 75 microstrains in the axial compression and IDT tests, respectively.

Testing was performed by applying sinusoidal loadings at different frequencies and temperatures. Prior to applying the first frequency at each temperature, the preconditioning cycles were applied at 25 Hz and one half the load used in actual testing for 25 Hz.

The complex modulus test was performed at various combinations of loading frequency and temperature. The selection of loading frequencies and temperatures requires two considerations. First, the dynamic moduli data from different temperatures must have some overlap to ensure the verification of the thermorheological behavior. This consideration means that for the given set of frequencies the test temperatures must be selected so that they are close enough to ensure the overlap. The second consideration is a practical one in that the number of test temperatures must be minimized in order to save testing time. It is noted that the most time-consuming part of the dynamic modulus test is the conditioning period to change the test temperature. These two considerations need to be investigated in order to develop a reliable and faster dynamic modulus test protocol.

The dynamic modulus test protocol that is widely accepted by the asphalt pavement industry is the AASHTO TP 62-03, which was developed by the NCHRP 9-19 research team and used in the round robin testing coordinated by the Connecticut Transportation Institute (2003). The test series recommended by the TP 62 protocol consists of testing at -10°, 4.4°, 21.1°, 37.8°, and 54.4°C at loading frequencies of 0.1, 0.5, 1.0, 5, 10, and 25 Hz at each temperature. In this project, after some preliminary testing it was felt that the temperature-frequency combinations could be optimized further

to reduce the testing time. This research effort is presented in the next section, which results in a modified dynamic modulus test protocol.

Following each loading frequency, a five-minute rest period was allowed before the next frequency was applied. The number of loading cycles at each frequency can be found in Table 3.2. Other than the temperature-frequency combinations, the dynamic modulus testing conducted in this research follows the AASHTO TP 62-03 guidelines.

Table 3.2 – Specimen Loading Information

Frequency (Hz)	Number of Loading Cycles
25 – pre	200
25	200
10	200
5	100
1	20
0.5	15
0.1	15
0.05	10
0.01	8

3.1.5 Data Analysis

Averaged deformations were used to calculate the dynamic modulus and phase angle. In the uniaxial case, readings from four LVDTs spaced at 90° intervals were averaged. In IDT, the vertical deformations and horizontal deformations from two surfaces were averaged to determine the deformation in each axis.

LabView software was used in determining the amplitudes of the sinusoidal load and deformation histories. This program uses the Levenberg-Marquardt algorithm which is a least squares approach to curve fitting. The software would read in the raw data and detect the last five cycles of data for each temperature and frequency combination, as per

AASHTO TP-62. The last five cycles of data were analyzed and fitted according to the following functional form:

$$f(t) = a + bt + c\cos(wt + f) \quad (3\text{-}1)$$

where $f(t)$ is load or deformation time history;

a, b, and c are regression coefficients;

f is the phase angle; and

w is the angular frequency.

Coefficient c represents the amplitude of the sinusoidal waveform, and the dynamic modulus is then calculated from the ratio of these coefficients from load and deformation histories. The difference in the phase angles from the load and deformation analyses represents the phase angle of the material. It was found that there is a slight difference between the intended loading frequency and the actual loading frequency. In this study, the actual loading frequency was used in developing and representing the mastercurves.

The data analysis method described above was used for determination of complex modulus for the asphalt mixtures and dynamic shear modulus for the binders.

3.2 Dynamic Modulus Test Protocol Modification

3.2.1 Development of Three-Temperature Protocol

The main interest of this part of the research was whether testing at a reduced number of temperatures with an increased number of frequencies would yield the same results (i.e., the same mastercurves). Should the evaluation prove positive, a considerable time savings could be effected for the dynamic modulus test. One key requirement in

developing a dynamic modulus mastercurve is to have an overlap of the dynamic modulus versus frequency curves between adjacent testing temperatures. This overlap can be seen in Figure 3.3 using the current TP 62 protocol. However, notice that duplication of data exists at the lowest modulus or highest temperature values. The aim of this study is to eliminate excessive duplication in the overlap while maintaining sufficient data for the shift analysis.

Since the mastercurve development combines the effects of testing frequency and temperature into one variable called *reduced frequency*, it is possible to modify the range of frequencies in each temperature to compensate for the modification in the number of test temperatures. This theoretical justification allows the increase in the number of frequencies and the decrease in the number of testing temperatures. Once the dynamic modulus mastercurve and the shift factors are determined uding the TP 62 protocol, the dynamic moduli values at any frequency and any temperature between -10° and 54.4°C can be calculated. Based on these calculations, a set of frequencies and temperatures that yield the least amount of testing time was determined. This set of frequencies and temperatures is presented in Table 3.3 as the modified test protocol.

Table 3.3 – Comparison of the Current and Three-Temperature Test Protocols

Test Protocol	***No. of Temperatures***	***Testing Temperatures (°C)***	***No. of Frequencies***	***Testing Frequencies (Hz)***	***Total Testing Time (hrs)***
Modified	**3**	-10, 10, and 35	**8**	25, 10, 5, 1, 0.5, 0.1, 0.05, 0.01	**9**
Current	**5**	-10, 4.4, 21.1, 37.8, 54.4	**6**	25, 10, 5, 1, 0.5, 0.1	**12**

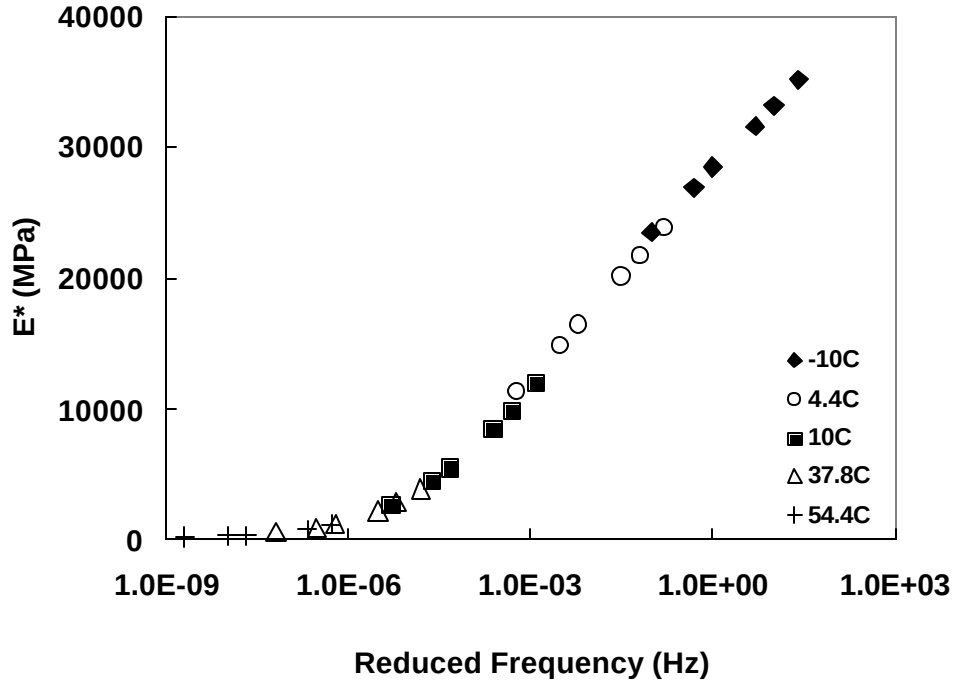


Figure 3.3 Overlapping of dynamic modulus curves from the five-temperature testing

3.2.2 Comparison of Results from Current and Three-Temperature Protocols

As mentioned previously, overlap is desirable in mastercurve development. Figure 3.4 shows the overlap between dynamic modulus curves using the temperatures proposed in the three-temperature protocol. It can be seen from Figure 3.4 that, by adding two low frequencies (i.e., 0.05 and 0.01 Hz), enough overlap is experienced to cover the reduction in the number of testing temperatures. The overlap is similar to that seen in five-temperature testing between -10° and 4.4°C or 4.4° and 21.1°C. Some of the replication at the higher temperatures does not exist in the three-temperature test data, which does not affect the quality of the overlap because enough data still exist to create the overlap.

Another important factor to consider in this comparison is the similarity between the dynamic modulus mastercurves from the two protocols. In Figure 3.5 the results from both tests are combined so that, graphically, the similarities can be seen. Each curve in Figure 3.5 represents the average of three replicates. When the average curves are compared in this figure, some discrepancies are seen at higher reduced frequencies (i.e., lower temperatures and/or higher frequencies). It is noted that both the three- and five-temperature tests use -10°C as the first test temperature. Also, it is noted that at a given temperature the test proceeds from the highest to lowest frequency. It can be seen that the difference in procedures adds 0.05 and 0.01 Hz to the three-temperature test. In other words, the testing procedure for both tests is identical until the additional frequencies are added and higher temperatures are used.

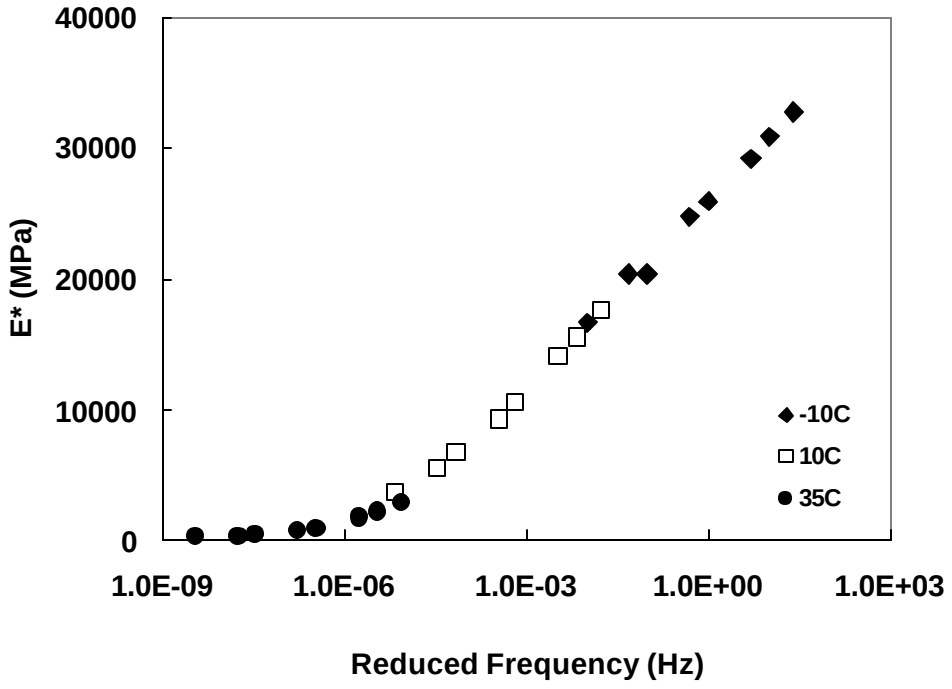


Figure 3.4 Overlapping of dynamic modulus curves from the three-temperature testing

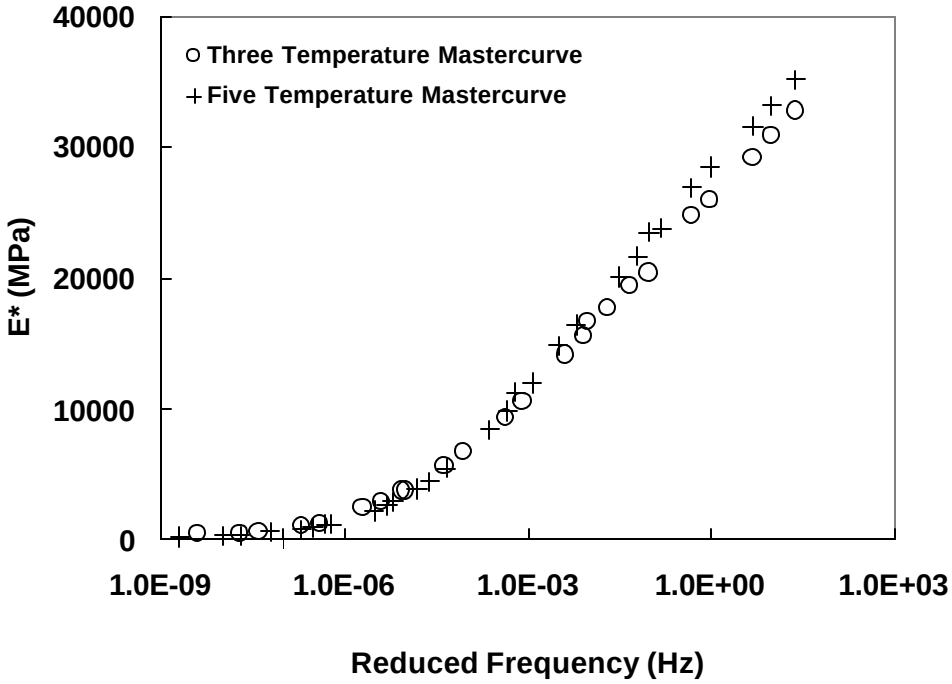


Figure 3.5 Comparison of mastercurves between three- and five-temperature testing

Therefore, the variations at low temperatures and high frequencies shown in Figure 3.5 are counterintuitive because the loading and temperature histories are identical initially. For this reason, the discrepancy observed in Figure 3.5 may be due to a factor other than the new testing procedure. Since these are virgin specimens made at the same time and tested, at least initially, under the same procedure, the results at -10°C should be the same if the specimen-to-specimen variation is minimal.

Since there are multiple specimens involved in each of the curves shown in Figure 3.5, a statistical analysis was necessary to determine if the average is indeed different. Since each test did not have the same reduced frequency, a comparison was made by

using the actual data at a given reduced frequency for the five-temperature data and comparing these data to the sigmoidal fit from the three-temperature data.

A t-test on two means was conducted at a significance level of α=0.05 for all the reduced frequencies at each of the five testing temperatures. The hypothesis test was constructed with the following parameters:

H_o: $\mu 1 - \mu 2 = 0$

H_1: $\mu 1 - \mu 2 \neq 0$

The null hypothesis was not rejected except in two instances (0.5 and 1 Hz at -10°C). Where the null hypothesis was not rejected, there was not enough evidence that the mean values were different for the two testing protocols. Although the null hypothesis was statistically rejected in those two frequencies, a visual comparison of the data from these two frequencies and the data from the other frequencies shown in Figure 3.5, coupled with the fact that at 26 other frequencies the difference was statistically insignificant, suggests that the differences caused by changing the test protocol are minimal.

3.2.3 Four-Temperature Protocol

Although the mastercurves developed under the three-temperature protocol appear to be the same as the ones developed under the five-temperature protocol, it was found that the shift factor relationships required to obtain the mastercurves are not the same between the two protocols. There are a couple of reasons why the shift factor relationships are different. First, the three-temperature protocol did not encompass the full range of temperatures that the five-temperature protocol did. As a result, data at temperatures greater than 35°C were extrapolated when the three-temperature protocol was used. Second, the number of points defining the shift factor relationship in the three-

temperature protocol was less than with the five-temperature protocol. Figure 3.6 shows the shift factor relationships for both protocols. The three-temperature curve is extrapolated to show the difference at 54.4°C.

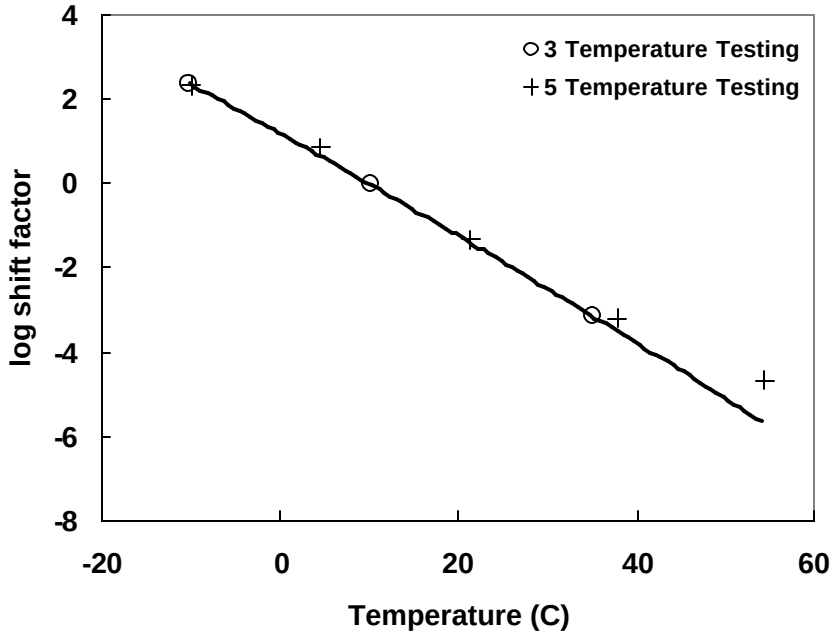


Figure 3.6 Prediction error for the shift factor at 54.4°C from the three-temperature test protocol

Since this error can be critical to the response and performance prediction at high temperatures, it was decided to add 54.4°C to the three-temperature test protocol. By doing so an additional point was added to the shift factor curve, and the full range of temperatures in TP 62 were included in the protocol. With this four-temperature protocol, the testing time (13 hours including the temperature conditioning) became shorter than the testing time (16 hours) for the original five-temperature protocol, and the temperature

and shift factor relationship was developed using the full range of temperatures, as given in TP 62. It needs to be also noted that the analysis time in the two protocols is the same.

The problem with the three-temperature protocol was not found until the middle of the project. Therefore, the first half of the mixtures were tested using the three-temperature protocol and the other half of the mixtures were tested using the four-temperature protocol. The remedial action taken to overcome this difference in the development of the dynamic modulus database is described in the beginning of Section 4.

3.3 Asphalt Binder Testing

The dynamic modulus predictive models require inputs of binder properties. In the case of the Witczak model the binder viscosity at the temperature in question is required, whereas the Hirsch model uses the binder's dynamic shear modulus as an input. These properties need to be determined from Rolling Thin Film Oven (RTFO)-aged binders because the mixture used in fabricating the specimens for the dynamic modulus testing undergoes only short-term aging. Seven binders were used in this study, and they are listed in Table 3.4. PG 70-22 from Associated Asphalt – Inman, SC was used for only one mixture and was not RTFO-aged due to time constraints.

Table 3.4 – Asphalt Binders Tested

Binder Type	Refinery – Source
PG 64-22	Associated Asphalt - Inman, SC
PG 64-22	Citgo – Wilmington, NC
PG 64-22	El Paso MEP – Charlotte, NC
PG 64-22	El Paso MEP - Apex, NC
PG 70-22	Citgo – Wilmington, NC
PG 70-22	Associated Asphalt - Salisbury, NC
PG 76-22	Associated Asphalt - Salisbury, NC

In the following sections, the details involved in determining binder viscosity and dynamic shear modulus are presented.

3.3.1 Determination of Binder Viscosity

It is noted that all the inputs in the Witczak model can be determined from the mix design except the bitumen viscosity. The bitumen viscosity must be determined for the temperature at which the dynamic modulus value of the mixture is desired. However, this temperature is too low for any viscosity tests to be performed. Fortunately, most refined asphalt cements exhibit a linear relationship when plotted on a log-log viscosity (centipoise) versus log-temperature scale (in degree Rankine: R = F + 459.7 F). In order to develop this relationship over a wide temperature range, penetration and rotational viscosity tests were conducted on RTFO-aged binders by the NCDOT Materials and Test (M&T) Unit.

The penetration (pen) measurements were converted into viscosity units using the following model developed at the University of Maryland as part of a SHRP study:

$$\log h = 10.5012 - 2.2601 \times \log (pen) + 0.00389 \times \log (pen)^2 \quad (3\text{-}2)$$

It should be noted that the above equation is applicable over a very wide range of penetration from 3 to 300. Also notable is that the viscosity obtained from the above equation is in poise. The second group of viscosity values at high temperatures was obtained from the rotational viscosity test with the use of the Brookfield Viscometer.

All penetration results converted to viscosity units (in cp) are used along with the rotational viscosity test results to obtain the following viscosity (η) - temperature (T_R) relationship:

$$\log \log h\ (cp) = A + VTS \times \log T_R \quad (3\text{-}3)$$

In the above equation, A and VTS (Viscosity Temperature Susceptibility) represent regression coefficients, which describe the unique consistency-temperature relationship of any blend. Figure 3.7 shows a typical temperature-viscosity relationship obtained in this research. The penetration, viscosity, A, and VTS values for seven binders used in this study are summarized in Appendix A. The A and VTS values can be used in Eq. (3-3) to predict the viscosity at a desired temperature for the prediction of the dynamic modulus of HMA using Witczak's model.

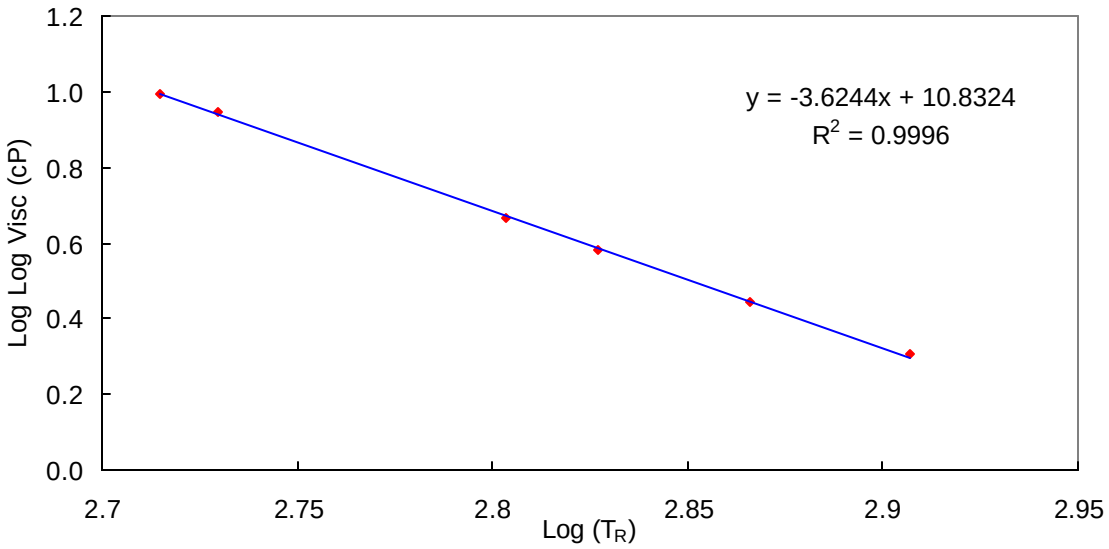


Figure 3.7 Viscosity-temperature relationship for PG 64-22 Inman

3.3.2 Determination of Dynamic Shear Modulus of Binder

A Dynamic Shear Rheometer (DSR) was used to determine the dynamic shear modulus (G*) of RTFO-aged asphalt binders listed in Table 3.4. G* was determined, using plate test geometry, by conducting a temperature-frequency sweep. This test method is applicable to asphalt binders with G* values in the range of 100 Pa to 10 MPa.

This range of modulus values is obtained from asphalt binders typically between 5° and 85°C. The dynamic shear moduli of seven binders are summarized in Appendix A.

3.3.2.1 Specimen Preparation for DSR Testing

Each binder was RTFO-aged by the M&T Unit. RTFO-aged binders were heated in closed cans until they became sufficiently fluid to pour the required specimens. The samples were stirred occasionally to remove any trapped air and to ensure homogeneity. PG 64-22 binders were heated to a temperature of 125°C, and PG 70-22 and PG 76-22 binders were heated to 135°C.

Three replicates of each binder type were poured into a silicone rubber mold to form a pellet with a diameter of 25 mm and a height of approximately 1.5 mm. The best two replicates were selected for testing and the third replicate was discarded. The silicon mold was allowed to cool to room temperature. The specimen was then carefully removed from the mold and centered on the lower plate of the DSR.

3.3.2.2 DSR Testing Equipment

The DSR test system was manufactured by Bohlin Instruments and consists of parallel metal plates, an environmental chamber, a loading device, and a control and data acquisition system. A metal base plate with a smooth polished surface and a diameter of 25 mm was used as the lower plate. A metal spindle with the same diameter and surface conditions was mounted to the upper rotating part of the apparatus.

An environmental water bath was used to maintain a constant specimen temperature. The environmental chamber controlled the temperature of the test specimen to an accuracy of ± 0.1°C and was capable of maintaining this consistency across the temperatures of interest.

3.3.2.3 DSR Test Method

A base plate and the spindle were mounted on the DSR device and tightened firmly. A zero gap level was established by manually spinning the spindle. While the spindle was spinning, the gap was closed until the spindle touched the base plate. The base plate and the spindle were then moved apart, and a gap setting of 1 mm plus 0.05 mm was established. The specimen was placed at the center of the base plate. The spindle was moved downward to compress the sample until the gap between the plates equaled the gap setting. The specimen was trimmed by carefully removing the extra asphalt around the entire perimeter using a heated trimming tool. After trimming the perimeter of the specimen, the gap between the plates was decreased by 0.05 mm to the desired testing gap of 1 mm.

The frame, detectors, and fixtures in the DSR change dimensions as the temperature changes, thus causing the zero gap to change. Therefore, the gap between the plates was set at the middle of the expected range of test temperatures to minimize that error. The test was conducted in a strain-control mode where the target strain value was set to 5%, as per AASHTO TP-1.

Machine control and data acquisition were both controlled via computer. The software was programmed to test at 15, 10, 5, 1, 0.5, 0.1, 0.05, and 0.01 Hz at 16°, 22°, 28°, 40°, and 54°C. After reaching each of the desired testing temperatures, the software was programmed to wait for 10 min. to ensure that the specimen had also reached that temperature. After the rest period the machine performed preconditioning cycles for 10 sec. before starting the test. Testing started from the lowest temperature to the highest, and at each temperature the test progressed from the highest frequency to the lowest.

4. DISCUSSION OF AXIAL COMPRESSION TEST RESULTS

The dynamic moduli at various temperatures and loading frequencies were determined in the axial compression mode using the modified test protocol. Three replicates were tested for each mixture, and the mastercurves were constructed using the averaged dynamic modulus values from the three replicates.

Appendix B summarizes the dynamic modulus and phase angle values for each temperature and frequency combination of the three replicates in each of the 42 mixtures. Two sets of tables are provided: the first set of tables (Table B-1 to Table B-42) are in the US Customary unit, and the second set of tables (Table B-43 to Table B-84) are in the metric unit.

For the mixtures tested using the three-temperature protocol, data at 54.4°C had to be predicted from the three-temperature data using the estimated shift factor for 54.4°C. The shift factor versus temperature relationships for all the mixtures were studied to develop reasonable estimates of the shift factor at 54.4°C for different mixtures. It was found that the mixtures with the same PG binder grade yielded similar shift factor values for 54.4°C. Therefore, the shift factor values at 54.4°C for the mixtures with the same binder grade were averaged and this average shift factor was used to predict the reduced frequency using Eq. (2-8). The reduced frequency in conjunction with the sigmoidal fit coefficients for each respective mixture were used to predict the moduli values at each reduced frequency using Eq. (2-9). Whenever the dynamic moduli at 54.4°C are predicted using the method described above, the tables in Appendix B show no statistical and replicate information for 54.4°C data.

The results from the S9.5C–Fine mixture are presented for demonstration purposes in Figures 4.1 to 4.3. In Figure 4.1, dynamic modulus mastercurves from three replicates are displayed. The reference temperature of 10°C was used as the basis for shifting the data. It is noted that, although each replicate was subjected to the same set of frequencies and temperatures, the reduced frequencies of the three replicates are slightly different. This difference is due to the fact that the actual temperature of the specimen measured by the dummy specimen in the temperature chamber is slightly different from the target temperature reported in the figure. All the dynamic modulus data for individual replicates were shifted using the actual measured temperatures instead of the target temperatures, which resulted in different reduced frequencies for the same set of target temperatures and loading frequencies.

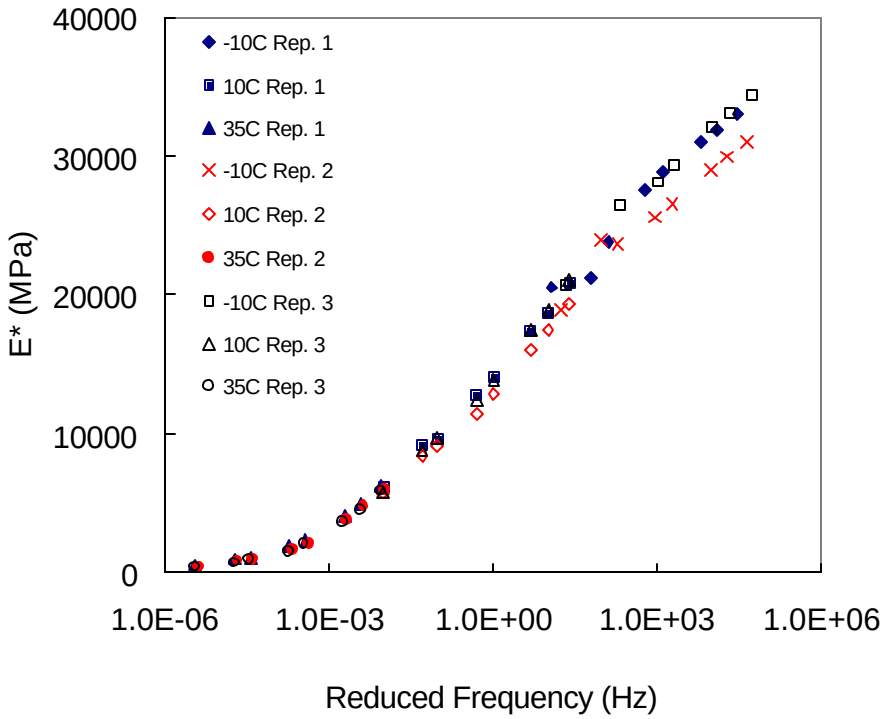


Figure 4.1 Dynamic moduli of S9.5C–Fine mixture

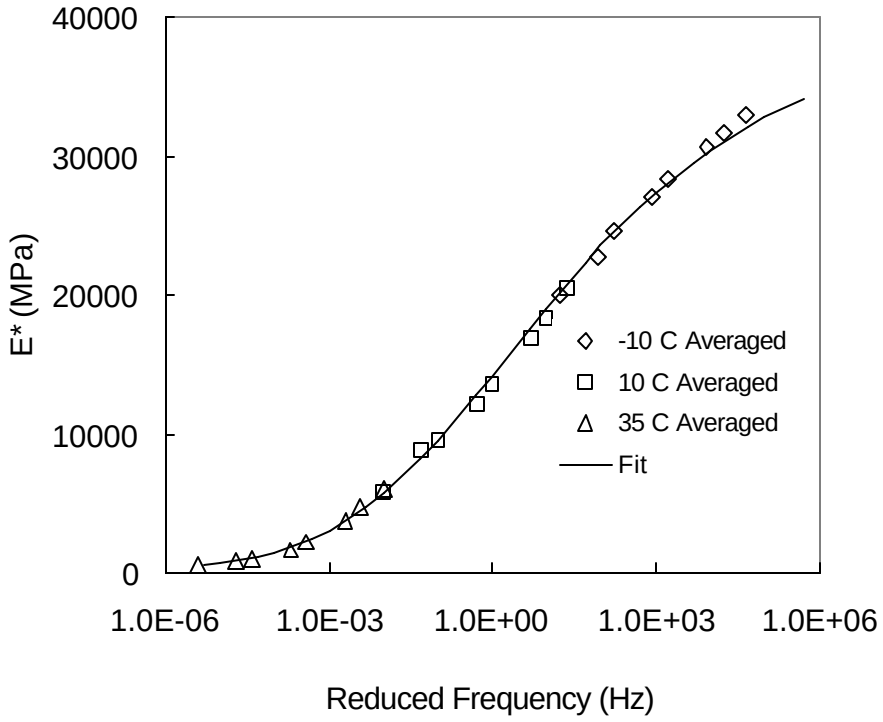


Figure 4.2 Dynamic modulus mastercurve for S9.5C–Fine mixture

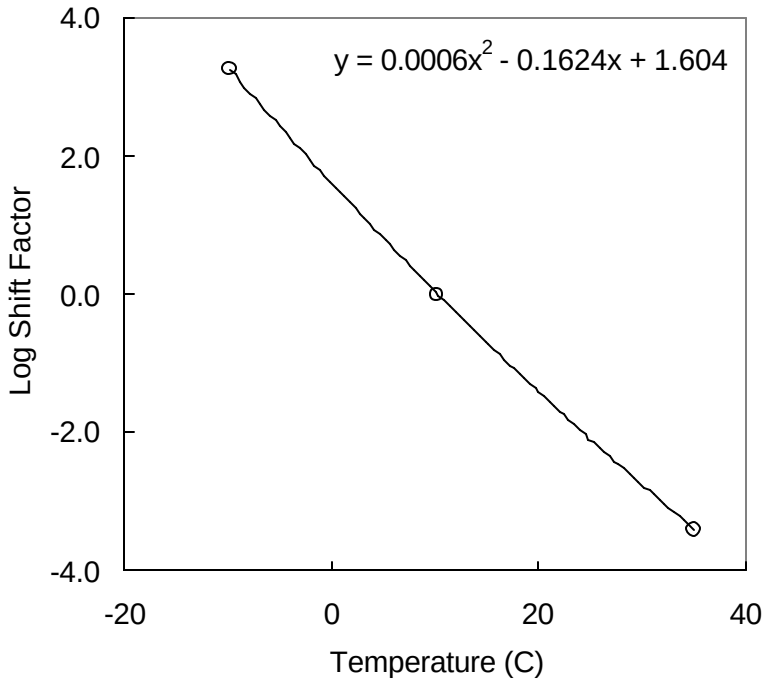


Figure 4.3 Shift factor-temperature relationship for S9.5C–Fine mixture

The mastercurve presented in Figure 4.2 was developed by averaging three replicates. An assumption was made that the temperature and frequency differences among the three replicates were negligible, and thus the three replicates could be averaged. Typically, the difference between the actual temperature measured from the dummy specimen and that of the target temperature would remain within +/- 0.2°C. The frequency variation was only noticeable at frequencies of 5 Hz and higher. At most, a 0.1 Hz error existed at even the highest frequency. An alternative to the method presented above is to calculate the dynamic modulus at the target frequency and temperature using the fitting functions of the mastercurve and shift factor and then averaging the three estimated numbers. However, because of the fitting error, it was found that less error would occur in the data by averaging at different temperature and frequency combinations than would occur from estimating the moduli values from the fit equations.

Figure 4.3 shows the shift factor versus temperature relationship. A quadratic equation was used to fit the shift factor-temperature relationship. Table 4.1 summarizes the coefficients of the sigmoidal function for the dynamic modulus mastercurve and the coefficients for the quadratic function used to represent the shift factor-temperature relationship. The coefficients determined from IDT testing are tabulated in Appendix C.

The coefficients shown in Table 4.1 allow the estimation of the dynamic modulus at any temperature and frequency combination using the following steps:

1. Identify the mixture where |E*| needs to be calculated.
2. Determine the frequency (f) in Hz and temperature in degrees Celsius at which |E*| is to be computed.
3. Determine the shift factor coefficients for the mixture from Table 4.1.

4. Substitute the coefficients into the following equation to compute the shift factor, where T is the temperature and a_T is the shift factor:

$$log(a_T) = a_1 T^2 + a_2 T + a_3 \quad (4\text{-}1)$$

5. Compute the reduced frequency ($f_R = f \times a_T$) from the actual frequency and the shift factor.

6. Determine the sigmoidal function regression coefficients a, b, d, and e for the selected mixture from Table 4.1.

7. Substitute the regression coefficients and f_R into the sigmoidal function in Eq. (2-9) to determine the dynamic modulus in MPa.

In the rest of this chapter, the dynamic modulus database developed from the axial compression testing is used to evaluate the predictive accuracy of the Witczak and Hirsch models. The effects of predictive errors on the pavement fatigue cracking and rutting performance are assessed using the mechanistic-empirical pavement design method. Also, the effects of the mixture variables on the dynamic modulus are discussed. Finally, the effects of confining pressure on the dynamic modulus are evaluated using triaxial compression test results.

Table 4.1 – Coefficients to Predict |E*| at Any Temperature and Frequency

Mixture			Shift Function Coefficients			Sigmoidal Coefficients			
			α1	α2	α3	a	b	d	e
S[a]9.5[b]A[c]	Coarse	Granite	0.00060	-0.16543	1.58849	1.38724	3.19616	1.75945	0.43460
S9.5A	Fine	Granite	0.00077	-0.15993	1.52679	1.41656	3.10378	1.46310	0.46369
S9.5A	Fine	Limestone	0.00074	-0.16339	1.55956	1.74392	2.67903	1.64762	0.48697
S9.5B	Coarse	Granite	0.00067	-0.14940	1.49840	1.32570	3.21009	1.54126	0.49085
S9.5B0[d]	Fine	Granite	0.00054	-0.15949	1.56317	0.86302	3.61944	1.76263	0.39345
S9.5B1[d]	Fine	Granite	0.00063	-0.15509	1.48742	1.80806	2.70608	1.49166	0.51246
S9.5B2[d]	Fine	Granite	0.00063	-0.16281	1.56548	1.78184	2.68257	1.72191	0.44429
S9.5B3[d]	Fine	Granite	0.00070	-0.16292	1.55952	1.61112	2.87367	1.71602	0.46512
S9.5B4[d]	Fine	Granite	0.00070	-0.15916	1.52175	1.51435	2.99846	1.67175	0.49359
S9.5B	Fine	Limestone	0.00057	-0.15964	1.53926	2.08083	2.39349	1.73194	0.46166
S9.5C	Coarse	Granite	0.00039	-0.15556	1.49484	1.11690	3.42690	1.96297	0.39558
S9.5C0[d]	Fine	Granite	0.00055	-0.16239	1.60396	0.95234	3.63149	1.99680	0.38857
S9.5C1[d]	Fine	Granite	0.00063	-0.16165	1.55359	1.80725	2.70330	1.78576	0.44931
S9.5C2[d]	Fine	Granite	0.00067	-0.15938	1.52689	1.84010	2.67905	1.84852	0.49910
S9.5C3[d]	Fine	Granite	0.00067	-0.15752	1.50795	1.62218	2.90129	1.65725	0.52524
S9.5C	Fine	Limestone	0.00061	-0.15655	1.50481	2.04012	2.36898	1.91150	0.51392
S12.5B	Coarse	Granite	0.00088	-0.16096	1.56637	1.34244	3.19566	1.63643	0.49564
S12.5B	Fine	Granite	0.00080	-0.16273	1.54227	0.93381	3.60575	1.83115	0.43273
S12.5C	Coarse	Granite	0.00060	-0.16543	1.58849	1.83404	2.75875	1.49861	0.38100
S12.5C	Fine	Granite	0.00043	-0.15267	1.51253	1.48148	3.13354	1.85892	0.41490
S12.5C	Fine	Limestone	0.00053	-0.14935	1.44096	2.31749	2.08901	1.77606	0.56767
S12.5D	Coarse	Granite	0.00060	-0.16045	1.54420	1.26038	3.36417	1.84298	0.40654
S12.5D	Fine	Granite	0.00051	-0.16232	1.56174	0.40363	4.21000	2.18061	0.33868
I19.0B	Coarse	Granite	0.00075	-0.15933	1.51615	1.36605	3.19382	1.56800	0.44184
I19.0B	Coarse	Limestone	0.00078	-0.16068	1.52856	2.02687	2.45922	1.94798	0.57696
I19.0B0[d]	Fine	Granite	0.00080	-0.16009	1.52354	1.08285	3.48199	1.73573	0.48212
I19.0B1[d]	Fine	Granite	0.00053	-0.14952	1.44195	2.32327	2.24418	1.66214	0.60812
I19.0B2[d]	Fine	Granite	0.00067	-0.16039	1.53712	1.67495	2.82577	1.82171	0.44801
I19.0B3[d]	Fine	Granite	0.00070	-0.16099	1.53979	1.78992	2.76709	1.69042	0.44607
I19.0B	Fine	Limestone	0.00076	-0.15876	1.51184	2.16441	2.29710	1.78711	0.53901
I19.0C	Coarse	Granite	-0.00015	-0.11840	1.19400	1.49981	3.13154	2.39859	0.45451
I19.0C	Fine	Granite	0.00052	-0.16137	1.55206	1.02532	3.52729	1.74412	0.36155
I19.0C	Fine	Limestone	0.00060	-0.15756	1.51529	1.87048	2.61784	1.99850	0.47320
I19.0D	Coarse	Granite	0.00047	-0.14957	1.48837	1.63555	2.94731	1.73702	0.45052
I19.0D	Fine	Granite	0.00060	-0.16355	1.60230	1.16137	3.42986	2.09133	0.40324
B25.0B	Coarse	Granite	0.00087	-0.15998	1.51815	1.25921	3.26262	1.71818	0.48357
B25.0B	Coarse	Limestone	0.00066	-0.15704	1.50427	2.03745	2.48150	2.09873	0.57232
B25.0B	Fine	Granite	0.00064	-0.15563	1.49960	1.17188	3.43787	1.91881	0.46299
B25.0B	Fine	Limestone	0.00059	-0.15705	1.51098	2.20753	2.29394	1.80533	0.53732
B25.0C	Coarse	Granite	0.00071	-0.15434	1.46972	1.85690	2.75864	1.63312	0.57629
B25.0C	Fine	Granite	0.00060	-0.16543	1.58849	1.18143	3.35734	1.79427	0.38735
B25.0C	Fine	Limestone	0.00064	-0.15256	1.46207	2.19797	2.22560	1.84270	0.58489

Note: [a]S for surface mix, I for intermediate mix, and B for base mix
[b]Nominal Maximum Aggregate Size (in mm)
[c]Traffic volume indicator
[d]Differentiates mixtures with the same designation

4.1 Effects of Predictive Errors Using Witczak and Hirsch Models on Pavement Performance

4.1.1 Predictive Model Comparison

The dynamic moduli predicted by the Hirsch and Witczak models were compared against the measured data to determine the quality of each model. The Witczak model was originally developed using the data from the whole range of temperatures and air voids. However, the Hirsch model was developed using the data from the temperature range of 4° and 38°C. That is, the measured dynamic modulus data at -10° and 54.4°C in this research fall outside the range of temperatures used in the Hirsch model. Also, the lowest temperature in this research that the DSR could handle was 16°C; therefore, the binder data for the Hirsch model at 10°C were extrapolated. As a result, data for 10°, 35°, and 54.4°C are presented for the Hirsch model, but only 35°C fits the input requirements for the model. Also, the air voids under which the Hirsch model was developed are between 5.6% and 11.2%, whereas all the data in this report have air voids of 4% ± 0.5%.

In order to determine the accuracy of the models, the % error approach was utilized at each frequency and temperature combination. The % error was determined by dividing the difference in the dynamic modulus between the measured and the predicted values by the measured dynamic modulus. This process resulted in large quantities of data that had to be summarized. The % error calculations were averaged for differing frequencies at the same temperature for each mixture. Following this, the data were grouped by ranges of % error. The ranges selected include ≤ 5, $5 < x \leq 15$, $15 < x \leq 25$, $25 < x \leq 35$, $35 < x \leq 45$, and >45 % error. After grouping, the percentage of the total number of mixtures that fell within each range was calculated and plotted against the test

temperature. Figure 4.4(a) provides a summary of the Witczak prediction, and Figure 4.4(b) provides a summary of the Hirsch prediction.

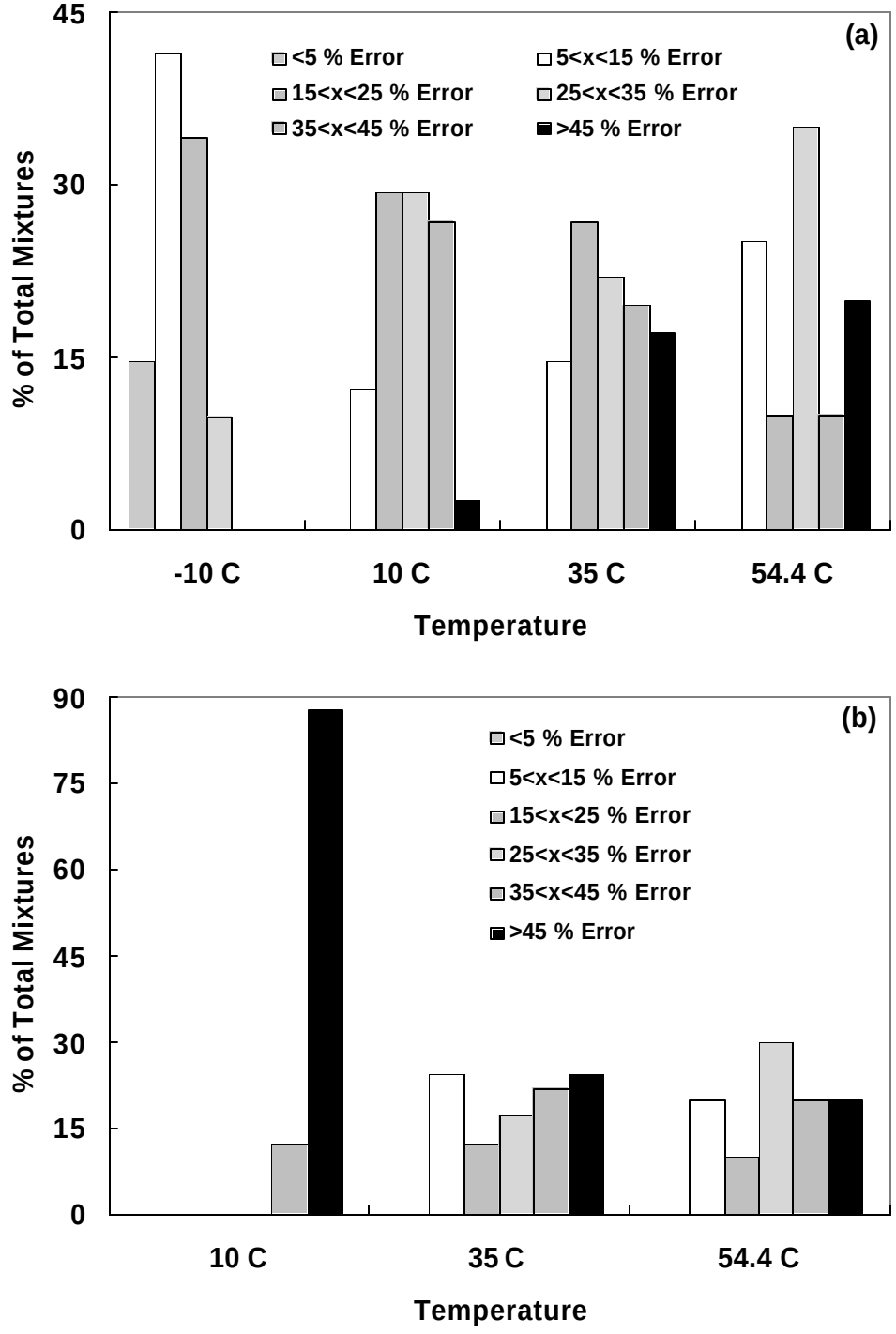


Figure 4.4 (a) Summary of percent error in dynamic moduli for Witczak's prediction; (b) Summary of percent error in dynamic moduli for Hirsch prediction.

First, it needs to be noted that the scales used in Figures 4.4(a) and 4.4(b) are different. From Figure 4.4(a) it appears that Witczak's prediction at cooler temperatures is more accurate than at warmer temperatures. Also, the Hirsch model, as shown in Figure 4.4(b), performs very poorly at 10°C and approximately the same as Witczak's model at the remaining temperatures. The poorer prediction of the Hirsch model at 10°C could be due to the fact that the binder data at this temperature were extrapolated.

In addition to the prediction summaries shown in Figure 4.4, it is likewise beneficial to see the prediction accuracies of the two models using other forms of graphs, as shown in Figures 4.5 to 4.7. In each of these graphs, open symbols are used to represent the Hirsch predictions, black symbols for the Witczak prediction, and gray symbols for the measured data. The figures illustrate a relatively good prediction using Witczak's model in the (a) and (b) graphs, whereas the (c) and (d) graphs show a mixture with a relatively poor prediction. The mixture with a good prediction is S9.5B–Fine replicate 3, and the one with a poor prediction is I19.0B–Fine replicate 1. Multiple plots are presented to allow various comparisons. The results from the Hirsch data at 10°C are shown in the figures also. Figure 4.7 shows the line of equality between the Witczak and Hirsch models and the measured data.

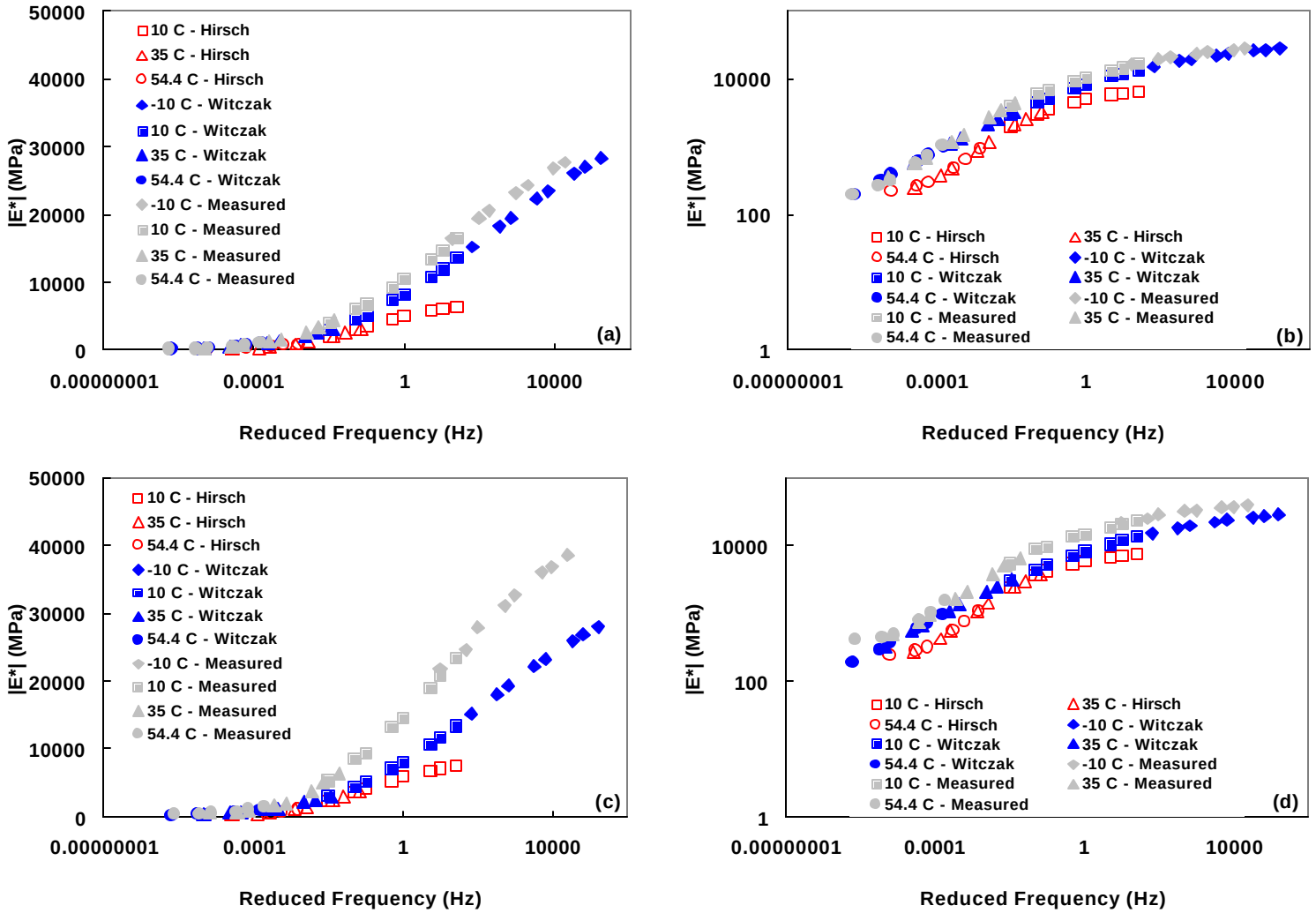


Figure 4.5 Mastercurves of measured moduli compared to predicted moduli yielding a relatively good prediction for S9.5B–Fine replicate 3 in figures (a) and (b) and a relatively poor prediction for I19.0B–Fine replicate 1 in figures (c) and (d)

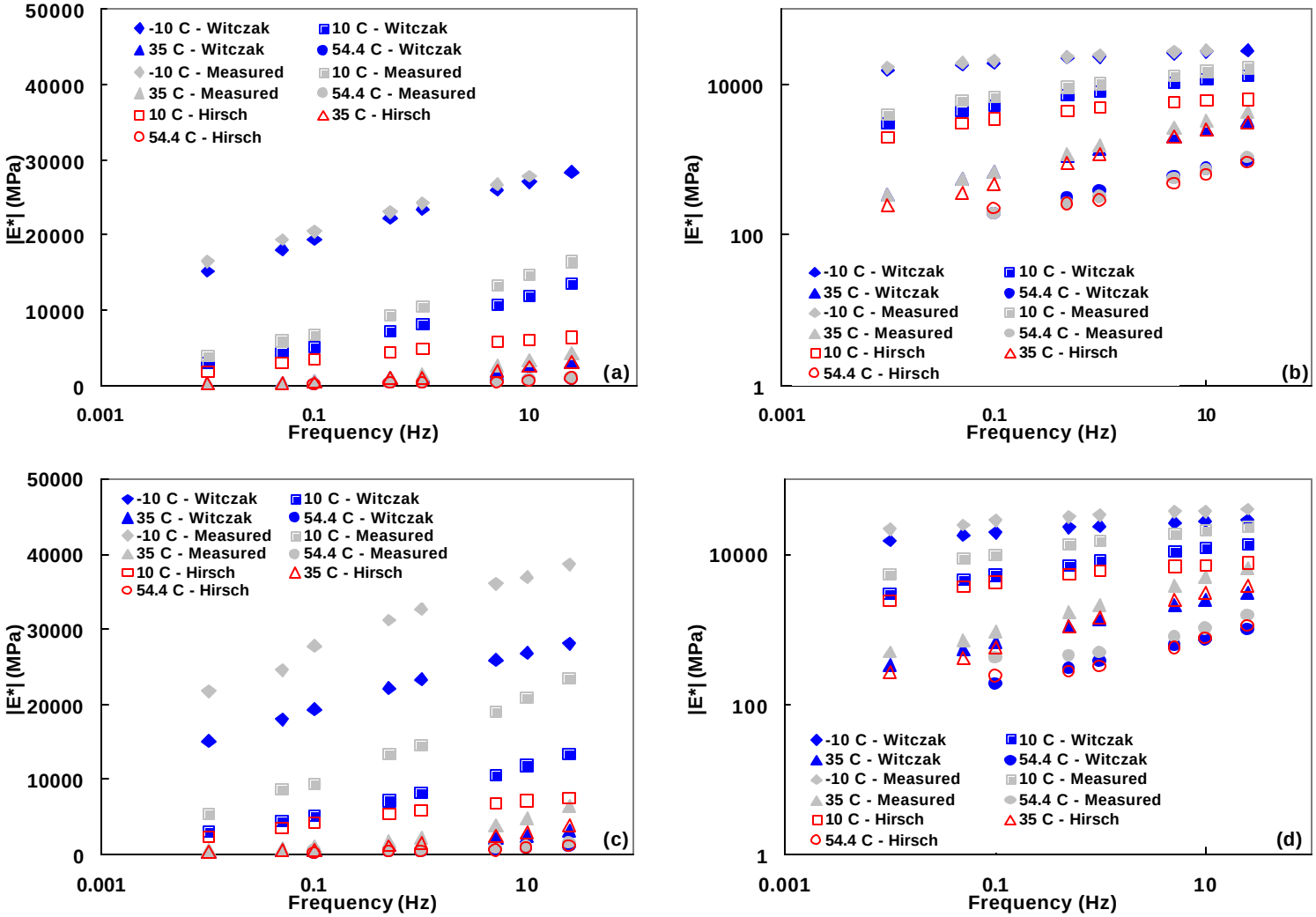


Figure 4.6 Unshifted measured moduli compared to unshifted predicted moduli yielding a relatively good prediction for S9.5B–Fine replicate 3 in figures (a) and (b) and a relatively poor prediction for I19.0B–Fine replicate 1 in figures (c) and (d)

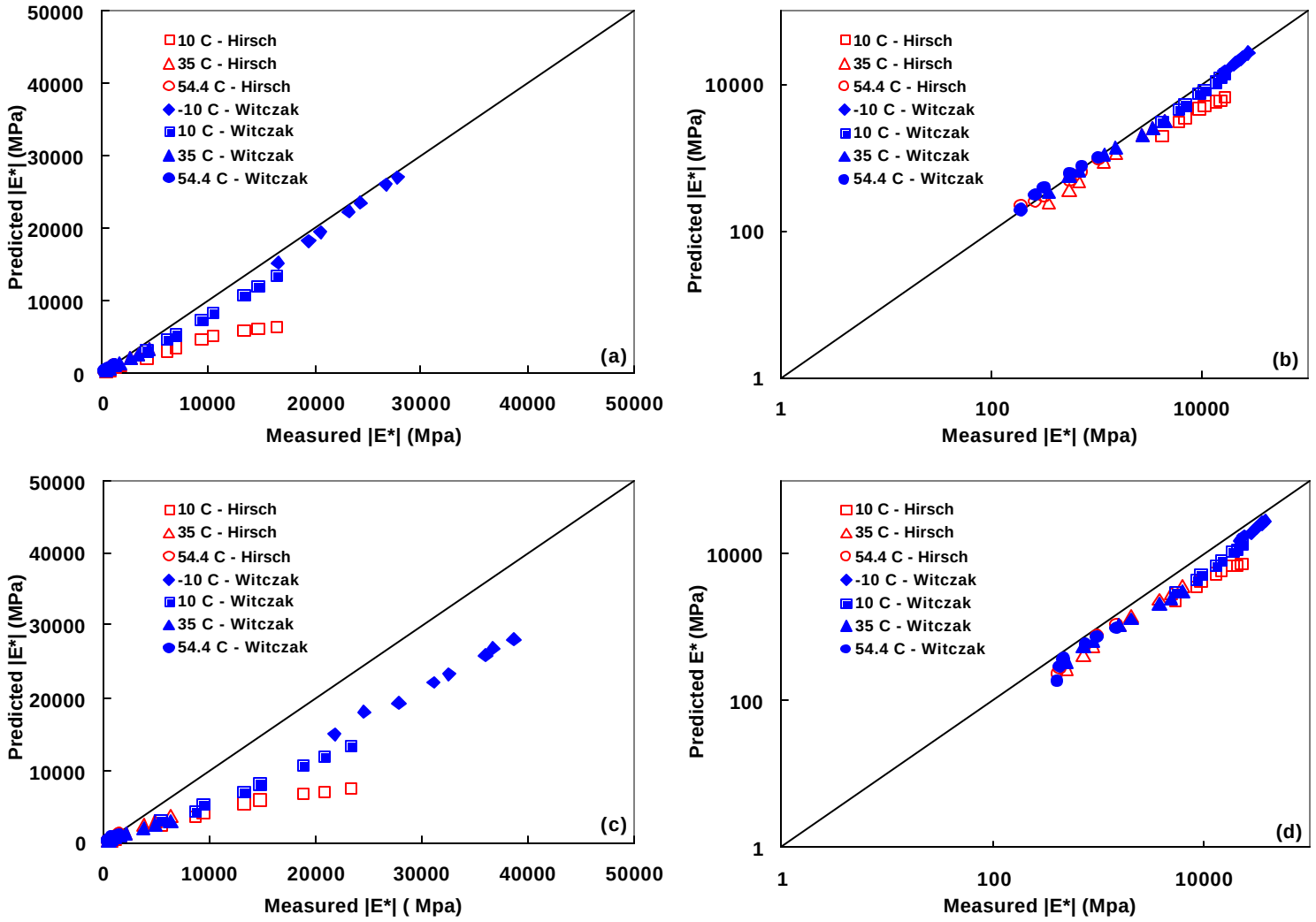


Figure 4.7 Line of equality of predicted moduli vs. measured moduli yielding a relatively good prediction for S9.5B–Fine replicate 3 in figures (a) and (b) and a relatively poor prediction for I19.0B–Fine replicate 1 in figures (c) and (d)

4.1.2 Effects of Predictive Errors on Pavement Performance

Simply stating the % error in the |E*| prediction is not the most important consideration for pavement engineers. The true consequences of these errors show up in performance predictions. To evaluate the effect of the errors involved in predicting the dynamic modulus of asphalt mixtures, three pavement scenarios were selected. Table 4.2 shows the critical components of the pavement structures and asphalt mixtures. The moduli of the aggregate base and subgrade used in the analysis are 414 and 105 MPa, respectively. These cases were used to predict performance in both fatigue cracking and permanent deformation using the measured dynamic moduli as well as using the predicted values from the Hirsch and Witczak models.

It would have been preferable if the NCHRP 1-37A Design Guide software could have been used for this evaluation; however, it was released too late to be implemented in this analysis. The performance prediction analysis that was adopted in this research employed the Asphalt Institute fatigue life prediction model and the rutting model presented in the NCHRP 1-37A Design Guide. Even though the analysis, without all the design components (i.e., traffic, climate, etc.), is not as comprehensive as the one presented in the NCHRP 1-37A Design Guide, it nonetheless yields some indications of the effects of prediction inaccuracy on the pavement design.

Table 4.2 – Summary of Performance Prediction Scenarios

Case	H_{AC}[a] (mm)	H_{Agg}[b] (mm)	Surface Course	Intermediate Course
#1	75	300	75 mm of S9.5B–Fine (Limestone) with poor prediction	-
#2	150	450	75 mm of S9.5B–Fine replicate 3 with good prediction	75 mm of I19.0B–Fine replicate 1 with poor prediction
#3	150	450	75 mm of S9.5–Fine (Limestone) with poor prediction	75 mm of I19.0B–Fine replicate 1 with poor prediction

Note:
[a]thickness of the asphalt layer; and [b]thickness of the aggregate base

4.1.2.1 Fatigue Life

The Asphalt Institute model presented in Eq. (4-2) was used to calculate the fatigue life of the three pavements described in Table 4.2. EverStress, a multilayered elastic analysis program, was used to calculate the tensile strain at the bottom of the asphalt layer. The dynamic modulus of the asphalt layer was determined at 25°C and a frequency of 10 Hz.

$$N_f = 0.00432 * C\left(\frac{1}{e_t}\right)^{3.921}\left(\frac{1}{E*}\right)^{0.854} \quad (4\text{-}2)$$

where $C = 10^M$;

$$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right);$$

V_b = effective binder content (%);

V_a = air voids (%);

N_f = number of repetitions to fatigue cracking;

e_t = tensile strain at the critical location; and

E^* = the dynamic modulus of asphalt concrete (psi).

In this analysis, it was assumed that the surface and intermediate courses have the same fatigue characteristics. That is, the fatigue model coefficients and the dynamic modulus of the intermediate course are used in Eq. (4-1) to calculate the fatigue life of pavement Cases 2 and 3.

Table 4.3 presents the fatigue lives predicted from Eq. (4-2) using the measured dynamic modulus and the dynamic moduli predicted from the Witczak and Hirsch models. Also presented in Table 4.3 are % error in N_f, that are calculated between the predicted fatigue life using the measured dynamic modulus and the predicted fatigue life using the predicted dynamic modulus.

For Case 1, it is interesting to note that the error in the modulus prediction is about 50% for both the Hirsch and Witczak models, but there is a reduction of only 25 to 30% in the predicted fatigue life. Case 2 was constructed to evaluate the effects of an inaccurate prediction of the dynamic modulus in an intermediate course, assuming that the surface course prediction is relatively accurate. Table 4.3 shows that the predicted modulus for the surface layer is relatively accurate, and the prediction error for the modulus of the intermediate course is about 50%. It is shown through the fatigue analysis that a 50% error in the dynamic modulus of the intermediate layer causes about a 40% error in the fatigue performance prediction even though the dynamic modulus of the surface layer is accurate.

Case 3 shows a combination of a poor prediction of the surface course coupled with a poor prediction of the intermediate course. The modulus prediction errors in Case 3 are about 50% for both the surface and intermediate courses. The error in the fatigue life prediction is over 50%. In Cases 1 and 2, the % error in the fatigue prediction is not as large as the % error in the modulus prediction. It is apparent that there are some compounding

effects of the prediction errors in the surface and intermediate courses on the fatigue performance prediction.

In summary, an approximately 50% error in the dynamic modulus predicted from the predictive models causes about 25 to 50% error in the fatigue life prediction. The magnitude of the fatigue life prediction error may change depending on the performance prediction analysis method used, pavement structures, and mixture types for the different layers.

Table 4.3 – Performance Prediction Results

	Fatigue Data – 25°C, 10Hz			**Rutting Data – 54.4°C, 10Hz – 12.5mm failure**		
Case 1	**N_f (in thousands)**	**N_f, % error**	**Modulus (MPa) top/bottom**	**N_f (in thousands)**	**N_f, % error**	**Modulus (MPa) top/bottom**
Measured	580	-	8542/ -	152	-	1303/ -
Hirsch	422	27.3	4316/ -	53	65.2	676/ -
Witczak	430	25.8	4640/ -	61	60.1	731/ -
Case 2						
Measured	3398	-	5240/9928	70	-	731/1000
Hirsch	1906	43.9	4095/4785	41	41.3	641/752
Witczak	2051	39.6	4868/4771	56	20.2	758/731
Case 3						
Measured	4360	-	8542/9928	230	-	1303/1000
Hirsch	1949	55.3	4316/4785	46	80.0	676/752
Witczak	2008	53.9	4640/4771	52	77.3	731/731

4.1.2.2 Rutting

The rutting model used in the analysis is shown in Eq. (4-3). The sublayering method adopted in the NCHRP 1-37A Design Guide was used. EverStress was used to calculate the resilient strains at three points within the asphalt layer. The analysis was performed assuming the temperature of 54.4°C and 10 Hz loading. The number of cycles to failure was determined based on the failure criterion of 12.5 mm surface rut depth.

$$\frac{e_p}{e_r} = k_1 * 10^{-3.4488} T^{1.5606} N^{0.479244} \quad (4\text{-}3)$$

where $k_1 = (C_1 + C_2 * depth) * 0.328196^{depth}$;

$C_1 = -0.1039 * h_{ac}^2 + 2.4868 * h_{ac} - 17.342$;

$C_2 = 0.0172 * h_{ac}^2 - 1.7331 * h_{ac} 27.428$;

$depth$ = distance to computational point (in.);

h_{ac} = total asphalt layer thickness (in.);

T = temperature (°F);

N = number of load repetitions;

e_p = accumulated plastic strain at N repetitions of load; and

e_r = resilient strain

Table 4.3 also provides a summary of the rutting predictions. The three pavement cases provide some insight as to how the dynamic modulus affects permanent deformation. The first case is comprised of only a thin surface layer. The dynamic modulus prediction error is less than 50%, whereas the % error in the number of cycles to failure is over 60%. Case 2 has a surface layer with a relatively good dynamic modulus prediction on top of an intermediate layer with a poor dynamic modulus prediction (about 25% error). It resulted in about a 20 to 40% error, depending on the predictive model type. The third case yields a very poor prediction due to the compounding effect of the two poor predictions from the surface and intermediate courses.

In summary, the prediction errors in the dynamic modulus have a significant effect on the rutting performance prediction. In the worst case scenario investigated in this research, up to an 80% error in the pavement service life prediction was found.

4.2 Effect of Mixture Variables on Dynamic Modulus

Since the dynamic modulus is one of the most important material properties, it is important to know how this property varies with differing mix designs. The large database of mixtures from North Carolina provides an opportunity to examine one aspect of this variability. NCDOT Superpave mixtures in Table 3.1 are classified depending on factors such as traffic level and gradation that allow grouping of similar mixtures. There are several mixtures that fall into the same classification. These classifications are S9.5B–Fine gradation, S9.5C–Fine gradation, and I19.0B–Fine gradation. Refer to Table 3.1 for more information on these designations. It is important to note that the mixtures in each classification meet the same aggregate gradation and traffic design requirements. Five mixtures are classified S9.5B–Fine, four mixtures are classified S9.5C–Fine, and four mixtures are classified I19.0B–Fine. The mastercurves are presented in Figures 4.8 through 4.10 to illustrate the variability between mixtures of the same classification. Each of the mastercurves is an average of three replicate specimens.

Fortunately, many of the replicate mixtures had the same aggregate source, PG, and asphalt source. As a result, further evaluation of these mixtures was possible. For example, in Figure 4.8(a) for the S9.5B–Fine mixtures, replicates 2, 3, and 4 have identical sources for component materials, and they have the closest mastercurves. Replicate 1 has a different aggregate source but the same binder grade and source, and its mastercurve is close to the other replicates. Replicate 0 is the least like the other replicates. This mixture has different aggregate and asphalt sources, but the PG grade is the same. The fact that replicate 1 has a different aggregate source and the curve is similar to replicates 2, 3, and 4 may indicate that the aggregate source has less impact on |E*| than the other variables. Replicate 0, having a

slightly different curve than replicates 1, 2, 3, and 4, may indicate that the binder source has a greater impact on |E*| even given that the PG is the same. However, the effect of the binder source is not significant compared to the effects of other binder variables that will be discussed below.

Also noteworthy are data from the S9.5C–Fine mixtures presented in Figures 4.9(a) and 4.9(b). All four mixtures have identical sources for both binder and aggregate. The only difference is that replicate 3 has a PG of 64-22 whereas the other mixtures have a grade of PG 70-22. Replicate 3 has the most deviation at lower reduced frequencies. This trend makes sense because the difference in these two binders is in the high temperatures, which affects the material's behavior at the low reduced frequencies. Also, replicates 1, 2, and 3 have a similar asphalt content, whereas a slightly higher asphalt content is used in replicate 3. The difference in the dynamic modulus mastercurves could be due to the binder grade or asphalt content, but is likely to stem from a combination of both.

Finally, Figures 4.10(a) and 4.10(b) show the I19.0B–Fine mixtures. The binder source and grade are the same for all four mixtures. The only differences are the aggregate source and asphalt content. However, from an investigation of the S9.5B–Fine mixtures, it was found that the aggregate source did not seem to impact the dynamic modulus value. It seems that a significantly higher asphalt content in the I19.0B–Fine replicate 0 (5.4%) than in the rest of the I19.0B mixtures (4.3 to 4.5%) is the main reason for the lower dynamic modulus at the low reduced frequencies.

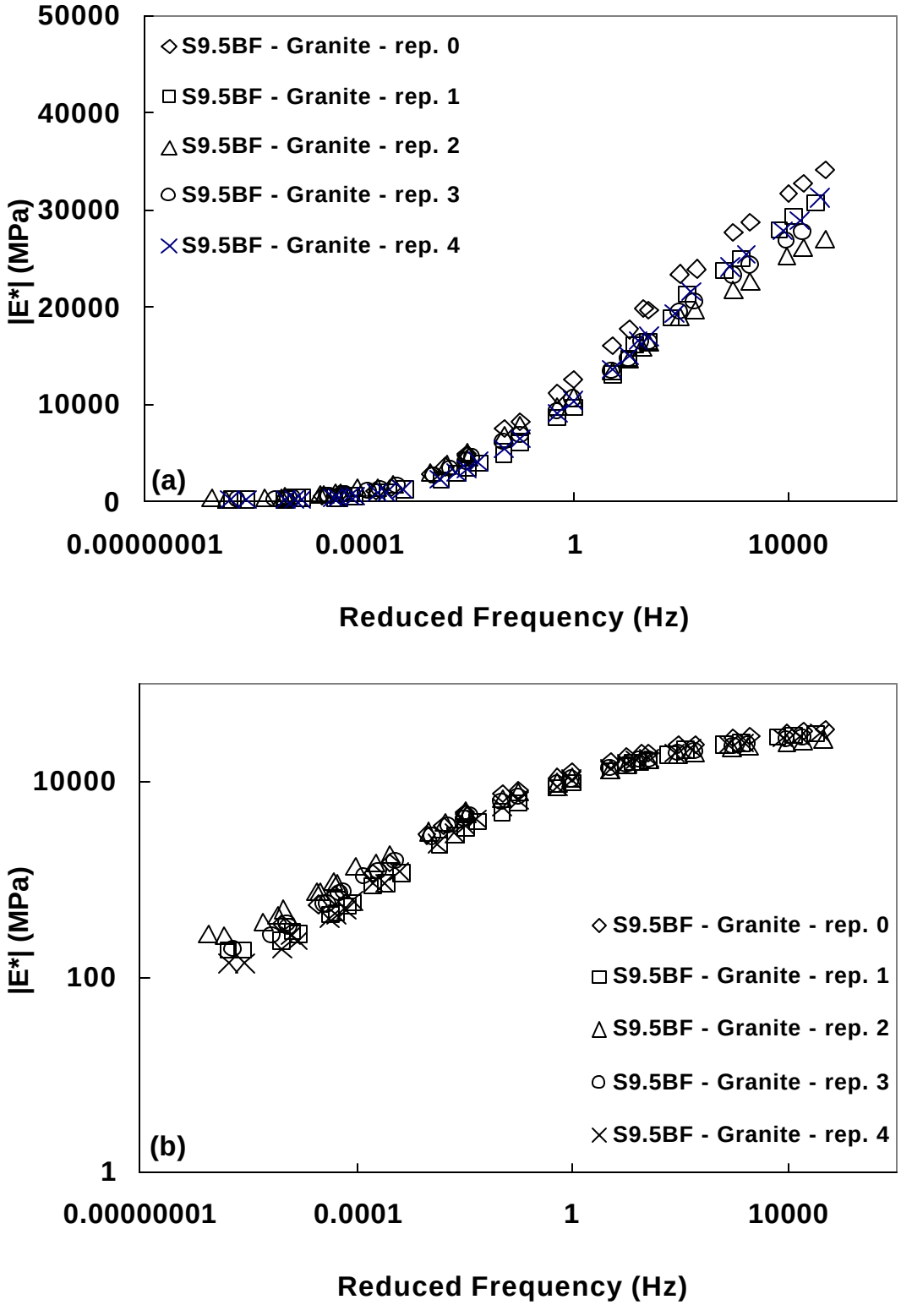


Figure 4.8 Mastercurves for S9.5B–Fine mixtures: (a) semi-log scale; (b) log-log scale

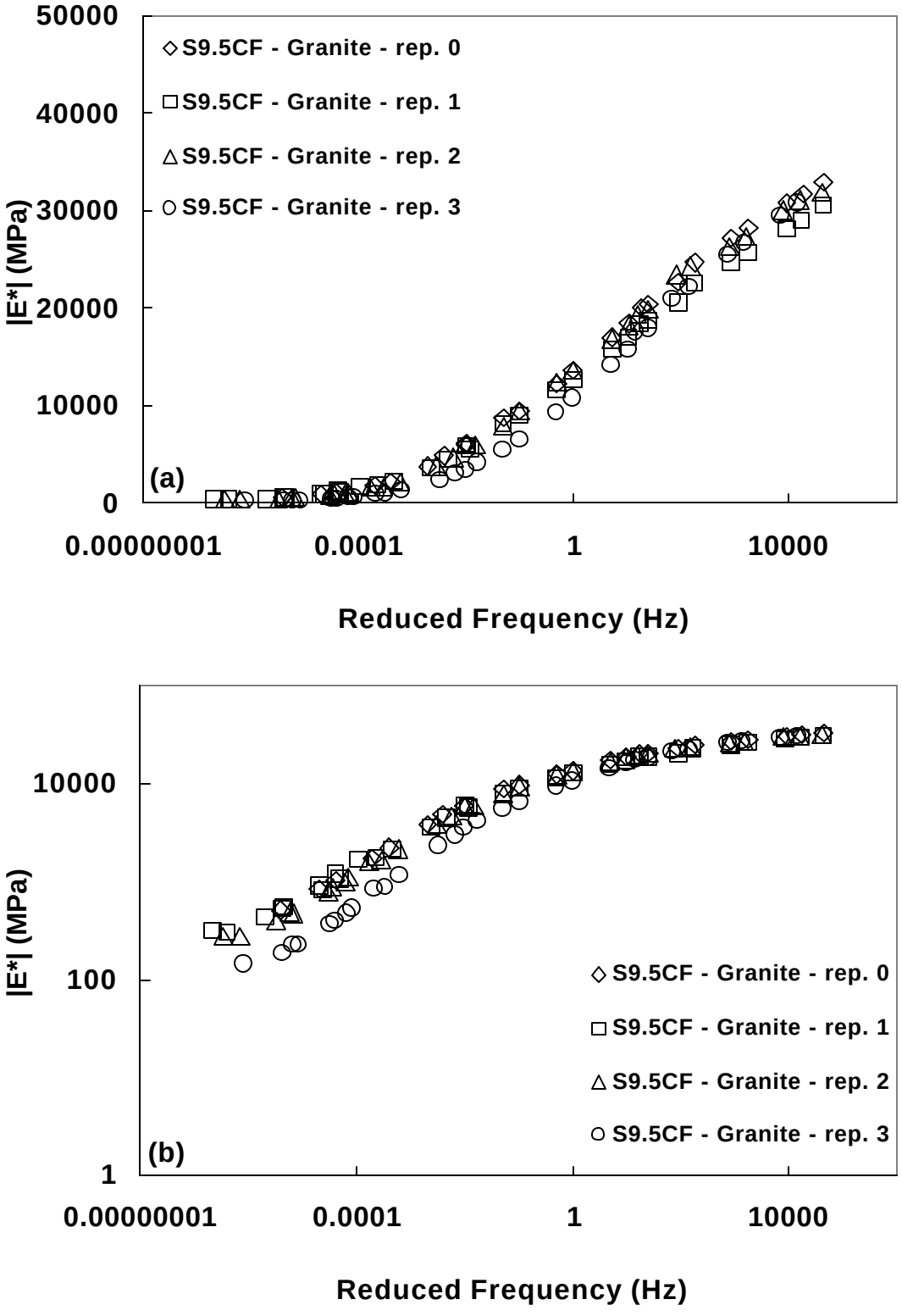


Figure 4.9 Mastercurves for S9.5C–Fine mixtures: (a) semi-log scale; (b) log-log scale

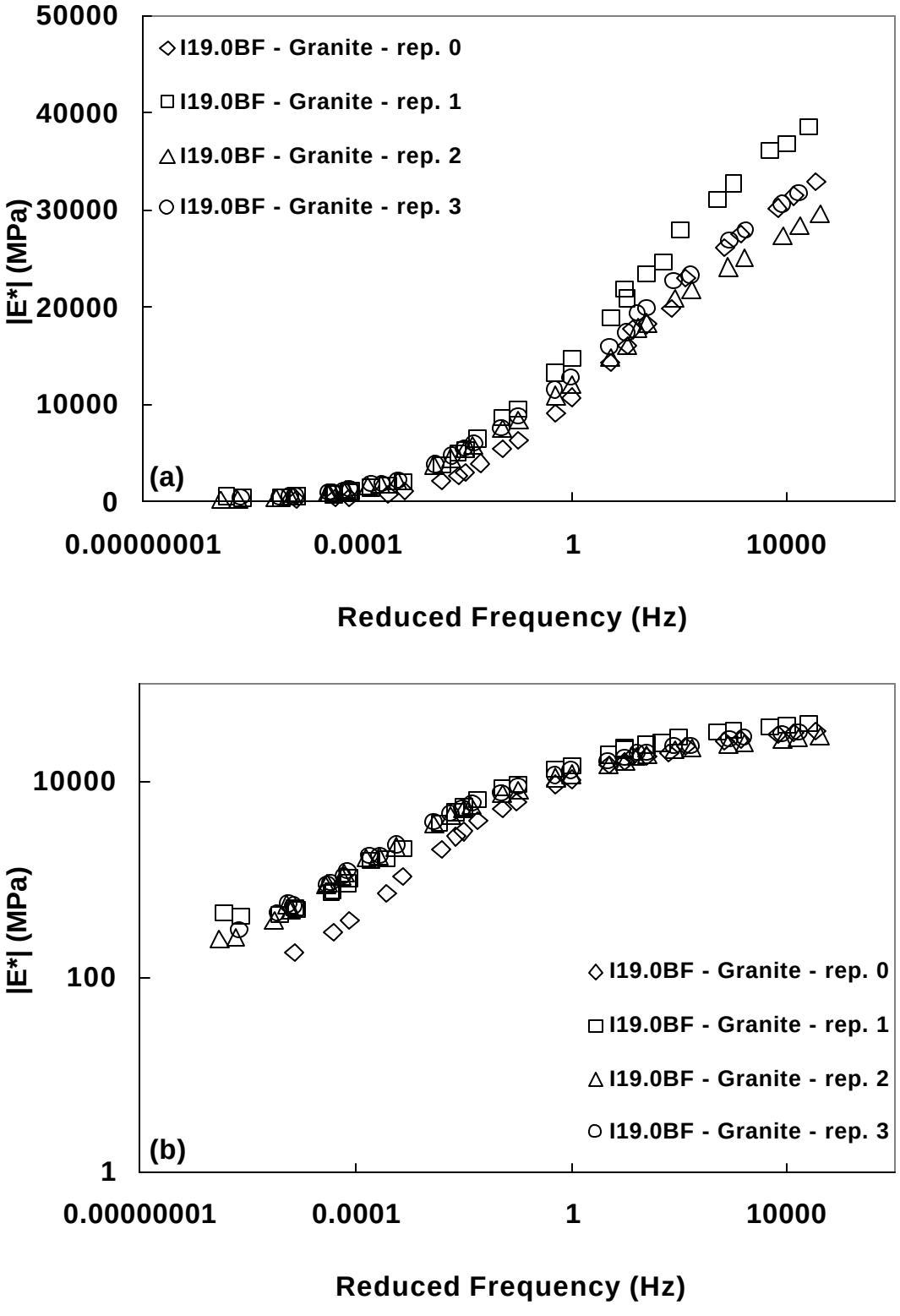


Figure 4.10 Mastercurves for I19.0B–Fine mixtures: (a) semi-log scale; (b) log-log scale

4.3 Effect of Confining Pressure on Dynamic Modulus

The dynamic moduli of the mixtures determined from unconfined and confined axial compression tests with the confining pressure of 137.9 kPa (20 psi) are compared in this section. The comparison for the S9.5C–Fine granite mixture is presented in Figures 4.11 and 4.12.

Figure 4.11 displays the dynamic moduli of the S9.5C–Fine mixture determined from uniaxial and triaxial tests in a semi-log scale. Although the effect of confinement seems to be insignificant in this figure, further analysis is necessary because the normal scale used in this figure for the dynamic modulus axis suppresses the information at the lower reduced frequencies. Therefore, the same data were plotted in a log-log scale in Figure 4.12. The effect of confinement is found to be significant at low reduced frequencies (i.e., a high temperature and/or low loading frequency). This observation is also supported by Figures 4.13 – 4.15 where uniaxial and triaxial dynamic moduli of the S9.5C–Fine mixture at low, medium, and high reduced frequencies are presented for various air void contents. The dynamic modulus versus air void content relationships are essentially the same between the uniaxial and triaxial data for 10,000 and 1 Hz, whereas at 0.0005 Hz the uniaxial dynamic moduli are smaller than those determined from triaxial compression. This finding is somewhat expected because, as the temperature increases or loading frequency decreases, the asphalt binder becomes softer, and the effect of confinement on the aggregate structure becomes more significant. The confinement makes the asphalt-aggregate mixture more resistant to stress in these conditions and, thus, the triaxial test yields a greater dynamic modulus than the uniaxial test.

The dynamic moduli of the I19.0C mixture at the three reduced frequencies are plotted in Figures 4.16 – 4.18. Different from those shown in Figures 4.13 – 4.15 for the S9.5C mixture, the triaxial dynamic moduli are, in general, greater than those determined from the uniaxial test. The difference is much greater at 0.0005 Hz. This observation is different from the one made from the S9.5C data and is probably due to the fact that the I190C has larger aggregate particles and, therefore, the effect of confinement is greater. The reduction in the dynamic modulus as the percent air voids increases is greater (i.e., the slope is steeper) in the triaxial data than in the uniaxial data.

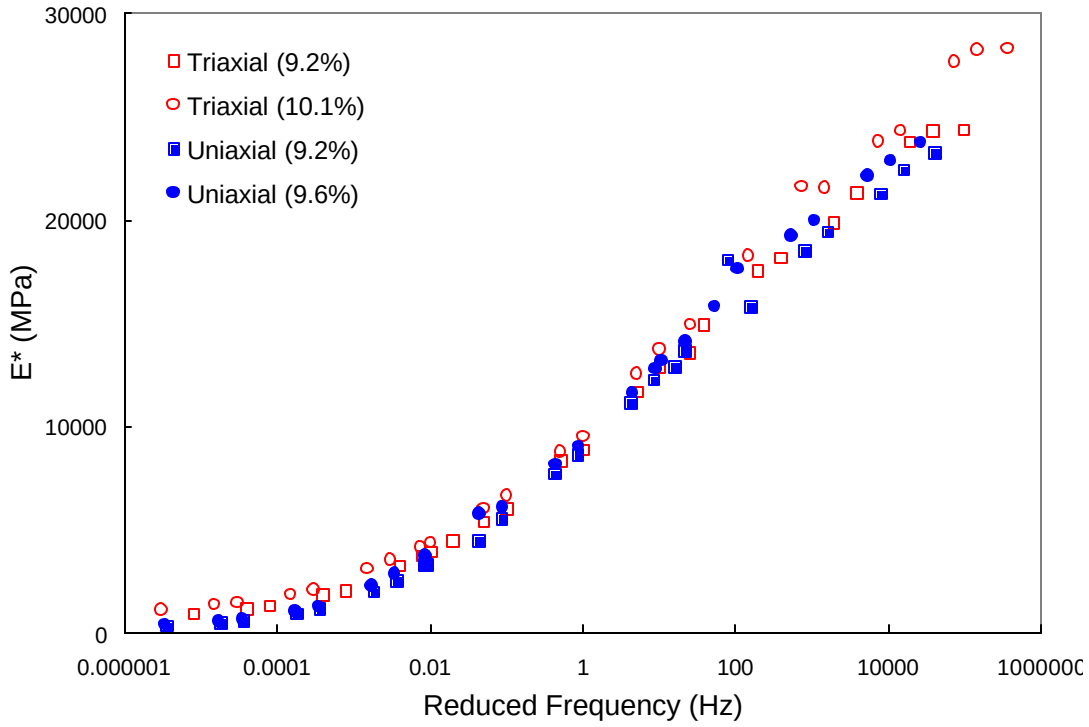


Figure 4.11 |E*| comparison between triaxial and uniaxial tests in semi-log scale for S9.5C–Fine mixture

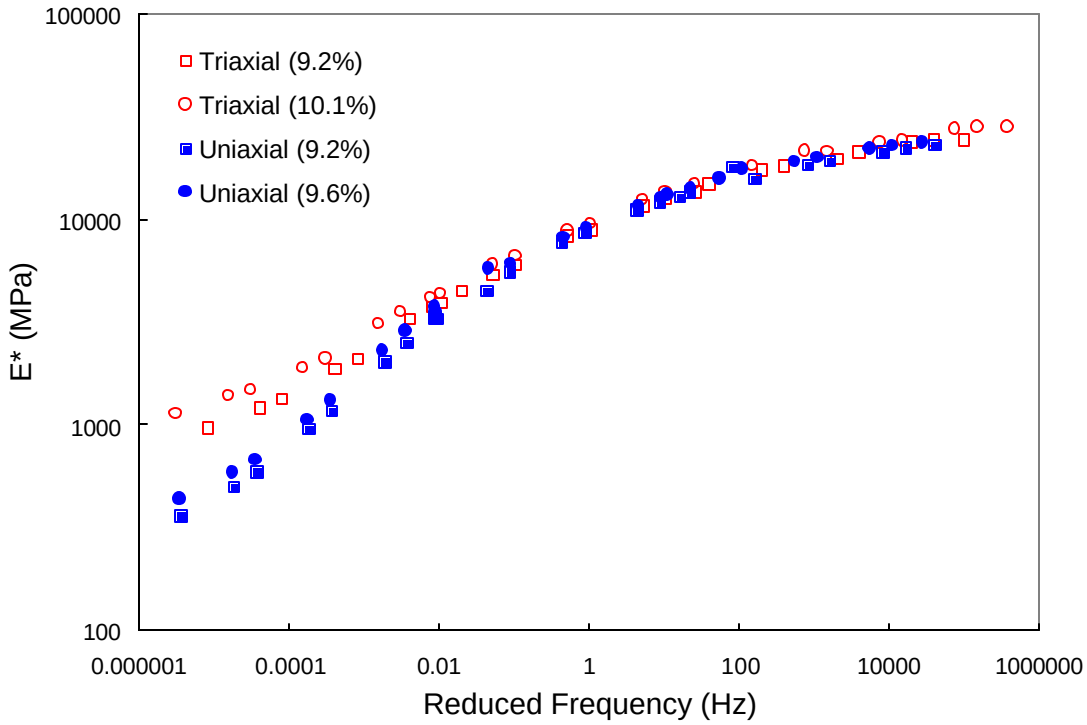


Figure 4.12 |E*| comparison between triaxial and uniaxial tests in log-log scale for S9.5C–Fine mixture

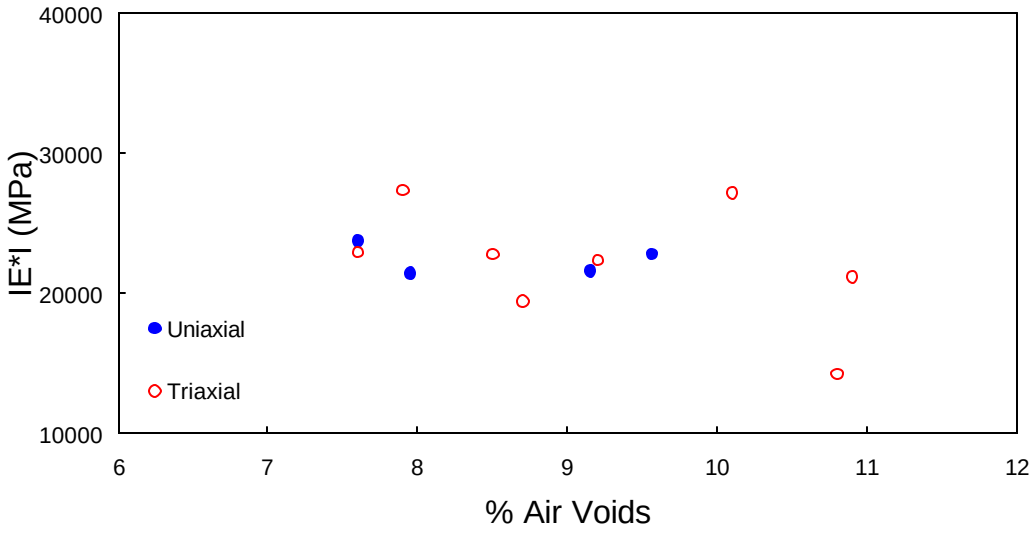


Figure 4.13 |E*| versus % AV at 10,000 Hz for S9.5C–Fine mixture

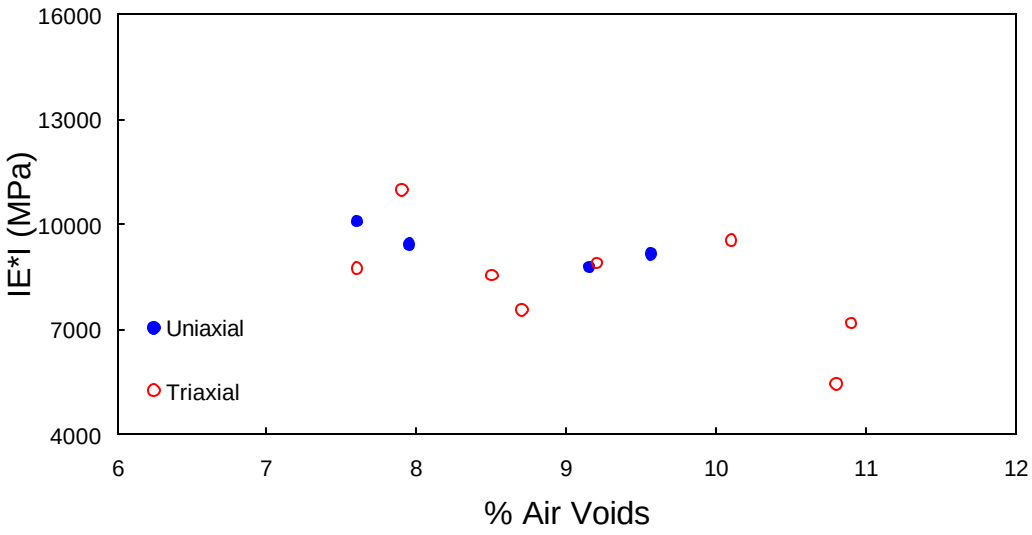


Figure 4.14 |E*| versus % AV at 1 Hz for S9.5C–Fine mixture

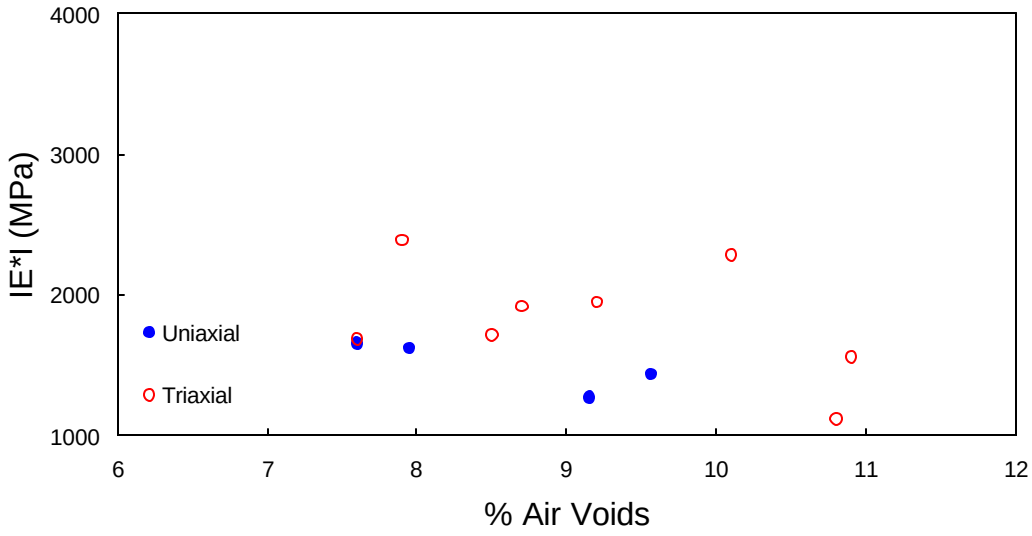


Figure 4.15 |E*| versus % AV at 0.0005 Hz for S9.5C Mix

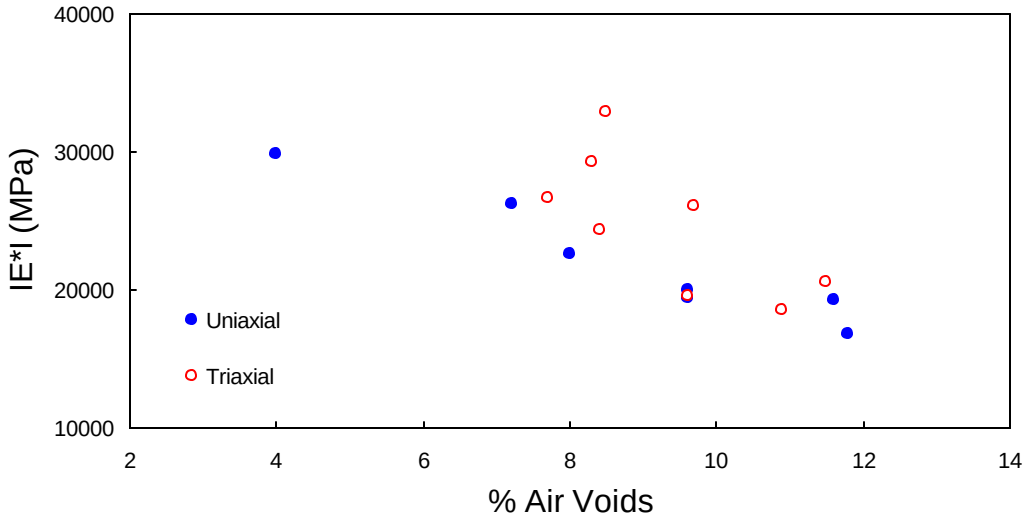


Figure 4.16 |E*| versus % AV at 10,000 Hz for I19.0C–Coarse mixture

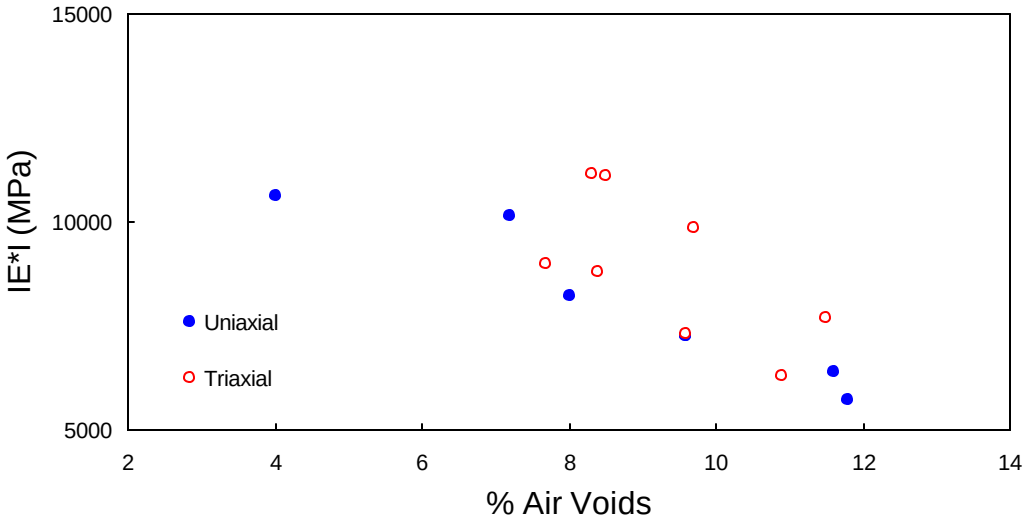


Figure 4.17 |E*| versus % AV at 1 Hz for I19.0C–Coarse mixture

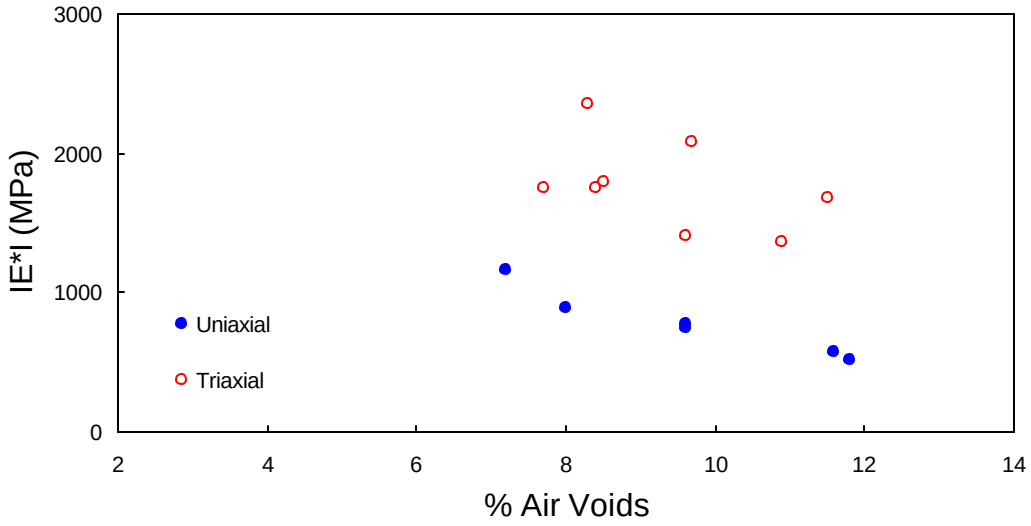


Figure 4.18 |E*| versus % AV at 0.0005 Hz for I19.0C–Coarse mixture

4.4 Effect of Accumulated Permanent Strain on Dynamic Modulus

In the current dynamic modulus test protocol, the same specimen is subjected to various loading frequencies and temperatures. Since the test is conducted in a controlled stress mode, the mean strain increases during the frequency-temperature sweep and, at the end of the frequency-temperature sweep, it could exceed 1000 microstrains. The AASHTO TP 62 specifies less than 1500 microstrains for any given temperature. Since the dynamic modulus is supposed to represent the linear viscoelastic response of the material, it was deemed appropriate to investigate the effect on the dynamic modulus of the cumulative damage that occurs during the dynamic modulus testing.

Two dynamic modulus tests were performed on the same set of specimens made of S9.5B-Coarse granite mixture. After the specimens were subjected to normal dynamic modulus test protocol, the load was removed, and they were “rested” for approximately 12 hours. Then, the second dynamic modulus test was performed on the same specimen using

the same frequency-temperature sequence. The results from the original run and the second run are displayed in Figure 4.19 to Figure 4.21.

It can be seen from these figures that the effect of an increased mean strain (i.e., permanent deformation) has no significant effect on the dynamic modulus, phase angle, and shift factor. This observation suggests that, due to very small strain levels used in the dynamic modulus test (50 to 75 microstrains), the test more or less "tickles" the mastic and does not fully capture the effect of aggregate displacement and reorientation which should have occurred during the increase of the mean strain. The same conclusion was drawn when the effect of anisotropy in Superpave gyratory compacted specimens on the dynamic modulus was evaluated (Underwood et al., 2005). It was found that significant anisotropy exists in Superpave gyratory compacted specimens due to aggregate orientation, and that the effect of this anisotropy on the dynamic modulus is negligible, whereas its effect on rutting is significant. Another piece of evidence will be presented in the next section wherein the dynamic modulus determined from the IDT test is found to be the same as that from the axial compression test, although the relationship between the loading direction and compaction direction is different in these two tests. These observations also support the major finding from the parametric study presented in Section 4.2 that the effect of aggregate factors on the dynamic modulus is much less significant than that of asphalt factors. These findings raise the concern as to whether the dynamic modulus test alone can predict the permanent deformation propensity of asphalt mixtures because the major factors that influence rutting are also related to the characteristics of aggregates.

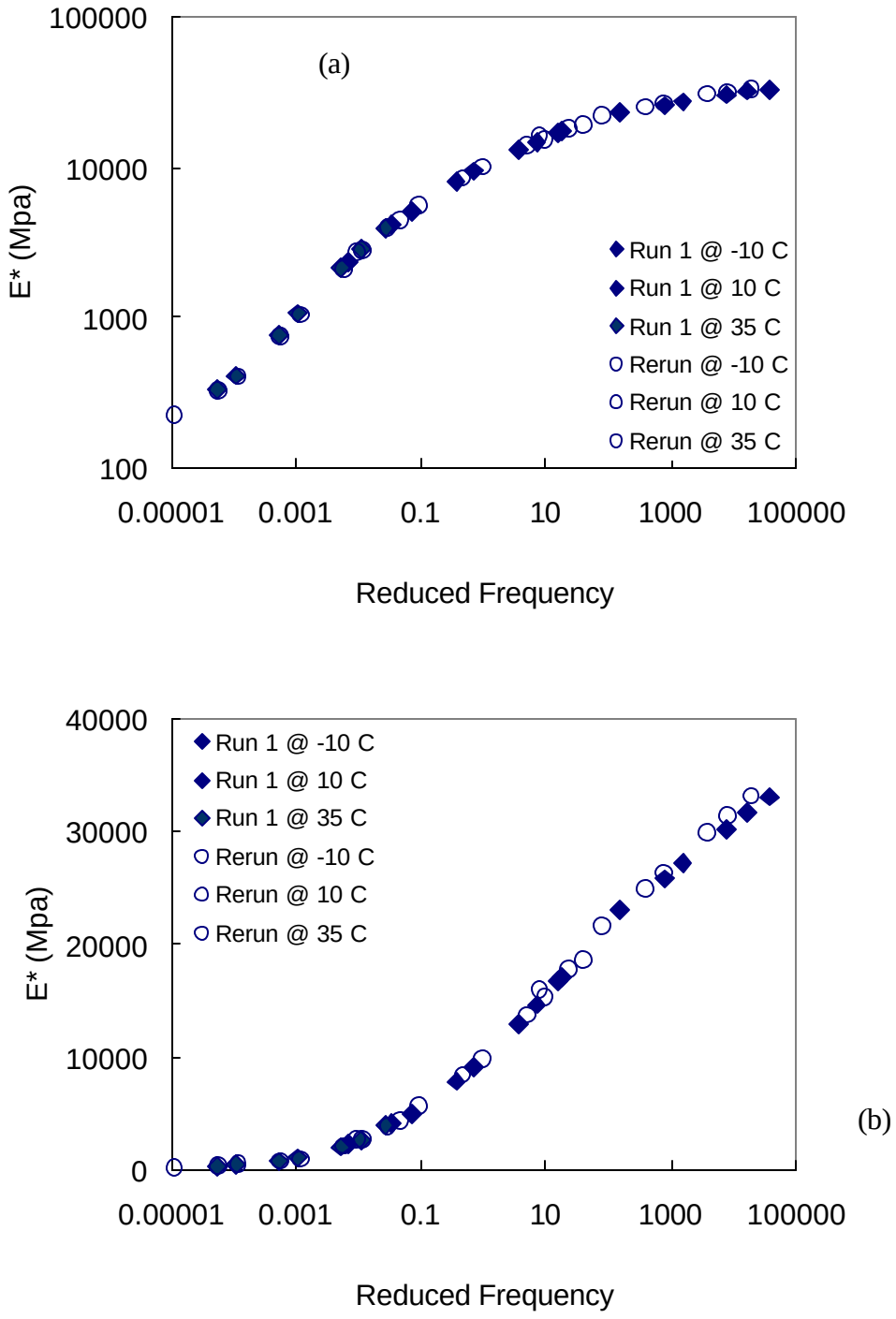


Figure 4.19 Dynamic modulus mastercurves for two consecutive tests: (a) log-log scale; (b) semi-log scale

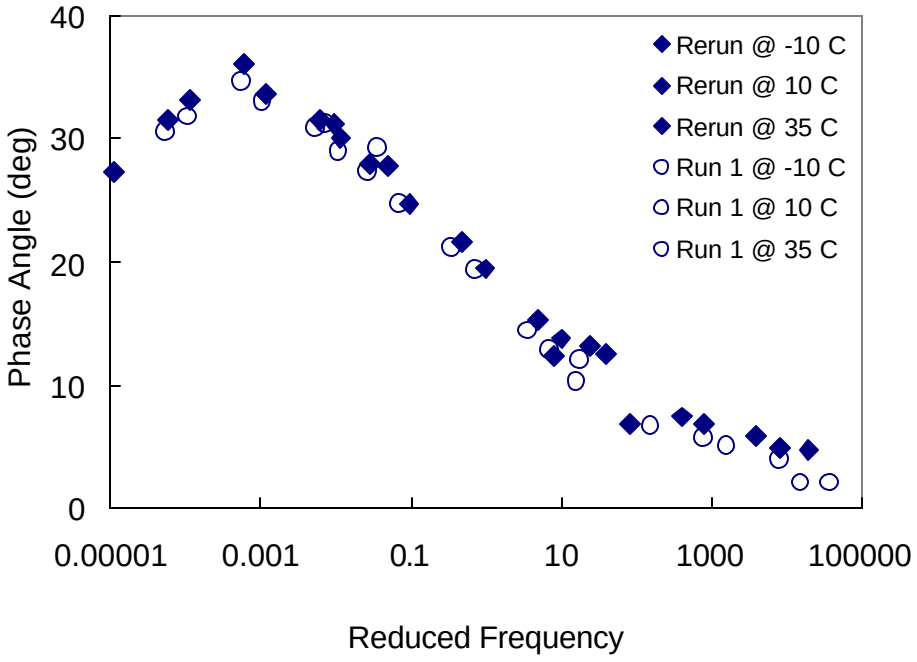


Figure 4.20 Phase angle mastercurves for two consecutive tests

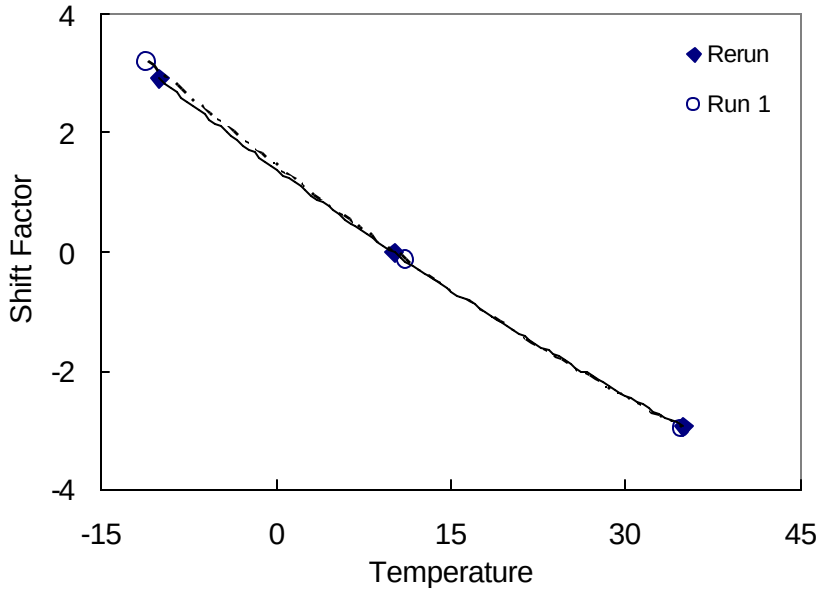


Figure 4.21 Shift factor versus temperature relationship for two consecutive tests

5. COMPARISON BETWEEN IDT AND AXIAL COMPRESSION TEST RESULTS

The dynamic modulus is a fundamental material property that should remain the same regardless of how the material is being tested, assuming that asphalt concrete is isotropic. Therefore, the results obtained from testing asphalt concrete in the IDT mode were compared to the results obtained from testing in the axial compression mode. All the IDT test results are summarized in Appendix C. Statistical analysis was conducted on the data obtained from all 24 mixtures to evaluate how different the IDT results are from those of the axial compression tests. Twelve mixtures are represented graphically in the following section, and all the data from the 24 mixtures are included in Appendix D.

5.1 Dynamic Modulus

5.1.1 Graphical Comparison

The IDT test data of the 24 mixtures were analyzed using the viscoelastic solutions presented previously in Section 2.3.2. The resulting dynamic modulus mastercurves from these analyses are plotted in Figures 5.1 to 5.3 for the 12 mixtures. The data presented in these figures are the averages of the three replicates. It can be observed from these figures that the dynamic modulus mastercurves developed from the IDT test using the biaxial linear viscoelastic solution are generally in good agreement with those determined from the axial compression test. It was also found that the time-temperature shift factors obtained during the construction of the mastercurves are essentially identical for the axial compression and IDT tests.

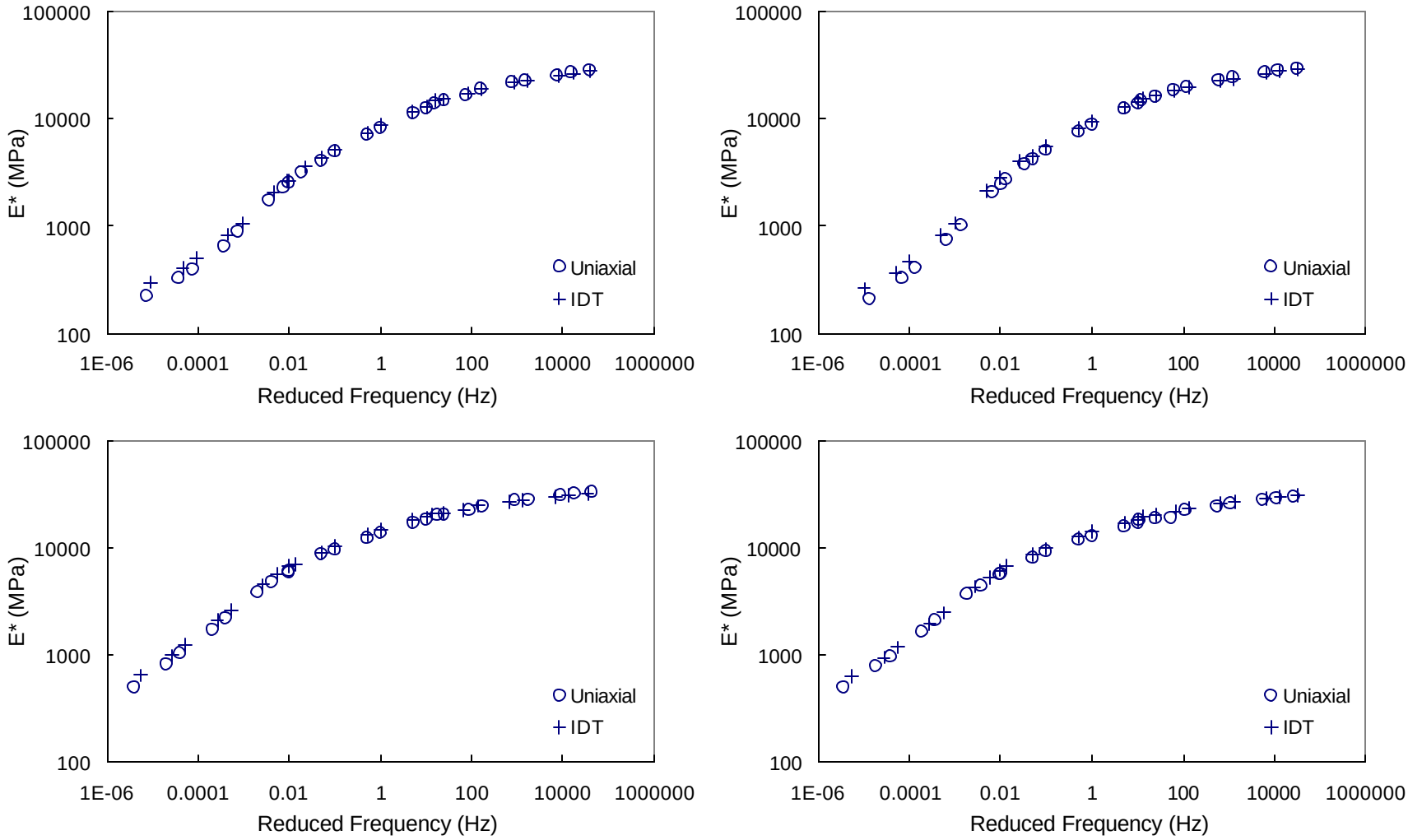


Figure 5.1 Dynamic modulus mastercurves for: (a) S9.5A-Fine; (b) S9.5B-Coarse; (c) S9.5C-Fine; (d) S9.5C-Coarse

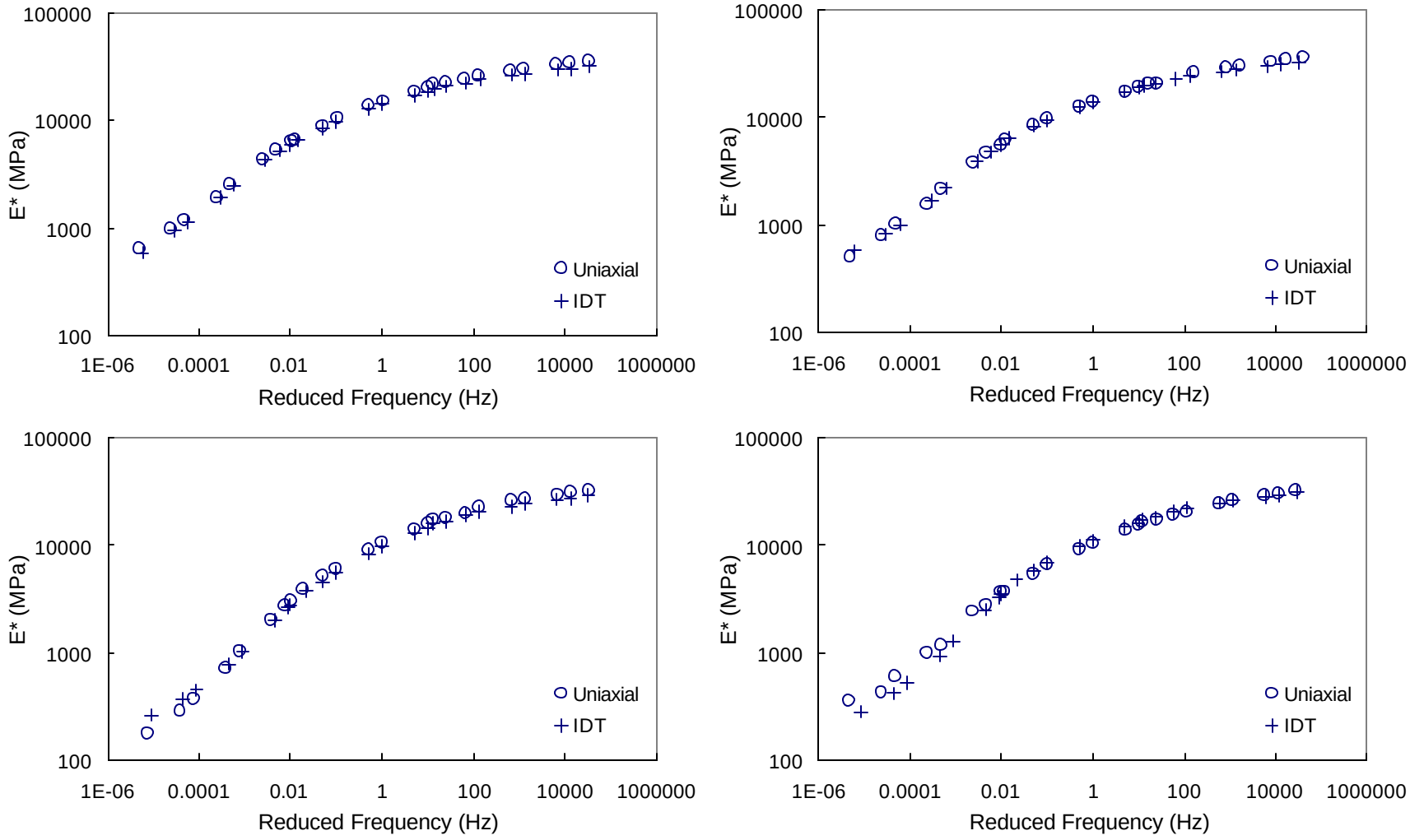


Figure 5.2 Dynamic modulus mastercurves for: (a) S12.5C-Fine; (b) S12.5D-Coarse; (c) I19.0B-Fine; (d) I19.0C-Coarse

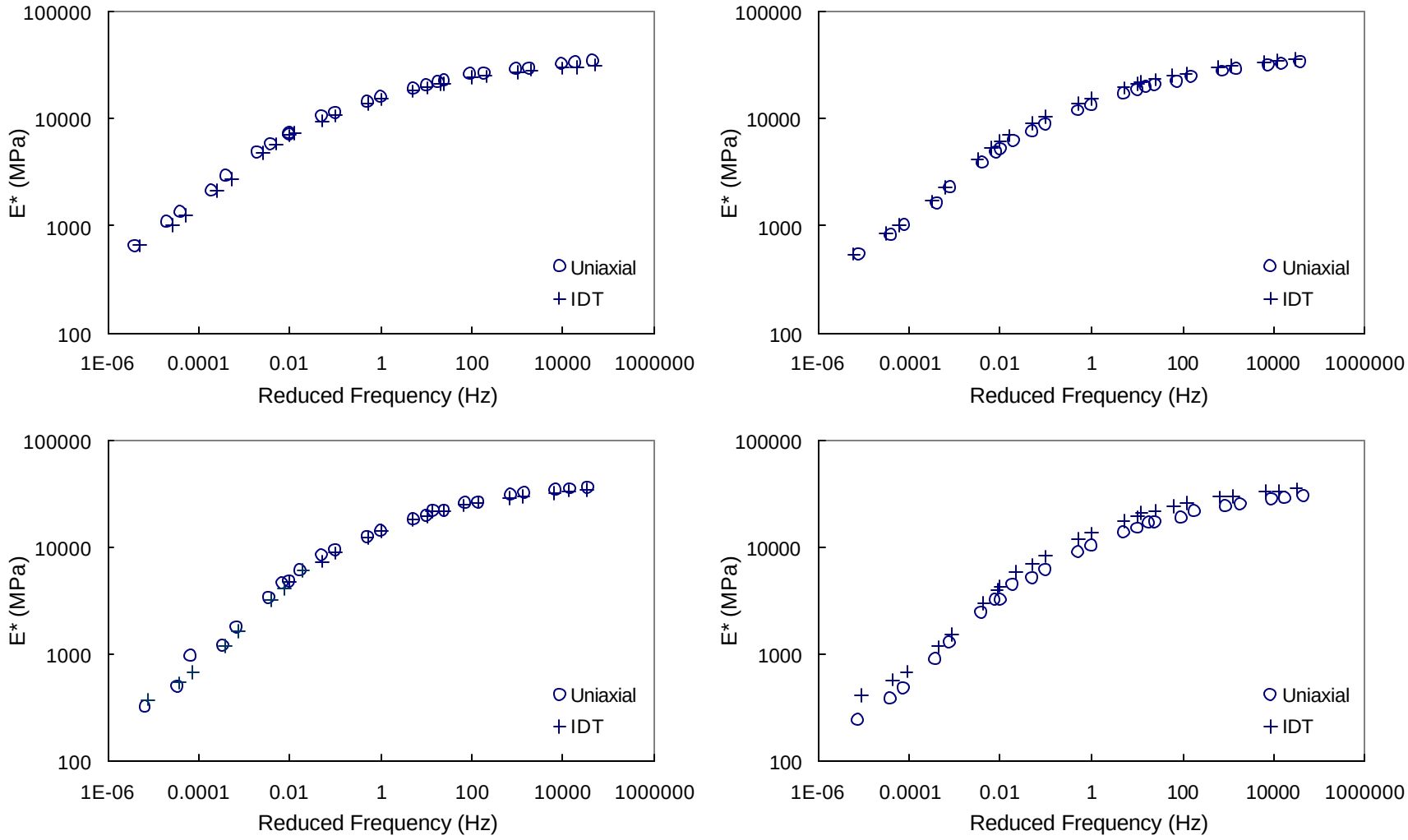


Figure 5.3 Dynamic modulus mastercurves for: (a) I19.0D-Fine; (b) I19.0D-Coarse; (c) B25.0B-Fine; (d) B25.0B-Coarse

5.1.2 Statistical Analysis

5.1.2.1 Using P-Value

Recognizing that a sample-to-sample variation exists, a statistical analysis was conducted using the unequal variance t-test for each mixture at two frequencies for each testing temperature. In this analysis, all the individual replicates (three from the axial compression and three from the IDT tests) were used. The null hypothesis is that the dynamic modulus from the IDT test is the same as that from the axial compression test. The P-value was calculated and compared with the critical value of 0.05 to reject or accept the null hypothesis. The P-value indicates the extent to which a computed test statistic is unusual in comparison with what would be expected under the null hypothesis. Therefore, in this study a P-value greater than 0.05 indicates that the dynamic modulus from the IDT test is statistically the same as that from the axial compression test. A summary of the P-values for 144 tests (2 frequencies × 3 temperatures × 24 mixtures) is given in Table 5.1. About 19% of the tests indicate that the dynamic modulus from the IDT test is statistically different from the dynamic modulus from the axial compression test.

Table 5.1 – Summary of P-Values and Percent Difference in Dynamic Moduli from IDT and Axial Compression Tests

	NMAS				
	9.5 mm	12.5 mm	19.0 mm	25.0 mm	All
P-value					
Less than 0.05	15%	14%	19%	33%	19%
Greater than 0.05	85%	86%	81%	67%	81%
% Difference					
Less than 5%	48%	46%	28%	25%	39%
Between 5 and 10%	21%	33%	42%	19%	31%
Between 10 and 20%	21%	21%	26%	19%	22%
Greater than 20%	10%	0%	4%	38%	8%

5.1.2.2 Using Percent Difference

In addition to the statistical analysis, the % difference was calculated for the dynamic moduli determined from the axial compression and IDT tests for 288 combinations of temperature and frequency (8 frequencies × 3 temperatures × 12 mixes). These values are also summarized in Table 5.1. A comparison of the data in this table and further investigation of individual test data resulted in several important observations. First, about 70% of the tests had a % difference below 10%. Secondly, although it is not shown in Table 5.1, further investigation of the testing conditions that have high % differences reveals that most of the high % difference come from 35ºC data due to the very small dynamic modulus values in the denominator of the % difference calculation. Finally, it can be observed in Table 5.1 that the % difference becomes greater as the NMAS increases. An investigation of the individual test data reveals the same trend; that is, the variability among the replicates increases as the NMAS increases. These observations may be related to the ratio of gauge length to NMAS. Typically, a factor of 3 is recommended to maintain a representative volume element (RVE). Meeting this requirement is not a problem in the axial compression test geometry. However, in the IDT tests with a 50.8 mm gauge length, this requirement is satisfied for the 9.5 and 12.5 mm mixes, but not for the 19.0 and 25.0 mm mixes, resulting in a higher variability among replicates and a higher % difference in the 19.0 and 25.0 mm mixes. Another observation made from a detailed data analysis is that, in some replicates of the 25.0 mm mix, a significant difference was found between displacements from the front and back surfaces of the IDT specimens. These observations suggest that the positions of large aggregate particles within the gauge length affect the data, and that a larger gauge length is required for 25.0 mm mixes. These observations are further supported in Chapter 6.

The visual observation of the average mastercurves in Figures 5.1 to 5.3 and further statistical analysis suggest that the dynamic modulus determined from the IDT test using the linear viscoelastic solution in Eq. (2-34) is statistically the same as the one measured from the axial compression test. This observation answers at least a portion of the question raised earlier regarding the effect of different relationships between the compaction direction and the direction in which the stress-strain analysis is performed in the axial compression and the IDT tests. This difference and possibly anisotropy may exist when the axial compression cylinders and the IDT specimens are compared. However, due to very small strain levels used in these tests (50 to 80 microstrains), the dynamic modulus test more or less "tickles" the mastic and does not fully capture the effect of these differences that are mostly related to the large aggregate orientation.

5.2 Phase Angle

It was observed that the phase angle obtained from axial compression testing is normally between the phase angles calculated from the horizontal and vertical strains in IDT testing. Based on this observation, the phase angles calculated from the horizontal and vertical strains were averaged and plotted in Figures 5.4 and 5.5. The averaged phase angles are close to the values from the axial compression testing. This finding needs to be refined further using a more rigorous approach. Appendix D contains more phase angle comparisons between IDT and axial compression tests.

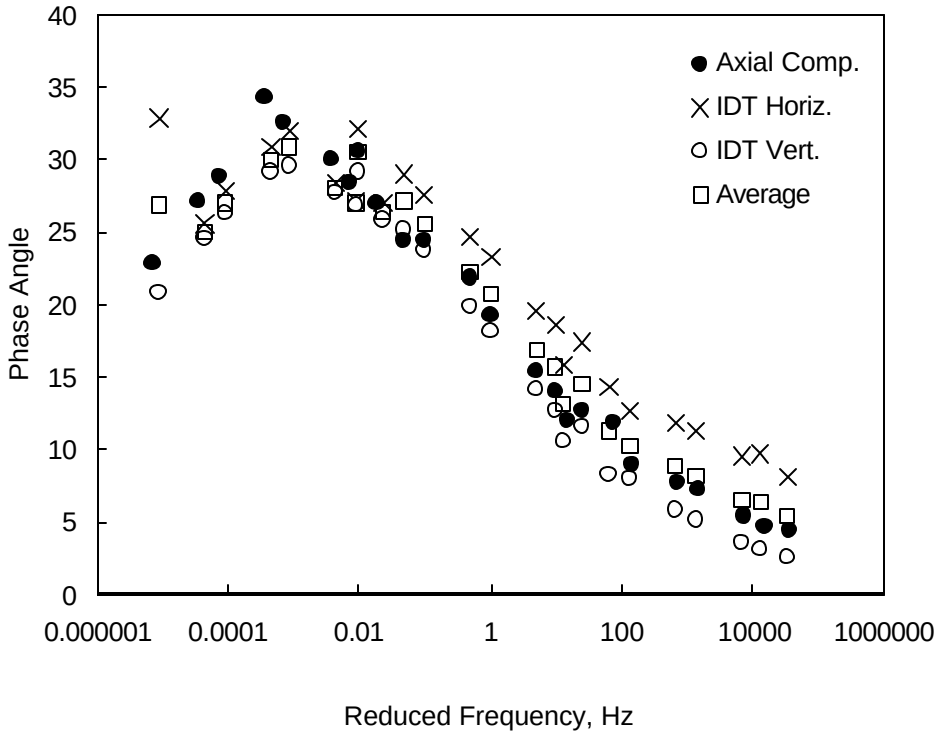


Figure 5.4 Phase angle mastercurves for S9.5A-Fine mixture

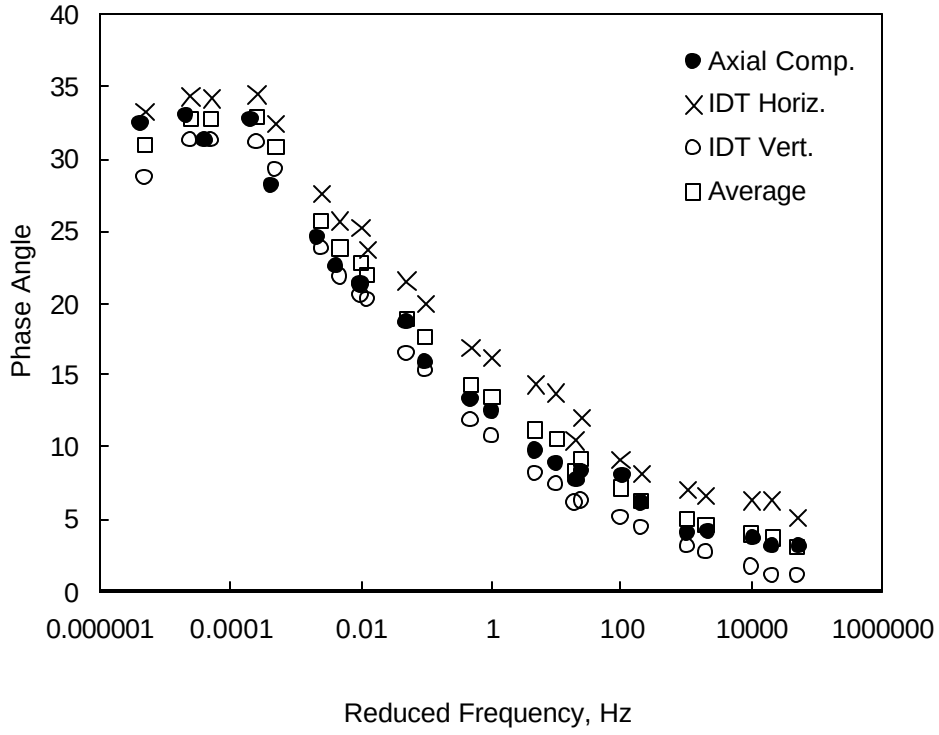


Figure 5.5 Phase angle mastercurves for I19.0D-Fine mixture

6. AGGREGATE SIZE EFFECT ON THE VARIABILITY OF IDT RESULTS

In this chapter, extensive studies have been undertaken to visually observe and quantify the effect of aggregate size on the variability of test results. Digital Image Correlation (DIC) technique was used to evaluate the effect on the actual strain distribution along both axes of the specimen, and thus on the dynamic modulus. Statistical analysis was used to quantify the effect of aggregate size for each of the four aggregate sizes, 9.5, 12.5, 19, and 25 mm, tested in this project.

6.1 Digital Image Correlation (DIC)

Over the past 20 years, advancements in optics, computing power, and general technology have opened numerous avenues in the research arena. DIC is one sector that has emerged as a powerful tool for material testing. In simplistic terms, DIC is a noncontact full field displacement/strain measurement technique. The technique is employed by comparing a digital image of an initial, undeformed specimen to that of a deformed specimen. The test setup requires a digital camera, light source, personal computer and software for post-testing analysis.

With LVDTs, the area of interest must be predefined because the sensors must be mounted to the test specimen. For example, in the IDT testing the vertical and horizontal axes are generally chosen and analyzed as per the prior discussion. However, with DIC, a full field of data is acquired during testing, so there is no limit to the area of interest in the test specimen provided that the area of interest is captured in the image. After testing, an area of interest is selected for analysis. Software creates a grayscale map for each pixel

within the area of interest and compares it with an original, undeformed image to calculate deformations.

The purpose of this study is to determine the actual strain distribution along the vertical and horizontal axes of the specimen using DIC for two mixtures with different NMASs, S9.5C-Fine and B25.0C-Fine. In this study, point strain profiles along a specified gauge length are evaluated.

6.1.1 Test Method

6.1.1.1 Test Protocol

As mentioned earlier, advanced digital technology has allowed for faster acquisition rates in DIC. Nonetheless, the limiting factor still remains the acquisition rate. The camera used for this testing has a maximum acquisition rate of 0.5 sec. and is, therefore, not capable of collecting cyclical data. For example, a 0.5 sec. acquisition rate and a 2 Hz cyclical loading rate would only allow the camera to acquire one point per cycle which in no way defines the loading and/or displacement curves. Thus, a constant crosshead rate monotonic IDT test was adopted for this study. A constant crosshead rate of 12.5 mm per minute was applied to failure of the specimen. This strain rate proved to be suitable to the camera acquisition rate for this mode of testing. All tests were conducted at 25°C.

6.1.1.2 Testing Equipment

Testing was performed using the same equipment used in dynamic modulus testing. A National Instruments data acquisition board was used to acquire load and displacement data from the testing machine. Also, a charge-coupled device (CCD) digital camera, manufactured by Pulnix, equipped with a 35-70 mm lens was used in the image acquisition. The data acquisition board used for image acquisition is distributed by Bitflow. The software

developed by Correlated Solutions was used to acquire and synchronize the image, load, and displacement data.

6.1.1.3 Test Setup

The SHRP LGD was used as the loading apparatus in the IDT test. The CCD camera was mounted and leveled on a tripod at a fixed distance from the specimen. The distance between the camera and the specimen was determined by the zoom and its ability to capture the largest possible image of the area of interest. The most important factor is that the area of interest is as large as possible in the picture's overall dimensions. Picture (or image) dimensions are measured in pixels, and it is desirable to have the best resolution possible. This resolution is accomplished by minimizing the physical dimension per pixel.

In the DIC analysis, a grayscale map of each pixel is formed, thus illustrating the need for many contrasting points speckled on the specimen surface. To create the speckle pattern, the specimen surface was first cleaned thoroughly using sand paper and an airbrush. This ensured that the surface was smooth without any chemical residues so that a speckle pattern could be uniformly applied. Then, the prepared specimens were painted white with an ordinary spray paint for several light coats. After an even white surface was obtained, the specimen was propped up against a newspaper and black spray paint was speckled onto the white background. Through careful manipulation of the spray nozzle with proper pressure from a certain distance, the uniform-sized speckle pattern was applied onto the surface randomly. The black paint was lightly sprayed several times until the desired speckle pattern density was achieved.

The optimum speckle pattern density is an even mix of dark and white areas, producing a pattern that is neither biased towards the white nor towards the black end of the

grayscale. The speckle pattern must be dense enough so that at the desired magnification there are no empty white areas which are detrimental to image analysis accuracy.

The lens used in this study had a variable aperture that allowed the lens to be adjusted based on the ambient and applied illumination. Too much light can create a solid white image while too little light can create a solid black image. That is, the process of obtaining the correct amount of light is important for obtaining quality data. The specimen was illuminated using a fiber optic light source in order to create appropriate contrast.

6.1.2 Data Analysis

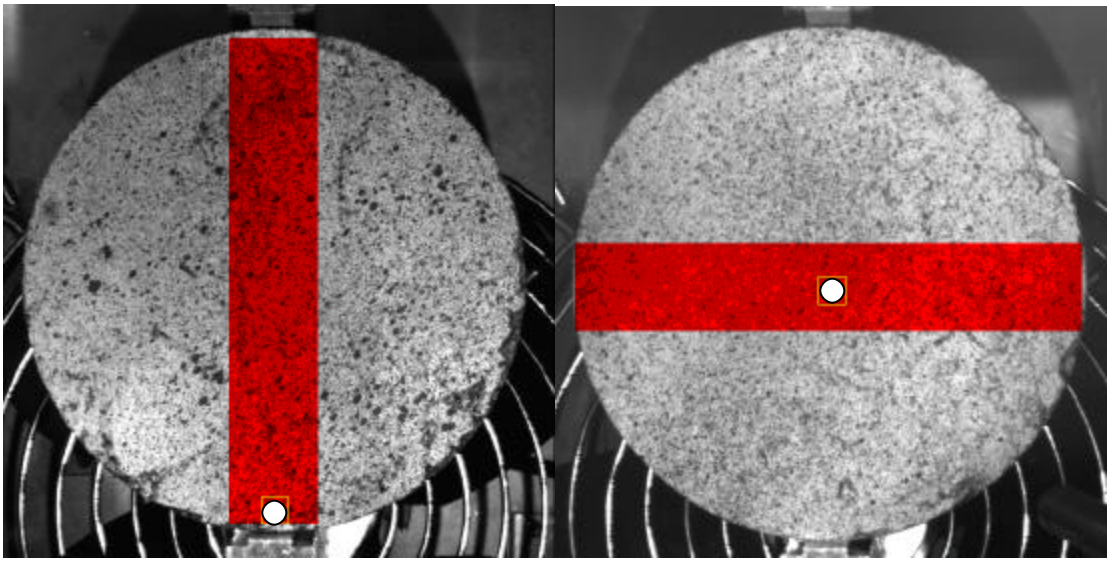
6.1.2.1 Data Acquisition and Analysis Software

Ram displacements, load cell measurements, and images were collected using software produced by Correlated Solutions. The rate of acquisition was at 0.5 sec. intervals. Once the images were acquired, post-testing analysis software, called VIC 2-D, was used to calculate the strain and displacement data. The following sections describe several key parameters in the analysis process that must be defined before the analysis is completed.

6.1.2.2 Area of Interest

A thin rectangular strip was selected along both the vertical and the horizontal axes of the specimen for analysis. Figure 6.1 illustrates the areas of interest selected in both axes. The width selected was approximately 16.5 mm, which was wide enough to allow the analysis software to successfully compute local strain values, or the strain at any given point. The width of the strip needed to be minimized so that only behavior along the vertical and horizontal axes would be observed, but it also needed to be wide enough to average the behavior. A single pixel width would not necessarily provide a general trend across the diameter of the specimen, but rather a jagged relationship between the strain and the radius

evaluated. Figure 6.2 displays an example of the vertical strain contours for the areas shown in Figure 6.1 for S9.5C-Fine mixture.

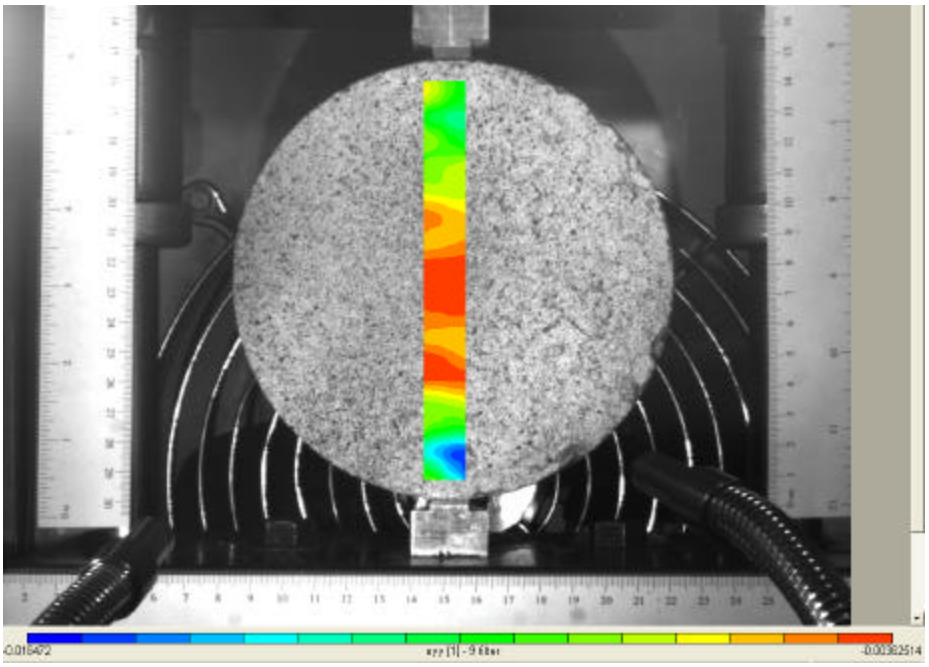


(a) (b)

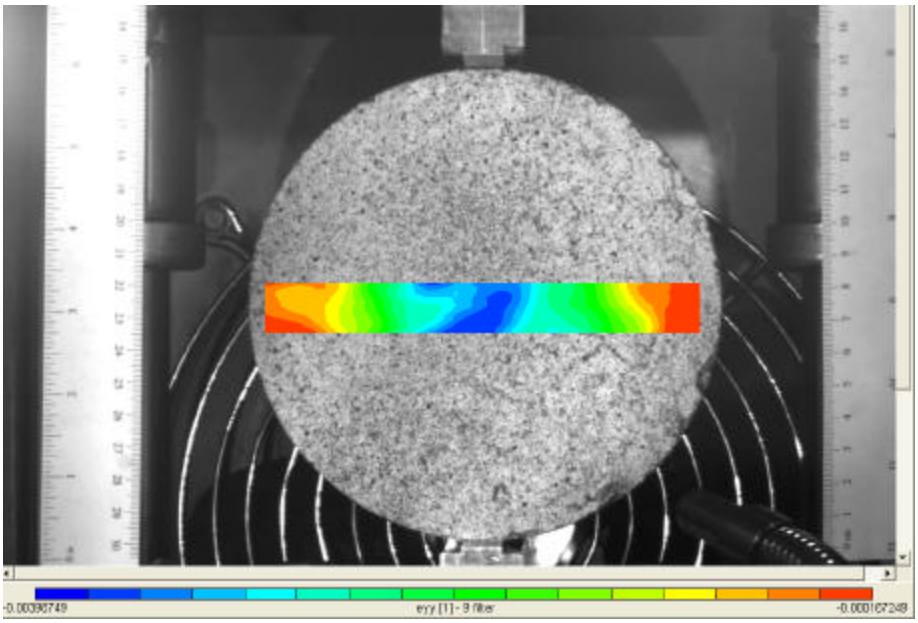
Figure 6.1 Areas of interest: (a) along the vertical axis; (b) along the horizontal axis

6.1.2.3 Seed Point

The term, *seed point*, refers to the point within the area of interest where the correlation process can begin. The correlation algorithms use the information from the seed point to obtain an initial estimate for the second point analyzed and continue in this manner until all points in the area of interest are analyzed. The seed point should be located in a region where the least amount of motion occurs during the test. It is easier to correlate the undeformed image with the deformed image if little movement has occurred between the seed point locations in each image. Selection of the seed point was consistent for all the horizontal strips analyzed and for all the vertical strips analyzed. The white circle in the middle of the images in Figures 6.1(a) and (b) represent the seed point location for each of the areas of interest that were analyzed.



(a)



(b)

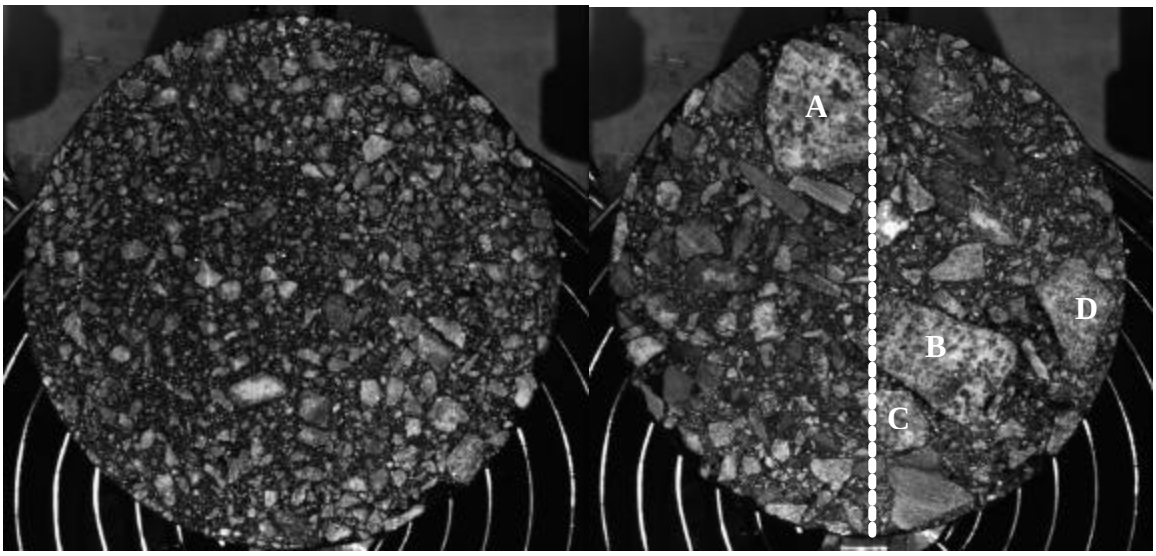
Figure 6.2 Vertical strain profiles: (a) along the vertical axis; (b) along the horizontal axis (S9.5C-Fine)

6.1.2.4 Strain Calculation

The strain calculation is the most complex aspect of this evaluation. The strain must be evaluated within a small subset of the larger area of interest. The movement of the surface is easily determined, but the gauge length that is used is the critical factor. The evaluation is not as simple as the conventional strain calculation approach (i.e., the change in displacement divided by the original gauge length). The movement observed must be evaluated in the local region of the point. Advanced mathematical techniques were utilized within the software to perform the computations.

6.1.3 Test Results

In this study, point strain profiles determined from the DIC analysis were used to understand the effect of aggregate particles on strain distribution. An image of the specimen was taken prior to painting in the same orientation that would be used during testing. The image showing the orientation of the aggregate particles could prove valuable in explaining the material response at different locations on the specimen face. Figure 6.3 shows the digital images of the S9.5C-Fine and B25.0C-Fine specimens prior to speckling. It is noted in Figure 6.3(b) that three large aggregate particles (marked by A, B, and C) are present along the vertical axis shown by dotted line. Effects of these aggregate particles on the strain distribution along the vertical axis will be discussed later in this section.



(a) (b)

Figure 6.3 Digital images of the specimen faces: (a) S9.5C-Fine; (b) B25.0C-Fine

6.1.3.1 S9.5C-Fine Mix

Vertical and horizontal strains were determined along both axes of the specimen using the software and plotted in Figures 6.4 and 6.5. In general, the strain profiles in both axes agree with the theoretical stress profiles (see Figure 2.5). In Figure 6.4 for the strains along the vertical axis, a slight drop was noticed near top and bottom loading strips, which is attributed to the shear plane developed under the loading strips. Also, the horizontal strain profile along the vertical axis shows a slight deviation from the stress profile which is known to be relatively constant.

6.1.3.2 B25.0C-Fine Mix

The strain analysis results of the DIC data from the B25.0C-Fine mixture are plotted in Figures 6.6 and 6.7. Similar to the results from the S9.5C-Fine mix, a slight drop in the strain was observed near the top and bottom ends in Figure 6.6. However, there is a significant difference between the two mixes in terms of the deviation and fluctuation from

the theoretical trend of the strain profile along the vertical axis. The B25.0C-Fine mix exhibits a much larger fluctuation to the extent that strain trends would be difficult to identify. This observation is expected as the non-homogeneity of the material increases with respect to aggregate size. Both vertical and horizontal strains exhibit a sinusoidal type of profile in the region where large aggregates are present (i.e., A, B, C in Figure 6.3(b)). Each cycle corresponds more or less to one large aggregate present along the vertical axis. This phenomenon is clearly visible by comparing the strain profile along the vertical axis (Figure 6.6) to the image of the specimen before testing (Figure 6.3(b)).

The strain profiles along the horizontal axis in Figure 6.7 show much less fluctuation and deviation than the strain profiles along the vertical axis. It was noticed that the peak vertical strain was shifted to the right by about 12 mm from the center of the specimen, thus indicating a large aggregate at that location. The vertical strain switched to tension towards the right end of the specimen, which is also attributed to the existence of a relatively large aggregate at the right end (D in Figure 6.3(b)).

6.2 Statistical Analysis

6.2.1 Standard Deviation

Within each mixture tested a standard deviation was computed for dynamic modulus values among the three replicates for each temperature/frequency combination. The standard deviation computed could not be used as the basis for quantifying the variability since the dynamic modulus changes with temperature and frequency. Thus, the data had to be normalized.

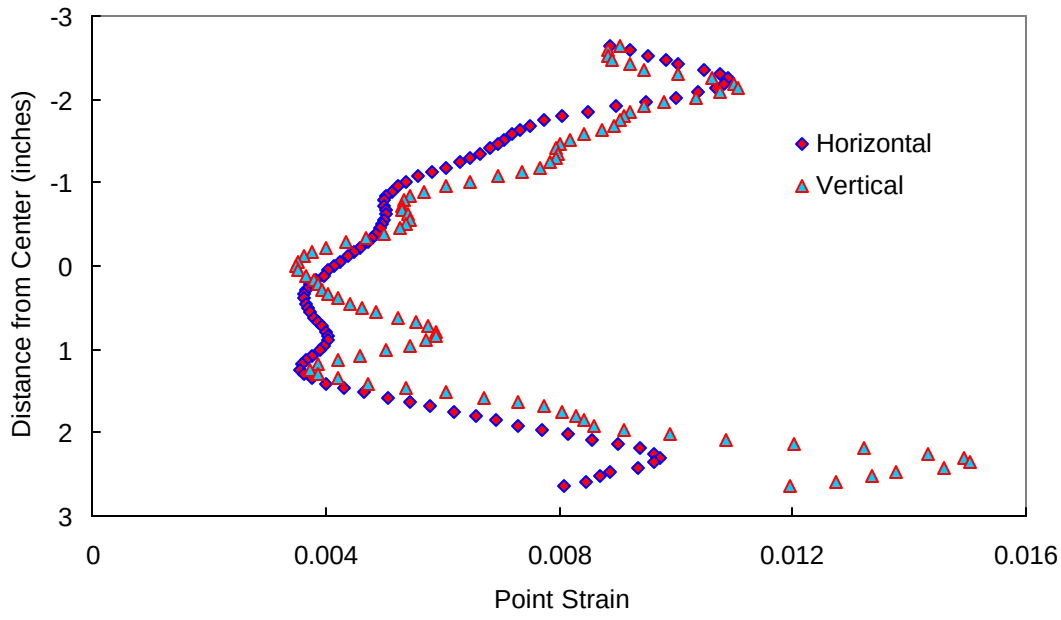


Figure 6.4 Strain profiles along the vertical axis (S9.5C-Fine)

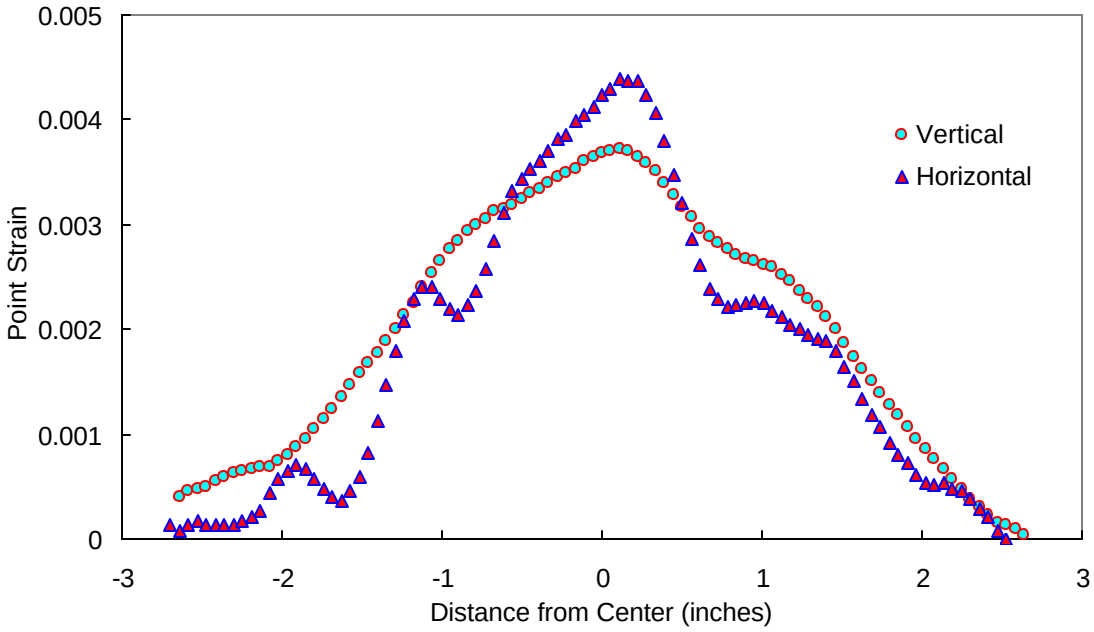


Figure 6.5 Strain profiles along the horizontal axis (S9.5C-Fine)

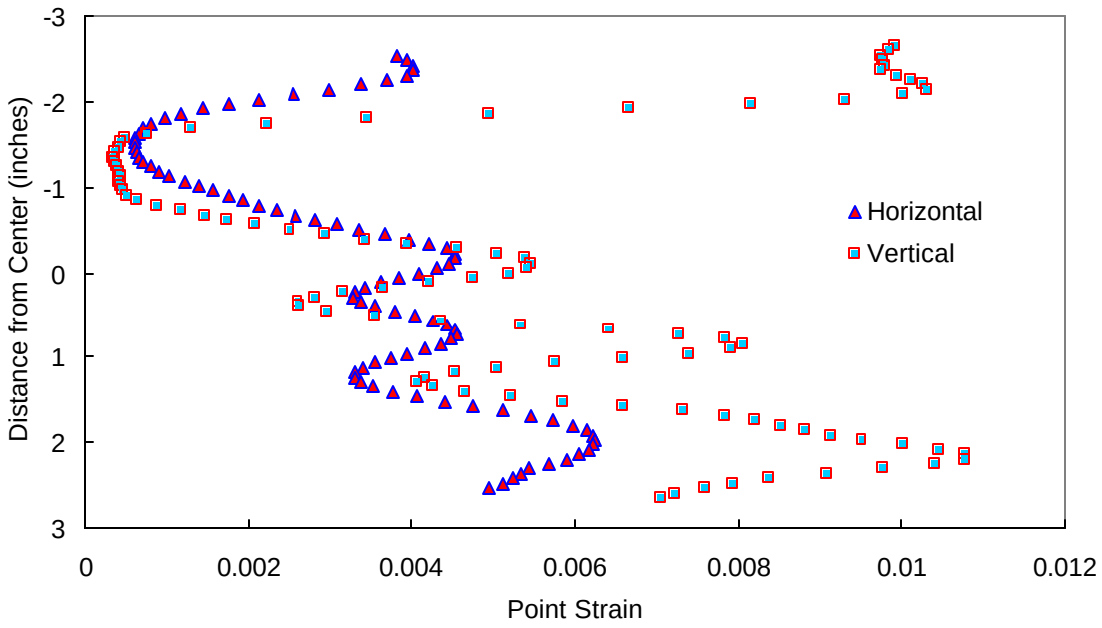


Figure 6.6 Strain profiles along the vertical axis (B25.0C-Fine)

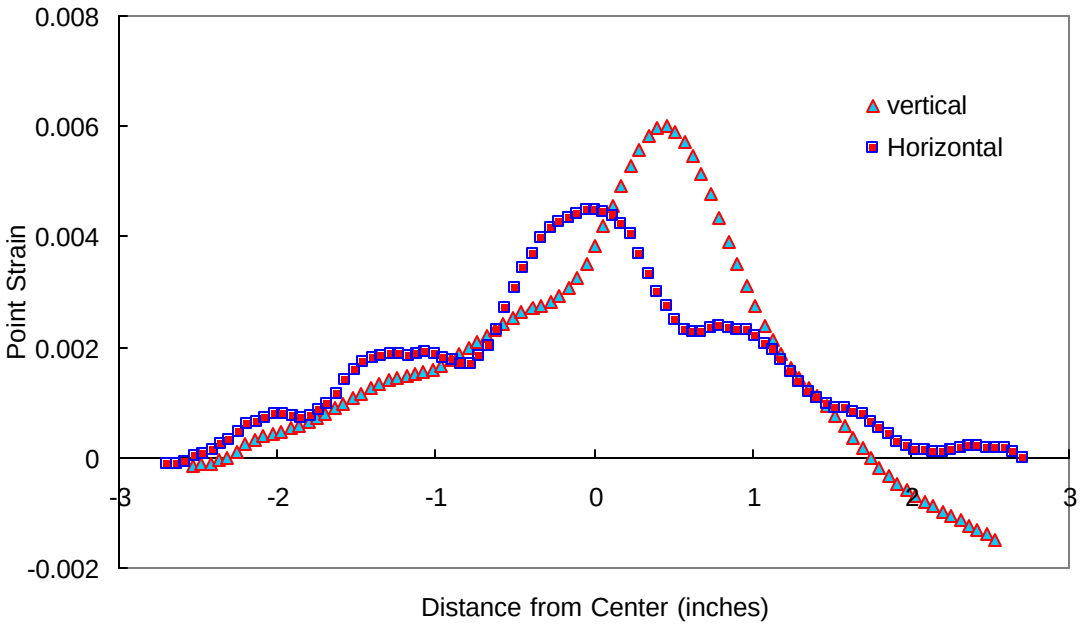


Figure 6.7 Strain profiles along the horizontal axis (B25.0C-Fine)

6.2.2 Coefficient of Variation

To normalize the standard deviation, the *coefficient of variation* was used to quantify the variability within each aggregate size. The coefficient of variation (CV) is defined as:

$$CV(\%) = \frac{Stdev}{Mean} \times 100 \qquad (6\text{-}1)$$

where *Stdev* stands for standard deviation, and the *Mean* is simply the average. The CV was computed for all frequency-temperature combinations within each mixture, and an average CV value was obtained for each mixture. Finally, the CV values for the mixtures within the same aggregate size designation were averaged to obtain a single CV value representing each aggregate size. Figure 6.8 shows a bar chart of the CV computed for each aggregate size.

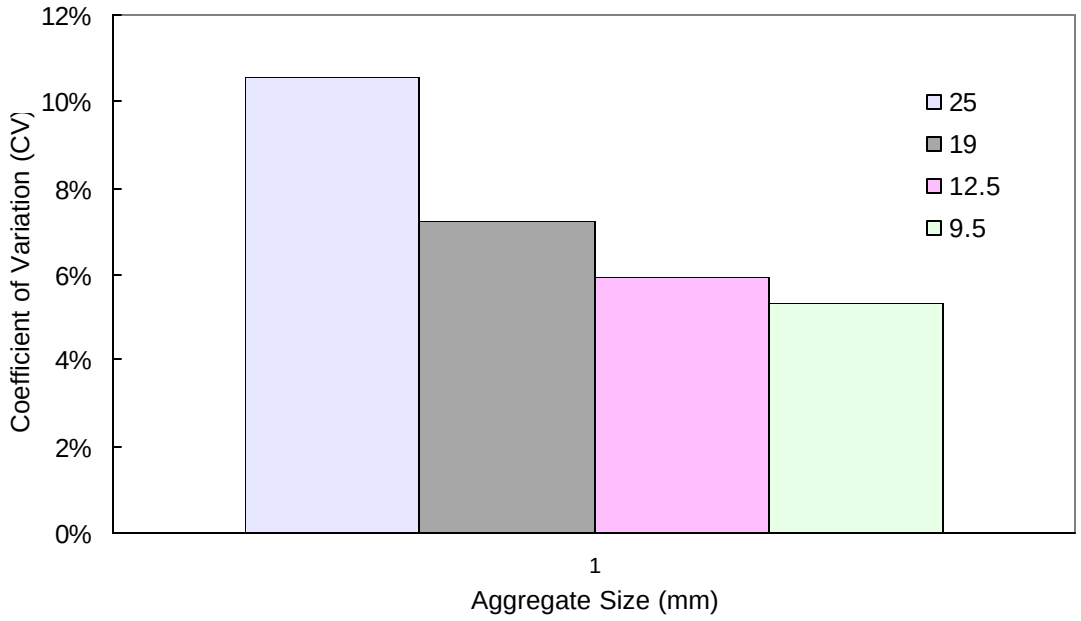


Figure 6.8 Computed CV for different aggregate sizes

From the plot, mixtures with a 25 mm NMAS show the largest CV value of 10.6%; mixtures with a 19 mm NMAS show a CV of 7.3%; mixtures with a 12.5 mm NMAS show a CV of 6.0%; and finally the 9.5 mm NMAS mixtures show the smallest CV value of 5.4%. The results support the findings from the visual observation obtained from DIC. The larger the aggregate size the more inconsistent the strain distribution is from the theoretical distribution and, thus, the higher the variability between replicates within each mixture.

7. CONCLUSIONS AND FUTURE RESEARCH RECOMMENDATIONS

The dynamic modulus testing of Superpave mixtures commonly used in North Carolina resulted in a large database that can be used for various purposes. A total of 42 mixtures were tested in axial compression. Among those mixtures, 24 mixtures were tested in the IDT mode. The database developed in this research project will allow one to obtain typical dynamic moduli values for local North Carolina asphalt mixtures without testing. The use of local dynamic moduli values will improve the accuracy of pavement design using the NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide.

The investigation of the effects of predictive errors in the dynamic modulus on the pavement performance was conducted by applying phenomenological pavement performance models and the multilayered elastic analysis to three pavement cases. The findings are summarized below:

1. About 50% error in the dynamic modulus predicted from the predictive models causes about 25 to 50% error in the fatigue life prediction.
2. In the rutting analysis, a much greater effect of the dynamic modulus predictive errors was found. In the worst case scenario investigated in this research, up to 80% error in the pavement service life was found.

The parametric study of the effects of mixture variables on the dynamic modulus reveals the following conclusions:

1. Aggregate source and gradation, within the same NCDOT Superpave classification, do not seem to have a significant effect on the dynamic modulus.

2. The binder source, binder PG, and asphalt content seem to affect the dynamic modulus of asphalt mixtures.

The investigation into reducing the number of testing temperatures for dynamic modulus suggests:

1. The mastercurves obtained from five-temperature and three-temperature test protocols are statistically the same.
2. However, the three-temperature protocol requires the extrapolation of the shift factor for temperatures higher than 35°C, which was the highest temperature in the three-temperature protocol. It was found that this extrapolation did not yield accurate enough dynamic moduli values at temperatures higher than 35°C. After considering these issues, a four-temperature protocol was developed.

A comparison of the uniaxial and triaxial test results shows that the effect of confining pressure on the dynamic modulus at low temperatures is minimal, but is significant at high temperatures. Also, two consecutive dynamic modulus tests on the same specimen revealed that the increased mean strain during the test has no significant effect on the dynamic modulus, phase angle, and shift factor. This finding supports the earlier finding that the aggregate factors do not have a significant effect on the dynamic modulus. From these observations, the ability of the dynamic modulus test alone to predict the permanent deformation propensity of asphalt mixtures is questioned.

The IDT test results were compared against the results from axial compression testing, and the following conclusions can be drawn:

1. The viscoelastic solution for the IDT complex modulus has been verified.

2. Statistical analysis proves that there is an 81% chance that the IDT dynamic modulus will be essentially the same as the axial compression dynamic modulus. One of the main reasons that there is a 19% chance that the IDT dynamic modulus will be statistically different from the axial compression dynamic modulus is due to specimen-to-specimen variability. Another possible reason is the fact that the relationship between compaction direction and the direction in which the load is applied is different in IDT than in axial compression testing.
3. There is an urgent need to develop a test protocol for the dynamic modulus in IDT since cores obtained from existing pavements cannot be used for axial compression testing, and because the state of stress induced in IDT specimens simulates the stress state in the field better than axial compression.
4. Statistical analysis proves that the amount of variability between replicates in any given mixture increases as the NMAS increases.
5. Digital Image Correlation results suggest using either a bigger specimen or a longer gauge length for 25.0 mm mixtures in order to determine the dynamic modulus in IDT testing.

The following recommendations are made for future research:

1. The effects of the predictive errors in the Witczak and Hirsch models need to be evaluated using the Guide software.
2. The dynamic modulus test protocol using the IDT mode must be developed. The DIC tests must be conducted on more mixtures with different NMAS and at different

temperatures to develop a recommendation for the gauge lengths for the different testing conditions and NMAS.

8. IMPLEMENTATION AND TECHNOLOGY TRANSFER PLAN

The products from this research project include:

1. Dynamic modulus and phase angle database for 42 different North Carolina asphalt mixtures; and
2. A test protocol and analytical solutions for determination of complex modulus in the indirect tension mode.

The dynamic modulus database will be used by the NCDOT PMU to evaluate the NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide for applicability to North Carolina pavements. If this evaluation yields successful results, the database will be used as input parameters for design of new pavements and overlay in North Carolina.

It is recommended that a half-day workshop to be conducted on the subject of the complex modulus and its test methods. The audience may include the engineers from the Pavement Management Unit, Materials and Tests Unit, and Construction Unit of NCDOT and other highway agencies in counties and municipalities.

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TYPICAL DYNAMIC MODULI FOR NORTH CAROLINA ASPHALT CONCRETE MIXTURES

APPENDICES

(Report No. FHWA/NC/2005-03)

To North Carolina Department of Transportation
(Research Project No. HWY-2003-09)

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16. Abstract

This report presents results from an experimental study on the dynamic modulus testing of hot mix asphalts (HMAs) in uniaxial compression and indirect tension (IDT) modes. The study includes forty-two mixtures that are commonly used in North Carolina and have varying aggregate sources, aggregate gradations, asphalt sources, asphalt grades, and asphalt contents. The procedures outlined in the AASHTO TP 62-03 *Standard Method of Test for Determining Dynamic Modulus of Hot-Mix Asphalt Concrete Mixtures* have been modified in this study by reducing the number of test temperatures from five to four and by increasing the number of loading frequencies. This modified four-temperature protocol resulted in a reduction of the testing time.

The dynamic modulus database developed from the axial compression testing was used to evaluate the prediction accuracy of the two dynamic modulus predictive models that are currently available, i.e., the Witczak and Hirsch models. A case study was conducted to determine the effects of predictive errors on the fatigue cracking and rutting performance of HMA pavements. The database was also used to investigate the effects of different mixture variables on the dynamic modulus. It was found that the binder variables (i.e., the source, performance grade, and content) have a much more significant effect on the dynamic modulus than the aggregate variables (i.e., source and gradation).

An analytical solution to determine the dynamic modulus, phase angle, and Poisson's ratio using the IDT test was developed using the theory of linear viscoelasticity. The resulting IDT dynamic modulus was found to be statistically the same as the dynamic modulus determined from the axial compression testing about 80% of the time. It was found that the amount of variability between replicates increases as the nominal maximum aggregate size (NMAS) increases. The digital image correlation (DIC) method, a noncontact, full-field displacement measurement technique, was employed to investigate the relationship between the displacement gauge length in the IDT test and the NMAS.

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APPENDIX A: BINDER TEST RESULTS

Table A-1. Determination of A and VTS for PG 64-22 from Associated Asphalt-Inman

Associated Asphalt - Inman					VTS	-3.6244	
PG 64-22					A	10.8324	
Temp (°C)	Temp (°F)	Log Temp (°Rankine)	Pen (0.1mm)	Viscosity (Poise)	Viscosity (cP)	Log Log Visc (cP)	Viscosity (Pa - sec)
15	59	2.7149	15	7.12E+07	7.12E+09	9.94E-01	
25	77	2.7297	44	6.30E+06	6.30E+08	9.44E-01	
80	176	2.8033		4.30E+02	4.30E+04	6.66E-01	43
100	212	2.8272			6.35E+03	5.80E-01	6.35
135	275	2.8661			5.90E+02	4.43E-01	0.59
175	347	2.9067			1.04E+02	3.05E-01	0.104
-10	14	2.6755		4.55E+11	4.55E+13	1.14E+00	
10	50	2.7073		2.97E+08	2.97E+10	1.02E+00	
35	95	2.7441		5.10E+05	5.10E+07	8.87E-01	

Table A-2. Determination of A and VTS for PG 64-22 from Citgo-Wilmington

Citgo - Wilmington					VTS	-3.52561	
PG 64-22					a	10.55788	
Temp (°C)	Temp (°F)	Log Temp (°Rankine)	Pen (0.1mm)	Viscosity (Poise)	Viscosity (cP)	Log Log Visc (cP)	Viscosity (Pa - sec)
15	59	2.7149	22	3.00E+07	3.00E+09	9.77E-01	
25	77	2.7297	42	7.00E+06	7.00E+08	9.47E-01	
80	176	2.8033		5.20E+02	5.20E+04	6.74E-01	52
100	212	2.8272			7.25E+03	5.87E-01	7.245
135	275	2.8661			6.80E+02	4.52E-01	0.68
175	347	2.9067			1.13E+02	3.12E-01	0.113
-10	14	2.6755		2.18E+11	2.18E+13	1.13E+00	
10	50	2.7073		2.01E+08	2.01E+10	1.01E+00	
35	95	2.7441		4.42E+05	4.42E+07	8.83E-01	

Table A-3. Determination of A and VTS for PG 70-22 from Citgo-Wilmington

Citgo - Wilmington					VTS	-3.34446	
PG 70-22					a	10.08125	
Temp (°C)	Temp (°F)	Log Temp (°Rankine)	Pen (0.1mm)	Viscosity (Poise)	Viscosity (cP)	Log Log Visc (cP)	Viscosity (Pa - sec)
15	59	2.7149	16	6.15E+07	6.15E+09	9.91E-01	
25	77	2.7297	31	1.39E+07	1.39E+09	9.61E-01	
80	176	2.8033		1.35E+03	1.35E+05	7.10E-01	135.3
100	212	2.8272			1.71E+04	6.27E-01	17.05
135	275	2.8661			1.29E+03	4.93E-01	1.29
175	347	2.9067			1.93E+02	3.59E-01	0.193
-10	14	2.6755		3.87E+11	3.87E+13	1.13E+00	
10	50	2.7073		4.32E+08	4.32E+10	1.03E+00	
35	95	2.7441		1.03E+06	1.03E+08	9.04E-01	

Table A-4. Determination of A and VTS for PG 76-22 from Associated Asphalt-Salisbury

Associated Asphalt - Salisbury					VTS	-3.05155	
PG 76-22					a	9.2822	
Temp (°C)	Temp (°F)	Log Temp (°Rankine)	Pen (0.1mm)	Viscosity (Poise)	Viscosity (cP)	Log Log Visc (cP)	Viscosity (Pa - sec)
15	59	2.7149	18	4.72E+07	4.72E+09	9.86E-01	
25	77	2.7297	32	1.29E+07	1.29E+09	9.60E-01	
80	176	2.8033		1.35E+03	1.35E+05	7.10E-01	135
100	212	2.8272			4.80E+04	6.70E-01	48
135	275	2.8661			2.46E+03	5.30E-01	2.46
175	347	2.9067			3.58E+02	4.07E-01	0.358
-10	14	2.6755		1.30E+11	1.30E+13	1.12E+00	
10	50	2.7073		3.08E+08	3.08E+10	1.02E+00	
35	95	2.7441		1.26E+06	1.26E+08	9.09E-01	
54	129.2	2.7700		5.62E+04	5.62E+06	8.29E-01	

Table A-5. Determination of A and VTS for PG 64-22 from El Paso-Apex

El Paso - Apex					VTS	-3.42311	
PG 64-22					A	10.28643	
Temp (°C)	Temp (°F)	Log Temp (°Rankine)	Pen (0.1mm)	Viscosity (Poise)	Viscosity (cP)	Log Log Visc (cP)	Viscosity (Pa - sec)
15	59	2.7149	19	4.18E+07	4.18E+09	9.83E-01	
25	77	2.7297	40	7.81E+06	7.81E+08	9.49E-01	
80	176	2.8033		9.36E+02	9.36E+04	6.96E-01	93.63
100	212	2.8272			1.19E+04	6.10E-01	11.9
135	275	2.8661			9.50E+02	4.74E-01	0.95
175	347	2.9067			1.43E+02	3.34E-01	0.143
-10	14	2.6755		2.65E+11	2.65E+13	1.13E+00	
10	50	2.7073		2.80E+08	2.80E+10	1.02E+00	
35	95	2.7441		6.61E+05	6.61E+07	8.93E-01	
54	129.2	2.7700		2.35E+04	2.35E+06	8.04E-01	

Table A-6. Determination of A and VTS for PG 64-22 from El Paso-Charlotte

El Paso - Charlotte					VTS	-3.44397	
PG 64-22					a	10.346	
Temp (°C)	Temp (°F)	Log Temp (°Rankine)	Pen (0.1mm)	Viscosity (Poise)	Viscosity (cP)	Log Log Visc (cP)	Viscosity (Pa - sec)
15	59	2.7149	19	4.18E+07	4.18E+09	9.83E-01	
25	77	2.7297	35	1.06E+07	1.06E+09	9.55E-01	
80	176	2.8033		9.50E+02	9.50E+04	6.97E-01	95
100	212	2.8272			1.20E+04	6.11E-01	12
135	275	2.8661			9.40E+02	4.73E-01	0.94
175	347	2.9067			1.42E+02	3.33E-01	0.142
-10	14	2.6755		3.47E+11	3.47E+13	1.13E+00	
10	50	2.7073		3.32E+08	3.32E+10	1.02E+00	
35	95	2.7441		7.28E+05	7.28E+07	8.96E-01	
54	129.2	2.7700		2.50E+04	2.50E+06	8.06E-01	

Table A-7. Determination of A and VTS for PG 70-22 from Associated Asphalt-Salisbury

Associated Asphalt - Salisbury					VTS	-3.34446	
PG 70-22					a	10.08125	
Temp (°C)	Temp (°F)	Log Temp (°Rankine)	Pen (0.1mm)	Viscosity (Poise)	Viscosity (cP)	Log Log Visc (cP)	Viscosity (Pa - sec)
15	59	2.7149	16	6.15E+07	6.15E+09	9.91E-01	
25	77	2.7297	31	1.39E+07	1.39E+09	9.61E-01	
80	176	2.8033		1.35E+03	1.35E+05	7.10E-01	135.3
100	212	2.8272			1.71E+04	6.27E-01	17.05
135	275	2.8661			1.29E+03	4.93E-01	1.29
175	347	2.9067			1.93E+02	3.59E-01	0.193
-10	14	2.6755		3.87E+11	3.87E+13	1.13E+00	
10	50	2.7073		4.32E+08	4.32E+10	1.03E+00	
35	95	2.7441		1.03E+06	1.03E+08	9.04E-01	

Table A-8. Dynamic Shear Modulus of All the Binders Used in This Study

Source	Grade	Temp. (°C)	Binder G* (Pa)							
			Frequency (Hz)							
			15	10	5	1	0.5	0.1	0.05	0.01
Associated Asphalt - Inman	PG 64-22	16	3,237,677	3,246,748	2,914,593	1,927,704	1,722,797	809,991	531,291	174,255
		22	3,064,134	2,640,702	2,276,306	1,226,527	768,040	272,860	165,166	47,419
		28	2,022,922	1,754,342	1,273,119	473,202	329,295	96,453	49,199	12,711
		40	1,018,632	800,251	507,370	137,415	89,076	24,661	12,713	3,101
El Paso - Apex	PG 64-22	16	3,749,787	3,308,899	2,953,155	2,073,504	1,686,351	980,900	577,083	201,998
		22	2,782,576	2,596,258	2,131,564	1,144,716	797,670	319,177	198,468	69,674
		28	1,899,065	1,676,711	1,230,065	498,564	290,091	119,769	69,296	23,862
		40	493,035	380,441	242,347	68,743	45,652	13,244	8,890	2,084
		54	84,095	63,784	36,887	10,632	6,085	1,599	832	188
El Paso - Charolotte	PG 64-22	16	3,724,668	3,482,872	3,289,336	2,200,444	2,244,740	946,337	695,062	274,109
		22	2,973,965	2,798,887	2,466,290	1,606,420	878,469	402,438	279,761	94,377
		28	2,466,789	2,008,662	1,545,261	712,802	477,080	162,603	100,062	32,739
		40	675,058	525,730	339,191	113,528	70,269	21,279	11,763	3,202
		54	109,547	82,716	48,365	12,916	7,413	2,068	1,070	242
Citgo - Wilmington	PG 64-22	16	3,565,665	3,454,562	3,242,074	2,636,172	2,058,281	898,621	609,724	184,389
		22	3,591,408	2,875,760	2,666,009	1,287,673	1,022,905	346,807	192,946	59,641
		28	2,334,075	2,102,260	1,517,348	587,962	375,191	111,020	67,565	17,105
		40	653,188	484,500	291,086	81,475	45,045	11,346	6,425	1,677
		54	85,169	61,161	33,883	7,500	4,280	1,061	535	112
Associated Asphalt - Salisbury	PG 70-22	16	3,359,118	3,323,034	2,962,792	2,829,143	1,837,843	1,057,713	758,826	340,527
		22	3,111,165	2,739,342	2,415,152	1,659,012	1,117,075	522,696	324,862	116,922
		28	2,212,058	2,018,484	1,583,006	771,436	504,701	189,274	122,068	43,405
		40	730,295	583,759	381,023	125,565	80,165	27,123	15,842	4,724
		54	131,221	99,495	59,972	18,161	9,498	2,695	1,426	365
Citgo - Wilmington	PG 70-22	16	3,645,130	3,509,145	3,007,192	3,611,468	2,468,176	1,160,803	723,926	333,999
		22	2,940,574	2,847,184	2,373,212	1,489,701	992,657	398,479	280,962	97,732
		28	2,306,384	2,056,574	1,538,675	662,799	471,533	162,059	99,663	28,200
		40	803,305	628,025	399,386	127,535	76,322	23,220	14,002	3,620
		54	132,403	96,647	57,472	15,864	9,650	2,306	1,253	296
Associated Asphalt - Salisbury	PG 76-22	16	3,406,098	3,539,715	3,516,410	2,345,146	1,831,219	864,765	692,723	228,329
		22	3,245,259	2,948,333	2,428,813	1,457,970	960,490	354,411	244,882	80,043
		28	2,183,022	1,905,210	1,426,036	602,625	373,991	126,936	73,312	27,507
		40	570,356	429,241	261,210	81,503	51,700	16,365	10,379	3,907
		54	88,340	65,633	39,168	13,036	7,512	2,671	1,632	628

APPENDIX B: AXIAL COMPRESSION DYNAMIC MODULUS DATA

Table B-1. S9.5AC–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2974685	356651	378741	422807	439331	481743	500131	522547
		Phase Angle, F (º)	8.8	0.0	3.6	5.1	5.4	4.1	3.5	3.7
		Average Peak Stress (psi)	176	209	217	237	245	270	278	301
		Average Peak Strain (με)	59	58	57	56	56	56	56	58
	2	|E*| (psi)	2958674	323012	350536	412850	429471	469242	489082	508522
		Phase Angle, F (º)	8.5	11.9	5.4	5.1	5.3	3.8	3.3	2.9
		Average Peak Stress (psi)	176	209	217	237	245	270	278	301
		Average Peak Strain (με)	59	65	62	58	57	57	57	59
	3	|E*| (Psi)	2684167	341945	314805	367579	383680	420399	432676	454235
		Phase Angle, F (º)	7.4	2.5	4.8	5.0	4.2	3.1	2.5	3.1
		Average Peak Stress (psi)	176	209	217	237	245	270	279	302
		Average Peak Strain (με)	65	61	69	65	64	64	64	66
	Avg.	|E*| Average (psi)	2872509	340536	348027	401079	417494	457128	473963	495101
		F Average	8.2	4.8	4.6	5.0	5.0	3.7	3.1	3.2
		|E*| Coeff. of Variation (psi)	0.057	0.050	0.092	0.073	0.071	0.071	0.076	0.073
		F Coeff. of Variation	0.09	1.32	0.19	0.01	0.14	0.15	0.17	0.12
		|E*| Std. Dev. (psi)	163304.9	168638.	320415.	294358.	296960.	324162.	361798.	360796.
		F Std. Dev.	0.765	6.289	0.882	0.040	0.678	0.546	0.525	0.396
10	1	|E*| (psi)	647541	106100	115282	162308	181036	233726	256989	
		Phase Angle, F (º)	30.1	20.1	25.6	18.8	17.0	13.7	12.2	
		Average Peak Stress (psi)	20	35	41	57	73	102	118	
		Average Peak Strain (με)	32	33	36	35	41	44	46	
	2	|E*| (psi)	737781	128273	129653	175507	195609	250046	275376	306288
		Phase Angle, F (º)	27.2	25.1	24.1	17.0	15.5	12.2	10.7	9.3
		Average Peak Stress (psi)	20	35	41	57	73	102	119	133
		Average Peak Strain (με)	28	27	32	33	38	41	43	43
	3	|E*| (Psi)	625698	900800	113265	146071	167613	213254	234923	261891
		Phase Angle, F (º)	27.2	27.9	21.7	17.2	15.1	11.6	10.7	9.7
		Average Peak Stress (psi)	20	35	41	57	73	102	119	134
		Average Peak Strain (με)	33	39	36	39	44	48	51	51
	Avg.	|E*| Average (psi)	670340	108151	119400	161296	181420	232342	255763	284090
		F Average	28.2	24.3	23.8	17.7	15.8	12.5	11.2	9.5
		|E*| Coeff. of Variation (psi)	0.089	0.177	0.075	0.091	0.077	0.079	0.079	0.111
		F Coeff. of Variation	0.06	0.16	0.08	0.06	0.06	0.09	0.08	0.03
		|E*| Std. Dev. (psi)	59417.8	191790.	89365.5	147441.	140021.	184345.	202540.	313937.
		F Std. Dev.	1.656	3.962	1.965	0.985	1.025	1.095	0.851	0.248
35	1	|E*| (psi)	55694	83832	99641	169984	214656	395518	504731	
		Phase Angle, F (º)	27.7	28.7	30.2	33.0	33.1	29.5	28.2	
		Average Peak Stress (psi)	2	3	4	5	8	16	20	
		Average Peak Strain (με)	44	39	41	31	37	40	39	
	2	|E*| (psi)	51000	75672	95837	168746	213659	414914	519311	693540
		Phase Angle, F (º)	29.0	31.1	33.0	34.0	33.1	29.1	27.8	26.4
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	48	43	43	32	37	38	38	51
	3	|E*| (Psi)	48575	75679	94852	164055	214371	401010	512099	681256
		Phase Angle, F (º)	28.9	31.0	31.4	34.2	33.0	28.8	27.3	25.3
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	50	43	43	32	37	40	38	53
	Avg.	|E*| Average (psi)	51756	78394	96777	167595	214229	403814	512047	687398
		F Average	28.5	30.3	31.5	33.7	33.1	29.1	27.8	25.8
		|E*| Coeff. of Variation (psi)	0.070	0.060	0.026	0.019	0.002	0.025	0.014	0.013
		F Coeff. of Variation	0.02	0.04	0.04	0.02	0.00	0.01	0.02	0.03
		|E*| Std. Dev. (psi)	3619.7	4709.2	2528.8	3127.4	513.2	9997.5	7289.9	8686.3
		F Std. Dev.	0.682	1.361	1.377	0.611	0.067	0.327	0.439	0.799
54.4	Est.	|E*| (psi)	16244	24076	29153	47427.3	59320	102252	129954	178541

Table B-2. S9.5AF–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2013906	264020	274782	312217	330368	373205	391831	414165
		Phase Angle, F (º)	11.1	12.8	9.5	6.5	5.9	4.4	3.7	3.3
		Average Peak Stress (psi)	204	229	237	254	262	270	279	301
		Average Peak Strain (με)	101	87	86	81	79	72	71	73
	2	|E*| (psi)	2153564		290237	333288	348480	388086	405692	428231
		Phase Angle, F (º)	12.4		7.3	8.4	7.7	5.8	4.9	4.7
		Average Peak Stress (psi)	172		213	230	238	263	271	294
		Average Peak Strain (με)	80		73	69	68	68	67	69
	3	|E*| (psi)	1969360	224836	271526	301147	319184	361750	380262	402532
		Phase Angle, F (º)	12.5	6.7	10.1	8.3	8.0	6.2	5.7	5.3
		Average Peak Stress (psi)	155	188	205	221	230	254	262	276
		Average Peak Strain (με)	79	84	75	74	72	70	69	69
	Avg.	|E*| Average (psi)	2045610	244428	278848	315550	332677	374347	392595	414976
		F Average	12.0	9.8	8.9	7.7	7.2	5.5	4.7	4.5
		|E*| Coeff. of Variation (psi)	0.047	0.113	0.036	0.052	0.044	0.035	0.032	0.031
		F Coeff. of Variation	0.06	0.44	0.16	0.14	0.16	0.17	0.21	0.23
		|E*| Std. Dev. (psi)	96107.0	277067.	99966.7	163277.	147840.	132048.	127323.	128688.
		F Std. Dev.	0.766	4.302	1.454	1.065	1.121	0.943	1.001	1.019
10	1	|E*| (psi)	354052	602799	695770	102626	121274	166035	187762	216345
		Phase Angle, F (º)	29.6	22.7	22.7	20.6	17.8	13.8	12.2	10.5
		Average Peak Stress (psi)	27	39	45	66	105	129	188	209
		Average Peak Strain (με)	75	64	65	64	86	78	100	97
	2	|E*| (psi)	400057	622394	785398	108674	126859	169878	192409	219629
		Phase Angle, F (º)	31.2	22.4	26.8	22.6	20.1	16.5	15.2	14.0
		Average Peak Stress (psi)	20	35	41	58	74	102	119	134
		Average Peak Strain (με)	51	56	52	53	58	60	62	61
	3	|E*| (psi)	354520	543085	689785	999784	116524	159195	179488	208128
		Phase Angle, F (º)	30.9	28.1	23.9	22.3	20.0	15.9	14.5	13.7
		Average Peak Stress (psi)	25	39	45	66	82	110	127	142
		Average Peak Strain (με)	69	72	65	66	70	69	71	68
	Avg.	|E*| Average (psi)	369543	589426	723651	103759	121552	165036	186553	214700
		F Average	30.6	24.4	24.5	21.8	19.3	15.4	14.0	12.7
		|E*| Coeff. of Variation (psi)	0.072	0.070	0.074	0.043	0.043	0.033	0.035	0.028
		F Coeff. of Variation	0.03	0.13	0.09	0.05	0.07	0.09	0.11	0.15
		|E*| Std. Dev. (psi)	26427.0	41310.9	53558.0	44574.5	51731.0	54107.1	65448.8	59243.4
		F Std. Dev.	0.895	3.200	2.146	1.080	1.316	1.408	1.582	1.956
35	1	|E*| (psi)	32053	46557	57000	93694	128358	252075	331846	464701
		Phase Angle, F (º)	22.1	26.9	29.3	34.2	32.7	30.2	28.2	27.0
		Average Peak Stress (psi)	2	2	2	4	7	11	15	24
		Average Peak Strain (με)	51	42	43	44	51	44	47	52
	2	|E*| (psi)	29916	45681	56727	94346	130826	260957	335106	470366
		Phase Angle, F (º)	23.5	27.2	28.4	34.2	32.5	29.7	28.1	26.6
		Average Peak Stress (psi)	2	3	4	5	8	16	20	35
		Average Peak Strain (με)	82	72	72	57	63	61	58	75
	3	|E*| (psi)	35712	49574	59822	97604	132334	255242	328857	455176
		Phase Angle, F (º)	23.1	27.2	29.0	34.6	32.6	30.0	29.0	27.3
		Average Peak Stress (psi)	2	3	4	5	8	16	20	35
		Average Peak Strain (με)	69	66	68	55	62	62	60	78
	Avg.	|E*| Average (psi)	32560	47271	57850	95215	130506	256091	331936	463414
		F Average	22.9	27.1	28.9	34.3	32.6	30.0	28.4	27.0
		|E*| Coeff. of Variation (psi)	0.090	0.043	0.030	0.022	0.015	0.018	0.009	0.017
		F Coeff. of Variation	0.03	0.01	0.02	0.01	0.00	0.01	0.02	0.01
		|E*| Std. Dev. (psi)	2931.4	2042.0	1713.7	2094.7	2006.9	4501.1	3125.5	7676.2
		F Std. Dev.	0.735	0.180	0.437	0.248	0.068	0.267	0.503	0.363
54.4	Est.	|E*| (psi)	10008	13634	15809	23786	28863	47717	60336	82962

Table B-3. S9.5AF–Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2026959	247100	243105	279348	292900	319382	331628	345874
		Phase Angle, F (º)	8.3	7.7	6.5	5.5	4.8	3.5	3.0	2.8
		Average Peak Stress (psi)	157	183	190	203	210	229	236	254
		Average Peak Strain (με)	77	74	78	73	72	72	71	74
	2	|E*| (psi)	2204462	258782	265759	308629	323797	351053	365208	381752
		Phase Angle, F (º)	8.4	10.9	6.6	5.3	5.0	3.9	3.2	3.3
		Average Peak Stress (psi)	157	183	190	203	209	229	236	254
		Average Peak Strain (με)	71	71	71	66	65	65	65	67
	3	|E*| (psi)	2159136	269164	253945	295584	310113	340237	352748	368362
		Phase Angle, F (º)	7.9	9.8	5.6	4.7	4.6	3.0	2.5	2.3
		Average Peak Stress (psi)	157	183	190	203	210	229	236	255
		Average Peak Strain (με)	73	68	75	69	68	67	67	69
	Avg.	|E*| Average (psi)	2130186	258349	254270	294520	308937	336891	349861	365329
		F Average	8.2	9.5	6.3	5.2	4.8	3.5	2.9	2.8
		|E*| Coeff. of Variation (psi)	0.043	0.043	0.045	0.050	0.050	0.048	0.049	0.050
		F Coeff. of Variation	0.03	0.17	0.09	0.08	0.04	0.12	0.12	0.18
		|E*| Std. Dev. (psi)	92225.2	110382.	113301.	146695.	154820.	160983.	169750.	181306.
		F Std. Dev.	0.249	1.627	0.546	0.390	0.186	0.436	0.340	0.491
10	1	|E*| (psi)	469836	676663	798718	110669	125413	161779	178177	200235
		Phase Angle, F (º)	25.3	20.7	19.3	16.4	14.8	11.2	10.0	9.5
		Average Peak Stress (psi)	31	43	52	68	80	110	126	137
		Average Peak Strain (με)	65	64	65	61	64	68	71	69
	2	|E*| (psi)	495535	736239	869190	116493	133680	171322	188629	214044
		Phase Angle, F (º)	26.2	24.6	20.0	17.2	15.8	12.7	10.7	10.2
		Average Peak Stress (psi)	33	46	56	72	85	118	134	146
		Average Peak Strain (με)	66	62	64	62	64	69	71	68
	3	|E*| (psi)	561970	823769	911186	124676	139649	176831	195589	217578
		Phase Angle, F (º)	24.2	17.7	18.2	15.3	14.0	10.6	9.5	8.5
		Average Peak Stress (psi)	33	46	56	72	85	118	134	147
		Average Peak Strain (με)	58	56	61	58	61	67	69	67
	Avg.	|E*| Average (psi)	509114	745557	859698	117279	132914	169977	187465	210619
		F Average	25.2	21.0	19.2	16.3	14.9	11.5	10.1	9.4
		|E*| Coeff. of Variation (psi)	0.093	0.099	0.066	0.060	0.054	0.045	0.047	0.044
		F Coeff. of Variation	0.04	0.16	0.05	0.06	0.06	0.09	0.06	0.09
		|E*| Std. Dev. (psi)	47544.3	73994.3	56832.1	70368.9	71487.8	76154.1	87640.3	91648.1
		F Std. Dev.	0.968	3.445	0.894	0.946	0.901	1.069	0.595	0.846
35	1	|E*| (psi)	44455	66473	82370	138537	179369	328663		535991
		Phase Angle, F (º)	27.5	29.3	30.7	32.2	31.6	28.3		25.0
		Average Peak Stress (psi)	2	3	4	7	11	15		41
		Average Peak Strain (με)	35	46	48	51	59	45		76
	2	|E*| (psi)	52200	69266	85362	137097	177832	323056	413596	526553
		Phase Angle, F (º)	22.6	28.4	29.9	31.9	31.8	28.0	24.8	25.1
		Average Peak Stress (psi)	2	3	4	7	11	16	25	44
		Average Peak Strain (με)	32	47	50	55	63	48	61	83
	3	|E*| (psi)	50525	75836	95011	160499	211105	380266	482241	623970
		Phase Angle, F (º)	27.3	29.6	29.6	30.9	30.8	26.3	23.7	22.9
		Average Peak Stress (psi)	2	3	4	8	11	16	25	44
		Average Peak Strain (με)	33	43	45	47	53	41	52	71
	Avg.	|E*| Average (psi)	49060	70525	87581	145377	189435	343995	447918	562171
		F Average	25.8	29.1	30.1	31.7	31.4	27.5	24.3	24.3
		|E*| Coeff. of Variation (psi)	0.083	0.068	0.075	0.090	0.099	0.092	0.108	0.096
		F Coeff. of Variation	0.11	0.02	0.02	0.02	0.02	0.04	0.03	0.05
		|E*| Std. Dev. (psi)	4075.2	4806.7	6606.5	13115.1	18781.9	31536.7	48539.1	53726.8
		F Std. Dev.	2.759	0.600	0.573	0.686	0.536	1.048	0.766	1.257
54.4	1	|E*| (psi)		32276	28790	36328	43583	77488		151273
		Phase Angle, F (º)		19.7	19.9	25.2	26.4	27.3		30.6
		Average Peak Stress (psi)		1	2	3	4	6		12
		Average Peak Strain (με)		29	54	85	91	83		79
	2	|E*| (psi)	21584	22462	24516	33863	41079	74812		146530
		Phase Angle, F (º)	14.1	16.9	18.9	23.7	25.7	26.4		28.9
		Average Peak Stress (psi)	1	1	2	3	4	7		13
		Average Peak Strain (με)	28	44	68	97	103	92		86
	3	|E*| (psi)	22848	23351	26716	37867	47089	87296	117617	173366
		Phase Angle, F (º)	16.3	18.2	19.3	23.5	25.0	25.3	24.8	26.7
		Average Peak Stress (psi)	1	1	2	4	5	9	13	17
		Average Peak Strain (με)	36	53	78	109	112	100	108	97
	Avg.	|E*| Average (psi)	22216	26030	26674	36019	43917	79865	117617	157056
		F Average	15.2	18.3	19.4	24.1	25.7	26.3	24.8	28.7
		|E*| Coeff. of Variation (psi)	0.040	0.209	0.080	0.056	0.069	0.082	0.000	0.091
		F Coeff. of Variation	0.10	0.08	0.03	0.04	0.03	0.04	0.00	0.07
		|E*| Std. Dev. (psi)	893.8	5427.3	2137.6	2019.8	3018.5	6573.0	0.0	14322.6
		F Std. Dev.	1.517	1.429	0.485	0.968	0.673	1.030	0.000	1.960

Table B-4. S9.5BC–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2424668		335181	375453	395276	437225	458737	480433
		Phase Angle, F (º)	10.2		6.7	5.7	5.1	4.0	2.1	2.1
		Average Peak Stress (psi)	180		225	242	246	270	278	301
		Average Peak Strain (με)	74		67	64	62	62	61	63
	2	|E*| (psi)	2019493	263980	261677	314676	334731	376450	396027	415589
		Phase Angle, F (º)	13.6	9.6	11.8	9.4	8.8	7.4	6.8	6.1
		Average Peak Stress (psi)	180	212	225	242	246	270	278	301
		Average Peak Strain (με)	89	80	86	77	73	72	70	72
	3	|E*| (psi)	2051064	269566	274540	316309	336595	380673	396863	418805
		Phase Angle, F (º)	10.7	6.6	5.8	6.6	5.6	3.7	3.4	3.1
		Average Peak Stress (psi)	180	213	225	242	246	270	278	301
		Average Peak Strain (με)	88	79	82	76	73	71	70	72
	Avg.	|E*| Average (psi)	2165075	266773	290466	335479	355534	398116	417209	438275
		F Average	11.5	8.1	8.1	7.3	6.5	5.0	4.1	3.8
		|E*| Coeff. of Variation (psi)	0.104	0.015	0.135	0.103	0.097	0.085	0.086	0.083
		F Coeff. of Variation	0.16	0.26	0.40	0.27	0.31	0.40	0.59	0.55
		|E*| Std. Dev. (psi)	225368.0	39496.3	392547.	346278.	344300.	339352.	359665.	365445.
		F Std. Dev.	1.817	2.088	3.222	1.925	2.031	2.038	2.407	2.063
10	1	|E*| (psi)	342121	607367	735468	114711	134476	187480	212080	248710
		Phase Angle, F (º)	31.1	29.2	24.7	21.2	19.3	14.3	12.8	12.1
		Average Peak Stress (psi)	37	57	74	90	106	147	167	183
		Average Peak Strain (με)	108	94	100	79	79	78	79	74
	2	|E*| (psi)	377891	656140	773584	111307	129731	179846	203672	231968
		Phase Angle, F (º)	33.8	27.0	27.6	22.6	20.6	16.4	15.0	13.6
		Average Peak Stress (psi)	25	45	61	90	106	147	167	183
		Average Peak Strain (με)	65	69	79	81	82	82	82	79
	3	|E*| (psi)	339011	610848	712578	106944	125167	173047	194828	224084
		Phase Angle, F (º)	30.8	25.9	23.2	20.0	18.0	13.9	12.4	11.3
		Average Peak Stress (psi)	25	45	61	90	106	147	168	183
		Average Peak Strain (με)	73	74	86	84	85	85	86	82
	Avg.	|E*| Average (psi)	353008	624785	740543	110987	129792	180125	203527	234921
		F Average	31.9	27.4	25.2	21.3	19.3	14.9	13.4	12.3
		|E*| Coeff. of Variation (psi)	0.061	0.044	0.042	0.035	0.036	0.040	0.042	0.054
		F Coeff. of Variation	0.05	0.06	0.09	0.06	0.07	0.09	0.10	0.10
		|E*| Std. Dev. (psi)	21605.4	27210.0	30818.1	38932.4	46551.1	72208.0	86268.7	125756.
		F Std. Dev.	1.634	1.663	2.247	1.287	1.295	1.362	1.378	1.175
35	1	|E*| (psi)		47572	59610	110664	154755	311686	408281	575219
		Phase Angle, F (º)		30.5	31.7	34.7	33.0	30.8	28.9	27.3
		Average Peak Stress (psi)		3	4	7	14	24	32	52
		Average Peak Strain (με)		70	69	67	91	77	77	90
	2	|E*| (psi)	34320	53387	65869	117576	156868	321433	413742	577491
		Phase Angle, F (º)	27.3	31.7	33.4	37.1	36.2	32.4	30.8	29.0
		Average Peak Stress (psi)	2	3	4	7	10	20	27	43
		Average Peak Strain (με)	56	61	62	56	64	62	66	75
	3	|E*| (psi)	26057	40702	52822	98753	134484	275425	365187	515851
		Phase Angle, F (º)	24.3	28.2	29.7	33.4	33.1	29.1	28.5	27.2
		Average Peak Stress (psi)	2	3	4	7	10	20	27	43
		Average Peak Strain (με)	81	79	77	66	75	71	75	84
	Avg.	|E*| Average (psi)	30189	47221	59434	108998	148702	302848	395737	556187
		F Average	25.8	30.1	31.6	35.1	34.1	30.8	29.4	27.8
		|E*| Coeff. of Variation (psi)	0.194	0.134	0.110	0.087	0.083	0.080	0.067	0.063
		F Coeff. of Variation	0.08	0.06	0.06	0.05	0.05	0.05	0.04	0.04
		|E*| Std. Dev. (psi)	5843.1	6349.8	6525.2	9521.0	12358.6	24243.7	26597.4	34950.8
		F Std. Dev.	2.096	1.746	1.887	1.864	1.798	1.684	1.261	0.979
54.4	Est.	|E*| (psi)	7542	10443	12183	18565	22916	39305	50618	71649

Table B-5. S9.5B0F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2078305	236462	267185	292869	307849	339048	352255	368036
		Phase Angle, F (º)	8.8	11.5	4.7	5.1	4.9	3.4	3.1	2.8
		Average Peak Stress (psi)	176	209	217	237	245	270	279	302
		Average Peak Strain (με)	85	88	81	81	80	80	79	82
	2	|E*| (psi)	1930854	219439	232802	273760	287023	319941	334193	350408
		Phase Angle, F (º)	9.5	12.6	8.9	5.6	6.1	4.6	4.3	3.6
		Average Peak Stress (psi)	176	209	217	237	245	270	279	302
		Average Peak Strain (με)	91	95	93	87	85	84	83	86
	3	|E*| (psi)	2113188	231496	257196	299436	313775	346364	359164	377390
		Phase Angle, F (º)	8.0	8.4	4.1	4.3	4.0	2.7	2.2	2.2
		Average Peak Stress (psi)	176	209	217	237	245	270	278	301
		Average Peak Strain (με)	83	90	84	79	78	78	77	80
	Avg.	|E*| Average (psi)	2040782	229132	252394	288688	302882	335118	348537	365278
		F Average	8.8	10.8	5.9	5.0	5.0	3.6	3.2	2.9
		|E*| Coeff. of Variation (psi)	0.047	0.038	0.070	0.046	0.046	0.041	0.037	0.038
		F Coeff. of Variation	0.09	0.20	0.44	0.14	0.20	0.26	0.33	0.25
		|E*| Std. Dev. (psi)	96785.0	87540.4	176871.	133384.	140504.	136430.	128938.	137006.
		F Std. Dev.	0.753	2.181	2.623	0.695	1.022	0.938	1.055	0.714
10	1	|E*| (psi)	456905	681548	816434	111078	125753	163341	180328	203091
		Phase Angle, F (º)	26.7	26.8	18.0	17.2	15.5	12.4	11.1	10.5
		Average Peak Stress (psi)	20	35	41	57	73	102	119	134
		Average Peak Strain (με)	45	51	50	52	58	62	66	66
	2	|E*| (psi)	478544	658144	812907	112424	125933	161875	179111	201672
		Phase Angle, F (º)	28.0	24.7	18.9	17.9	16.3	13.2	11.6	11.1
		Average Peak Stress (psi)	20	35	41	57	73	102	119	134
		Average Peak Strain (με)	43	53	50	51	58	63	66	66
	3	|E*| (psi)	476812	758076	856390	113523	128577			
		Phase Angle, F (º)	26.2	24.2	19.4	16.0	14.7			
		Average Peak Stress (psi)	20	35	41	57	73			
		Average Peak Strain (με)	43	46	48	50	57			
	Avg.	|E*| Average (psi)	470753	699256	828577	112342	126754	162608	179720	202382
		F Average	27.0	25.2	18.8	17.0	15.5	12.8	11.4	10.8
		|E*| Coeff. of Variation (psi)	0.026	0.075	0.029	0.011	0.012	0.006	0.005	0.005
		F Coeff. of Variation	0.03	0.05	0.04	0.06	0.05	0.05	0.03	0.04
		|E*| Std. Dev. (psi)	12024.7	52266.5	24151.4	12250.4	15811.6	10366.4	8606.3	10034.6
		F Std. Dev.	0.911	1.379	0.710	0.966	0.804	0.597	0.333	0.472
35	1	|E*| (psi)	31908	50038	64542	112839	147793	279633	356938	476304
		Phase Angle, F (º)	31.1	33.4	33.7	34.1	33.5	29.4	27.9	26.2
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	77	65	63	47	54	56	55	75
	2	|E*| (psi)	37845	60388	75520	129270	167292	305228	385503	503828
		Phase Angle, F (º)	31.5	31.8	33.3	34.5	33.3	29.5	27.5	25.9
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	65	54	54	41	48	52	51	71
	3	|E*| (psi)	35314	57052	70881	122104	156351	285160	357817	469854
		Phase Angle, F (º)	29.8	30.5	31.6	32.5	32.0	27.9	26.4	25.3
		Average Peak Stress (psi)	2	3	4	5	8	16	20	35
		Average Peak Strain (με)	69	57	58	43	51	55	55	75
	Avg.	|E*| Average (psi)	35023	55826	70314	121404	157145	290007	366752	483328
		F Average	30.8	31.9	32.9	33.7	32.9	28.9	27.3	25.8
		|E*| Coeff. of Variation (psi)	0.085	0.095	0.078	0.068	0.062	0.046	0.044	0.037
		F Coeff. of Variation	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.02
		|E*| Std. Dev. (psi)	2979.3	5282.8	5510.9	8237.6	9773.4	13468.4	16244.1	18043.6
		F Std. Dev.	0.900	1.433	1.093	1.081	0.838	0.918	0.765	0.433
54.4	Est.	|E*| (psi)	9137	14649	18275	31183	39740	70198	89923	124007

Table B-6. S9.5B1F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2384552	288041	310805	353497	374230	420448	439468	462488
		Phase Angle, F (º)	14.5	7.4	14.9	11.1	11.1	10.0	9.3	9.0
		Average Peak Stress (psi)	176	209	217	238	245	270	279	302
		Average Peak Strain (με)	74	72	70	67	66	64	63	65
	2	|E*| (psi)	2277720	250927	301262	331884	350546	391821	408103	428023
		Phase Angle, F (º)	9.7	10.4	10.0	6.7	5.7	4.6	4.2	4.1
		Average Peak Stress (psi)	176	209	217	238	245	270	279	302
		Average Peak Strain (με)	77	83	72	72	70	69	68	70
	3	|E*| (psi)	2345731	284712	309010	345862	359683	402967		
		Phase Angle, F (º)	10.0	13.9	8.0	6.4	6.6	5.0		
		Average Peak Stress (psi)	176	209	217	238	245	270		
		Average Peak Strain (με)	75	73	70	69	68	67		
	Avg.	|E*| Average (psi)	2336001	274560	307025	343748	361486	405079	423785	445255
		F Average	11.4	10.6	11.0	8.1	7.8	6.6	6.8	6.6
		|E*| Coeff. of Variation (psi)	0.023	0.075	0.017	0.032	0.033	0.036	0.052	0.055
		F Coeff. of Variation	0.23	0.31	0.32	0.33	0.37	0.46	0.54	0.54
		|E*| Std. Dev. (psi)	54076.9	205341.	50716.2	109604.	119445.	144300.	221782.	243709.
		F Std. Dev.	2.678	3.263	3.550	2.643	2.866	3.012	3.630	3.510
10	1	|E*| (psi)	514888	729909	947362	128189	145698	198347	224105	251773
		Phase Angle, F (º)	36.3	28.0	28.1	26.0	24.1	20.9	19.0	17.8
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	40	48	43	45	50	51	53	53
	2	|E*| (psi)	460664	680067	809657	118716	135221	180425	201481	227899
		Phase Angle, F (º)	28.3	20.7	22.9	19.3	17.4	14.4	12.9	12.4
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	44	51	51	48	54	57	59	58
	3	|E*| (psi)	473687	678400	866128	123407	140331	187505	209627	238407
		Phase Angle, F (º)	27.8	25.9	24.9	19.6	18.0	14.6	13.4	12.4
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	43	51	47	46	52	54	57	56
	Avg.	|E*| Average (psi)	483080	696125	874382	123438	140416	188759	211738	239360
		F Average	30.8	24.9	25.3	21.6	19.8	16.6	15.1	14.2
		|E*| Coeff. of Variation (psi)	0.059	0.042	0.079	0.038	0.037	0.048	0.054	0.050
		F Coeff. of Variation	0.16	0.15	0.10	0.18	0.19	0.22	0.23	0.22
		|E*| Std. Dev. (psi)	28305.6	29269.5	69222.5	47364.5	52391.5	90263.3	114587.	119654.
		F Std. Dev.	4.778	3.799	2.607	3.782	3.687	3.678	3.415	3.139
35	1	|E*| (psi)	45262	65667	81058	136043	175711	329336	419243	564166
		Phase Angle, F (º)	27.7	30.4	31.4	35.2	34.1	30.8	29.1	27.3
		Average Peak Stress (psi)	2	3	4	5	8	16	20	35
		Average Peak Strain (με)	54	50	50	39	46	48	47	62
	2	|E*| (psi)	38612	58227	70995	121837	160278	305829	393392	539560
		Phase Angle, F (º)	23.7	28.4	28.2	32.2	31.6	28.7	27.2	25.5
		Average Peak Stress (psi)	2	3	4	5	8	16	20	35
		Average Peak Strain (με)	63	56	58	43	50	52	50	65
	3	|E*| (psi)	39026	60941	76234	131428	172468	329138	425458	575914
		Phase Angle, F (º)	25.1	27.7	29.7	33.0	32.8	29.3	27.2	25.2
		Average Peak Stress (psi)	2	3	4	5	8	16	20	35
		Average Peak Strain (με)	63	54	54	40	47	48	46	61
	Avg.	|E*| Average (psi)	40967	61612	76096	129769	169486	321434	412698	559880
		F Average	25.5	28.8	29.8	33.5	32.8	29.6	27.8	26.0
		|E*| Coeff. of Variation (psi)	0.091	0.061	0.066	0.056	0.048	0.042	0.041	0.033
		F Coeff. of Variation	0.08	0.05	0.06	0.05	0.04	0.04	0.04	0.04
		|E*| Std. Dev. (psi)	3725.3	3765.1	5032.9	7246.4	8137.1	13515.0	17005.3	18551.8
		F Std. Dev.	2.020	1.408	1.640	1.532	1.224	1.108	1.089	1.131
54.4	1	|E*| (psi)		35625	30567	36879	42748	68540	89592	132975
		Phase Angle, F (º)		17.6	12.6	19.5	21.6	27.2	29.2	32.2
		Average Peak Stress (psi)		1	1	2	2	3	3	4
		Average Peak Strain (με)		23	41	44	56	43	38	28
	2	|E*| (psi)		25130	27464	32482	38049	60886	79984	118136
		Phase Angle, F (º)		16.6	15.2	20.4	21.7	27.0	28.6	31.2
		Average Peak Stress (psi)		1	1	2	2	3	3	4
		Average Peak Strain (με)		32	45	50	63	48	42	32
	3	|E*| (psi)		20778	23141	30363	37093	63962	84202	128874
		Phase Angle, F (º)		13.3	14.8	21.1	23.2	27.0	29.0	31.7
		Average Peak Stress (psi)		1	1	2	2	3	3	4
		Average Peak Strain (με)		39	53	54	65	46	40	29
	Avg.	|E*| Average (psi)		27178	27057	33241	39297	64463	84593	126662
		F Average		15.8	14.2	20.3	22.2	27.1	28.9	31.7
		|E*| Coeff. of Variation (psi)		0.281	0.138	0.100	0.077	0.060	0.057	0.060
		F Coeff. of Variation		0.14	0.10	0.04	0.04	0.00	0.01	0.02
		|E*| Std. Dev. (psi)		7632.8	3729.6	3323.8	3026.8	3851.3	4815.7	7662.9
		F Std. Dev.		2.261	1.371	0.783	0.869	0.124	0.322	0.507

Table B-7. S9.5B2F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2348201	259502	281777	323089	336085	373293	386945	
		Phase Angle, F (º)	11.0	5.5	7.0	7.2	7.4	6.1	5.7	
		Average Peak Stress (psi)	176	209	217	238	246	270	279	
		Average Peak Strain (με)	75	81	77	74	73	72	72	
	2	|E*| (psi)	2303039	290454	291732	318338	329822	365066	378058	394856
		Phase Angle, F (º)	10.7	9.3	9.0	7.3	6.9	5.9	5.3	4.9
		Average Peak Stress (psi)	176	209	217	238	246	270	279	302
		Average Peak Strain (με)	76	72	74	75	74	74	74	76
	3	|E*| (psi)	2236568	274315	278001	310131	321673	355209	367646	385633
		Phase Angle, F (º)	9.5	4.9	6.0	6.0	5.9	4.4	4.0	3.8
		Average Peak Stress (psi)	176	209	217	238	246	270	279	301
		Average Peak Strain (με)	79	76	78	77	76	76	76	78
	Avg.	|E*| Average (psi)	2295936	274757	283837	317186	329193	364523	377550	390245
		F Average	10.4	6.6	7.3	6.8	6.7	5.5	5.0	4.4
		|E*| Coeff. of Variation (psi)	0.024	0.056	0.025	0.021	0.022	0.025	0.026	0.017
		F Coeff. of Variation	0.08	0.36	0.21	0.11	0.12	0.17	0.18	0.16
		|E*| Std. Dev. (psi)	56154.4	154809.	70935.9	65553.4	72267.1	90540.6	96592.7	65214.7
		F Std. Dev.	0.814	2.374	1.510	0.746	0.776	0.932	0.919	0.714
10	1	|E*| (psi)	782745	115260	122320	149389	161237	198049	216690	242554
		Phase Angle, F (º)	29.7	24.5	23.3	18.7	17.5	14.4	12.9	11.3
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	26	30	33	38	46	51	55	55
	2	|E*| (psi)	698515	881709	113022	142132	155381	193958	210921	235365
		Phase Angle, F (º)	28.8	21.8	24.0	19.4	17.4	14.6	13.3	12.3
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	29	40	36	40	47	53	56	57
	3	|E*| (psi)	679431	896492	103694	137569	151461	189608	207939	233347
		Phase Angle, F (º)	26.7	25.9	18.6	17.7	16.0	13.2	12.5	11.9
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	30	39	40	42	49	54	57	57
	Avg.	|E*| Average (psi)	720230	976934	113012	143030	156026	193872	211850	237088
		F Average	28.4	24.1	21.9	18.6	17.0	14.1	12.9	11.8
		|E*| Coeff. of Variation (psi)	0.076	0.156	0.082	0.042	0.032	0.022	0.021	0.020
		F Coeff. of Variation	0.05	0.09	0.13	0.05	0.05	0.05	0.03	0.04
		|E*| Std. Dev. (psi)	54974.1	152312.	93133.7	59607.9	49202.0	42214.3	44489.8	48393.4
		F Std. Dev.	1.558	2.096	2.947	0.859	0.845	0.740	0.438	0.492
35	1	|E*| (psi)	68972	104955	131093	214721	268484	460092	559206	695509
		Phase Angle, F (º)	36.3	35.2	35.5	35.3	33.6	27.9	26.3	23.7
		Average Peak Stress (psi)	2	3	4	5	8	16	20	35
		Average Peak Strain (με)	36	31	31	25	30	34	35	51
	2	|E*| (psi)	65377	103646	124107	205037	251724	437132	545682	675596
		Phase Angle, F (º)	34.8	35.1	36.3	37.6	35.7	30.3	28.9	25.7
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	38	32	33	26	32	36	36	53
	3	|E*| (psi)	76299	114776	135121	220732	265266	440782	544693	677311
		Phase Angle, F (º)	34.7	34.2	34.7	35.7	33.5	28.6	26.6	24.0
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	32	29	30	24	30	36	36	52
	Avg.	|E*| Average (psi)	70216	107792	130107	213497	261824	446002	549861	682805
		F Average	35.3	34.8	35.5	36.2	34.3	28.9	27.3	24.5
		|E*| Coeff. of Variation (psi)	0.079	0.056	0.043	0.037	0.034	0.028	0.015	0.016
		F Coeff. of Variation	0.02	0.02	0.02	0.03	0.04	0.04	0.05	0.04
		|E*| Std. Dev. (psi)	5566.2	6083.6	5573.0	7918.8	8894.3	12337.8	8108.6	11035.2
		F Std. Dev.	0.879	0.548	0.827	1.251	1.260	1.236	1.427	1.072
54.4	1	|E*| (psi)		31752	35983	50548	61586	108392	141104	198550
		Phase Angle, F (º)		22.5	25.0	29.0	29.9	31.0	31.2	32.6
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		26	35	32	39	28	25	20
	2	|E*| (psi)		36981	37073	48642	57280	101033	130044	192597
		Phase Angle, F (º)		33.5	26.4	30.5	31.3	32.7	33.0	35.8
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		22	34	34	42	30	28	22
	3	|E*| (psi)		48512	43107	57662	67739	112703	142388	195076
		Phase Angle, F (º)		23.5	21.6	26.3	28.5	29.3	30.0	32.7
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		17	29	28	36	27	25	21
	Avg.	|E*| Average (psi)		39082	38721	52284	62202	107376	137845	195408
		F Average		26.5	24.3	28.6	29.9	31.0	31.4	33.7
		|E*| Coeff. of Variation (psi)		0.219	0.099	0.091	0.085	0.055	0.049	0.015
		F Coeff. of Variation		0.23	0.10	0.07	0.05	0.06	0.05	0.05
		|E*| Std. Dev. (psi)		8575.1	3837.6	4754.0	5256.5	5900.7	6786.7	2990.4
		F Std. Dev.		6.057	2.464	2.091	1.374	1.717	1.510	1.841

Table B-8. S9.5B3F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2454685	285788	297176	346570	363676	399537	414347	
		Phase Angle, F (º)	8.0	11.2	4.2	4.6	3.7	2.6	1.9	
		Average Peak Stress (psi)	180	217	229	237	245	270	278	
		Average Peak Strain (με)	73	76	77	69	67	67	67	
	2	|E*| (psi)	2268863	249289	289700	321684	338160	373950	388217	
		Phase Angle, F (º)	8.1	6.5	6.7	4.7	4.7	3.1	2.2	
		Average Peak Stress (psi)	180	217	229	237	245	270	278	
		Average Peak Strain (με)	79	87	79	74	73	72	72	
	3	|E*| (psi)	2461874	311845	307699	341265	356232	390086	404943	
		Phase Angle, F (º)	9.8	5.3	9.3	6.3	6.0	4.2	3.6	
		Average Peak Stress (psi)	180	217	229	237	245	270	278	
		Average Peak Strain (με)	73	69	74	70	69	69	69	
	Avg.	|E*| Average (psi)	2395141	282307	298192	336506	352689	387857	402502	
		F Average	8.6	7.7	6.7	5.2	4.8	3.3	2.6	
		|E*| Coeff. of Variation (psi)	0.046	0.111	0.030	0.039	0.037	0.033	0.033	
		F Coeff. of Variation	0.12	0.41	0.38	0.19	0.24	0.25	0.35	
		|E*| Std. Dev. (psi)	109418.4	314230.	90426.6	131079.	131213.	129385.	132350.	
		F Std. Dev.	1.028	3.138	2.529	0.997	1.146	0.818	0.922	
10	1	|E*| (psi)	561560	839793	955852	134178	151506	194968	214814	
		Phase Angle, F (º)	24.3	23.8	19.2	16.4	14.8	11.5	10.1	
		Average Peak Stress (psi)	45	57	70	90	106	147	167	
		Average Peak Strain (με)	80	68	73	67	70	75	78	
	2	|E*| (psi)	578952	881038	995305	131268	148559	188851	207546	233329
		Phase Angle, F (º)	23.6	18.2	17.6	15.1	13.9	10.8	9.6	8.5
		Average Peak Stress (psi)	45	57	70	90	106	147	167	183
		Average Peak Strain (με)	78	65	70	69	72	78	81	79
	3	|E*| (psi)	644879	908716	103278	140861	156594	197749	217476	243185
		Phase Angle, F (º)	24.4	24.5	18.8	16.1	14.9	11.8	10.6	10.0
		Average Peak Stress (psi)	45	57	70	90	106	147	167	183
		Average Peak Strain (με)	70	63	67	64	68	74	77	75
	Avg.	|E*| Average (psi)	595130	876516	994648	135436	152220	193856	213279	238257
		F Average	24.1	22.2	18.5	15.9	14.5	11.4	10.1	9.3
		|E*| Coeff. of Variation (psi)	0.074	0.040	0.039	0.036	0.027	0.023	0.024	0.029
		F Coeff. of Variation	0.02	0.16	0.05	0.04	0.04	0.04	0.05	0.11
		|E*| Std. Dev. (psi)	43952.3	34683.6	38471.4	49187.5	40649.5	45521.4	51399.0	69689.6
		F Std. Dev.	0.434	3.461	0.862	0.680	0.555	0.500	0.496	1.031
35	1	|E*| (psi)	44172	71861	90878	159147	208974	381142	478448	628357
		Phase Angle, F (º)	26.4	29.0	29.8	31.0	29.9	25.9	23.9	22.6
		Average Peak Stress (psi)	4	5	6	11	16	24	36	56
		Average Peak Strain (με)	83	68	68	71	77	63	75	90
	2	|E*| (psi)	49316	79791	99131	169564	217292	387191	479999	626181
		Phase Angle, F (º)	29.3	29.4	30.7	31.8	30.4	26.3	24.3	22.4
		Average Peak Stress (psi)	3	5	6	11	16	24	36	56
		Average Peak Strain (με)	58	61	62	67	74	62	75	90
	3	|E*| (psi)	57795	89233	110029	184467	236817	416185	523433	667767
		Phase Angle, F (º)	29.4	30.1	30.7	31.3	30.5	26.4	24.1	22.9
		Average Peak Stress (psi)	3	5	6	11	16	24	36	57
		Average Peak Strain (με)	50	55	56	61	68	58	69	85
	Avg.	|E*| Average (psi)	50428	80295	100013	171059	221028	394839	493960	640768
		F Average	28.4	29.5	30.4	31.4	30.3	26.2	24.1	22.6
		|E*| Coeff. of Variation (psi)	0.136	0.108	0.096	0.074	0.065	0.047	0.052	0.037
		F Coeff. of Variation	0.06	0.02	0.02	0.01	0.01	0.01	0.01	0.01
		|E*| Std. Dev. (psi)	6879.0	8697.0	9605.9	12726.0	14292.4	18731.5	25535.8	23406.9
		F Std. Dev.	1.706	0.557	0.490	0.389	0.312	0.259	0.232	0.252
54.4	1	|E*| (psi)		23486	24667	34189	41664	71366	95732	140159
		Phase Angle, F (º)		14.1	19.0	23.8	25.5	28.5	29.1	33.0
		Average Peak Stress (psi)		1	1	2	2	3	3	4
		Average Peak Strain (με)		34	50	48	58	42	36	28
	2	|E*| (psi)		26618	26924	38308	46347	82869	107161	156249
		Phase Angle, F (º)		18.4	20.7	24.9	27.0	29.8	30.2	32.9
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		30	46	43	52	36	33	26
	3	|E*| (psi)		31422	31433	42866	51059	88002	115032	165098
		Phase Angle, F (º)		25.4	22.1	24.8	26.0	29.6	30.2	34.0
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		26	39	38	47	34	31	25
	Avg.	|E*| Average (psi)		27175	27675	38454	46357	80746	105975	153835
		F Average		19.3	20.6	24.5	26.1	29.3	29.8	33.3
		|E*| Coeff. of Variation (psi)		0.147	0.124	0.113	0.101	0.106	0.092	0.082
		F Coeff. of Variation		0.30	0.08	0.03	0.03	0.02	0.02	0.02
		|E*| Std. Dev. (psi)		3996.9	3445.0	4340.4	4697.9	8519.0	9704.7	12643.4
		F Std. Dev.		5.699	1.549	0.643	0.763	0.712	0.667	0.601

Table B-9. S9.5B4F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2419727	266343	326756	358543	375742	413935	427828	
		Phase Angle, F (º)	13.5	9.8	10.6	9.3	9.1	7.3	6.6	
		Average Peak Stress (psi)	197	229	238	254	262	286	295	
		Average Peak Strain (με)	81	86	73	71	70	69	69	
	2	|E*| (psi)	2482624	317922	326830	358715	377503	417640	434348	453323
		Phase Angle, F (º)	10.0	12.6	9.6	6.1	5.6	4.3	3.6	2.5
		Average Peak Stress (psi)	197	229	238	254	262	286	295	319
		Average Peak Strain (με)	79	72	73	71	69	69	68	70
	3	|E*| (psi)	2322255	254607	289044	333980	349028	383396	397279	
		Phase Angle, F (º)	9.5	7.2	8.4	6.1	5.2	3.6	2.8	
		Average Peak Stress (psi)	197	229	238	254	262	287	295	
		Average Peak Strain (με)	85	90	82	76	75	75	74	
	Avg.	|E*| Average (psi)	2408202	279624	314210	350412	367424	404990	419818	453323
		F Average	11.0	9.9	9.5	7.2	6.7	5.1	4.3	2.5
		|E*| Coeff. of Variation (psi)	0.034	0.120	0.069	0.041	0.043	0.046	0.047	
		F Coeff. of Variation	0.20	0.27	0.12	0.26	0.33	0.39	0.46	
		|E*| Std. Dev. (psi)	80803.4	336820.	217945.	142313.	159560.	187924.	197898.	
		F Std. Dev.	2.164	2.683	1.099	1.842	2.175	1.966	1.982	
10	1	|E*| (psi)	513886	844793	959275	134153	154171	202262	221862	250935
		Phase Angle, F (º)	32.8	30.0	27.2	22.0	20.7	16.6	14.8	
		Average Peak Stress (psi)	41	57	70	90	107	147	168	183
		Average Peak Strain (με)	80	68	73	67	69	73	76	73
	2	|E*| (psi)	510871	760986	971694	135503	153800	201343	223855	254170
		Phase Angle, F (º)	28.2	23.5	21.4	18.3	16.9	12.9	11.5	10.6
		Average Peak Stress (psi)	41	57	70	90	107	147	168	184
		Average Peak Strain (με)	80	75	72	67	69	73	75	72
	3	|E*| (psi)	489451	737471	875820	124324	141887	184923	204885	231999
		Phase Angle, F (º)	27.3	26.4	20.6	17.7	16.2	12.4	10.9	10.0
		Average Peak Stress (psi)	41	57	70	90	107	147	168	184
		Average Peak Strain (με)	84	78	80	73	75	80	82	79
	Avg.	|E*| Average (psi)	504736	781083	935596	131327	149953	196176	216867	245701
		F Average	29.4	26.6	23.0	19.4	17.9	14.0	12.4	10.3
		|E*| Coeff. of Variation (psi)	0.026	0.072	0.056	0.046	0.047	0.050	0.048	0.049
		F Coeff. of Variation	0.10	0.12	0.16	0.12	0.13	0.16	0.17	0.04
		|E*| Std. Dev. (psi)	13323.0	56413.2	52138.9	61021.4	69874.5	97561.3	104246.	119761.
		F Std. Dev.	2.937	3.241	3.631	2.337	2.405	2.303	2.066	0.457
35	1	|E*| (psi)	40733	58881	74218	132717	179997	345492	449352	610342
		Phase Angle, F (º)	27.4	30.2	31.6	34.2	33.0	30.5	28.3	25.9
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	51	69	72	71	78	58	71	92
	2	|E*| (psi)	35364	54775	70086	127898	173391	331908	432210	594121
		Phase Angle, F (º)	27.0	29.9	31.0	33.5	32.5	29.3	26.9	24.8
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	58	74	76	73	81	60	74	95
	3	|E*| (psi)	36745	56340	71087	128074	170810	321531	412912	561620
		Phase Angle, F (º)	25.4	28.5	30.0	32.8	31.8	29.1	26.5	24.5
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	56	72	75	73	82	62	77	100
	Avg.	|E*| Average (psi)	37614	56665	71797	129563	174733	332977	431492	588694
		F Average	26.6	29.6	30.9	33.5	32.4	29.6	27.2	25.1
		|E*| Coeff. of Variation (psi)	0.074	0.037	0.030	0.021	0.027	0.036	0.042	0.042
		F Coeff. of Variation	0.04	0.03	0.03	0.02	0.02	0.03	0.04	0.03
		|E*| Std. Dev. (psi)	2788.1	2072.3	2155.3	2732.7	4738.2	12016.5	18230.4	24809.7
		F Std. Dev.	1.070	0.901	0.811	0.718	0.602	0.755	0.965	0.727
54.4	1	|E*| (psi)		20036	20702	28247	35364	66030	91187	139913
		Phase Angle, F (º)		18.6	16.4	22.0	23.9	27.0	27.5	29.3
		Average Peak Stress (psi)		1	2	4	5	9	12	17
		Average Peak Strain (με)		62	100	146	148	131	136	118
	2	|E*| (psi)		18112	18878	26179	32781	61393	84278	131044
		Phase Angle, F (º)		16.0	17.4	22.4	24.4	26.7	27.1	29.2
		Average Peak Stress (psi)		1	2	4	5	9	12	16
		Average Peak Strain (με)		68	110	157	160	139	147	125
	3	|E*| (psi)		21952	20751	27428	33392	60927	82866	126977
		Phase Angle, F (º)		15.9	16.5	20.6	22.7	26.0	26.5	28.6
		Average Peak Stress (psi)		1	2	4	5	9	12	16
		Average Peak Strain (με)		56	100	150	157	140	149	129
	Avg.	|E*| Average (psi)		20033	20110	27285	33846	62784	86110	132645
		F Average		16.9	16.8	21.7	23.7	26.5	27.0	29.0
		|E*| Coeff. of Variation (psi)		0.096	0.053	0.038	0.040	0.045	0.052	0.050
		F Coeff. of Variation		0.09	0.03	0.04	0.04	0.02	0.02	0.01
		|E*| Std. Dev. (psi)		1919.6	1067.4	1041.4	1350.0	2821.5	4452.7	6614.8
		F Std. Dev.		1.544	0.528	0.961	0.891	0.522	0.479	0.386

Table B-10. S9.5BF–Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2576430	316512	313030	347024	359709	391358	404721	
		Phase Angle, F (º)	11.0	7.0	7.0	7.6	7.4	6.2	5.9	
		Average Peak Stress (psi)	197	229	238	254	262	287	295	
		Average Peak Strain (με)	76	72	76	73	73	73	73	
	2	|E*| (psi)	2479594	293447	290032	328410	340426	364616	375897	391917
		Phase Angle, F (º)	7.6	10.0	4.8	5.4	4.9	3.2	2.7	2.3
		Average Peak Stress (psi)	167	195	202	216	223	243	251	271
		Average Peak Strain (με)	67	66	70	66	65	67	67	69
	3	|E*| (psi)	2564911	319561	305075	342123	353951	385285	398923	414379
		Phase Angle, F (º)	10.5	13.8	8.0	8.6	8.8	7.6	6.8	6.4
		Average Peak Stress (psi)	167	195	202	216	223	243	251	271
		Average Peak Strain (με)	65	61	66	63	63	63	63	66
	Avg.	|E*| Average (psi)	2540312	309840	302712	339185	351362	380419	393180	403148
		F Average	9.7	10.3	6.6	7.2	7.0	5.7	5.1	4.4
		|E*| Coeff. of Variation (psi)	0.021	0.046	0.039	0.028	0.028	0.037	0.039	0.039
		F Coeff. of Variation	0.19	0.33	0.25	0.23	0.28	0.39	0.42	0.66
		|E*| Std. Dev. (psi)	52897.5	142782.	116797.	96484.2	98989.9	140192.	152462.	158827.
		F Std. Dev.	1.846	3.405	1.657	1.640	1.969	2.218	2.147	2.873
10	1	|E*| (psi)	757013	106643	118380	157198	174288	218053	237259	258904
		Phase Angle, F (º)	28.2	26.7	22.1	18.7	16.9	13.5	11.9	11.2
		Average Peak Stress (psi)	41	57	70	90	107	147	168	184
		Average Peak Strain (με)	54	54	59	57	61	68	71	71
	2	|E*| (psi)	837950	110057	129711	167200	181614	221410	238405	263002
		Phase Angle, F (º)	24.9	22.9	18.7	15.0	14.0	11.1	10.0	9.6
		Average Peak Stress (psi)	35	49	59	77	90	125	143	156
		Average Peak Strain (με)	41	44	46	46	50	56	60	59
	3	|E*| (psi)	844184	113218	127968	165962	180600	218542	236930	261504
		Phase Angle, F (º)	25.7	18.3	20.2	17.7	16.2	13.2	12.2	11.5
		Average Peak Stress (psi)	35	49	59	77	90	125	143	156
		Average Peak Strain (με)	41	43	46	46	50	57	60	60
	Avg.	|E*| Average (psi)	813049	109972	125353	163453	178834	219335	237531	261137
		F Average	26.2	22.6	20.3	17.1	15.7	12.6	11.4	10.8
		|E*| Coeff. of Variation (psi)	0.060	0.030	0.049	0.033	0.022	0.008	0.003	0.008
		F Coeff. of Variation	0.07	0.18	0.08	0.11	0.10	0.10	0.11	0.10
		|E*| Std. Dev. (psi)	48628.9	32881.9	61015.2	54525.7	39697.3	18134.4	7742.5	20736.0
		F Std. Dev.	1.710	4.178	1.689	1.935	1.508	1.320	1.207	1.058
35	1	|E*| (psi)	117227	137185	160962	252466	311489	561591	678403	845559
		Phase Angle, F (º)	30.2	36.3	35.6	36.2	35.0	30.6	26.5	24.3
		Average Peak Stress (psi)	2	4	5	9	14	20	32	57
		Average Peak Strain (με)	18	30	33	37	45	36	47	67
	2	|E*| (psi)	113925	155858	180877	284524	352394	608081	720763	871528
		Phase Angle, F (º)	29.6	32.8	35.3	35.4	33.5	29.1	25.3	23.1
		Average Peak Stress (psi)	2	3	5	8	12	17	27	48
		Average Peak Strain (με)	15	22	25	28	34	28	37	55
	3	|E*| (psi)	156242	173622	200851	302199	360296	590193	697927	838618
		Phase Angle, F (º)	35.2	36.1	35.7	35.3	32.2	28.0	24.8	22.1
		Average Peak Stress (psi)	2	3	5	8	12	17	27	48
		Average Peak Strain (με)	11	20	22	26	33	29	39	57
	Avg.	|E*| Average (psi)	129131	155555	180897	279730	341393	586622	699031	851902
		F Average	31.7	35.1	35.6	35.6	33.6	29.2	25.5	23.2
		|E*| Coeff. of Variation (psi)	0.182	0.117	0.110	0.090	0.077	0.040	0.030	0.020
		F Coeff. of Variation	0.10	0.06	0.01	0.01	0.04	0.04	0.04	0.05
		|E*| Std. Dev. (psi)	23536.7	18220.5	19944.4	25211.0	26197.3	23450.0	21201.1	17347.7
		F Std. Dev.	3.099	1.946	0.208	0.500	1.368	1.270	0.896	1.066
54.4	1	|E*| (psi)	54071	56274	54666	66094	77030	134770	173796	248565
		Phase Angle, F (º)	26.0	20.2	23.8	29.8	31.1	30.7	29.3	30.1
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	15	22	38	62	68	66	75	72
	2	|E*| (psi)	40218	40934	49804	69685	84752	157070	202354	279661
		Phase Angle, F (º)	18.6	19.6	23.6	30.2	31.2	31.2	29.6	29.7
		Average Peak Stress (psi)	1	1	2	3	4	8	11	15
		Average Peak Strain (με)	17	26	35	50	53	48	54	53
	3	|E*| (psi)	60750	47896	50660	70199	84849	146564	189789	266573
		Phase Angle, F (º)	28.4	22.5	23.2	25.9	27.0	27.5	26.3	26.8
		Average Peak Stress (psi)	1	1	2	3	4	8	11	15
		Average Peak Strain (με)	11	22	35	50	53	51	59	57
	Avg.	|E*| Average (psi)	51679	48368	51710	68659	82210	146135	188647	264933
		F Average	24.3	20.8	23.5	28.7	29.7	29.8	28.4	28.9
		|E*| Coeff. of Variation (psi)	0.203	0.159	0.050	0.033	0.055	0.076	0.076	0.059
		F Coeff. of Variation	0.21	0.07	0.01	0.08	0.08	0.07	0.06	0.06
		|E*| Std. Dev. (psi)	10472.9	7680.7	2595.9	2236.3	4486.7	11156.3	14313.1	15613.0
		F Std. Dev.	5.092	1.520	0.321	2.373	2.413	1.993	1.810	1.798

Table B-11. S9.5CC–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2542444	277306	322391	344016	358620	391912	408844	414319
		Phase Angle, F (º)	6.9	10.0	5.6	4.3	2.6	3.0	2.6	0.0
		Average Peak Stress (psi)	196	229	237	254	262	286	295	319
		Average Peak Strain (με)	77	83	74	74	73	73	72	77
	2	|E*| (psi)	2699840		318915	371027	382313	418920	438604	458985
		Phase Angle, F (º)	10.0		6.4	7.6	6.3	5.7	5.7	5.4
		Average Peak Stress (psi)	180		229	238	246	270	251	271
		Average Peak Strain (με)	67		72	64	64	64	57	59
	3	|E*| (psi)	2618752	283612	332123	350432	367378	401530	415715	431336
		Phase Angle, F (º)	8.2	2.8	5.6	6.4	4.6	4.1	3.5	3.2
		Average Peak Stress (psi)	180	217	229	238	246	270	279	302
		Average Peak Strain (με)	69	77	69	68	67	67	67	70
	Avg.	|E*| Average (psi)	2620345	280459	324476	355158	369437	404121	421054	434880
		F Average	8.4	6.4	5.9	6.1	4.5	4.3	3.9	2.9
		|E*| Coeff. of Variation (psi)	0.030	0.016	0.021	0.040	0.032	0.034	0.037	0.052
		F Coeff. of Variation	0.19	0.80	0.08	0.28	0.41	0.32	0.40	0.94
		|E*| Std. Dev. (psi)	78709.9	44591.9	68463.7	141119.	119802.	136888.	155817.	225433.
		F Std. Dev.	1.600	5.088	0.457	1.703	1.843	1.385	1.585	2.699
10	1	|E*| (psi)	801585	114336	130755	165020	181531	222573	244223	268444
		Phase Angle, F (º)	21.2	13.1	15.2	13.3	11.4	10.0	8.9	6.4
		Average Peak Stress (psi)	37	52	63	81	96	132	168	184
		Average Peak Strain (με)	46	45	48	49	53	59	69	68
	2	|E*| (psi)	867816	116571	140184	174589	193707	234740	253114	282720
		Phase Angle, F (º)	24.3	16.4	20.6	16.7	14.1	12.5	11.1	10.7
		Average Peak Stress (psi)	41	57	70	90	107	147	168	184
		Average Peak Strain (με)	47	49	50	52	55	63	66	65
	3	|E*| (psi)	799855	117196	126043	165242	182864	225325	242489	271580
		Phase Angle, F (º)	22.8	15.1	19.9	14.5	12.4	10.6	9.6	9.0
		Average Peak Stress (psi)	45	57	70	90	106	147	168	184
		Average Peak Strain (με)	56	49	55	55	58	65	69	68
	Avg.	|E*| Average (psi)	823085	116035	132328	168284	186034	227546	246609	274248
		F Average	22.7	14.9	18.6	14.9	12.7	11.0	9.9	8.7
		|E*| Coeff. of Variation (psi)	0.047	0.013	0.054	0.032	0.036	0.028	0.023	0.027
		F Coeff. of Variation	0.07	0.11	0.16	0.12	0.11	0.11	0.12	0.25
		|E*| Std. Dev. (psi)	38747.4	15035.5	72007.0	54618.7	66783.0	63804.2	57003.5	75029.7
		F Std. Dev.	1.562	1.628	2.902	1.725	1.370	1.264	1.150	2.175
35	1	|E*| (psi)	65702	106168	133870	230900	293701	516914	630769	802639
		Phase Angle, F (º)	30.1	31.2	30.7	31.1	28.3	25.9	23.5	21.3
		Average Peak Stress (psi)	2	4	5	8	13	18	29	51
		Average Peak Strain (με)	29	34	36	37	44	35	45	64
	2	|E*| (psi)	79757	118567	147782	247775	312447	549836	654766	824215
		Phase Angle, F (º)	35.7	34.0	33.5	33.3	30.0	28.5	25.5	23.0
		Average Peak Stress (psi)	2	4	5	9	14	20	32	57
		Average Peak Strain (με)	26	35	36	38	46	37	49	69
	3	|E*| (psi)	72185	112568	135396	231301	296929	510009	635433	807169
		Phase Angle, F (º)	30.7	29.6	30.5	31.0	29.1	26.7	23.9	22.1
		Average Peak Stress (psi)	3	5	6	11	16	24	36	57
		Average Peak Strain (με)	40	43	45	50	54	47	57	71
	Avg.	|E*| Average (psi)	72548	112434	139016	236658	301026	525587	640322	811341
		F Average	32.2	31.6	31.6	31.8	29.1	27.0	24.3	22.1
		|E*| Coeff. of Variation (psi)	0.097	0.055	0.055	0.041	0.033	0.040	0.020	0.014
		F Coeff. of Variation	0.10	0.07	0.05	0.04	0.03	0.05	0.04	0.04
		|E*| Std. Dev. (psi)	7034.4	6200.8	7630.0	9629.1	10022.2	21282.8	12723.7	11376.9
		F Std. Dev.	3.059	2.208	1.699	1.290	0.870	1.351	1.047	0.842
54.4	Est.	|E*| (psi)	18710	30168	37565	63527	80206	138366	174335	235396

Table B-12. S9.5C0F-Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2980005	307872	344485	399121	417000	449990	463487	479392
		Phase Angle, F (º)	7.7	8.2	6.7	5.5	5.0	3.9	3.5	2.9
		Average Peak Stress (psi)	205	229	238	255	263	272	280	302
		Average Peak Strain (με)	69	75	69	64	63	60	60	63
	2	|E*| (psi)	2734440	347600	342322	370322	386092	420426	433337	451093
		Phase Angle, F (º)	8.1	9.5	7.6	5.3	4.6	3.5	3.1	2.8
		Average Peak Stress (psi)	205	229	238	255	263	271	280	304
		Average Peak Strain (με)	75	66	69	69	68	65	65	67
	3	|E*| (psi)	2993559		382720	407708	426113	464293	480658	499431
		Phase Angle, F (º)	8.6		5.4	6.7	5.9	4.1	3.4	3.8
		Average Peak Stress (psi)	205		237	255	263	272	280	304
		Average Peak Strain (με)	68		62	62	62	59	58	61
	Avg.	|E*| Average (psi)	2902668	327736	356509	392384	409735	444903	459160	476638
		F Average	8.1	8.9	6.6	5.8	5.2	3.8	3.3	3.1
		|E*| Coeff. of Variation (psi)	0.050	0.086	0.064	0.050	0.051	0.050	0.052	0.051
		F Coeff. of Variation	0.05	0.10	0.17	0.12	0.13	0.08	0.06	0.17
		|E*| Std. Dev. (psi)	145847.1	280923.	227250.	195825.	209760.	223716.	239553.	242865.
		F Std. Dev.	0.445	0.918	1.105	0.720	0.662	0.298	0.205	0.532
10	1	|E*| (psi)	894141	132973	140714	184953	204436	252022	271970	301614
		Phase Angle, F (º)	21.4	19.7	14.5	13.1	11.8	9.3	8.3	7.1
		Average Peak Stress (psi)	53	78	90	132	140	173	189	211
		Average Peak Strain (με)	60	59	64	71	68	69	70	70
	2	|E*| (psi)	822798	121351	131577	166390	185643	232637	252967	279805
		Phase Angle, F (º)	22.3	17.3	17.3	13.9	12.9	10.0	9.4	8.4
		Average Peak Stress (psi)	53	78	90	132	140	173	189	210
		Average Peak Strain (με)	65	64	69	79	75	74	75	75
	3	|E*| (psi)	836181	128763	140464	180671	201735	252920	274855	306399
		Phase Angle, F (º)	23.5	18.6	16.8	15.1	13.6	11.3	10.1	9.4
		Average Peak Stress (psi)	53	78	90	132	140	173	189	210
		Average Peak Strain (με)	64	60	64	73	69	68	69	69
	Avg.	|E*| Average (psi)	851040	127696	137585	177338	197272	245860	266597	295939
		F Average	22.4	18.5	16.2	14.0	12.8	10.2	9.3	8.3
		|E*| Coeff. of Variation (psi)	0.045	0.046	0.038	0.055	0.052	0.047	0.045	0.048
		F Coeff. of Variation	0.05	0.06	0.09	0.07	0.07	0.10	0.10	0.14
		|E*| Std. Dev. (psi)	37921.2	58839.2	52046.7	97198.4	101603.	114601.	118919.	141759.
		F Std. Dev.	1.047	1.201	1.516	1.037	0.907	1.013	0.937	1.170
35	1	|E*| (psi)	82091	132855	165053	275282	345625	589723	717646	904020
		Phase Angle, F (º)	30.8	31.7	32.3	32.0	29.8	25.0	22.6	20.7
		Average Peak Stress (psi)	3	5	6	10	17	28	41	66
		Average Peak Strain (με)	40	37	37	37	48	48	56	73
	2	|E*| (psi)	67976	113356	143653	242329	310830	549019	687931	870358
		Phase Angle, F (º)	30.9	32.8	34.6	32.8	31.0	26.1	23.4	21.8
		Average Peak Stress (psi)	3	5	6	10	17	28	40	65
		Average Peak Strain (με)	48	43	43	43	53	52	59	75
	3	|E*| (psi)	67571	109324	137480	230854	297123	528087	657789	845456
		Phase Angle, F (º)	33.0	33.8	40.9	35.0	32.8	26.7	24.6	22.7
		Average Peak Stress (psi)	3	5	6	10	17	28	40	65
		Average Peak Strain (με)	48	45	46	45	56	54	61	77
	Avg.	|E*| Average (psi)	72546	118512	148729	249488	317859	555610	687789	873278
		F Average	31.6	32.8	36.0	33.3	31.2	25.9	23.6	21.7
		|E*| Coeff. of Variation (psi)	0.114	0.106	0.097	0.092	0.079	0.056	0.044	0.034
		F Coeff. of Variation	0.04	0.03	0.12	0.05	0.05	0.03	0.04	0.05
		|E*| Std. Dev. (psi)	8268.8	12583.9	14470.1	23062.7	25003.1	31342.0	29929.1	29391.1
		F Std. Dev.	1.208	1.065	4.454	1.569	1.512	0.862	0.992	1.001
54.4	Est.	|E*| (psi)	17114	28427	35824	62366	79626	140106	177816	242068

Table B-13. S9.5C1F–Granite (US Customary6 Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2678086	338696	314964	359640	374397	408187	423183	439248
		Phase Angle, F (º)	9.9	6.6	6.9	6.9	6.5	5.1	4.7	4.4
		Average Peak Stress (psi)	180	217	229	237	245	269	278	300
		Average Peak Strain (με)	67	64	73	66	65	66	66	68
	2	|E*| (psi)	2791556	286904	346827	371957	385111	418237	431855	448477
		Phase Angle, F (º)	5.9	5.9	4.8	3.5	3.1	2.2	1.6	1.3
		Average Peak Stress (psi)	180	217	229	237	245	269	278	300
		Average Peak Strain (με)	64	76	66	64	64	64	64	67
	3	|E*| (psi)	2535845	269863	317357	340547	357005	389821	402124	
		Phase Angle, F (º)	7.4	3.9	7.2	4.8	4.8	3.2	2.9	
		Average Peak Stress (psi)	180	217	229	237	245	269	278	
		Average Peak Strain (με)	71	80	72	70	69	69	69	
	Avg.	|E*| Average (psi)	2668495	298488	326383	357381	372171	405415	419054	443862
		F Average	7.7	5.5	6.3	5.1	4.8	3.5	3.0	2.8
		|E*| Coeff. of Variation	0.048	0.120	0.054	0.044	0.038	0.036	0.036	0.015
		F Coeff. of Variation	0.26	0.25	0.21	0.34	0.35	0.42	0.51	0.78
		|E*| Std. Dev. (psi)	128125.0	358485	177455	158261	141848	144092	152895	65259.
		F Std. Dev.	1.996	1.385	1.291	1.748	1.698	1.491	1.546	2.210
10	1	|E*| (psi)	888443	132003	133304	172354	189525	231942	251588	277677
		Phase Angle, F (º)	23.5	19.5	17.4	15.8	14.3	11.6	10.6	9.7
		Average Peak Stress (psi)	45	57	70	90	106	147	167	183
		Average Peak Strain (με)	51	43	52	52	56	63	66	66
	2	|E*| (psi)	890331	114093	134200	173419	190936	232228	250901	277726
		Phase Angle, F (º)	18.6	12.6	15.4	11.9	10.8	8.8	7.9	7.6
		Average Peak Stress (psi)	45	57	70	90	106	147	167	183
		Average Peak Strain (με)	51	50	52	52	56	63	67	66
	3	|E*| (psi)	784779	102019	124857	158810	174237	216031	234810	258318
		Phase Angle, F (º)	21.1	15.3	16.7	13.5	12.2	9.6	8.8	8.3
		Average Peak Stress (psi)	45	57	70	90	106	147	167	183
		Average Peak Strain (με)	57	56	56	57	61	68	71	71
	Avg.	|E*| Average (psi)	854518	116038	130787	168194	184899	226734	245766	271240
		F Average	21.1	15.8	16.5	13.7	12.5	10.0	9.1	8.5
		|E*| Coeff. of Variation	0.071	0.130	0.039	0.048	0.050	0.041	0.039	0.041
		F Coeff. of Variation	0.12	0.22	0.06	0.14	0.14	0.15	0.15	0.13
		|E*| Std. Dev. (psi)	60402.9	150863	51548.	81442.	92605.	92697.	94947.	111909
		F Std. Dev.	2.471	3.459	1.042	1.987	1.752	1.468	1.395	1.084
35	1	|E*| (psi)	89211	129756	159945	255932	317296	536559	643341	812174
		Phase Angle, F (º)	34.8	34.5	34.3	32.7	30.6	26.6	24.2	22.2
		Average Peak Stress (psi)	3	5	6	11	16	24	36	57
		Average Peak Strain (με)	32	38	38	44	51	45	56	70
	2	|E*| (psi)	76904	122182	157753	261721	330646	556283	679600	854731
		Phase Angle, F (º)	31.1	31.2	31.0	29.9	28.0	23.6	21.6	20.1
		Average Peak Stress (psi)	3	5	6	11	16	24	36	57
		Average Peak Strain (με)	37	40	39	43	49	43	53	66
	3	|E*| (psi)	76776	113489	140815	229247	283506	486762	601838	762003
		Phase Angle, F (º)	30.0	30.7	30.9	30.6	28.8	25.0	22.3	21.1
		Average Peak Stress (psi)	3	5	6	11	16	24	36	56
		Average Peak Strain (με)	38	43	44	49	57	49	60	74
	Avg.	|E*| Average (psi)	80964	121809	152838	248967	310483	526535	641593	809636
		F Average	32.0	32.1	32.0	31.1	29.1	25.1	22.7	21.2
		|E*| Coeff. of Variation	0.088	0.067	0.068	0.070	0.078	0.068	0.061	0.057
		F Coeff. of Variation	0.08	0.07	0.06	0.05	0.05	0.06	0.06	0.05
		|E*| Std. Dev. (psi)	7142.7	8140.1	10469.	17321.	24297.	35828.	38910.	46416.
		F Std. Dev.	2.503	2.095	1.915	1.441	1.320	1.531	1.303	1.074
54.4	1	|E*| (psi)		58492	47336	67782	80575	139685	180836	253055
		Phase Angle, F (º)		28.5	27.7	29.5	30.4	31.3	31.7	32.9
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		14	26	24	30	22	20	17
	2	|E*| (psi)		41334	41869	63627	78639	135396	173518	247555
		Phase Angle, F (º)		26.2	23.4	26.1	27.4	28.3	27.7	27.2
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		20	30	26	31	23	21	18
	3	|E*| (psi)		32812	38593	57228	70973	120841	156326	218334
		Phase Angle, F (º)		18.6	19.9	24.8	25.9	27.8	27.9	30.0
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		25	32	28	34	25	23	20
	Avg.	|E*| Average (psi)		44213	42599	62879	76729	131974	170227	239648
		F Average		24.5	23.7	26.8	27.9	29.1	29.1	30.0
		|E*| Coeff. of Variation		0.296	0.104	0.085	0.066	0.075	0.074	0.078
		F Coeff. of Variation		0.21	0.16	0.09	0.08	0.07	0.08	0.10
		|E*| Std. Dev. (psi)		13079.	4416.8	5316.7	5077.7	9877.2	12582.	18661.
		F Std. Dev.		5.169	3.878	2.411	2.294	1.930	2.265	2.854

Table B-14. S9.5C2F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2835987	368428	354672	385480	403175	442882	462780	
		Phase Angle, F (º)	9.0	8.0	4.4	5.9	5.4	4.3	4.1	
		Average Peak Stress (psi)	180	217	229	237	245	269	278	
		Average Peak Strain (με)	63	59	65	62	61	61	60	
	2	|E*| (psi)	2828527	298168	350698	381342	396857	430537	442977	464353
		Phase Angle, F (º)	8.7	8.0	8.5	5.2	5.0	3.7	3.0	3.0
		Average Peak Stress (psi)	180	217	229	237	245	269	278	300
		Average Peak Strain (με)	64	73	65	62	62	63	63	65
	3	|E*| (psi)	2757137	349391	348685	372950	391656	429100	443030	460037
		Phase Angle, F (º)	7.9	5.9	6.4	5.2	5.0	4.2	3.6	3.3
		Average Peak Stress (psi)	180	217	229	237	245	269	278	300
		Average Peak Strain (με)	65	62	66	64	63	63	63	65
	Avg.	|E*| Average (psi)	2807217	338662	351352	379924	397229	434173	449596	462195
		F Average	8.5	7.3	6.4	5.4	5.1	4.1	3.6	3.1
		|E*| Coeff. of Variation (psi)	0.016	0.107	0.009	0.017	0.015	0.017	0.025	0.007
		F Coeff. of Variation	0.06	0.17	0.32	0.07	0.05	0.09	0.14	0.06
		|E*| Std. Dev. (psi)	43530.6	363375.	30465.4	63842.7	57685.1	75762.8	114180.	30521.8
		F Std. Dev.	0.533	1.239	2.055	0.387	0.247	0.348	0.514	0.199
10	1	|E*| (psi)	927594	119587	144253	186159	205447	252486	273880	
		Phase Angle, F (º)	23.2	21.8	19.3	15.0	13.4	10.9	10.1	
		Average Peak Stress (psi)	45	57	70	90	106	147	167	
		Average Peak Strain (με)	48	48	48	48	52	58	61	
	2	|E*| (psi)	848370	114193	132981	174956	192294	236670	257479	286672
		Phase Angle, F (º)	24.0	16.7	16.9	15.0	13.2	10.7	9.5	8.7
		Average Peak Stress (psi)	45	57	70	90	106	147	167	182
		Average Peak Strain (με)	53	50	52	51	55	62	65	64
	3	|E*| (psi)	830206	109120	132562	172049	192260	240748	264739	290846
		Phase Angle, F (º)	22.8	17.0	19.2	14.5	13.3	11.0	10.4	9.5
		Average Peak Stress (psi)	45	57	70	90	106	147	167	182
		Average Peak Strain (με)	54	52	52	52	55	61	63	63
	Avg.	|E*| Average (psi)	868723	114300	136598	177722	196667	243301	265366	288759
		F Average	23.4	18.5	18.5	14.8	13.3	10.8	10.0	9.1
		|E*| Coeff. of Variation (psi)	0.060	0.046	0.049	0.042	0.039	0.034	0.031	0.010
		F Coeff. of Variation	0.03	0.16	0.07	0.02	0.01	0.02	0.05	0.06
		|E*| Std. Dev. (psi)	51786.1	52344.4	66320.8	74503.5	76038.2	82115.1	82184.5	29510.4
		F Std. Dev.	0.596	2.898	1.363	0.312	0.094	0.174	0.471	0.561
35	1	|E*| (psi)	75826	119666	153083	262378	338255	594093	737124	928530
		Phase Angle, F (º)	33.5	34.5	33.1	33.3	31.7	27.2	24.1	22.1
		Average Peak Stress (psi)	3	5	6	11	16	24	36	57
		Average Peak Strain (με)	38	41	40	43	48	41	49	61
	2	|E*| (psi)	70288	111720	134600	228388	291698	520961	644581	827195
		Phase Angle, F (º)	33.5	33.3	34.6	33.1	31.8	27.1	24.8	22.6
		Average Peak Stress (psi)	3	5	6	11	16	24	36	56
		Average Peak Strain (με)	41	44	46	49	55	46	56	68
	3	|E*| (psi)	63245	102477	130392	223948	291010	519873	650536	831064
		Phase Angle, F (º)	30.6	31.5	31.7	31.2	30.3	26.3	23.8	22.1
		Average Peak Stress (psi)	3	5	6	11	16	24	36	57
		Average Peak Strain (με)	45	48	47	51	55	46	55	68
	Avg.	|E*| Average (psi)	69786	111288	139358	238238	306988	544976	677414	862263
		F Average	32.6	33.1	33.2	32.5	31.3	26.9	24.2	22.3
		|E*| Coeff. of Variation (psi)	0.090	0.077	0.087	0.088	0.088	0.078	0.076	0.067
		F Coeff. of Variation	0.05	0.05	0.04	0.04	0.03	0.02	0.02	0.01
		|E*| Std. Dev. (psi)	6305.7	8603.0	12070.7	21023.6	27080.6	42540.6	51796.3	57421.3
		F Std. Dev.	1.680	1.499	1.416	1.148	0.832	0.464	0.531	0.284
54.4	1	|E*| (psi)		45480	44786	63233	74505	133418	172482	243111
		Phase Angle, F (º)		20.0	22.5	29.0	29.7	31.8	32.1	33.9
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		18	28	26	32	23	21	18
	2	|E*| (psi)		38451	36724	52535	64796	117442	155678	221583
		Phase Angle, F (º)		29.1	25.4	28.8	30.3	32.6	32.7	34.2
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		21	34	31	37	26	23	19
	3	|E*| (psi)		33925	38848	55881	67452	120421	155464	225138
		Phase Angle, F (º)		17.2	21.9	26.7	27.9	30.3	30.2	31.6
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		24	32	29	36	26	23	19
	Avg.	|E*| Average (psi)		39286	40120	57216	68918	123760	161208	229944
		F Average		22.1	23.3	28.2	29.3	31.6	31.7	33.2
		|E*| Coeff. of Variation (psi)		0.148	0.104	0.096	0.073	0.069	0.061	0.050
		F Coeff. of Variation		0.28	0.08	0.05	0.04	0.04	0.04	0.04
		|E*| Std. Dev. (psi)		5822.3	4178.8	5472.3	5017.8	8495.4	9764.4	11540.5
		F Std. Dev.		6.219	1.908	1.272	1.257	1.134	1.302	1.429

Table B-15. S9.5C3F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2740300	296869	351838	394825	413201	458670	478917	501938
		Phase Angle, F (º)	14.3	13.7	9.1	10.4	9.7	7.9	7.6	7.4
		Average Peak Stress (psi)	180	217	229	238	245	270	278	301
		Average Peak Strain (με)	66	73	65	60	59	59	58	60
	2	|E*| (psi)	2457667	310582	303198	358730	372878	414314	431167	450044
		Phase Angle, F (º)	9.7	12.0	8.0	5.1	5.0	3.3	2.8	2.4
		Average Peak Stress (psi)	180	217	229	238	245	270	278	301
		Average Peak Strain (με)	73	70	76	66	66	65	65	67
	3	|E*| (psi)	2422630	301226	309889	352170	369369	411801	425170	
		Phase Angle, F (º)	8.5	11.8	3.5	4.8	4.3	2.7	2.1	
		Average Peak Stress (psi)	180	217	229	238	245	270	279	
		Average Peak Strain (με)	74	72	74	67	66	66	66	
	Avg.	|E*| Average (psi)	2540199	302892	321642	368575	385149	428262	445085	475991
		F Average	10.8	12.5	6.9	6.8	6.4	4.6	4.2	4.9
		|E*| Coeff. of Variation (psi)	0.069	0.023	0.082	0.062	0.063	0.062	0.066	0.077
		F Coeff. of Variation	0.28	0.09	0.43	0.47	0.46	0.61	0.73	0.71
		|E*| Std. Dev. (psi)	174175.6	70063.9	263636.	229690.	243565.	263640.	294525.	366946.
		F Std. Dev.	3.046	1.084	2.967	3.165	2.947	2.824	3.038	3.504
10	1	|E*| (psi)	573653	889888	105028	152293	173607	225505	249883	285418
		Phase Angle, F (º)	33.0	25.3	26.5	22.4	20.7	16.8	15.7	14.6
		Average Peak Stress (psi)	45	57	70	90	106	147	168	183
		Average Peak Strain (με)	78	64	66	59	61	65	67	64
	2	|E*| (psi)	452914	681891	878295	124423	143721	193051	215768	245967
		Phase Angle, F (º)	29.3	25.3	24.1	18.8	17.1	13.0	11.7	10.6
		Average Peak Stress (psi)	45	57	70	90	106	147	168	183
		Average Peak Strain (με)	99	84	79	72	74	76	78	75
	3	|E*| (psi)	486009	789008	903598	129766	148577	195762	217462	247657
		Phase Angle, F (º)	27.2	22.2	22.0	17.3	15.6	11.7	10.4	9.5
		Average Peak Stress (psi)	45	57	70	90	106	147	168	183
		Average Peak Strain (με)	93	73	77	69	72	75	77	74
	Avg.	|E*| Average (psi)	504192	786929	944058	135494	155302	204772	227705	259680
		F Average	29.8	24.3	24.2	19.5	17.8	13.8	12.6	11.6
		|E*| Coeff. of Variation (psi)	0.124	0.132	0.098	0.109	0.103	0.088	0.084	0.086
		F Coeff. of Variation	0.10	0.07	0.09	0.13	0.15	0.19	0.22	0.23
		|E*| Std. Dev. (psi)	62389.7	104014.	92857.4	147914.	160378.	180057.	192261.	223051.
		F Std. Dev.	2.923	1.820	2.277	2.609	2.627	2.654	2.768	2.656
35	1	|E*| (psi)	36248	57254	73114	134514	182811	362949	473041	638048
		Phase Angle, F (º)	28.2	31.4	32.9	35.4	34.4	31.7	29.3	27.1
		Average Peak Stress (psi)	3	5	6	11	16	24	36	56
		Average Peak Strain (με)	79	85	84	84	88	66	76	89
	2	|E*| (psi)	31884	50135	63869	116860	157845	307439	407179	567059
		Phase Angle, F (º)	24.2	27.4	28.7	32.1	31.4	28.6	26.8	25.6
		Average Peak Stress (psi)	3	5	6	11	16	24	36	56
		Average Peak Strain (με)	90	97	96	97	102	78	88	99
	3	|E*| (psi)	30895	50983	65996	122575	164918	316773	411543	570216
		Phase Angle, F (º)	24.8	28.0	29.1	32.1	31.2	27.7	25.5	24.7
		Average Peak Stress (psi)	3	5	6	11	16	24	36	56
		Average Peak Strain (με)	93	96	93	92	98	76	87	99
	Avg.	|E*| Average (psi)	33009	52791	67660	124650	168525	329054	430588	591774
		F Average	25.7	28.9	30.2	33.2	32.3	29.3	27.2	25.8
		|E*| Coeff. of Variation (psi)	0.086	0.074	0.072	0.072	0.076	0.090	0.086	0.068
		F Coeff. of Variation	0.08	0.07	0.08	0.06	0.06	0.07	0.07	0.05
		|E*| Std. Dev. (psi)	2848.1	3888.3	4841.6	9007.8	12867.8	29722.8	36830.6	40105.0
		F Std. Dev.	2.146	2.166	2.322	1.916	1.826	2.097	1.904	1.216
54.4	1	|E*| (psi)		24217	24006	29904	35412	62958	84899	133740
		Phase Angle, F (º)		13.3	19.2	25.1	26.7	32.1	33.5	36.0
		Average Peak Stress (psi)		1	1	2	2	3	3	4
		Average Peak Strain (με)		33	52	55	68	47	40	29
	2	|E*| (psi)		20621	20379	26582	32248	56233	76805	118337
		Phase Angle, F (º)		17.2	15.9	22.1	23.9	28.5	30.4	32.7
		Average Peak Stress (psi)		1	1	2	2	3	3	4
		Average Peak Strain (με)		39	61	62	74	52	44	32
	3	|E*| (psi)		15808	17440	24071	30313	53270	71680	109318
		Phase Angle, F (º)		10.5	14.3	21.9	23.8	27.7	28.7	32.6
		Average Peak Stress (psi)		1	1	2	2	3	3	4
		Average Peak Strain (με)		51	71	68	79	55	48	36
	Avg.	|E*| Average (psi)		20215	20608	26853	32658	57487	77795	120465
		F Average		13.7	16.5	23.0	24.8	29.4	30.9	33.8
		|E*| Coeff. of Variation (psi)		0.209	0.160	0.109	0.079	0.086	0.086	0.103
		F Coeff. of Variation		0.24	0.15	0.08	0.07	0.08	0.08	0.06
		|E*| Std. Dev. (psi)		4219.4	3289.0	2926.3	2573.9	4963.9	6665.0	12349.5
		F Std. Dev.		3.333	2.454	1.773	1.614	2.360	2.462	1.975

Table B-16. S9.5CF–Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2410074	289126	278262	316906	326838	352283	362688	376148
		Phase Angle, F (º)	5.6	2.2	3.0	3.4	3.0	2.0	1.5	1.6
		Average Peak Stress (psi)	157	183	190	203	209	229	236	255
		Average Peak Strain (με)	65	63	68	64	64	65	65	68
	2	|E*| (psi)	2501432	294507	304867	325258	338290	365351	376173	388686
		Phase Angle, F (º)	7.0	3.8	5.3	4.5	4.3	3.6	3.0	2.8
		Average Peak Stress (psi)	196	229	237	254	262	286	295	319
		Average Peak Strain (με)	78	78	78	78	77	78	78	82
	3	|E*| (psi)	2199234	250656	254431	287183	296094	324289	333703	346090
		Phase Angle, F (º)	7.4	2.6	5.0	4.8	4.7	3.8	3.3	3.2
		Average Peak Stress (psi)	157	183	190	203	210	229	236	255
		Average Peak Strain (με)	71	73	75	71	71	71	71	74
	Avg.	|E*| Average (psi)	2370247	278097	279187	309782	320407	347308	357521	370308
		F Average	6.7	2.8	4.4	4.3	4.0	3.1	2.6	2.5
		|E*| Coeff. of Variation (psi)	0.065	0.086	0.090	0.065	0.068	0.060	0.061	0.059
		F Coeff. of Variation	0.14	0.29	0.27	0.17	0.22	0.32	0.38	0.34
		|E*| Std. Dev. (psi)	154985.9	239160.	252305.	200121.	218210.	209781.	217012.	218899.
		F Std. Dev.	0.955	0.823	1.220	0.712	0.888	0.991	0.967	0.869
10	1	|E*| (psi)	833695	108931	127472	163139	178527	215177	232849	253120
		Phase Angle, F (º)	19.4	14.0	15.7	12.3	11.1	8.7	7.4	6.7
		Average Peak Stress (psi)	33	46	56	72	85	118	134	147
		Average Peak Strain (με)	39	42	44	44	48	55	58	58
	2	|E*| (psi)	879877	124080	133445	168202	182437	218092	232653	255883
		Phase Angle, F (º)	22.2	20.4	15.0	13.7	12.6	9.9	8.7	8.0
		Average Peak Stress (psi)	41	57	70	90	106	147	168	184
		Average Peak Strain (με)	46	46	52	54	58	68	72	72
	3	|E*| (psi)	797400	111279	116987	148162	161444	196873	214271	232892
		Phase Angle, F (º)	21.4	19.7	17.0	13.7	12.6	10.4	9.5	10.1
		Average Peak Stress (psi)	33	46	56	72	85	118	134	147
		Average Peak Strain (με)	41	41	48	49	53	60	63	63
	Avg.	|E*| Average (psi)	836991	114763	125968	159834	174136	210047	226591	247298
		F Average	21.0	18.1	15.9	13.3	12.1	9.7	8.5	8.3
		|E*| Coeff. of Variation (psi)	0.049	0.071	0.066	0.065	0.064	0.055	0.047	0.051
		F Coeff. of Variation	0.07	0.19	0.06	0.06	0.07	0.09	0.13	0.20
		|E*| Std. Dev. (psi)	41337.5	81537.7	83314.2	104204.	111641.	115020.	106695.	125524.
		F Std. Dev.	1.453	3.510	1.018	0.801	0.834	0.834	1.075	1.690
35	1	|E*| (psi)	88845	124479	151664	244678	311354	525041	638513	795317
		Phase Angle, F (º)	29.9	31.9	30.6	31.9	29.5	24.7	22.0	19.6
		Average Peak Stress (psi)	2	3	4	7	11	16	26	45
		Average Peak Strain (με)	19	26	28	31	36	30	40	56
	2	|E*| (psi)	97256	140237	170550	275646	343786	575326	684095	837903
		Phase Angle, F (º)	35.3	34.1	33.8	33.0	30.6	25.9	22.6	20.4
		Average Peak Stress (psi)	2	4	5	9	14	20	32	57
		Average Peak Strain (με)	21	29	31	34	41	35	47	68
	3	|E*| (psi)	89556	140066	170117	271006	337159	566498	677036	821558
		Phase Angle, F (º)	26.4	30.2	31.7	32.7	30.5	26.2	22.7	20.6
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	23	29	31	34	42	35	47	69
	Avg.	|E*| Average (psi)	91886	134927	164110	263777	330766	555622	666548	818259
		F Average	30.5	32.0	32.0	32.5	30.2	25.6	22.4	20.2
		|E*| Coeff. of Variation (psi)	0.051	0.067	0.066	0.063	0.052	0.048	0.037	0.026
		F Coeff. of Variation	0.15	0.06	0.05	0.02	0.02	0.03	0.02	0.03
		|E*| Std. Dev. (psi)	4664.5	9048.8	10781.0	16701.9	17135.1	26849.2	24534.4	21483.8
		F Std. Dev.	4.488	1.975	1.636	0.550	0.589	0.799	0.382	0.560
54.4	1	|E*| (psi)	40026	41508	43868	63597	79290	142212	188202	259372
		Phase Angle, F (º)	18.5	25.6	23.7	26.9	27.3	26.3	25.2	25.7
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	20	30	47	64	66	62	70	70
	2	|E*| (psi)	39453	43691	44843	65277	82211	149048	194097	272579
		Phase Angle, F (º)	27.3	24.8	27.2	28.4	28.5	27.3	26.2	26.2
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	21	28	46	63	64	60	68	66
	3	|E*| (psi)	43498	48613	48729	66652	83094	146432	190667	260342
		Phase Angle, F (º)	13.9	22.0	22.4	26.3	27.1	27.2	25.6	25.8
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	19	25	42	62	63	60	68	68
	Avg.	|E*| Average (psi)	40992	44604	45813	65175	81532	145897	190989	264098
		F Average	19.9	24.1	24.4	27.2	27.6	26.9	25.7	25.9
		|E*| Coeff. of Variation (psi)	0.053	0.082	0.056	0.023	0.024	0.024	0.016	0.028
		F Coeff. of Variation	0.34	0.08	0.10	0.04	0.03	0.02	0.02	0.01
		|E*| Std. Dev. (psi)	2188.6	3639.4	2571.8	1530.1	1990.9	3448.9	2960.6	7361.1
		F Std. Dev.	6.813	1.925	2.459	1.045	0.773	0.545	0.539	0.251

Table B-17. S12.5BC–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2527259	331728	340520	372885	391701	434802	452227	474906
		Phase Angle, F (º)	9.8	5.8	6.7	5.6	4.6	4.5	3.9	3.2
		Average Peak Stress (psi)	180	213	225	242	246	270	278	301
		Average Peak Strain (με)	71	64	66	65	63	62	62	63
	2	|E*| (psi)	2333889	311151	314733	346583	365195	404270	421235	442685
		Phase Angle, F (º)	11.9	7.9	7.4	7.0	5.6	5.1	4.6	4.3
		Average Peak Stress (psi)	180	213	225	242	246	270	278	301
		Average Peak Strain (με)	77	68	72	70	67	67	66	68
	3	|E*| (psi)	2462268	326572	313108	359567	376953	417306	433872	454639
		Phase Angle, F (º)	10.5	9.8	5.1	6.9	5.0	4.5	4.0	3.5
		Average Peak Stress (psi)	180	213	225	242	245	270	279	302
		Average Peak Strain (με)	73	65	72	67	65	65	64	66
	Avg.	|E*| Average (psi)	2441138	323150	322787	359679	377950	418793	435778	457410
		F Average	10.7	7.8	6.4	6.5	5.1	4.7	4.1	3.6
		|E*| Coeff. of Variation (psi)	0.040	0.033	0.048	0.037	0.035	0.037	0.036	0.036
		F Coeff. of Variation	0.10	0.25	0.19	0.12	0.10	0.07	0.09	0.15
		|E*| Std. Dev. (psi)	98401.5	107069.	153786.	131512.	132811.	153201.	155839.	162879.
		F Std. Dev.	1.046	1.999	1.182	0.759	0.509	0.319	0.369	0.548
10	1	|E*| (psi)	416172	733042	825358	124420	144840	198425	222565	255791
		Phase Angle, F (º)	31.3	24.9	24.3	20.6	17.8	14.7	12.8	11.9
		Average Peak Stress (psi)	25	45	61	90	107	147	167	183
		Average Peak Strain (με)	59	61	74	72	74	74	75	71
	2	|E*| (psi)	391436	660134	795093	120168	139952	190193	215225	248378
		Phase Angle, F (º)	32.7	24.9	26.0	21.6	18.6	14.9	13.0	13.0
		Average Peak Stress (psi)	25	45	61	90	106	147	168	183
		Average Peak Strain (με)	63	68	77	75	76	77	78	74
	3	|E*| (psi)	461401	709485	931316	131054	150900	202812	225649	255576
		Phase Angle, F (º)	30.4	28.0	24.6	19.2	16.2	14.0	12.3	10.9
		Average Peak Stress (psi)	25	45	61	90	106	143	168	183
		Average Peak Strain (με)	53	63	66	69	71	70	74	72
	Avg.	|E*| Average (psi)	423003	700887	850589	125214	145231	197143	221146	253248
		F Average	31.4	25.9	25.0	20.5	17.5	14.6	12.7	11.9
		|E*| Coeff. of Variation (psi)	0.084	0.053	0.084	0.044	0.038	0.032	0.024	0.017
		F Coeff. of Variation	0.04	0.07	0.04	0.06	0.07	0.03	0.03	0.09
		|E*| Std. Dev. (psi)	35479.1	37207.1	71530.9	54858.9	54844.1	64063.4	53548.0	42193.7
		F Std. Dev.	1.149	1.781	0.877	1.209	1.250	0.489	0.371	1.080
35	1	|E*| (psi)	31328	50763	64832	122702	165488	335907	439464	611479
		Phase Angle, F (º)	27.0	30.0	31.3	34.8	33.1	30.8	29.1	27.6
		Average Peak Stress (psi)	2	3	4	7	10	20	27	43
		Average Peak Strain (με)	66	65	63	53	61	59	62	71
	2	|E*| (psi)	27771	45328	58259	107620	148342	307203	407171	577586
		Phase Angle, F (º)	24.1	26.4	28.7	33.1	31.8	30.5	29.4	27.8
		Average Peak Stress (psi)	2	3	4	7	10	20	27	43
		Average Peak Strain (με)	74	72	70	61	68	64	67	75
	3	|E*| (psi)	37743	56971	72219	129614	176085	345448	452489	622593
		Phase Angle, F (º)	25.1	28.8	30.0	34.1	31.6	29.8	28.3	26.7
		Average Peak Stress (psi)	2	3	4	7	10	20	27	44
		Average Peak Strain (με)	55	57	56	50	57	57	61	70
	Avg.	|E*| Average (psi)	32281	51021	65103	119979	163305	329519	433041	603886
		F Average	25.4	28.4	30.0	34.0	32.2	30.4	28.9	27.3
		|E*| Coeff. of Variation (psi)	0.157	0.114	0.107	0.094	0.086	0.060	0.054	0.039
		F Coeff. of Variation	0.06	0.07	0.04	0.03	0.03	0.02	0.02	0.02
		|E*| Std. Dev. (psi)	5053.8	5825.5	6983.6	11246.9	13999.6	19906.7	23331.3	23444.9
		F Std. Dev.	1.477	1.848	1.258	0.853	0.825	0.505	0.532	0.579
54.4	Est.	|E*| (psi)	8267	11458	13489	21176	26252	45832	59320	84412

Table B-18. S12.5BF–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2384775	309946	314816	342275	360539	395669	411208	427821
		Phase Angle, F (º)	9.9	6.7	6.6	6.5	5.1	5.0	4.0	3.6
		Average Peak Stress (psi)	196	229	237	254	262	286	295	318
		Average Peak Strain (με)	82	74	75	74	73	72	72	74
	2	|E*| (psi)	2510049		298949	355251	371080	409126	421068	441839
		Phase Angle, F (º)	8.6		6.8	5.4	4.0	3.9	3.1	3.5
		Average Peak Stress (psi)	196		237	254	262	286	295	318
		Average Peak Strain (με)	78		79	71	71	70	70	72
	3	|E*| (psi)	2511303	269676	315341	355991	372745	411163	422393	441441
		Phase Angle, F (º)	9.1	4.7	4.1	5.2	4.0	3.3	2.9	2.5
		Average Peak Stress (psi)	196	229	237	254	262	286	295	318
		Average Peak Strain (με)	78	85	75	71	70	70	70	72
	Avg.	|E*| Average (psi)	2468709	289811	309702	351173	368122	405319	418223	437034
		F Average	9.2	5.7	5.8	5.7	4.4	4.1	3.3	3.2
		|E*| Coeff. of Variation (psi)	0.029	0.098	0.030	0.022	0.018	0.021	0.015	0.018
		F Coeff. of Variation	0.07	0.25	0.26	0.13	0.15	0.22	0.18	0.19
		|E*| Std. Dev. (psi)	72691.6	284752.	93159.1	77141.7	66194.4	84194.9	61110.0	79809.6
		F Std. Dev.	0.678	1.393	1.488	0.722	0.642	0.897	0.586	0.599
10	1	|E*| (psi)	505411	827837	954872	131539	149001	193857	214887	245475
		Phase Angle, F (º)	27.5	24.0	22.1	17.9	15.6	12.9	11.1	10.9
		Average Peak Stress (psi)	53	70	82	103	119	159	184	199
		Average Peak Strain (με)	105	84	86	78	80	82	85	81
	2	|E*| (psi)	577391	883319	102341	143066	160983	207949	229174	260926
		Phase Angle, F (º)	25.9	18.9	21.6	17.2	14.4	12.3	11.1	10.5
		Average Peak Stress (psi)	53	70	82	102	119	159	184	200
		Average Peak Strain (με)	92	79	80	72	74	77	80	77
	3	|E*| (psi)	517347	818450	944304	133244	152086	199829	219668	249490
		Phase Angle, F (º)	26.3	20.1	22.2	17.2	14.8	11.7	10.5	9.8
		Average Peak Stress (psi)	53	69	82	102	119	159	184	200
		Average Peak Strain (με)	103	85	87	77	78	80	84	80
	Avg.	|E*| Average (psi)	533383	843202	974196	135950	154023	200545	221243	251964
		F Average	26.6	21.0	22.0	17.5	14.9	12.3	10.9	10.4
		|E*| Coeff. of Variation (psi)	0.072	0.042	0.044	0.046	0.040	0.035	0.033	0.032
		F Coeff. of Variation	0.03	0.13	0.01	0.02	0.04	0.05	0.03	0.05
		|E*| Std. Dev. (psi)	38576.4	35057.8	42947.8	62214.7	62215.3	70734.0	72725.4	80170.6
		F Std. Dev.	0.800	2.690	0.311	0.421	0.603	0.582	0.363	0.562
35	1	|E*| (psi)	37855	62946	78610	143152	193190	358968	460205	629318
		Phase Angle, F (º)	29.2	32.2	32.2	32.9	29.5	28.4	26.0	24.5
		Average Peak Stress (psi)	3	5	6	11	20	32	44	64
		Average Peak Strain (με)	76	77	78	80	105	88	95	102
	2	|E*| (psi)	40242	70619	89534	165085	225843	414134	525096	693905
		Phase Angle, F (º)	27.1	29.7	30.4	31.9	28.5	27.1	24.6	23.2
		Average Peak Stress (psi)	3	5	6	11	20	32	44	65
		Average Peak Strain (με)	71	71	69	69	90	77	84	93
	3	|E*| (psi)	36346	61557	76153	143787	199371	373607	483352	665532
		Phase Angle, F (º)	26.0	26.1	30.1	31.7	28.7	26.6	25.7	24.4
		Average Peak Stress (psi)	3	5	6	11	20	32	44	65
		Average Peak Strain (με)	79	81	81	80	102	85	91	97
	Avg.	|E*| Average (psi)	38148	65041	81433	150675	206135	382236	489551	662918
		F Average	27.4	29.3	30.9	32.2	28.9	27.4	25.4	24.0
		|E*| Coeff. of Variation (psi)	0.051	0.075	0.087	0.083	0.084	0.075	0.067	0.049
		F Coeff. of Variation	0.06	0.10	0.04	0.02	0.02	0.03	0.03	0.03
		|E*| Std. Dev. (psi)	1964.5	4880.5	7122.9	12483.4	17345.3	28577.4	32886.7	32372.3
		F Std. Dev.	1.630	3.038	1.154	0.637	0.503	0.898	0.742	0.720
54.4	Est.	|E*| (psi)	7832	12473	15519	27267	35244	65267	85572	122122

Table B-19. S12.5CC–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2822607	331475	360963	385556	403691	447347	465547	487913
		Phase Angle, F (º)	6.9	12.3	7.0	4.4	4.5	3.8	3.2	3.3
		Average Peak Stress (psi)	196	229	237	254	262	286	295	319
		Average Peak Strain (με)	70	69	66	66	65	64	63	65
	2	|E*| (psi)	2576799	284103	327128	351893	372931	408464	423105	445085
		Phase Angle, F (º)	7.1		6.4	4.3	4.0	3.1	2.4	2.6
		Average Peak Stress (psi)	196	229	237	254	262	286	295	319
		Average Peak Strain (με)	76	81	73	72	70	70	70	72
	3	|E*| (psi)	2762276	345789	337022	377794	394487	436760	455643	479108
		Phase Angle, F (º)	6.6	7.9	2.4	4.8	3.1	2.8	2.4	2.4
		Average Peak Stress (psi)	196	229	237	254	262	286	295	319
		Average Peak Strain (με)	71	66	70	67	66	66	65	67
	Avg.	|E*| Average (psi)	2720561	320456	341704	371748	390369	430857	448098	470702
		F Average	6.9	10.1	5.3	4.5	3.9	3.2	2.7	2.8
		|E*| Coeff. of Variation (psi)	0.047	0.101	0.051	0.047	0.040	0.047	0.050	0.048
		F Coeff. of Variation	0.03	0.31	0.47	0.05	0.19	0.16	0.18	0.18
		|E*| Std. Dev. (psi)	128103.6	322854.	173969.	176271.	157879.	201025.	222038.	226177.
		F Std. Dev.	0.218	3.089	2.484	0.217	0.734	0.517	0.474	0.492
10	1	|E*| (psi)	762608	100681	118263	159445	177593	220755	243708	273590
		Phase Angle, F (º)	21.9	20.6	16.8	14.6	13.8	10.9	9.9	9.2
		Average Peak Stress (psi)	53	70	82	102	119	159	176	192
		Average Peak Strain (με)	70	69	69	64	67	72	72	70
	2	|E*| (psi)	740425	101302	117835	151950	166855	209027	229669	255390
		Phase Angle, F (º)	20.4	20.8	17.1	13.3	12.4	9.9	8.8	8.3
		Average Peak Stress (psi)	53	70	82	102	119	159	176	192
		Average Peak Strain (με)	72	69	70	67	71	76	76	75
	3	|E*| (psi)	794538	107005	120966	161167	178982	226218	246723	276784
		Phase Angle, F (º)	19.8	20.3	16.3	12.9	12.1	9.8	8.8	8.3
		Average Peak Stress (psi)	53	70	82	102	119	159	176	192
		Average Peak Strain (με)	67	65	68	63	66	70	71	69
	Avg.	|E*| Average (psi)	765857	102996	119022	157520	174477	218667	240034	268588
		F Average	20.7	20.6	16.8	13.6	12.8	10.2	9.2	8.6
		|E*| Coeff. of Variation (psi)	0.036	0.034	0.014	0.031	0.038	0.040	0.038	0.043
		F Coeff. of Variation	0.05	0.01	0.02	0.06	0.07	0.06	0.07	0.06
		|E*| Std. Dev. (psi)	27202.5	34854.5	16977.4	49007.7	66366.7	87832.1	91012.3	115408.
		F Std. Dev.	1.098	0.264	0.387	0.855	0.885	0.603	0.623	0.530
35	1	|E*| (psi)	113222	157280	175601	275742	339745	554613	662600	829783
		Phase Angle, F (º)	28.2	26.6	28.0	28.6	26.3	22.7	21.0	20.2
		Average Peak Stress (psi)	4	5	7	11	24	32	44	65
		Average Peak Strain (με)	33	31	42	41	72	58	67	78
	2	|E*| (psi)	107477	169908	179843	272654	339717	543785	653330	804761
		Phase Angle, F (º)	28.6	27.3	27.4	27.7	25.3	22.0	20.2	19.7
		Average Peak Stress (psi)	4	5	7	11	24	32	44	65
		Average Peak Strain (με)	34	31	41	42	72	59	68	81
	3	|E*| (psi)	129100	182196	202646	307383	377098	604092	724372	891498
		Phase Angle, F (º)	27.5	26.7	28.1	27.6	25.3	22.4	20.7	19.8
		Average Peak Stress (psi)	4	5	7	11	24	32	44	65
		Average Peak Strain (με)	29	27	36	37	65	53	61	73
	Avg.	|E*| Average (psi)	116600	169794	186030	285260	352187	567497	680101	842014
		F Average	28.1	26.8	27.8	27.9	25.7	22.4	20.7	19.9
		|E*| Coeff. of Variation (psi)	0.096	0.073	0.078	0.067	0.061	0.057	0.057	0.053
		F Coeff. of Variation	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.01
		|E*| Std. Dev. (psi)	11200.2	12458.5	14545.1	19221.4	21573.9	32151.7	38619.6	44643.3
		F Std. Dev.	0.580	0.366	0.375	0.567	0.584	0.354	0.397	0.294
54.4	Est.	|E*| (psi)	40611	55549	64397	93259	110519	166358	199282	253526

Table B-20. S12.5CF–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	3268954		376879	426767	447058	485564	505089	523026
		Phase Angle, F (º)	7.2		3.0	4.4	4.3	3.1	2.2	2.2
		Average Peak Stress (psi)	176		213	238	254	270	283	302
		Average Peak Strain (με)	54		56	56	57	56	56	58
	2	|E*| (psi)	2933994	313718	364754	407309	424874	465607	479750	498119
		Phase Angle, F (º)	12.2	7.2	7.0	9.0	8.5	7.3	6.8	6.3
		Average Peak Stress (psi)	197	221	229	254	262	286	295	319
		Average Peak Strain (με)	67	71	63	62	62	62	61	64
	3	|E*| (psi)	3289241	391378	403325	448113	462203	503150	521423	540814
		Phase Angle, F (º)	9.8	2.2	11.0	7.3	6.8	5.5	4.6	3.8
		Average Peak Stress (psi)	197	221	229	254	262	286	295	318
		Average Peak Strain (με)	60	57	57	57	57	57	57	59
	Avg.	|E*| Average (psi)	3164063	352548	381653	427396	444712	484774	502087	520653
		F Average	9.8	4.7	7.0	6.9	6.5	5.3	4.5	4.1
		|E*| Coeff. of Variation (psi)	0.063	0.156	0.052	0.048	0.042	0.039	0.042	0.041
		F Coeff. of Variation	0.26	0.74	0.57	0.34	0.33	0.41	0.50	0.49
		|E*| Std. Dev. (psi)	199503.4	549138.	197236.	204094.	187750.	187839.	209981.	214462.
		F Std. Dev.	2.493	3.519	3.967	2.306	2.114	2.152	2.258	2.039
10	1	|E*| (psi)	966240	122481	156616	201684	218595	268548	290421	321450
		Phase Angle, F (º)	21.4	18.0	18.4	13.8	12.2	9.9	8.7	8.3
		Average Peak Stress (psi)	45	57	66	86	102	135	156	167
		Average Peak Strain (με)	47	47	42	43	47	50	54	52
	2	|E*| (psi)	905319	119085	140825	191384	212542	265343	288034	323621
		Phase Angle, F (º)	27.3	22.5	19.9	18.3	16.2	13.9	12.9	12.1
		Average Peak Stress (psi)	53	70	82	103	119	159	176	192
		Average Peak Strain (με)	59	58	58	54	56	60	61	59
	3	|E*| (psi)	995858	144202	166907	212546	234024	281889	308213	341669
		Phase Angle, F (º)	25.4	24.8	20.3	16.5	15.3	12.6	12.0	11.5
		Average Peak Stress (psi)	53	70	82	103	119	159	175	192
		Average Peak Strain (με)	54	48	49	48	51	57	57	56
	Avg.	|E*| Average (psi)	955806	128589	154782	201871	221720	271927	295556	328913
		F Average	24.7	21.8	19.5	16.2	14.6	12.1	11.2	10.6
		|E*| Coeff. of Variation (psi)	0.048	0.106	0.085	0.052	0.050	0.032	0.037	0.034
		F Coeff. of Variation	0.12	0.16	0.05	0.14	0.14	0.17	0.20	0.19
		|E*| Std. Dev. (psi)	46162.9	136268.	131372.	105823.	110763.	87749.5	110258.	110998.
		F Std. Dev.	3.015	3.444	0.980	2.263	2.072	2.028	2.205	2.029
35	1	|E*| (psi)	80931	137641	173900	273396	361289	614670	740562	939989
		Phase Angle, F (º)	27.8	28.4	28.6	31.0	27.8	24.0	22.4	20.9
		Average Peak Stress (psi)	4	8	12	16	24	36	44	57
		Average Peak Strain (με)	50	60	71	60	68	59	60	60
	2	|E*| (psi)	100759	141327	168068	261402	351909	602415	732421	918376
		Phase Angle, F (º)	33.2	36.0	32.2	34.7	29.7	26.6	24.3	22.7
		Average Peak Stress (psi)	4	5	7	11	25	32	44	65
		Average Peak Strain (με)	37	35	44	44	70	54	60	71
	3	|E*| (psi)	93628	147515	182889	297972	407501	686346	851068	107315
		Phase Angle, F (º)	30.3	30.0	31.6	33.2	29.1	25.7	23.3	21.7
		Average Peak Stress (psi)	5	6	8	12	24	32	44	64
		Average Peak Strain (με)	52	41	45	41	60	46	51	60
	Avg.	|E*| Average (psi)	91773	142161	174952	277590	373566	634477	774684	977172
		F Average	30.4	31.5	30.8	33.0	28.9	25.4	23.4	21.8
		|E*| Coeff. of Variation (psi)	0.109	0.035	0.043	0.067	0.080	0.071	0.086	0.086
		F Coeff. of Variation	0.09	0.13	0.06	0.06	0.03	0.05	0.04	0.04
		|E*| Std. Dev. (psi)	10043.3	4989.5	7466.4	18642.2	29760.6	45335.9	66276.0	83820.8
		F Std. Dev.	2.691	3.967	1.927	1.888	0.959	1.324	0.968	0.928
54.4	Est.	|E*| (psi)	25382	38290	46557	75275	93549	157221	196816	264404

Table B-21. S12.5CF–Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2332993	281712	273066	306039	318669	342044	353069	365606
		Phase Angle, F (º)	5.5	4.6	2.9	3.8	3.0	2.4	1.7	1.9
		Average Peak Stress (psi)	196	229	237	253	261	286	295	318
		Average Peak Strain (με)	84	81	87	83	82	84	83	87
	2	|E*| (psi)	2487187	265869	290837	327149	338292	364762	375345	383259
		Phase Angle, F (º)	8.4	9.7	4.5	5.6	5.2	4.4	3.8	3.7
		Average Peak Stress (psi)	157	183	190	203	210	229	236	255
		Average Peak Strain (με)	63	69	65	62	62	63	63	67
	3	|E*| (psi)	1920802	247543	276594	312994	330289	358359	368938	380864
		Phase Angle, F (º)	12.4	9.2	8.0	7.6	7.0	6.1	5.1	4.6
		Average Peak Stress (psi)	157	183	190	203	209	229	236	255
		Average Peak Strain (με)	82	74	69	65	63	64	64	67
	Avg.	|E*| Average (psi)	2246994	265041	280166	315394	329083	355055	365784	376576
		F Average	8.8	7.8	5.1	5.7	5.1	4.3	3.6	3.4
		|E*| Coeff. of Variation (psi)	0.130	0.065	0.034	0.034	0.030	0.033	0.031	0.025
		F Coeff. of Variation	0.39	0.36	0.51	0.33	0.39	0.43	0.48	0.39
		|E*| Std. Dev. (psi)	292822.1	170994.	94084.4	107576.	98670.4	117137.	114681.	95756.6
		F Std. Dev.	3.443	2.830	2.620	1.882	1.993	1.854	1.700	1.339
10	1	|E*| (psi)	758290	101920	117845	150768	164060	200241	218122	238254
		Phase Angle, F (º)	20.4	19.7	13.4	12.4	10.9	8.8	7.8	7.6
		Average Peak Stress (psi)	33	46	56	72	85	118	134	146
		Average Peak Strain (με)	43	45	47	48	52	59	61	61
	2	|E*| (psi)	799285	118758	127901	158877	175856	216938	232977	253436
		Phase Angle, F (º)	22.8	19.1	18.8	14.4	13.3	11.2	10.2	9.6
		Average Peak Stress (psi)	33	46	56	72	85	118	134	147
		Average Peak Strain (με)	41	39	43	45	48	54	58	58
	3	|E*| (psi)	813574	118164	130280	163263	178135	214601	231729	253094
		Phase Angle, F (º)	28.6	27.1	19.9	18.4	15.9	12.9	11.8	11.3
		Average Peak Stress (psi)	33	46	56	72	85	118	134	147
		Average Peak Strain (με)	40	39	43	44	48	55	58	58
	Avg.	|E*| Average (psi)	790383	112948	125342	157636	172684	210593	227610	248261
		F Average	24.0	22.0	17.4	15.1	13.3	11.0	10.0	9.5
		|E*| Coeff. of Variation (psi)	0.036	0.085	0.053	0.040	0.044	0.043	0.036	0.035
		F Coeff. of Variation	0.18	0.20	0.20	0.20	0.19	0.19	0.20	0.19
		|E*| Std. Dev. (psi)	28697.2	95544.6	66009.4	63391.1	75543.6	90412.5	82399.4	86685.8
		F Std. Dev.	4.234	4.447	3.469	3.031	2.537	2.036	2.036	1.828
35	1	|E*| (psi)	76069	120372	151879	247384	315177	542647	667082	820661
		Phase Angle, F (º)	26.2	28.1	28.5	29.8	27.6	22.4	20.5	19.9
		Average Peak Stress (psi)	3	5	9	13	19	32	45	51
		Average Peak Strain (με)	43	41	56	53	62	59	67	62
	2	|E*| (psi)	105696	143128	165300	251505	319879	552707	668994	825474
		Phase Angle, F (º)	23.5	27.5	30.1	31.9	29.6	25.7	22.9	22.4
		Average Peak Stress (psi)	3	5	8	13	19	32	45	52
		Average Peak Strain (με)	31	34	50	52	61	58	67	62
	3	|E*| (psi)	103818	138531	164668	250833	318445	544131	662817	814639
		Phase Angle, F (º)	31.5	31.8	30.1	32.2	30.1	25.6	23.1	22.1
		Average Peak Stress (psi)	3	5	9	13	19	32	45	52
		Average Peak Strain (με)	32	35	52	52	61	59	68	63
	Avg.	|E*| Average (psi)	95194	134010	160616	249908	317833	546495	666298	820258
		F Average	27.1	29.1	29.6	31.3	29.1	24.6	22.1	21.5
		|E*| Coeff. of Variation (psi)	0.174	0.090	0.047	0.009	0.008	0.010	0.005	0.007
		F Coeff. of Variation	0.15	0.08	0.03	0.04	0.05	0.08	0.07	0.06
		|E*| Std. Dev. (psi)	16589.9	12032.6	7572.7	2211.0	2410.1	5430.9	3162.2	5428.8
		F Std. Dev.	4.083	2.311	0.900	1.305	1.332	1.855	1.454	1.350
54.4	1	|E*| (psi)	35843	42885	46359	64826	79965	141608	185365	260793
		Phase Angle, F (º)	10.5	11.5	20.8	23.8	25.0	25.9	25.0	25.9
		Average Peak Stress (psi)	1	1	2	3	4	7	10	14
		Average Peak Strain (με)	18	23	36	51	53	50	56	53
	2	|E*| (psi)		65038	70888	80673	92974	152119	192172	260997
		Phase Angle, F (º)		14.7	15.4	22.0	24.9	27.1	26.2	27.3
		Average Peak Stress (psi)		1	2	3	4	7	10	14
		Average Peak Strain (με)		15	23	41	46	47	54	53
	3	|E*| (psi)	74831	68571	60355	74114	87412	144811	190871	263295
		Phase Angle, F (º)	20.0	25.4	24.2	26.3	27.1	28.1	26.6	28.2
		Average Peak Stress (psi)	1	1	2	3	4	7	10	14
		Average Peak Strain (με)	9	14	27	44	48	49	54	52
	Avg.	|E*| Average (psi)	55337	58831	59201	73204	86784	146179	189469	261695
		F Average	15.3	17.2	20.1	24.0	25.7	27.0	26.0	27.1
		|E*| Coeff. of Variation (psi)	0.498	0.237	0.208	0.109	0.075	0.037	0.019	0.005
		F Coeff. of Variation	0.44	0.42	0.22	0.09	0.05	0.04	0.03	0.04
		|E*| Std. Dev. (psi)	27569.3	13922.8	12305.1	7962.2	6527.0	5387.9	3613.4	1389.6
		F Std. Dev.	6.731	7.292	4.434	2.160	1.270	1.079	0.827	1.175

Table B-22. S12.5DC–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2998437	312100	394178	423204	439486	477574	493716	516568
		Phase Angle, F (º)	12.2	13.7	11.9	8.8	8.1	6.7	6.2	6.0
		Average Peak Stress (psi)	184	213	221	246	262	278	291	309
		Average Peak Strain (με)	61	68	56	58	60	58	59	60
	2	|E*| (psi)	3012788	324851	374310	428532	450901	492179	510542	531726
		Phase Angle, F (º)	8.5	4.6	5.8	5.8	5.2	4.0	3.7	3.7
		Average Peak Stress (psi)	176	205	213	238	253	270	282	301
		Average Peak Strain (με)	58	63	57	55	56	55	55	57
	3	|E*| (psi)	3066624		362551	431071	445203	494299	511740	533135
		Phase Angle, F (º)	7.9		6.4	5.1	4.4	3.4	2.6	2.9
		Average Peak Stress (psi)	184		221	246	262	278	291	310
		Average Peak Strain (με)	60		61	57	59	56	57	58
	Avg.	|E*| Average (psi)	3025950	318476	377013	427602	445197	488017	505333	527143
		F Average	9.5	9.2	8.0	6.6	5.9	4.7	4.2	4.2
		|E*| Coeff. of Variation (psi)	0.012	0.028	0.042	0.009	0.013	0.019	0.020	0.017
		F Coeff. of Variation	0.25	0.70	0.42	0.30	0.33	0.38	0.44	0.39
		|E*| Std. Dev. (psi)	35948.7	90162.1	159861.	40147.6	57073.1	91059.1	100778.	91852.7
		F Std. Dev.	2.345	6.439	3.361	1.963	1.978	1.775	1.814	1.615
10	1	|E*| (psi)	777338	114240	134132	180426	200657	248566	273703	287830
		Phase Angle, F (º)	27.0	18.3	18.7	18.0	16.1	12.7	11.6	9.6
		Average Peak Stress (psi)	53	70	82	102	119	155	180	192
		Average Peak Strain (με)	68	61	61	57	59	62	66	67
	2	|E*| (psi)	847146	132817	150911	193623	212938	264105	287612	322194
		Phase Angle, F (º)	23.5	23.5	18.9	15.4	14.5	11.4	10.6	10.1
		Average Peak Stress (psi)	45	57	66	86	102	135	155	167
		Average Peak Strain (με)	53	43	43	44	48	51	54	52
	3	|E*| (psi)								
		Phase Angle, F (º)								
		Average Peak Stress (psi)								
		Average Peak Strain (με)								
	Avg.	|E*| Average (psi)	812242	123529	142522	187024	206797	256336	280658	305012
		F Average	25.2	20.9	18.8	16.7	15.3	12.1	11.1	9.8
		|E*| Coeff. of Variation (psi)	0.061	0.106	0.083	0.050	0.042	0.043	0.035	0.080
		F Coeff. of Variation	0.10	0.18	0.01	0.11	0.07	0.08	0.06	0.04
		|E*| Std. Dev. (psi)	49361.7	131356.	118647.	93316.4	86846.6	109874.	98356.3	242989.
		F Std. Dev.	2.529	3.662	0.161	1.796	1.139	0.959	0.693	0.399
35	1	|E*| (psi)	76000	119946	154755	230030	317052	547227	684433	892562
		Phase Angle, F (º)	25.1	25.6	26.2	31.8	28.3	26.1	24.7	23.6
		Average Peak Stress (psi)	10	16	25	29	41	57	65	82
		Average Peak Strain (με)	135	136	159	125	128	103	94	92
	2	|E*| (psi)	68446	108299	137299	214775	294942	527188	662812	870307
		Phase Angle, F (º)	25.2	26.8	26.5	31.1	28.3	24.9	23.6	22.7
		Average Peak Stress (psi)	6	10	16	20	28	44	52	65
		Average Peak Strain (με)	89	94	119	95	97	84	79	75
	3	|E*| (psi)	73250	118588	156114	240099	332173	573090	716598	936499
		Phase Angle, F (º)	23.9	25.4	25.3	30.7	27.1	24.2	23.1	22.2
		Average Peak Stress (psi)	10	16	25	29	41	57	65	82
		Average Peak Strain (με)	140	138	157	119	123	99	90	87
	Avg.	|E*| Average (psi)	72565	115611	149390	228301	314722	549168	687948	899789
		F Average	24.7	25.9	26.0	31.2	27.9	25.1	23.8	22.9
		|E*| Coeff. of Variation (psi)	0.053	0.055	0.070	0.056	0.059	0.042	0.039	0.037
		F Coeff. of Variation	0.03	0.03	0.02	0.02	0.02	0.04	0.03	0.03
		|E*| Std. Dev. (psi)	3823.4	6368.6	10492.8	12750.0	18724.5	23012.3	27065.0	33682.8
		F Std. Dev.	0.697	0.754	0.586	0.598	0.694	0.931	0.790	0.696
54.4	Est.	|E*| (psi)	18484	28766	35373	58956	74216	128225	162464	221456

Table B-23. S12.5DF–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	3085563	344951	359436	413491	426340	457969	475218	493891
		Phase Angle, F (º)	9.8	1.0	5.1	7.2	7.4	6.1	5.4	5.4
		Average Peak Stress (psi)	176	209	217	238	246	270	279	302
		Average Peak Strain (με)	57	61	60	58	58	59	59	61
	2	|E*| (psi)		303330	346189	406933	422297	456965	471978	
		Phase Angle, F (º)		5.7	6.9	4.8	4.9	3.9	4.0	
		Average Peak Stress (psi)		209	217	238	246	270	278	
		Average Peak Strain (με)		69	63	58	58	59	59	
	3	|E*| (psi)	2957364	310928	354007	379965	395789	428099	440474	
		Phase Angle, F (º)	6.8	1.2	2.8	4.9	4.8	3.6	3.3	
		Average Peak Stress (psi)	176	209	217	238	246	270	279	
		Average Peak Strain (με)	60	67	61	63	62	63	63	
	Avg.	|E*| Average (psi)	3021464	319736	353210	400129	414809	447678	462557	493891
		F Average	8.3	2.6	4.9	5.6	5.7	4.5	4.2	5.4
		|E*| Coeff. of Variation (psi)	0.030	0.069	0.019	0.044	0.040	0.038	0.041	
		F Coeff. of Variation	0.25	1.01	0.42	0.25	0.25	0.31	0.26	
		|E*| Std. Dev. (psi)	90650.3	221648.	66594.1	177684.	165946.	169632.	191926.	
		F Std. Dev.	2.108	2.664	2.055	1.403	1.435	1.387	1.096	
10	1	|E*| (psi)	1082008	128993	149943	204125	218720	262467	282323	310663
		Phase Angle, F (º)	28.6	16.3	23.1	17.5	15.7	13.7	12.2	12.1
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	19	27	27	28	34	39	42	43
	2	|E*| (psi)	1018430	132975	168840	198139	218169	263064	284877	313270
		Phase Angle, F (º)	23.8	28.0	15.6	14.0	13.3	10.5	9.1	8.6
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	20	26	24	29	34	39	42	43
	3	|E*| (psi)	1127644	161688	157434	200810	215396	255010	275029	298389
		Phase Angle, F (º)	23.1	27.6	13.5	14.8	12.7	10.0	9.3	8.8
		Average Peak Stress (psi)	20	35	41	57	74	102	119	134
		Average Peak Strain (με)	18	22	26	29	34	40	43	45
	Avg.	|E*| Average (psi)	1076027	141219	158739	201025	217428	260180	280743	307441
		F Average	25.2	24.0	17.4	15.4	13.9	11.4	10.2	9.8
		|E*| Coeff. of Variation (psi)	0.051	0.126	0.060	0.015	0.008	0.017	0.018	0.026
		F Coeff. of Variation	0.12	0.28	0.29	0.12	0.11	0.18	0.17	0.20
		|E*| Std. Dev. (psi)	54852.4	178387.	95161.4	29986.0	17812.3	44875.6	51105.3	79467.5
		F Std. Dev.	2.960	6.656	5.043	1.850	1.570	2.009	1.749	1.977
35	1	|E*| (psi)	91101	149022	182329	309763	377357	617759	775100	943495
		Phase Angle, F (º)	35.9	37.2	37.9	37.4	35.2	29.9	28.1	24.8
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	27	22	22	17	21	26	26	38
	2	|E*| (psi)	88250	138211	167703	276306	340691	591358	725603	903783
		Phase Angle, F (º)	32.7	32.1	34.9	34.4	33.1	27.6	26.3	23.0
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	28	24	24	19	24	27	27	40
	3	|E*| (psi)	97219	155507	194763	327900	394617	645676	782342	954393
		Phase Angle, F (º)	34.7	34.8	34.6	34.4	32.4	26.5	24.5	22.1
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	25	21	21	16	21	25	25	38
	Avg.	|E*| Average (psi)	92190	147580	181598	304657	370888	618265	761015	933890
		F Average	34.4	34.7	35.8	35.4	33.6	28.0	26.3	23.3
		|E*| Coeff. of Variation (psi)	0.050	0.059	0.075	0.086	0.074	0.044	0.041	0.029
		F Coeff. of Variation	0.05	0.07	0.05	0.05	0.04	0.06	0.07	0.06
		|E*| Std. Dev. (psi)	4582.7	8738.1	13544.3	26173.3	27538.7	27162.7	30880.7	26637.1
		F Std. Dev.	1.653	2.528	1.813	1.773	1.462	1.729	1.792	1.390

Table B-24. I19.0BC–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2314294	257774	282600	338675	356613	397971	416695	438047
		Phase Angle, F (º)	10.5	11.9	7.5	6.8	6.3	5.3	4.9	4.6
		Average Peak Stress (psi)	196	229	237	254	262	286	294	318
		Average Peak Strain (με)	85	89	84	75	73	72	71	73
	2	|E*| (psi)	2196001	284774	285501	321684	339090	379625	396210	416734
		Phase Angle, F (º)	8.9	5.0	4.2	4.7	4.3	3.2	2.4	2.4
		Average Peak Stress (psi)	196	229	237	254	262	286	294	318
		Average Peak Strain (με)	89	80	83	79	77	75	74	76
	3	|E*| (psi)	2520115	337371	316418	377177	399904	446818	468929	495880
		Phase Angle, F (º)	11.7	10.8	10.4	8.0	7.2	6.0	5.4	5.6
		Average Peak Stress (psi)	196	229	237	254	262	286	294	318
		Average Peak Strain (με)	78	68	75	67	65	64	63	64
	Avg.	|E*| Average (psi)	2343470	293306	294839	345845	365203	408138	427278	450220
		F Average	10.4	9.2	7.4	6.5	6.0	4.8	4.2	4.2
		|E*| Coeff. of Variation (psi)	0.070	0.138	0.064	0.082	0.086	0.085	0.088	0.091
		F Coeff. of Variation	0.14	0.40	0.43	0.26	0.25	0.30	0.37	0.39
		|E*| Std. Dev. (psi)	164014.8	404785.	187437.	284325.	313038.	347312.	374967.	409532.
		F Std. Dev.	1.415	3.700	3.146	1.675	1.477	1.462	1.576	1.616
10	1	|E*| (psi)	480839	769713	892483	124093	142810	190781	213179	243423
		Phase Angle, F (º)	27.0	22.9	21.9	19.0	17.5	14.0	12.6	11.8
		Average Peak Stress (psi)	53	70	82	102	119	159	175	191
		Average Peak Strain (με)	111	90	92	82	83	83	82	79
	2	|E*| (psi)	418924	636021	780494	112324	130156	176722	198951	225973
		Phase Angle, F (º)	26.6	25.1	20.7	18.3	16.6	12.8	11.5	10.5
		Average Peak Stress (psi)	53	70	82	102	119	159	175	191
		Average Peak Strain (με)	127	109	105	91	91	90	88	85
	3	|E*| (psi)	511606	799415	971316	136142	156131	208791	234793	270117
		Phase Angle, F (º)	28.0	27.4	23.0	20.2	18.6	14.9	13.5	12.5
		Average Peak Stress (psi)	53	70	82	102	119	159	175	192
		Average Peak Strain (με)	104	87	84	75	76	76	75	71
	Avg.	|E*| Average (psi)	470456	735050	881431	124186	143032	192098	215641	246505
		F Average	27.2	25.1	21.9	19.2	17.5	13.9	12.5	11.6
		|E*| Coeff. of Variation (psi)	0.100	0.118	0.109	0.096	0.091	0.084	0.084	0.090
		F Coeff. of Variation	0.03	0.09	0.05	0.05	0.06	0.08	0.08	0.08
		|E*| Std. Dev. (psi)	47205.6	87037.8	95890.0	119096.	129891.	160752.	180473.	222327.
		F Std. Dev.	0.717	2.290	1.175	0.976	1.008	1.048	1.015	0.974
35	1	|E*| (psi)	43221	65122	81656	140832	198702	353602	450777	612059
		Phase Angle, F (º)	26.3	29.5	28.7	31.7	28.5	27.8	26.4	25.5
		Average Peak Stress (psi)	4	5	7	11	24	32	44	64
		Average Peak Strain (με)	85	75	90	81	122	90	97	104
	2	|E*| (psi)	36744	56510	71610	123299	175282	307958	397175	543061
		Phase Angle, F (º)	22.3	25.1	25.5	29.1	26.8	26.4	25.2	24.8
		Average Peak Stress (psi)	4	5	7	11	24	32	44	64
		Average Peak Strain (με)	100	87	103	92	139	104	110	117
	3	|E*| (psi)	47444	70997	85608	143501	197717	348086	446770	606920
		Phase Angle, F (º)	26.6	28.8	29.1	31.5	28.3	27.6	26.8	25.5
		Average Peak Stress (psi)	4	5	7	11	24	32	44	64
		Average Peak Strain (με)	78	69	86	79	123	92	98	105
	Avg.	|E*| Average (psi)	42470	64210	79625	135877	190567	336548	431574	587347
		F Average	25.1	27.8	27.8	30.8	27.9	27.2	26.1	25.3
		|E*| Coeff. of Variation (psi)	0.127	0.113	0.091	0.081	0.070	0.074	0.069	0.065
		F Coeff. of Variation	0.10	0.08	0.07	0.05	0.03	0.03	0.03	0.02
		|E*| Std. Dev. (psi)	5389.1	7286.4	7216.9	10974.9	13246.3	24913.5	29857.6	38438.3
		F Std. Dev.	2.433	2.360	1.984	1.461	0.945	0.779	0.821	0.384
54.4	Est.	|E*| (psi)	11313	15954	19000	29443	36259	61206	77450	106603

Table B-25. I19.0BC-Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	3322678	371809	404967	424247	432126	458689	468760	484412
		Phase Angle, F (º)	8.4	13.3	5.8	6.2	5.6	3.8	2.9	3.1
		Average Peak Stress (psi)	196	229	237	254	262	286	295	318
		Average Peak Strain (με)	59	62	59	60	61	62	63	66
	2	|E*| (psi)	2803501	301191	346162	376952	389176	418740	431194	446582
		Phase Angle, F (º)	9.0	8.9	9.0	5.6	5.0	4.4	3.9	3.8
		Average Peak Stress (psi)	196	229	237	254	262	286	294	318
		Average Peak Strain (με)	70	76	69	67	67	68	68	71
	3	|E*| (psi)	2909365	351606	357997	375827	389263	420939	432953	445130
		Phase Angle, F (º)	7.5	10.5	6.2	4.7	4.4	2.9	2.4	2.8
		Average Peak Stress (psi)	196	229	237	254	262	286	295	318
		Average Peak Strain (με)	67	65	66	67	67	68	68	71
	Avg.	|E*| Average (psi)	3011848	341535	369709	392342	403522	432789	444303	458708
		F Average	8.3	10.9	7.0	5.5	5.0	3.7	3.1	3.2
		|E*| Coeff. of Variation (psi)	0.091	0.106	0.084	0.070	0.061	0.052	0.048	0.049
		F Coeff. of Variation	0.09	0.20	0.25	0.14	0.13	0.21	0.24	0.16
		|E*| Std. Dev. (psi)	274341.5	363703.	311023.	276360.	247721.	224566.	211993.	222721.
		F Std. Dev.	0.764	2.224	1.733	0.759	0.642	0.779	0.743	0.521
10	1	|E*| (psi)	831463	117392	139208	188693	209848	257176	279041	310723
		Phase Angle, F (º)	29.4	26.6	23.2	18.7	16.5	12.3	11.0	10.3
		Average Peak Stress (psi)	41	57	70	90	106	147	167	183
		Average Peak Strain (με)	49	49	50	48	51	57	60	59
	2	|E*| (psi)	783223	119526	123726	166912	182065	229327	254691	282056
		Phase Angle, F (º)	26.8	20.9	19.9	17.1	15.3	11.6	10.9	9.9
		Average Peak Stress (psi)	41	57	69	90	106	147	167	183
		Average Peak Strain (με)	52	48	56	54	58	64	66	65
	3	|E*| (psi)	825504	111388	136889	179767	198242	245658	266857	293714
		Phase Angle, F (º)	26.7	20.6	17.5	16.0	13.7	10.5	9.1	8.5
		Average Peak Stress (psi)	41	57	70	90	106	147	168	184
		Average Peak Strain (με)	50	51	51	50	54	60	63	63
	Avg.	|E*| Average (psi)	813397	116102	133274	178457	196718	244053	266863	295498
		F Average	27.6	22.7	20.2	17.3	15.2	11.5	10.3	9.6
		|E*| Coeff. of Variation (psi)	0.032	0.036	0.063	0.061	0.071	0.057	0.046	0.049
		F Coeff. of Variation	0.05	0.15	0.14	0.08	0.09	0.08	0.10	0.10
		|E*| Std. Dev. (psi)	26300.2	42197.1	83500.0	109495.	139543.	139936.	121751.	144165.
		F Std. Dev.	1.508	3.358	2.864	1.351	1.415	0.900	1.048	0.974
35	1	|E*| (psi)	72892	111988	144559	258097	348116	633429	789396	101507
		Phase Angle, F (º)	31.4	33.0	33.0	36.1	33.6	29.9	26.4	24.1
		Average Peak Stress (psi)	2	4	5	9	14	20	32	57
		Average Peak Strain (με)	28	36	37	36	41	31	41	56
	2	|E*| (psi)	69355	108900	139362	247057	330039	587716	742306	944735
		Phase Angle, F (º)	29.3	31.2	31.7	33.6	30.9	27.8	24.4	22.0
		Average Peak Stress (psi)	2	4	5	9	14	20	32	57
		Average Peak Strain (με)	30	37	38	38	43	34	43	60
	3	|E*| (psi)	72913	114095	142696	252523	333926	586835	745527	966001
		Phase Angle, F (º)	29.9	32.2	31.9	33.5	31.2	28.4	24.4	21.8
		Average Peak Stress (psi)	2	4	5	9	14	20	32	57
		Average Peak Strain (με)	28	36	37	37	42	34	43	59
	Avg.	|E*| Average (psi)	71720	111661	142206	252559	337360	602660	759077	975270
		F Average	30.2	32.1	32.2	34.4	31.9	28.7	25.1	22.6
		|E*| Coeff. of Variation (psi)	0.029	0.023	0.019	0.022	0.028	0.044	0.035	0.037
		F Coeff. of Variation	0.04	0.03	0.02	0.04	0.05	0.04	0.05	0.06
		|E*| Std. Dev. (psi)	2048.2	2612.9	2632.7	5520.0	9515.0	26650.4	26307.0	36073.0
		F Std. Dev.	1.097	0.910	0.743	1.469	1.504	1.078	1.172	1.247
54.4	1	|E*| (psi)	42049	41226	37714	53574	67222	126298	176679	265576
		Phase Angle, F (º)	17.4	19.4	21.0	23.9	25.3	27.6	26.6	27.4
		Average Peak Stress (psi)	1	1	2	4	5	9	13	19
		Average Peak Strain (με)	20	30	54	76	78	70	75	70
	2	|E*| (psi)	37528	37664	39032	54761	68469	126610	175582	263632
		Phase Angle, F (º)	15.2	17.6	21.6	24.8	26.0	28.1	27.0	27.9
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	22	33	53	74	76	70	75	70
	3	|E*| (psi)	33502	38863	41394	58070	71886	133428	182364	274099
		Phase Angle, F (º)	13.4	19.0	19.5	23.5	24.7	26.9	26.6	27.8
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	24	32	50	70	73	67	73	67
	Avg.	|E*| Average (psi)	37693	39251	39380	55468	69192	128778	178208	267769
		F Average	15.3	18.6	20.7	24.1	25.3	27.6	26.8	27.7
		|E*| Coeff. of Variation (psi)	0.113	0.046	0.047	0.042	0.035	0.031	0.020	0.021
		F Coeff. of Variation	0.13	0.05	0.05	0.03	0.03	0.02	0.01	0.01
		|E*| Std. Dev. (psi)	4276.2	1812.7	1864.5	2329.9	2414.5	4029.4	3640.8	5567.4
		F Std. Dev.	2.037	0.949	1.077	0.658	0.640	0.617	0.241	0.233

Table B-26. I19.0B0F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2408775	311531	308634	359473	377256	417680	434094	455612
		Phase Angle, F (º)	11.3	4.5	9.9	6.5	5.2	4.1	3.6	3.6
		Average Peak Stress (psi)	197	229	238	254	262	287	295	318
		Average Peak Strain (με)	82	74	77	71	69	69	68	70
	2	|E*| (psi)	2811286		378153	416713	435999	479501	498415	521396
		Phase Angle, F (º)	12.1		6.4	7.1	5.5	5.6	3.9	4.0
		Average Peak Stress (psi)	177		214	229	236	257	265	286
		Average Peak Strain (με)	63		56	55	54	54	53	55
	3	|E*| (psi)	2457437	262547	313280	361166	381085	418044	431217	448770
		Phase Angle, F (º)	9.7	11.2	3.1	4.9	4.6	3.2	2.7	2.8
		Average Peak Stress (psi)	137	160	166	178	183	200	206	222
		Average Peak Strain (με)	56	61	53	49	48	48	48	49
	Avg.	|E*| Average (psi)	2559166	287039	333356	379118	398113	438409	454575	475259
		F Average	11.0	7.9	6.5	6.2	5.1	4.3	3.4	3.5
		|E*| Coeff. of Variation (psi)	0.086	0.121	0.117	0.086	0.083	0.081	0.084	0.084
		F Coeff. of Variation	0.11	0.60	0.52	0.18	0.09	0.29	0.19	0.18
		|E*| Std. Dev. (psi)	219694.2	346370.	388648.	325699.	328654.	355876.	379933.	401016.
		F Std. Dev.	1.225	4.685	3.396	1.111	0.465	1.243	0.636	0.623
10	1	|E*| (psi)	401287	656816	818313	122084	142459	196620	222353	250537
		Phase Angle, F (º)	31.7	28.7	25.3	21.8	18.4	15.2	15.3	12.2
		Average Peak Stress (psi)	37	49	57	72	83	111	122	192
		Average Peak Strain (με)	93	74	70	59	58	57	55	77
	2	|E*| (psi)	500998	893085	989151	148181	170949	225919	250142	283412
		Phase Angle, F (º)	31.6	25.9	25.7	21.4	18.4	14.9	13.2	12.4
		Average Peak Stress (psi)	37	48	57	72	83	111	128	139
		Average Peak Strain (με)	74	54	58	48	49	49	51	49
	3	|E*| (psi)	435437	743312	878413	129454	150369	200561	223857	255225
		Phase Angle, F (º)	31.0	24.0	24.9	19.1	15.9	13.2	11.6	10.8
		Average Peak Stress (psi)	37	49	57	72	83	111	128	140
		Average Peak Strain (με)	85	65	65	55	55	55	57	55
	Avg.	|E*| Average (psi)	445907	764404	895292	133239	154593	207700	232117	263058
		F Average	31.4	26.2	25.3	20.7	17.6	14.5	13.4	11.8
		|E*| Coeff. of Variation (psi)	0.114	0.156	0.097	0.101	0.095	0.077	0.067	0.068
		F Coeff. of Variation	0.01	0.09	0.01	0.07	0.08	0.07	0.14	0.08
		|E*| Std. Dev. (psi)	50673.7	119538.	86660.9	134537.	147072.	159007.	156275.	177823.
		F Std. Dev.	0.407	2.355	0.372	1.458	1.462	1.074	1.851	0.890
35	1	|E*| (psi)	27267		51198	98045	146778	284274	386090	555929
		Phase Angle, F (º)	19.3		30.7	35.3	31.3	31.4	29.9	28.8
		Average Peak Stress (psi)	2		4	7	15	19	26	38
		Average Peak Strain (με)	86		87	70	99	65	67	68
	2	|E*| (psi)		45099	60408	114604	162807	318197	429830	615436
		Phase Angle, F (º)		30.0	30.6	33.8	31.2	31.3	28.8	27.5
		Average Peak Stress (psi)		3	4	8	14	22	30	44
		Average Peak Strain (με)		73	71	70	87	69	70	72
	3	|E*| (psi)	24421	38040	50568	97691	142767	294551	384767	547267
		Phase Angle, F (º)	26.1	28.1	30.2	33.9	31.1	30.1	28.6	27.2
		Average Peak Stress (psi)	2	3	4	8	14	22	30	44
		Average Peak Strain (με)	86	89	85	82	99	76	78	81
	Avg.	|E*| Average (psi)	25844	41569	54058	103447	150784	299007	400229	572878
		F Average	22.7	29.0	30.5	34.3	31.2	30.9	29.1	27.8
		|E*| Coeff. of Variation (psi)	0.078	0.120	0.102	0.093	0.070	0.058	0.064	0.065
		F Coeff. of Variation	0.21	0.05	0.01	0.02	0.00	0.02	0.02	0.03
		|E*| Std. Dev. (psi)	2012.7	4991.7	5508.1	9664.1	10603.9	17394.9	25643.7	37110.2
		F Std. Dev.	4.817	1.347	0.241	0.802	0.126	0.697	0.661	0.865
54.4	Est.	|E*| (psi)	5947	8847	10878	18130	23206	43221	57290	83977

Table B-27. I19.0B1F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	3166123	389331	377006	445655	467839	513813	529123	552350
		Phase Angle, F (º)	7.4	-1.2	2.5	3.7	3.3	2.4	1.9	2.0
		Average Peak Stress (psi)	176	209	217	238	246	270	279	301
		Average Peak Strain (με)	56	54	58	53	53	53	53	55
	2	|E*| (psi)	3094456	338064	423168	452790	473668	526937		
		Phase Angle, F (º)	13.7	7.5	9.0	9.9	10.0	9.1		
		Average Peak Stress (psi)	176	209	217	238	246	270		
		Average Peak Strain (με)	57	62	51	53	52	51		
	3	|E*| (psi)	3237066	341525	409633	456046	477966	527303	538308	568390
		Phase Angle, F (º)	11.9	11.4	13.4	9.1	8.6	7.9	6.8	6.7
		Average Peak Stress (psi)	176	209	217	238	246	270	279	301
		Average Peak Strain (με)	54	61	53	52	51	51	52	53
	Avg.	|E*| Average (psi)	3165882	356307	403269	451497	473158	522684	533715	560370
		F Average	11.0	5.9	8.3	7.6	7.3	6.5	4.4	4.3
		|E*| Coeff. of Variation (psi)	0.023	0.080	0.059	0.012	0.011	0.015	0.012	0.020
		F Coeff. of Variation	0.29	1.09	0.66	0.44	0.49	0.55	0.79	0.77
		|E*| Std. Dev. (psi)	71305.0	286521.	237301.	53147.8	50828.9	76848.7	64945.1	113424.
		F Std. Dev.	3.239	6.450	5.481	3.352	3.566	3.526	3.466	3.331
10	1	|E*| (psi)	739710	124409	131390	184343	206657	267399	293800	331012
		Phase Angle, F (º)	26.8	29.6	23.7	17.5	14.8	11.7	10.4	9.5
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	28	28	31	31	36	38	40	40
	2	|E*| (psi)	767217	138338	129101	194215	213331	276815	306449	342915
		Phase Angle, F (º)	35.2	28.4	27.7	24.4	22.6	18.7	17.5	16.0
		Average Peak Stress (psi)	20	35	41	57	74	102	119	134
		Average Peak Strain (με)	27	25	32	30	35	37	39	39
	3	|E*| (psi)	843584	114069	149290	199052	218040	278748	306943	344662
		Phase Angle, F (º)	34.9	33.1	29.7	22.7	21.6	17.8	17.0	15.2
		Average Peak Stress (psi)	20	35	41	57	74	102	119	133
		Average Peak Strain (με)	24	31	27	29	34	37	39	39
	Avg.	|E*| Average (psi)	783504	125605	136594	192537	212676	274320	302398	339529
		F Average	32.3	30.4	27.0	21.6	19.7	16.1	15.0	13.6
		|E*| Coeff. of Variation (psi)	0.069	0.097	0.081	0.039	0.027	0.022	0.025	0.022
		F Coeff. of Variation	0.15	0.08	0.11	0.17	0.22	0.24	0.26	0.26
		|E*| Std. Dev. (psi)	53817.8	121787.	110549.	74969.4	57196.4	60719.3	74497.6	74279.2
		F Std. Dev.	4.758	2.435	3.082	3.608	4.244	3.804	3.961	3.509
35	1	|E*| (psi)	51743	87475	110685	203539	270243	518465	653976	877976
		Phase Angle, F (º)	25.3	29.3	30.6	33.3	32.4	27.7	25.9	23.8
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	47	37	37	26	30	31	30	41
	2	|E*| (psi)	79905	109258	133525	228657	287199	530935		
		Phase Angle, F (º)	30.2	32.1	34.0	38.1	36.1	33.5		
		Average Peak Stress (psi)	2	3	4	5	8	16		
		Average Peak Strain (με)	31	30	31	23	28	30		
	3	|E*| (psi)	84940	122162	154669	271746	334921	591810	773057	967991
		Phase Angle, F (º)	31.0	33.8	36.2	40.3	37.9	33.9	33.0	29.2
		Average Peak Stress (psi)	2	3	4	5	8	16	20	36
		Average Peak Strain (με)	29	27	26	20	24	27	26	37
	Avg.	|E*| Average (psi)	72196	106298	132960	234647	297454	547070	713516	922984
		F Average	28.8	31.7	33.6	37.2	35.5	31.7	29.5	26.5
		|E*| Coeff. of Variation (psi)	0.248	0.165	0.165	0.147	0.113	0.072	0.118	0.069
		F Coeff. of Variation	0.11	0.07	0.08	0.10	0.08	0.11	0.17	0.14
		|E*| Std. Dev. (psi)	17890.5	17531.4	21997.3	34496.0	33536.2	39244.1	84203.1	63650.6
		F Std. Dev.	3.122	2.252	2.818	3.564	2.807	3.485	4.971	3.807
54.4	1	|E*| (psi)		28593	30745	42818	52574	95443	125756	188815
		Phase Angle, F (º)		19.1	17.2	22.0	24.4	29.4	30.7	32.1
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		28	40	38	46	32	28	21
	2	|E*| (psi)		77657	75601	72411	75401	112705	145329	218771
		Phase Angle, F (º)		6.7	12.6	21.8	24.2	30.3	32.3	35.5
		Average Peak Stress (psi)		1	1	2	2	3	3	4
		Average Peak Strain (με)		10	16	22	32	27	24	18
	3	|E*| (psi)		88684	72652	74478	79835	126201	164860	246256
		Phase Angle, F (º)		21.2	13.8	22.5	24.1	31.8	32.6	35.7
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		9	17	22	30	24	21	16
	Avg.	|E*| Average (psi)		64978	59666	63236	69270	111450	145315	217947
		F Average		15.7	14.5	22.1	24.2	30.5	31.9	34.5
		|E*| Coeff. of Variation (psi)		0.492	0.421	0.280	0.211	0.138	0.135	0.132
		F Coeff. of Variation		0.50	0.16	0.02	0.01	0.04	0.03	0.06
		|E*| Std. Dev. (psi)		31989.3	25089.8	17712.5	14628.5	15417.3	19551.7	28729.2
		F Std. Dev.		7.853	2.378	0.362	0.176	1.204	1.011	2.025

Table B-28. I19.0B2F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2502308	275151	318280	342523	356967	390300	403526	420499
		Phase Angle, F (º)	7.5	10.6	5.9	5.1	4.8	3.5	3.0	2.7
		Average Peak Stress (psi)	176	209	217	238	246	270	279	301
		Average Peak Strain (με)	70	76	68	69	69	69	69	72
	2	|E*| (psi)	2639296	329801	329444	357280	371162	405603	418370	437365
		Phase Angle, F (º)	7.8	9.7	7.7	5.1	4.7	3.8	3.2	3.0
		Average Peak Stress (psi)	197	229	238	254	262	286	295	318
		Average Peak Strain (με)	74	70	72	71	71	71	71	73
	3	|E*| (psi)	2594848	302956	303496	346213	362505	395048	416335	429867
		Phase Angle, F (º)	8.0	11.4	6.3	5.1	4.9	3.7	3.5	2.8
		Average Peak Stress (psi)	197	229	238	254	262	286	295	318
		Average Peak Strain (με)	76	76	78	73	72	72	71	74
	Avg.	|E*| Average (psi)	2578817	302636	317073	348672	363545	396984	412744	429244
		F Average	7.8	10.6	6.6	5.1	4.8	3.6	3.3	2.9
		|E*| Coeff. of Variation (psi)	0.027	0.090	0.041	0.022	0.020	0.020	0.019	0.020
		F Coeff. of Variation	0.03	0.08	0.15	0.01	0.02	0.05	0.08	0.05
		|E*| Std. Dev. (psi)	69887.2	273264.	130159.	76795.6	71545.6	78326.5	80473.6	84498.7
		F Std. Dev.	0.236	0.851	0.989	0.043	0.097	0.179	0.267	0.134
10	1	|E*| (psi)	705641	107565	111760	148709	166032	206334	226021	
		Phase Angle, F (º)	22.1	18.8	18.3	14.3	13.6	10.5	9.6	
		Average Peak Stress (psi)	41	57	70	90	106	147	168	
		Average Peak Strain (με)	58	53	62	61	64	71	74	
	2	|E*| (psi)	788118	115969	121890	162778	180210	221294	239829	268010
		Phase Angle, F (º)	22.5	16.9	16.1	14.5	13.4	11.1	10.1	9.4
		Average Peak Stress (psi)	41	57	70	90	106	147	168	183
		Average Peak Strain (με)	52	49	57	55	59	66	70	68
	3	|E*| (psi)	801245	103239	128820	161850	177359	217911	236569	263010
		Phase Angle, F (º)	21.8	19.3	16.6	14.3	12.8	10.5	9.5	8.9
		Average Peak Stress (psi)	41	57	70	90	106	147	168	183
		Average Peak Strain (με)	51	56	54	56	60	68	71	70
	Avg.	|E*| Average (psi)	765001	108924	120823	157779	174534	215180	234140	265510
		F Average	22.1	18.3	17.0	14.4	13.3	10.7	9.7	9.2
		|E*| Coeff. of Variation (psi)	0.068	0.059	0.071	0.050	0.043	0.036	0.031	0.013
		F Coeff. of Variation	0.02	0.07	0.07	0.01	0.03	0.03	0.03	0.04
		|E*| Std. Dev. (psi)	51825.0	64730.0	85799.6	78687.8	74995.1	78451.5	72174.0	35353.6
		F Std. Dev.	0.358	1.280	1.166	0.137	0.402	0.347	0.305	0.363
35	1	|E*| (psi)	68112	108557	136636	230679	294141	508216	625286	793900
		Phase Angle, F (º)	32.7	33.1	32.1	31.5	29.8	25.5	23.1	20.9
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	30	38	39	40	48	39	51	71
	2	|E*| (psi)	78904	121129	150767	250824	313258	534399	655970	820103
		Phase Angle, F (º)	32.7	32.2	32.5	32.2	30.2	26.5	23.7	21.5
		Average Peak Stress (psi)	2	4	5	9	14	20	32	57
		Average Peak Strain (με)	26	34	35	37	45	37	49	69
	3	|E*| (psi)	95642	143465	169983	270931	330950	557174	667737	838419
		Phase Angle, F (º)	35.7	33.7	33.5	31.5	29.7	26.0	22.5	21.5
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	22	28	31	34	43	36	48	67
	Avg.	|E*| Average (psi)	80886	124384	152462	250811	312783	533263	649665	817474
		F Average	33.7	33.0	32.7	31.8	29.9	26.0	23.1	21.3
		|E*| Coeff. of Variation (psi)	0.171	0.142	0.110	0.080	0.059	0.046	0.034	0.027
		F Coeff. of Variation	0.05	0.02	0.02	0.01	0.01	0.02	0.03	0.02
		|E*| Std. Dev. (psi)	13871.9	17680.4	16738.1	20125.8	18409.0	24498.4	21917.0	22376.1
		F Std. Dev.	1.691	0.738	0.724	0.392	0.293	0.524	0.589	0.364
54.4	1	|E*| (psi)	21968	27635	31437	49794	64326	119554	159752	230110
		Phase Angle, F (º)	20.2	24.9	23.0	25.7	27.0	27.1	26.4	27.2
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	37	45	66	81	81	74	82	78
	2	|E*| (psi)	25266		33507	53250	67491	123780	164026	236185
		Phase Angle, F (º)	23.4		23.2	25.6	26.8	26.9	26.3	27.3
		Average Peak Stress (psi)	1		2	4	5	9	13	18
		Average Peak Strain (με)	32		62	76	77	71	80	77
	3	|E*| (psi)	40047	41602	42782	63360	79222	141719	184891	259584
		Phase Angle, F (º)	28.2	26.1	27.1	28.8	29.3	29.1	28.1	28.2
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	20	30	48	64	66	63	72	70
	Avg.	|E*| Average (psi)	29093	34619	35909	55468	70347	128351	169556	241960
		F Average	23.9	25.5	24.4	26.7	27.7	27.7	26.9	27.5
		|E*| Coeff. of Variation (psi)	0.331	0.285	0.168	0.127	0.112	0.092	0.079	0.064
		F Coeff. of Variation	0.17	0.03	0.09	0.07	0.05	0.04	0.04	0.02
		|E*| Std. Dev. (psi)	9628.2	9876.2	6041.7	7049.8	7847.9	11768.1	13451.0	15562.2
		F Std. Dev.	4.036	0.813	2.305	1.824	1.361	1.236	1.000	0.538

Table B-29. I19.0B3F–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2985801	321903	360838	413445	433528	474037	492581	
		Phase Angle, F (º)	7.1	10.3	7.6	3.8	4.1	2.7	2.3	
		Average Peak Stress (psi)	180	217	229	238	245	270	278	
		Average Peak Strain (με)	60	67	63	57	57	57	56	
	2	|E*| (psi)	2688533	341902	321523	369659	382959	420386	434093	
		Phase Angle, F (º)	8.2	6.1	3.9	5.4	5.0	3.6	3.0	
		Average Peak Stress (psi)	180	217	229	238	245	270	278	
		Average Peak Strain (με)	67	63	71	64	64	64	64	
	3	|E*| (psi)	2700251	320395	330988	378509	397303	435155	451678	471866
		Phase Angle, F (º)	8.2	12.0	8.2	4.6	4.4	3.1	2.2	2.3
		Average Peak Stress (psi)	180	217	229	238	245	270	278	301
		Average Peak Strain (με)	67	68	69	63	62	62	62	64
	Avg.	|E*| Average (psi)	2791528	328067	337783	387204	404597	443192	459450	471866
		F Average	7.8	9.5	6.6	4.6	4.5	3.1	2.5	2.3
		|E*| Coeff. of Variation (psi)	0.060	0.037	0.061	0.060	0.064	0.063	0.065	
		F Coeff. of Variation	0.08	0.32	0.36	0.17	0.10	0.14	0.18	
		|E*| Std. Dev. (psi)	168347.4	120051.	205195.	231520.	260617.	277139.	300088.	
		F Std. Dev.	0.627	3.057	2.371	0.810	0.442	0.452	0.463	
10	1	|E*| (psi)	833636	120971	137606	179107	199734	248409	271922	303610
		Phase Angle, F (º)	21.7	21.9	15.1	13.7	12.5	10.1	9.1	8.6
		Average Peak Stress (psi)	45	57	70	90	106	147	167	183
		Average Peak Strain (με)	54	47	51	50	53	59	62	60
	2	|E*| (psi)	760963	106840	125793	161098	178248	223343	243072	271078
		Phase Angle, F (º)	22.3	21.9	17.6	14.5	13.4	10.6	9.3	8.8
		Average Peak Stress (psi)	45	57	70	90	106	147	167	183
		Average Peak Strain (με)	59	54	55	56	60	66	69	67
	3	|E*| (psi)	706652	953710	116745	154120	173025	220571	242482	
		Phase Angle, F (º)	23.0	19.8	16.8	15.0	13.8	10.8	9.7	
		Average Peak Stress (psi)	45	57	70	90	106	147	167	
		Average Peak Strain (με)	64	60	60	58	61	67	69	
	Avg.	|E*| Average (psi)	767084	107727	126715	164775	183669	230774	252492	287344
		F Average	22.3	21.2	16.5	14.4	13.2	10.5	9.4	8.7
		|E*| Coeff. of Variation (psi)	0.083	0.119	0.083	0.078	0.077	0.066	0.067	0.080
		F Coeff. of Variation	0.03	0.06	0.08	0.04	0.05	0.04	0.04	0.02
		|E*| Std. Dev. (psi)	63712.6	128233.	104611.	128930.	141556.	153349.	168296.	230037.
		F Std. Dev.	0.642	1.256	1.241	0.641	0.671	0.375	0.328	0.166
35	1	|E*| (psi)	82972	127945	159988	263669	333396	568251	700440	891661
		Phase Angle, F (º)	27.8	27.7	29.1	29.7	28.3	24.3	22.2	20.9
		Average Peak Stress (psi)	3	5	6	11	16	24	36	56
		Average Peak Strain (με)	35	38	38	43	48	42	51	63
	2	|E*| (psi)	81111	127339	157999	259924	325728	557972	681773	850297
		Phase Angle, F (º)	33.5	31.8	32.4	31.7	30.0	25.7	23.2	21.5
		Average Peak Stress (psi)	3	5	6	11	16	24	36	56
		Average Peak Strain (με)	35	38	39	44	50	43	53	66
	3	|E*| (psi)	76740	114439	139696	232758	293214	503895	617143	790557
		Phase Angle, F (º)	29.8	30.1	30.9	30.6	29.3	25.1	23.0	21.8
		Average Peak Stress (psi)	3	5	6	11	16	24	36	57
		Average Peak Strain (με)	37	43	44	49	55	48	58	71
	Avg.	|E*| Average (psi)	80274	123241	152561	252117	317446	543373	666452	844172
		F Average	30.4	29.9	30.8	30.7	29.2	25.1	22.8	21.4
		|E*| Coeff. of Variation (psi)	0.040	0.062	0.073	0.067	0.067	0.064	0.066	0.060
		F Coeff. of Variation	0.10	0.07	0.05	0.03	0.03	0.03	0.02	0.02
		|E*| Std. Dev. (psi)	3199.2	7629.0	11186.0	16869.3	21332.6	34573.0	43711.4	50829.5
		F Std. Dev.	2.938	2.031	1.666	1.036	0.855	0.680	0.520	0.457
54.4	1	|E*| (psi)		39432	46337	66311	80613	136670	179900	253870
		Phase Angle, F (º)		26.0	19.8	24.7	25.9	27.3	27.8	29.6
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		20	27	25	30	22	20	16
	2	|E*| (psi)		65952		67205	79242	139951	183744	260857
		Phase Angle, F (º)		30.4		29.3	31.1	32.4	32.4	32.6
		Average Peak Stress (psi)		1		2	2	3	4	4
		Average Peak Strain (με)		15		24	31	22	20	16
	3	|E*| (psi)		37559	41048	57452	70006	120045	157303	225426
		Phase Angle, F (º)		16.0	21.2	26.5	27.1	29.0	29.2	30.9
		Average Peak Stress (psi)		1	1	2	2	3	4	4
		Average Peak Strain (με)		22	30	29	35	25	23	18
	Avg.	|E*| Average (psi)		47648	43692	63656	76620	132222	173649	246718
		F Average		24.2	20.5	26.8	28.0	29.6	29.8	31.0
		|E*| Coeff. of Variation (psi)		0.333	0.086	0.085	0.075	0.081	0.082	0.076
		F Coeff. of Variation		0.31	0.05	0.09	0.10	0.09	0.08	0.05
		|E*| Std. Dev. (psi)		15880.0	3739.9	5391.3	5769.4	10672.5	14285.8	18767.2
		F Std. Dev.		7.378	1.013	2.345	2.746	2.573	2.352	1.481

Table B-30. 19.0BF–Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2585542	294854	301780	342863	353917	382322	393824	408819
		Phase Angle, F (º)	8.4	11.9	5.6	5.9	5.4	4.1	3.5	3.2
		Average Peak Stress (psi)	197	229	238	254	262	287	295	320
		Average Peak Strain (με)	76	78	79	74	74	75	75	78
	2	|E*| (psi)	2720388	287216	329675	364358	374918	408351	423804	431262
		Phase Angle, F (º)	7.8	5.9	7.6	5.1	4.9	3.6	3.2	2.9
		Average Peak Stress (psi)	197	229	238	254	262	287	295	320
		Average Peak Strain (με)	72	80	72	70	70	70	70	74
	3	|E*| (psi)	2692429	323398	323065	354483	370035	399339	411025	427888
		Phase Angle, F (º)	10.3	5.0	6.3	7.3	7.2	6.1	5.8	5.0
		Average Peak Stress (psi)	197	229	238	254	262	287	295	319
		Average Peak Strain (με)	73	71	74	72	71	72	72	75
	Avg.	|E*| Average (psi)	2666120	301823	318173	353901	366290	396671	409551	422656
		F Average	8.8	7.6	6.5	6.1	5.8	4.6	4.2	3.7
		|E*| Coeff. of Variation (psi)	0.027	0.063	0.046	0.030	0.030	0.033	0.037	0.029
		F Coeff. of Variation	0.15	0.49	0.16	0.18	0.20	0.29	0.33	0.30
		|E*| Std. Dev. (psi)	71169.1	190708.	145765.	107591.	109900.	132184.	150442.	121015.
		F Std. Dev.	1.314	3.745	1.043	1.111	1.178	1.311	1.383	1.136
10	1	|E*| (psi)	777065	115708	121013	161664	177305	217862	236846	261615
		Phase Angle, F (º)	25.5	20.3	18.8	16.4	15.0	11.1	10.0	9.3
		Average Peak Stress (psi)	41	57	70	90	107	147	168	184
		Average Peak Strain (με)	53	50	58	56	60	68	71	70
	2	|E*| (psi)	810253	108315	126203	167607	185491	230008	249007	274112
		Phase Angle, F (º)	25.3	17.6	18.3	15.5	14.3	11.0	9.7	8.7
		Average Peak Stress (psi)	41	57	70	90	107	147	168	184
		Average Peak Strain (με)	51	53	55	54	57	64	67	67
	3	|E*| (psi)	861499	114878	129175	170580	187572	228855	245828	270795
		Phase Angle, F (º)	27.7	26.6	20.8	17.8	16.2	13.3	11.8	11.0
		Average Peak Stress (psi)	41	57	70	90	107	147	168	183
		Average Peak Strain (με)	48	50	54	53	57	64	68	68
	Avg.	|E*| Average (psi)	816272	112967	125464	166617	183456	225575	243894	268841
		F Average	26.2	21.5	19.3	16.6	15.2	11.8	10.5	9.7
		|E*| Coeff. of Variation (psi)	0.052	0.036	0.033	0.027	0.030	0.030	0.026	0.024
		F Coeff. of Variation	0.05	0.21	0.07	0.07	0.06	0.11	0.11	0.12
		|E*| Std. Dev. (psi)	42537.8	40500.1	41311.1	45397.9	54280.0	67043.4	63072.7	64735.7
		F Std. Dev.	1.299	4.583	1.362	1.153	0.964	1.275	1.130	1.186
35	1	|E*| (psi)	82679	125466	155589	257999	331650	560137	692848	862448
		Phase Angle, F (º)	32.4	33.2	32.0	32.5	30.2	27.0	24.1	21.8
		Average Peak Stress (psi)	2	4	5	9	14	20	32	57
		Average Peak Strain (με)	25	33	34	36	43	36	46	66
	2	|E*| (psi)	89287	123515	153923	253052	327035	569156	695566	880433
		Phase Angle, F (º)	33.1	35.6	33.6	34.3	31.9	28.6	24.6	22.4
		Average Peak Stress (psi)	2	4	5	9	14	20	32	57
		Average Peak Strain (με)	23	33	35	37	43	35	46	64
	3	|E*| (psi)	112732	152827	184211	288878	360319	628678	763316	911631
		Phase Angle, F (º)	34.3	34.5	36.1	36.0	34.4	29.9	25.8	23.5
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	18	27	29	32	39	32	42	62
	Avg.	|E*| Average (psi)	94899	133936	164574	266643	339668	585990	717243	884837
		F Average	33.3	34.4	33.9	34.3	32.2	28.5	24.9	22.6
		|E*| Coeff. of Variation (psi)	0.166	0.122	0.103	0.073	0.053	0.064	0.056	0.028
		F Coeff. of Variation	0.03	0.04	0.06	0.05	0.07	0.05	0.03	0.04
		|E*| Std. Dev. (psi)	15792.9	16388.9	17026.1	19414.5	18032.5	37242.4	39923.3	24885.9
		F Std. Dev.	1.000	1.247	2.034	1.780	2.097	1.441	0.868	0.891
54.4	1	|E*| (psi)	36207	36237	38055	56067	70146	128349	174136	260945
		Phase Angle, F (º)	20.4	19.2	21.4	25.4	26.1	26.8	25.8	27.0
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	22	34	54	73	75	69	75	67
	2	|E*| (psi)	71215	79328	73158	98273	121669	221292	275878	373549
		Phase Angle, F (º)	16.7	17.2	25.6	27.9	28.3	30.0	32.1	34.3
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	11	16	28	42	43	40	47	48
	3	|E*| (psi)	46689	46219	46983	64586	80734	151649	202080	289593
		Phase Angle, F (º)	25.3	27.9	26.7	30.3	30.2	30.1	28.6	29.1
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	17	27	44	63	65	58	65	61
	Avg.	|E*| Average (psi)	51370	53928	52732	72975	90850	167096	217365	308029
		F Average	20.8	21.4	24.6	27.8	28.2	29.0	28.8	30.2
		|E*| Coeff. of Variation (psi)	0.350	0.418	0.346	0.306	0.300	0.289	0.242	0.190
		F Coeff. of Variation	0.21	0.27	0.11	0.09	0.07	0.06	0.11	0.12
		|E*| Std. Dev. (psi)	17967.2	22556.2	18243.9	22318.7	27210.3	48358.7	52565.1	58521.8
		F Std. Dev.	4.313	5.717	2.766	2.426	2.058	1.877	3.164	3.745

Table B-31. I19.0CC–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2436985	285586	297847	365825	384860	438242	467909	493744
		Phase Angle, F (º)	13.8	4.6	12.7	10.8	11.0	10.3	9.1	8.5
		Average Peak Stress (psi)	139	143	147	151	155	154	154	157
		Average Peak Strain (με)	57	50	49	41	40	35	33	32
	2	|E*| (psi)	2457143	280886	308165	365386	381115	428663	449808	483761
		Phase Angle, F (º)	14.8	7.5	15.8	12.5	12.9	12.0	10.3	10.2
		Average Peak Stress (psi)	122	135	143	147	151	154	154	157
		Average Peak Strain (με)	50	48	46	40	40	36	34	32
	3	|E*| (psi)	2357552		281811	344399	363862	404581	424178	446687
		Phase Angle, F (º)	11.2		8.0	8.5	8.0	6.6	6.3	6.2
		Average Peak Stress (psi)	122		143	147	151	154	154	157
		Average Peak Strain (με)	52		51	43	41	38	36	35
	Avg.	|E*| Average (psi)	2417226	283236	295941	358537	376612	423829	447298	474731
		F Average	13.3	6.1	12.2	10.6	10.6	9.7	8.6	8.3
		|E*| Coeff. of Variation (psi)	0.022	0.012	0.045	0.034	0.030	0.041	0.049	0.052
		F Coeff. of Variation	0.14	0.34	0.32	0.19	0.23	0.29	0.24	0.24
		|E*| Std. Dev. (psi)	52653.8	33232.3	132801.	122453.	111997.	173437.	219730.	247938.
		F Std. Dev.	1.827	2.086	3.923	2.018	2.479	2.792	2.042	2.026
10	1	|E*| (psi)	499132	752820	928215	134365	152053	205308	229424	261498
		Phase Angle, F (º)	32.1	24.5	27.5	22.2	20.8	17.2	16.0	14.8
		Average Peak Stress (psi)	24	45	53	73	85	106	118	132
		Average Peak Strain (με)	49	59	57	55	56	51	51	51
	2	|E*| (psi)	576872	829782	102942	139262	157635	207282	228600	258568
		Phase Angle, F (º)	33.6	25.6	24.9	22.5	20.9	17.9	16.1	14.7
		Average Peak Stress (psi)	24	45	53	73	85	106	118	131
		Average Peak Strain (με)	42	54	52	53	54	51	51	51
	3	|E*| (psi)	500578	821436	947401	131943	149250	198790	219711	248227
		Phase Angle, F (º)	29.7	29.5	25.2	19.6	18.4	14.8	13.3	12.1
		Average Peak Stress (psi)	24	45	53	73	85	106	118	132
		Average Peak Strain (με)	49	55	56	56	57	53	54	53
	Avg.	|E*| Average (psi)	525527	801346	968347	135190	152979	203793	225911	256098
		F Average	31.8	26.5	25.9	21.4	20.0	16.6	15.1	13.9
		|E*| Coeff. of Variation (psi)	0.085	0.053	0.056	0.028	0.028	0.022	0.024	0.027
		F Coeff. of Variation	0.06	0.10	0.05	0.07	0.07	0.10	0.10	0.11
		|E*| Std. Dev. (psi)	44471.8	42231.6	53757.7	37285.0	42684.1	44436.8	53857.2	69717.6
		F Std. Dev.	1.980	2.638	1.414	1.584	1.428	1.646	1.585	1.493
35	1	|E*| (psi)	40542	63223	73690	127004		313310	408740	562833
		Phase Angle, F (º)	28.7	30.8	31.8	33.4		30.1	29.1	27.5
		Average Peak Stress (psi)	2	3	4	8		20	23	35
		Average Peak Strain (με)	60	53	55	63		63	57	62
	2	|E*| (psi)	62311	83393	96341	157852	202818	363858	462182	610699
		Phase Angle, F (º)	32.6	35.4	33.9	34.5	34.0	30.6	29.8	28.1
		Average Peak Stress (psi)	2	3	4	8	10	19	23	33
		Average Peak Strain (με)	39	39	42	51	49	53	49	54
	3	|E*| (psi)	42014	60617	75597	133941	175774	342535	444583	610519
		Phase Angle, F (º)	27.3	28.4	31.2	32.8	33.1	30.1	28.6	26.7
		Average Peak Stress (psi)	2	3	4	8	10	19	23	34
		Average Peak Strain (με)	58	53	53	60	57	57	52	56
	Avg.	|E*| Average (psi)	48289	69078	81876	139599	189296	339901	438502	594684
		F Average	29.5	31.5	32.3	33.6	33.5	30.3	29.2	27.4
		|E*| Coeff. of Variation (psi)	0.252	0.180	0.153	0.116	0.101	0.075	0.062	0.046
		F Coeff. of Variation	0.09	0.11	0.04	0.03	0.02	0.01	0.02	0.03
		|E*| Std. Dev. (psi)	12165.4	12465.7	12563.4	16183.6	19122.7	25376.9	27235.4	27583.4
		F Std. Dev.	2.740	3.544	1.406	0.859	0.630	0.262	0.598	0.709
54.4	Est.	|E*| (psi)	39740	66282	83687	147068	188114	330831	418434	563471

Table B-32. I19.0CF–Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2113319	266514	252834	297160	311375	344536	357949	374181
		Phase Angle, F (º)	7.5	6.0	4.5	4.1	3.8	2.6	2.1	2.0
		Average Peak Stress (psi)	197	229	238	254	262	286	295	319
		Average Peak Strain (με)	93	86	94	85	84	83	82	85
	2	|E*| (psi)	2239395	286270	281401	321101	336933			
		Phase Angle, F (º)	9.2	5.8	9.4	5.9	5.5			
		Average Peak Stress (psi)	197	229	238	254	262			
		Average Peak Strain (με)	88	80	84	79	78			
	3	|E*| (psi)	2533067	270032	298484	351878	366951	406755	423626	445316
		Phase Angle, F (º)	8.6	9.5	7.3	5.4	5.9	4.6	4.3	4.0
		Average Peak Stress (psi)	197	229	238	254	262	286	295	319
		Average Peak Strain (με)	78	85	80	72	71	70	70	72
	Avg.	|E*| Average (psi)	2295260	274272	277573	323380	338420	375646	390787	409749
		F Average	8.4	7.1	7.1	5.1	5.1	3.6	3.2	3.0
		|E*| Coeff. of Variation (psi)	0.094	0.038	0.083	0.085	0.082	0.117	0.119	0.123
		F Coeff. of Variation	0.10	0.29	0.35	0.18	0.22	0.40	0.49	0.47
		|E*| Std. Dev. (psi)	215378.3	105384.	230648.	274300.	278173.	439957.	464405.	503001.
		F Std. Dev.	0.853	2.093	2.471	0.940	1.107	1.445	1.566	1.414
10	1	|E*| (psi)	547962	816536	940601	123039	138772	177006	194990	218632
		Phase Angle, F (º)	22.2	22.0	16.5	14.6	12.9	10.3	9.1	8.4
		Average Peak Stress (psi)	41	53	61	82	98	135	151	167
		Average Peak Strain (με)	75	65	65	67	71	76	78	76
	2	|E*| (psi)	545406	829312	913868	127559	142355	182837	202239	229539
		Phase Angle, F (º)	24.8	24.2	18.5	16.4	15.0	12.1	10.9	10.3
		Average Peak Stress (psi)	41	53	61	82	98	135	151	167
		Average Peak Strain (με)	75	64	67	64	69	74	75	73
	3	|E*| (psi)	730830	108878	120931	156029	173069	214473	236904	264968
		Phase Angle, F (º)	23.4	24.3	17.3	15.9	14.3	11.8	10.7	10.1
		Average Peak Stress (psi)	41	53	61	82	98	135	151	167
		Average Peak Strain (με)	56	49	51	53	57	63	64	63
	Avg.	|E*| Average (psi)	608066	911545	102126	135542	151399	191439	211377	237713
		F Average	23.5	23.5	17.4	15.6	14.1	11.4	10.2	9.6
		|E*| Coeff. of Variation (psi)	0.175	0.169	0.160	0.132	0.125	0.105	0.106	0.102
		F Coeff. of Variation	0.05	0.06	0.06	0.06	0.08	0.08	0.10	0.11
		|E*| Std. Dev. (psi)	106324.3	153627.	163406.	178853.	188525.	201606.	224015.	242253.
		F Std. Dev.	1.284	1.307	0.998	0.971	1.089	0.941	0.999	1.031
35	1	|E*| (psi)	54176	87373	109141	183611	241278	411038	501034	633957
		Phase Angle, F (º)	26.9	28.0	28.6	28.7	26.6	23.1	21.4	20.7
		Average Peak Stress (psi)	3	4	6	10	20	30	40	60
		Average Peak Strain (με)	57	47	56	55	84	73	80	95
	2	|E*| (psi)	56345	85220	105429	173965	226839	388625	476536	609355
		Phase Angle, F (º)	29.3	30.6	29.7	30.4	27.5	24.3	22.8	21.9
		Average Peak Stress (psi)	3	4	6	10	20	30	40	60
		Average Peak Strain (με)	54	48	58	58	90	77	84	99
	3	|E*| (psi)	80382	118582	145863	231943	301784	510141		
		Phase Angle, F (º)	27.0	29.7	29.6	30.7	27.8	25.5		
		Average Peak Stress (psi)	3	4	6	10	20	30		
		Average Peak Strain (με)	38	34	42	44	67	59		
	Avg.	|E*| Average (psi)	63634	97058	120144	196506	256634	436601	488785	621656
		F Average	27.7	29.4	29.3	29.9	27.3	24.3	22.1	21.3
		|E*| Coeff. of Variation (psi)	0.229	0.192	0.186	0.158	0.155	0.148	0.035	0.028
		F Coeff. of Variation	0.05	0.05	0.02	0.04	0.02	0.05	0.05	0.04
		|E*| Std. Dev. (psi)	14544.3	18671.3	22349.9	31065.9	39762.2	64665.4	17322.5	17396.0
		F Std. Dev.	1.369	1.351	0.623	1.102	0.585	1.204	1.004	0.811
54.4	Est.	|E*| (psi)	17840	27992	34519	56710	70488	117771	146633	194931

Table B-33. I19.0CF – Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2866496	318080	326240	370146	385151	413765	425706	442346
		Phase Angle, F (º)	8.1	1.4	7.5	5.3	5.3	3.8	3.1	3.1
		Average Peak Stress (psi)	177	206	214	228	236	258	265	287
		Average Peak Strain (με)	62	65	65	62	61	62	62	65
	2	|E*| (psi)	2753643	287584	328235	356114	366526	395858	405794	414888
		Phase Angle, F (º)	10.8	8.8	10.8	7.9	7.5	6.5	6.0	5.4
		Average Peak Stress (psi)	196	229	237	253	262	286	294	318
		Average Peak Strain (με)	71	80	72	71	71	72	73	77
	3	|E*| (psi)	2841989	338701	337815	365184	378090	406606	414921	429755
		Phase Angle, F (º)	12.0	13.5	11.0	8.9	8.3	6.9	6.5	6.1
		Average Peak Stress (psi)	196	229	237	253	262	286	294	318
		Average Peak Strain (με)	69	68	70	69	69	70	71	74
	Avg.	|E*| Average (psi)	2820710	314788	330763	363815	376589	405410	415474	428996
		F Average	10.3	7.9	9.8	7.4	7.0	5.8	5.2	4.9
		|E*| Coeff. of Variation (psi)	0.021	0.082	0.019	0.020	0.025	0.022	0.024	0.032
		F Coeff. of Variation	0.19	0.77	0.20	0.25	0.22	0.30	0.36	0.32
		|E*| Std. Dev. (psi)	59359.7	257173.	61875.6	71153.3	94026.9	90131.0	99678.3	137449.
		F Std. Dev.	1.991	6.100	1.972	1.866	1.520	1.709	1.851	1.549
10	1	|E*| (psi)	978796	125510	148675	191542	209214	252187	270480	299112
		Phase Angle, F (º)	24.1	20.5	19.9	15.6	13.6	10.8	9.4	8.7
		Average Peak Stress (psi)	37	52	63	81	96	132	151	165
		Average Peak Strain (με)	38	41	42	42	46	52	56	55
	2	|E*| (psi)	983356	127131	144673	186475	204078	242049	260002	281775
		Phase Angle, F (º)	28.0	21.0	22.3	18.4	17.7	14.1	12.8	11.9
		Average Peak Stress (psi)	41	57	69	90	106	147	167	183
		Average Peak Strain (με)	42	45	48	48	52	61	64	65
	3	|E*| (psi)	1095123	156707	158638	204437	219530	257422	273227	297966
		Phase Angle, F (º)	28.8	26.8	21.5	19.4	18.2	14.8	13.3	12.5
		Average Peak Stress (psi)	41	57	69	90	106	147	167	183
		Average Peak Strain (με)	37	36	44	44	48	57	61	62
	Avg.	|E*| Average (psi)	1019091	136449	150662	194151	210940	250553	267903	292951
		F Average	27.0	22.8	21.2	17.8	16.5	13.2	11.8	11.0
		|E*| Coeff. of Variation (psi)	0.065	0.129	0.048	0.048	0.037	0.031	0.026	0.033
		F Coeff. of Variation	0.09	0.15	0.06	0.11	0.15	0.16	0.18	0.18
		|E*| Std. Dev. (psi)	65884.5	175623.	71917.4	92611.3	78693.4	78155.3	69791.3	96959.3
		F Std. Dev.	2.549	3.487	1.267	1.956	2.522	2.089	2.095	2.009
35	1	|E*| (psi)	125989	181883	215491	338964	411486	690789	828421	100780
		Phase Angle, F (º)	38.0	36.1	34.6	35.3	32.7	28.5	24.5	21.5
		Average Peak Stress (psi)	2	4	5	8	13	18	29	50
		Average Peak Strain (με)	16	22	25	25	31	26	35	50
	2	|E*| (psi)	122317	171660	207219	336910	411917	717802	858988	100956
		Phase Angle, F (º)	43.4	40.3	39.0	37.7	35.8	29.4	27.2	24.6
		Average Peak Stress (psi)	2	4	5	9	14	24	32	56
		Average Peak Strain (με)	17	24	26	28	34	34	37	56
	3	|E*| (psi)	103137	156379	192465	307996	390738	662530	805821	100175
		Phase Angle, F (º)	34.8	36.1	33.6	33.5	31.9	26.1	23.5	23.5
		Average Peak Stress (psi)	4	6	11	16	24	40	57	65
		Average Peak Strain (με)	39	39	55	53	62	61	70	65
	Avg.	|E*| Average (psi)	117148	169974	205058	327956	404714	690374	831077	100637
		F Average	38.7	37.5	35.7	35.5	33.5	28.0	25.1	23.2
		|E*| Coeff. of Variation (psi)	0.105	0.076	0.057	0.053	0.030	0.040	0.032	0.004
		F Coeff. of Variation	0.11	0.06	0.08	0.06	0.06	0.06	0.08	0.07
		|E*| Std. Dev. (psi)	12271.5	12835.2	11664.0	17317.0	12105.2	27638.2	26682.7	4095.3
		F Std. Dev.	4.330	2.399	2.854	2.084	2.094	1.672	1.933	1.569
54.4	1	|E*| (psi)	45081	49974	53410	79466	104518	172112	224785	316428
		Phase Angle, F (º)	24.2	23.0	21.7	25.2	24.3	26.2	25.6	26.2
		Average Peak Stress (psi)	1	2	3	6	10	11	15	22
		Average Peak Strain (με)	27	32	61	77	96	67	67	70
	2	|E*| (psi)	28739	35984	40903	66813	92688	164830	218486	310939
		Phase Angle, F (º)	28.6	32.8	27.9	30.2	28.2	29.3	28.0	28.4
		Average Peak Stress (psi)	1	2	3	6	10	11	15	22
		Average Peak Strain (με)	43	45	80	92	108	69	68	70
	3	|E*| (psi)	42614	51340	56214	83258	112207	185214	240516	333503
		Phase Angle, F (º)	23.3	26.7	24.1	26.6	25.8	27.4	26.5	27.3
		Average Peak Stress (psi)	1	2	3	6	10	11	15	22
		Average Peak Strain (με)	29	32	58	74	89	62	63	67
	Avg.	|E*| Average (psi)	38811	45766	50176	76512	103138	174052	227929	320290
		F Average	25.3	27.5	24.6	27.3	26.1	27.6	26.7	27.3
		|E*| Coeff. of Variation (psi)	0.227	0.186	0.162	0.113	0.095	0.059	0.050	0.037
		F Coeff. of Variation	0.11	0.18	0.13	0.09	0.08	0.06	0.05	0.04
		|E*| Std. Dev. (psi)	8809.6	8498.9	8152.1	8611.5	9832.4	10329.7	11346.7	11767.2
		F Std. Dev.	2.841	4.928	3.152	2.560	1.970	1.595	1.235	1.087

Table B-34. I19.0DC – Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	3054294		365886	421447	438542	476420	491519	513289
		Phase Angle, F (º)	8.5		4.3	5.7	4.3	2.8	2.4	2.3
		Average Peak Stress (psi)	197		238	254	262	287	295	310
		Average Peak Strain (με)	64		65	60	60	60	60	60
	2	|E*| (psi)	2941317	326029	356882	406040	424578	462553	478530	499408
		Phase Angle, F (º)	7.6	13.1	9.0	5.0	4.6	3.3	2.6	2.6
		Average Peak Stress (psi)	197	229	238	254	262	287	295	318
		Average Peak Strain (με)	67	70	67	63	62	62	62	64
	3	|E*| (psi)	2744958	324368	354414	379572	399805	440414	456191	478891
		Phase Angle, F (º)	8.1	13.4	6.8	4.9	4.8	3.2	3.1	3.1
		Average Peak Stress (psi)	197	229	238	254	262	286	294	318
		Average Peak Strain (με)	72	71	67	67	66	65	65	66
	Avg.	|E*| Average (psi)	2913523	325198	359061	402353	420975	459796	475413	497196
		F Average	8.1	13.2	6.7	5.2	4.6	3.1	2.7	2.7
		|E*| Coeff. of Variation (psi)	0.054	0.004	0.017	0.053	0.047	0.039	0.038	0.035
		F Coeff. of Variation	0.05	0.02	0.35	0.08	0.06	0.08	0.12	0.14
		|E*| Std. Dev. (psi)	156530.0	11742.2	60385.8	211797.	196180.	181609.	178691.	173054.
		F Std. Dev.	0.437	0.225	2.373	0.427	0.272	0.234	0.337	0.385
10	1	|E*| (psi)	773975	110358	136940	180753	202692	256654	281577	311234
		Phase Angle, F (º)	24.2	18.4	19.0	15.7	14.6	10.8	9.8	9.3
		Average Peak Stress (psi)	53	70	82	103	119	160	172	192
		Average Peak Strain (με)	69	63	60	57	59	62	61	62
	2	|E*| (psi)	791298	117804	131401	178141	199535	252205	277010	307080
		Phase Angle, F (º)	23.1	15.5	19.2	14.9	13.2	10.3	9.5	8.9
		Average Peak Stress (psi)	53	70	82	103	119	159	175	191
		Average Peak Strain (με)	67	59	62	58	60	63	63	62
	3	|E*| (psi)	700419	103403	117409	159612	180165	234148	259325	290173
		Phase Angle, F (º)	23.4	16.0	19.5	16.0	14.0	11.1	10.0	9.3
		Average Peak Stress (psi)	53	70	82	103	119	159	175	191
		Average Peak Strain (με)	76	67	70	64	66	68	68	66
	Avg.	|E*| Average (psi)	755231	110522	128584	172836	194130	247669	272637	302829
		F Average	23.6	16.6	19.3	15.6	14.0	10.8	9.8	9.2
		|E*| Coeff. of Variation (psi)	0.064	0.065	0.078	0.067	0.063	0.048	0.043	0.037
		F Coeff. of Variation	0.02	0.09	0.01	0.04	0.05	0.04	0.02	0.03
		|E*| Std. Dev. (psi)	48251.8	72016.7	100656.	115258.	121971.	119188.	117529.	111553.
		F Std. Dev.	0.583	1.565	0.250	0.583	0.674	0.401	0.230	0.241
35	1	|E*| (psi)	94420	130969	156206	251785	340403	573914	725188	930272
		Phase Angle, F (º)	29.7	30.6	30.8	35.0	29.4	26.6	24.1	23.4
		Average Peak Stress (psi)	5	6	8	12	24	32	44	65
		Average Peak Strain (με)	52	47	53	49	72	56	61	69
	2	|E*| (psi)	78799	124824	156650	247838	340792	586310	723685	934498
		Phase Angle, F (º)	29.7	30.5	31.1	32.9	28.0	25.6	23.1	22.0
		Average Peak Stress (psi)	4	5	7	11	25	32	44	64
		Average Peak Strain (με)	47	39	47	46	72	54	60	68
	3	|E*| (psi)	63971	99911	129378	211390	307652	531133	668142	867233
		Phase Angle, F (º)	27.7	28.8	29.5	32.9	27.8	25.4	23.4	22.5
		Average Peak Stress (psi)	4	5	7	11	24	32	44	64
		Average Peak Strain (με)	58	48	57	54	80	60	66	74
	Avg.	|E*| Average (psi)	79063	118568	147411	237004	329616	563786	705672	910668
		F Average	29.0	30.0	30.5	33.6	28.4	25.9	23.5	22.7
		|E*| Coeff. of Variation (psi)	0.193	0.139	0.106	0.094	0.058	0.051	0.046	0.041
		F Coeff. of Variation	0.04	0.03	0.03	0.04	0.03	0.02	0.02	0.03
		|E*| Std. Dev. (psi)	15226.0	16447.0	15618.5	22270.4	19022.5	28949.3	32510.4	37674.5
		F Std. Dev.	1.163	1.022	0.851	1.241	0.872	0.647	0.467	0.721
54.4	Est.	|E*| (psi)	21321	30168	35679	55259	67878	112549	141122	191305

Table B-35. I19.0DF – Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	3507890	393487	403388	461299	469983	514104	527518	548181
		Phase Angle, F (º)	6.2		8.0	3.8	3.0	2.2	1.4	1.8
		Average Peak Stress (psi)	196	229	237	254	262	286	295	318
		Average Peak Strain (με)	56	58	59	55	56	56	56	58
	2	|E*| (psi)	3066966	379872	383360	404623	424099	459699	469055	491004
		Phase Angle, F (º)	7.2	5.8	4.3	2.9	3.1	2.8	2.2	2.3
		Average Peak Stress (psi)	196	229	237	254	262	286	295	318
		Average Peak Strain (με)	64	60	62	63	62	62	63	65
	3	|E*| (psi)	3026513	364818	374920	397295	415146	450983	463697	482116
		Phase Angle, F (º)	8.3	10.4	7.9	5.0	5.3	4.5	4.0	3.9
		Average Peak Stress (psi)	196	229	237	254	262	286	294	318
		Average Peak Strain (με)	65	63	63	64	63	63	63	66
	Avg.	|E*| Average (psi)	3200456	379392	387222	421072	436410	474929	486757	507100
		F Average	7.2	8.1	6.7	3.9	3.8	3.2	2.5	2.7
		|E*| Coeff. of Variation (psi)	0.083	0.038	0.038	0.083	0.067	0.072	0.073	0.071
		F Coeff. of Variation	0.14	0.40	0.31	0.28	0.35	0.37	0.52	0.41
		|E*| Std. Dev. (psi)	267012.7	143402.	146217.	350292.	294183.	342055.	354021.	358536.
		F Std. Dev.	1.024	3.272	2.090	1.091	1.305	1.176	1.330	1.109
10	1	|E*| (psi)	1117641	172280	181213	228131	250266	302290	323886	356426
		Phase Angle, F (º)	20.7	15.4	13.3	12.3	11.7	8.4	7.8	7.0
		Average Peak Stress (psi)	53	70	82	102	119	159	176	192
		Average Peak Strain (με)	48	40	45	45	47	53	54	54
	2	|E*| (psi)	1002019	151649	163164	201351	222274	269854	291263	320152
		Phase Angle, F (º)	21.0	16.2	14.7	12.7	11.8	9.1	8.2	7.6
		Average Peak Stress (psi)	53	70	82	103	119	159	176	191
		Average Peak Strain (με)	53	46	50	51	53	59	60	60
	3	|E*| (psi)	991878	142880	152560	196949	215671	262350	283020	310114
		Phase Angle, F (º)	21.9	21.0	17.1	14.0	13.3	10.4	9.7	9.1
		Average Peak Stress (psi)	53	70	82	102	119	159	175	191
		Average Peak Strain (με)	54	49	54	52	55	61	62	61
	Avg.	|E*| Average (psi)	1037179	155603	165646	208810	229404	278164	299390	328897
		F Average	21.2	17.5	15.0	13.0	12.3	9.3	8.6	7.9
		|E*| Coeff. of Variation (psi)	0.067	0.097	0.087	0.081	0.080	0.076	0.072	0.074
		F Coeff. of Variation	0.03	0.17	0.13	0.07	0.07	0.11	0.12	0.13
		|E*| Std. Dev. (psi)	69865.9	150935.	144864.	168761.	183665.	212277.	216109.	243629.
		F Std. Dev.	0.615	3.005	1.909	0.869	0.874	0.988	1.023	1.061
35	1	|E*| (psi)	93839	156496	194931	315022	433228	736501	882699	111476
		Phase Angle, F (º)	30.2	33.0	31.1	32.7	28.0	24.5	21.1	20.1
		Average Peak Stress (psi)	4	5	7	11	24	32	44	65
		Average Peak Strain (με)	39	31	38	36	56	44	50	58
	2	|E*| (psi)	92710	156089	191045	303262	405744	677862	824984	103382
		Phase Angle, F (º)	32.8	34.0	31.6	32.6	28.1	24.3	22.0	20.6
		Average Peak Stress (psi)	4	5	7	11	24	32	44	65
		Average Peak Strain (με)	40	31	39	38	60	47	54	63
	3	|E*| (psi)	99904	160544	199437	312099	420300	697087	842249	103201
		Phase Angle, F (º)	31.9	32.1	30.9	32.8	28.2	24.7	23.1	21.7
		Average Peak Stress (psi)	4	5	7	11	24	32	44	64
		Average Peak Strain (με)	37	30	37	37	58	46	52	62
	Avg.	|E*| Average (psi)	95485	157710	195138	310128	419757	703817	849977	106020
		F Average	31.6	33.0	31.2	32.7	28.1	24.5	22.1	20.8
		|E*| Coeff. of Variation (psi)	0.041	0.016	0.022	0.020	0.033	0.042	0.035	0.045
		F Coeff. of Variation	0.04	0.03	0.01	0.00	0.00	0.01	0.05	0.04
		|E*| Std. Dev. (psi)	3869.1	2463.3	4199.5	6122.6	13749.9	29893.4	29623.7	47258.0
		F Std. Dev.	1.307	0.912	0.372	0.072	0.083	0.209	1.003	0.768
54.4	Est.	|E*| (psi)	23496	38580	48443	83542	106168	184633	233076	314587

Table B-36. B25.0BC – Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2669859		331750	393700	410413	455794	471267	487530
		Phase Angle, F (º)	13.9		8.6	10.1	8.3	7.8	7.0	6.4
		Average Peak Stress (psi)	196		238	254	262	287	295	319
		Average Peak Strain (με)	74		72	65	64	63	63	65
	2	|E*| (psi)	2308190	282226	304328	326919	342925	375111	387592	402156
		Phase Angle, F (º)	7.5	10.9	5.1	3.9	2.0	1.8	1.1	1.3
		Average Peak Stress (psi)	180	213	225	242	246	270	279	302
		Average Peak Strain (με)	78	75	74	74	72	72	72	75
	3	|E*| (psi)	2309560	254400	299019	325369	342626	377264	393455	408650
		Phase Angle, F (º)	7.5	2.9	5.4	3.7	1.5	1.6	1.3	0.9
		Average Peak Stress (psi)	196	229	238	254	262	286	295	319
		Average Peak Strain (με)	85	90	79	78	77	76	75	78
	Avg.	|E*| Average (psi)	2429203	268313	311699	348663	365322	402723	417438	432779
		F Average	9.6	6.9	6.4	5.9	4.0	3.7	3.1	2.9
		|E*| Coeff. of Variation (psi)	0.086	0.073	0.056	0.112	0.107	0.114	0.112	0.110
		F Coeff. of Variation	0.39	0.82	0.30	0.62	0.96	0.94	1.06	1.07
		|E*| Std. Dev. (psi)	208415.2	196758.	175664.	390113.	390507.	459732.	467093.	475271.
		F Std. Dev.	3.719	5.652	1.904	3.654	3.789	3.508	3.311	3.056
10	1	|E*| (psi)	495621	792861	951179	136915	157633	212648	233666	268032
		Phase Angle, F (º)	29.1	23.0	26.3	21.1	18.1	14.8	12.9	12.1
		Average Peak Stress (psi)	53	70	82	103	119	160	184	200
		Average Peak Strain (με)	107	88	86	75	75	75	79	75
	2	|E*| (psi)	452376	712496	890185	125708	144414	190549	210557	236274
		Phase Angle, F (º)	25.6	19.1	19.3	16.5	13.8	10.7	9.3	8.4
		Average Peak Stress (psi)	37	57	74	90	107	147	168	183
		Average Peak Strain (με)	81	80	83	72	74	77	80	78
	3	|E*| (psi)	447775	709808	840429	125170	144080	190184	211120	236657
		Phase Angle, F (º)	25.9	24.1	20.3	16.3	13.3	10.4	9.0	7.8
		Average Peak Stress (psi)	53	70	82	103	119	159	184	200
		Average Peak Strain (με)	119	98	97	82	82	84	87	85
	Avg.	|E*| Average (psi)	465257	738388	893931	129264	148709	197793	218447	246988
		F Average	26.9	22.0	22.0	18.0	15.0	11.9	10.4	9.4
		|E*| Coeff. of Variation (psi)	0.057	0.064	0.062	0.051	0.052	0.065	0.060	0.074
		F Coeff. of Variation	0.07	0.12	0.17	0.15	0.18	0.20	0.21	0.25
		|E*| Std. Dev. (psi)	26396.1	47193.9	55470.4	66309.6	77305.1	128653.	131824.	182261.
		F Std. Dev.	1.963	2.619	3.762	2.694	2.648	2.443	2.166	2.321
35	1	|E*| (psi)	38145	60336	74984	139526	192320	365930	472388	656586
		Phase Angle, F (º)	23.1	28.1	29.3	32.2	29.2	29.5	27.6	25.7
		Average Peak Stress (psi)	3	5	6	12	20	32	44	64
		Average Peak Strain (με)	76	81	82	82	105	87	93	98
	2	|E*| (psi)	34749	54705	68680	127813	182181	356533	456019	640196
		Phase Angle, F (º)	24.0	28.6	29.2	31.8	29.1	28.0	25.6	24.3
		Average Peak Stress (psi)	2	3	4	7	14	24	32	52
		Average Peak Strain (με)	59	60	59	58	78	67	69	81
	3	|E*| (psi)	31872	51060	66008	124243	176202	345259	451361	630396
		Phase Angle, F (º)	21.9	27.1	28.7	31.8	28.9	27.7	26.1	24.9
		Average Peak Stress (psi)	2	3	4	7	14	24	32	52
		Average Peak Strain (με)	64	64	62	59	81	69	70	83
	Avg.	|E*| Average (psi)	34922	55367	69891	130527	183568	355907	459922	642393
		F Average	23.0	27.9	29.1	32.0	29.1	28.4	26.4	25.0
		|E*| Coeff. of Variation (psi)	0.090	0.084	0.066	0.061	0.044	0.029	0.024	0.021
		F Coeff. of Variation	0.05	0.03	0.01	0.01	0.01	0.03	0.04	0.03
		|E*| Std. Dev. (psi)	3140.1	4673.2	4609.0	7995.2	8147.9	10349.7	11043.6	13232.2
		F Std. Dev.	1.053	0.779	0.322	0.251	0.167	0.943	1.013	0.695
54.4	Est.	|E*| (psi)	8122	11603	13924	22626	28427	50763	66137	94565

Table B-37. B25.0BC – Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	3550993	392872	401460	453213	465471	495362	509141	523378
		Phase Angle, F (º)	11.7	15.4	9.4	8.2	7.9	6.2	5.6	5.2
		Average Peak Stress (psi)	177	206	214	229	236	258	266	286
		Average Peak Strain (με)	50	53	53	50	51	52	52	55
	2	|E*| (psi)	3080484	362550	348411	390128	403972	426135	436379	451153
		Phase Angle, F (º)	6.8	0.4	2.8	3.8	3.0	1.9	2.1	1.6
		Average Peak Stress (psi)	177	206	214	229	236	258	266	288
		Average Peak Strain (με)	57	57	61	59	58	60	61	64
	3	|E*| (psi)	3331634	414380	372162	426007	436432	460988	472445	487995
		Phase Angle, F (º)	7.5	5.9	5.2	4.4	4.1	2.7	2.3	2.3
		Average Peak Stress (psi)	177	206	214	229	236	258	266	287
		Average Peak Strain (με)	53	50	57	54	54	56	56	59
	Avg.	|E*| Average (psi)	3321037	389934	374011	423116	435292	460828	472655	487508
		F Average	8.7	7.2	5.8	5.5	5.0	3.6	3.3	3.0
		|E*| Coeff. of Variation (psi)	0.071	0.067	0.071	0.075	0.071	0.075	0.077	0.074
		F Coeff. of Variation	0.31	1.05	0.58	0.44	0.52	0.63	0.60	0.63
		|E*| Std. Dev. (psi)	235433.7	260394.	265729.	316417.	307654.	346138.	363816.	361148.
		F Std. Dev.	2.674	7.594	3.358	2.405	2.583	2.267	1.990	1.913
10	1	|E*| (psi)	1130769	181696	188984	235235	256152	305097	327934	362562
		Phase Angle, F (º)	32.7	28.7	25.8	20.1	18.1	13.6	12.6	11.8
		Average Peak Stress (psi)	37	52	63	81	96	133	151	165
		Average Peak Strain (με)	33	28	33	35	37	43	46	45
	2	|E*| (psi)	972335	128145	161642	202347	220613	264531	284016	310474
		Phase Angle, F (º)	24.6	20.5	17.1	14.1	12.4	9.2	7.7	7.1
		Average Peak Stress (psi)	37	52	63	81	96	133	151	166
		Average Peak Strain (με)	38	40	39	40	43	50	53	53
	3	|E*| (psi)	1118079	146323	172769	226569	248346	293535	313948	341161
		Phase Angle, F (º)	26.2	16.8	20.5	15.0	13.4	10.2	9.4	8.5
		Average Peak Stress (psi)	37	52	63	81	96	133	151	166
		Average Peak Strain (με)	33	35	36	36	39	45	48	49
	Avg.	|E*| Average (psi)	1073727	152055	174465	221384	241704	287721	308633	338065
		F Average	27.8	22.0	21.1	16.4	14.6	11.0	9.9	9.1
		|E*| Coeff. of Variation (psi)	0.082	0.179	0.079	0.077	0.077	0.073	0.073	0.077
		F Coeff. of Variation	0.15	0.28	0.21	0.20	0.21	0.21	0.25	0.27
		|E*| Std. Dev. (psi)	88037.2	272313.	137493.	170460.	186773.	208989.	224363.	261814.
		F Std. Dev.	4.286	6.093	4.356	3.219	3.006	2.341	2.501	2.428
35	1	|E*| (psi)	125012	165454	206495	344077	439242	829061	997852	123611
		Phase Angle, F (º)	36.1	37.3	40.1	41.7	37.9	33.9	29.9	25.8
		Average Peak Stress (psi)	2	4	5	8	13	18	29	51
		Average Peak Strain (με)	15	22	23	24	29	22	29	41
	2	|E*| (psi)	89045	141326	180874	311831	407925	717805	878920	112016
		Phase Angle, F (º)	27.9	29.1	31.0	31.6	30.1	25.9	22.5	20.3
		Average Peak Stress (psi)	2	4	5	8	13	18	29	51
		Average Peak Strain (με)	21	26	26	27	31	25	33	45
	3	|E*| (psi)	95824	146520	182485	322440	423300	756675	925763	115883
		Phase Angle, F (º)	33.4	33.1	33.8	34.6	31.9	27.6	23.5	20.9
		Average Peak Stress (psi)	2	4	5	8	13	18	29	51
		Average Peak Strain (με)	19	25	26	26	30	24	31	44
	Avg.	|E*| Average (psi)	103294	151100	189951	326116	423489	767847	934178	117170
		F Average	32.5	33.2	35.0	36.0	33.3	29.1	25.3	22.3
		|E*| Coeff. of Variation (psi)	0.185	0.084	0.076	0.050	0.037	0.074	0.064	0.050
		F Coeff. of Variation	0.13	0.12	0.13	0.14	0.12	0.14	0.16	0.13
		|E*| Std. Dev. (psi)	19111.7	12699.2	14349.9	16434.4	15659.4	56463.0	59910.9	59037.2
		F Std. Dev.	4.151	4.086	4.636	5.175	4.118	4.189	4.048	3.006
54.4	1	|E*| (psi)	91261	79151	63973	78788	94085	169229	227145	342205
		Phase Angle, F (º)	25.3	31.6	26.3	31.0	31.8	32.9	32.4	32.5
		Average Peak Stress (psi)	1	1	2	4	5	8	12	16
		Average Peak Strain (με)	8	14	29	47	50	47	51	47
	2	|E*| (psi)	36536	43738	41850	64720	82161	153165	209865	315657
		Phase Angle, F (º)	19.8	21.1	21.0	25.0	26.1	26.7	26.3	26.9
		Average Peak Stress (psi)	1	1	2	4	5	8	12	16
		Average Peak Strain (με)	20	25	45	57	58	52	56	50
	3	|E*| (psi)	31764	36409	41027	64733	82891	158678	217665	330512
		Phase Angle, F (º)	18.3	19.4	22.4	26.4	27.8	28.2	27.9	27.5
		Average Peak Stress (psi)	1	1	2	4	5	8	12	16
		Average Peak Strain (με)	23	31	45	57	57	50	54	49
	Avg.	|E*| Average (psi)	53187	53100	48950	69414	86379	160357	218225	329458
		F Average	21.1	24.1	23.2	27.5	28.6	29.3	28.8	29.0
		|E*| Coeff. of Variation (psi)	0.622	0.430	0.266	0.117	0.077	0.051	0.040	0.040
		F Coeff. of Variation	0.17	0.27	0.12	0.11	0.10	0.11	0.11	0.11
		|E*| Std. Dev. (psi)	33059.1	22857.0	13016.4	8118.2	6683.7	8162.6	8653.4	13305.2
		F Std. Dev.	3.654	6.599	2.761	3.145	2.912	3.269	3.187	3.052

Table B-38. B25.0BF – Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	3306898	350114	394726	473662	489173	528971	547743	567076
		Phase Angle, F (º)	12.7	7.4	9.9	9.4	8.3	6.6	6.4	5.7
		Average Peak Stress (psi)	196	229	237	254	263	287	296	320
		Average Peak Strain (με)	59	65	60	54	54	54	54	56
	2	|E*| (psi)	3344397	383679	392568	463410	483149	517276	533838	
		Phase Angle, F (º)	9.6		6.5	6.5	6.0	4.9	4.0	
		Average Peak Stress (psi)	196	229	237	254	263	287	296	
		Average Peak Strain (με)	59	60	60	55	54	56	55	
	3	|E*| (psi)	2808610	370351	353313	390967	406910	441002	452718	470831
		Phase Angle, F (º)	8.9	6.3	4.0	5.8	5.2	3.6	3.1	2.8
		Average Peak Stress (psi)	196	229	237	254	262	286	295	319
		Average Peak Strain (με)	70	62	67	65	64	65	65	68
	Avg.	|E*| Average (psi)	3153302	368048	380202	442680	459744	495750	511433	518953
		F Average	10.4	6.8	6.8	7.2	6.5	5.1	4.5	4.2
		|E*| Coeff. of Variation (psi)	0.095	0.046	0.061	0.102	0.100	0.096	0.100	0.131
		F Coeff. of Variation	0.20	0.11	0.44	0.26	0.25	0.30	0.38	0.50
		|E*| Std. Dev. (psi)	299100.2	169004.	233116.	450767.	458543.	477724.	513217.	680550.
		F Std. Dev.	2.030	0.735	2.968	1.876	1.609	1.506	1.711	2.109
10	1	|E*| (psi)	763601	135566	146206	196965	224076	282519	309034	349312
		Phase Angle, F (º)	31.8	24.2	27.9	20.5	18.7	14.9	13.4	12.3
		Average Peak Stress (psi)	41	53	61	82	99	135	152	168
		Average Peak Strain (με)	54	39	42	42	44	48	49	48
	2	|E*| (psi)	742980	128232	143175	192805	213595	268340	292986	
		Phase Angle, F (º)	29.5	25.5	21.4	18.7	16.4	12.2	11.3	
		Average Peak Stress (psi)	53	70	82	103	119	160	177	
		Average Peak Strain (με)	72	54	57	53	56	60	60	
	3	|E*| (psi)	582100	979919	113432	153096	176819	230459	253159	282808
		Phase Angle, F (º)	28.1	24.8	21.6	17.7	15.8	11.9	10.3	9.3
		Average Peak Stress (psi)	53	70	82	103	119	159	176	192
		Average Peak Strain (με)	91	71	72	67	67	69	69	68
	Avg.	|E*| Average (psi)	696227	120596	134271	180955	204830	260440	285060	316060
		F Average	29.8	24.8	23.6	19.0	16.9	13.0	11.7	10.8
		|E*| Coeff. of Variation (psi)	0.143	0.165	0.135	0.134	0.121	0.103	0.101	0.149
		F Coeff. of Variation	0.06	0.02	0.16	0.08	0.09	0.13	0.14	0.20
		|E*| Std. Dev. (psi)	99373.1	199170.	181109.	242163.	248178.	269143.	287686.	470256.
		F Std. Dev.	1.855	0.616	3.711	1.435	1.567	1.647	1.602	2.153
35	1	|E*| (psi)	53374	85282	109068	200152	279198	531708	679211	914318
		Phase Angle, F (º)	32.6	36.2	36.4	38.9	34.7	31.4	29.0	26.7
		Average Peak Stress (psi)	3	4	6	10	21	30	40	61
		Average Peak Strain (με)	57	48	56	51	74	57	59	67
	2	|E*| (psi)	49464	78133		196478	288747	544934	779877	951041
		Phase Angle, F (º)	26.2	31.8		35.4	31.8	29.1	22.9	24.7
		Average Peak Stress (psi)	4	5		12	25	32	11	65
		Average Peak Strain (με)	74	63		59	85	59	14	68
	3	|E*| (psi)	36474	53851	70701	127168	202907	394198	525293	746081
		Phase Angle, F (º)	24.4	26.4	28.7	35.4	30.2	29.2	27.3	25.4
		Average Peak Stress (psi)	4	5	7	11	25	32	44	63
		Average Peak Strain (με)	101	91	104	90	121	81	83	85
	Avg.	|E*| Average (psi)	46437	72422	89884	174599	256950	490280	661460	870480
		F Average	27.7	31.5	32.5	36.6	32.2	29.9	26.4	25.6
		|E*| Coeff. of Variation (psi)	0.191	0.227	0.302	0.235	0.183	0.170	0.194	0.126
		F Coeff. of Variation	0.16	0.16	0.17	0.05	0.07	0.04	0.12	0.04
		|E*| Std. Dev. (psi)	8847.0	16475.6	27130.1	41118.1	47046.1	83471.6	128217.	109285.
		F Std. Dev.	4.346	4.905	5.422	2.007	2.247	1.320	3.144	0.988
54.4	Est.	|E*| (psi)	10443	16389	20305	35389	45832	85717	112839	162297

Table B-39. B25.0BF – Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2737557	298368	346759	369356	379975	413000	425522	439752
		Phase Angle, F (º)	9.7	12.0	6.3	6.8	6.7	5.2	4.5	4.2
		Average Peak Stress (psi)	167	195	202	216	223	243	250	270
		Average Peak Strain (με)	61	65	58	58	59	59	59	61
	2	|E*| (psi)	2730451	298284	333076	372380	383055	413316	425935	445316
		Phase Angle, F (º)	9.5	5.2	9.5	7.7	6.1	5.5	4.9	4.6
		Average Peak Stress (psi)	167	195	202	216	223	243	251	271
		Average Peak Strain (με)	61	65	61	58	58	59	59	61
	3	|E*| (psi)	3281448	389204	388925	440780	458843	487956	533849	
		Phase Angle, F (º)	8.5	1.0	8.6	5.8	4.6	4.0	5.3	
		Average Peak Stress (psi)	147	172	178	190	196	215	221	
		Average Peak Strain (με)	45	44	46	43	43	44	41	
	Avg.	|E*| Average (psi)	2916486	328619	356253	394172	407291	438091	461769	442534
		F Average	9.2	6.1	8.1	6.8	5.8	4.9	4.9	4.4
		|E*| Coeff. of Variation (psi)	0.108	0.160	0.082	0.102	0.110	0.099	0.135	0.009
		F Coeff. of Variation	0.07	0.92	0.21	0.14	0.18	0.16	0.08	0.07
		|E*| Std. Dev. (psi)	316086.8	524680.	291100.	403917.	446719.	431852.	624234.	39345.3
		F Std. Dev.	0.620	5.559	1.676	0.963	1.070	0.794	0.380	0.291
10	1	|E*| (psi)	814758	124530	132603	171108	190126	232609	251512	277799
		Phase Angle, F (º)	27.8	23.1	22.6	17.6	16.2	12.7	11.4	10.2
		Average Peak Stress (psi)	35	49	59	77	91	125	142	155
		Average Peak Strain (με)	43	39	45	45	48	54	56	56
	2	|E*| (psi)	792050	108256	128183	171764	189590	231327	250414	276597
		Phase Angle, F (º)	28.2	24.4	22.0	18.6	16.5	12.8	11.5	10.7
		Average Peak Stress (psi)	30	43	52	68	80	110	126	138
		Average Peak Strain (με)	38	40	41	39	42	48	50	50
	3	|E*| (psi)	1020643	150062	155317	209937	229953	278028	298172	329149
		Phase Angle, F (º)	26.8	18.0	19.0	16.2	14.8	11.2	10.1	9.2
		Average Peak Stress (psi)	31	43	52	68	80	110	125	136
		Average Peak Strain (με)	30	29	34	32	35	40	42	41
	Avg.	|E*| Average (psi)	875817	127616	138701	184269	203223	247321	266700	294515
		F Average	27.6	21.9	21.2	17.4	15.8	12.2	11.0	10.0
		|E*| Coeff. of Variation (psi)	0.144	0.165	0.105	0.121	0.114	0.108	0.102	0.102
		F Coeff. of Variation	0.03	0.15	0.09	0.07	0.06	0.08	0.07	0.07
		|E*| Std. Dev. (psi)	125936.0	210730.	145582.	222308.	231504.	266003.	272614.	299998.
		F Std. Dev.	0.726	3.351	1.936	1.199	0.919	0.921	0.773	0.730
35	1	|E*| (psi)	98382	132274	155676	254741	325261	579655	714005	890007
		Phase Angle, F (º)	34.6	36.8	36.5	37.2	34.7	30.8	26.2	23.5
		Average Peak Stress (psi)	2	3	5	8	12	17	27	47
		Average Peak Strain (με)	18	26	29	31	37	29	38	53
	2	|E*| (psi)	99529	126249	151109	244096	311641	541803	706823	847660
		Phase Angle, F (º)	34.7	31.6	32.8	32.8	31.3	27.4	22.3	22.5
		Average Peak Stress (psi)	2	3	4	7	11	15	24	41
		Average Peak Strain (με)	16	24	26	29	34	27	33	49
	3	|E*| (psi)	114971	170309	207704	332769	423348	712527	850879	105514
		Phase Angle, F (º)	31.8	31.4	33.2	34.0	32.3	26.8	24.4	22.0
		Average Peak Stress (psi)	2	4	4	7	10	15	23	41
		Average Peak Strain (με)	18	24	19	21	25	21	28	39
	Avg.	|E*| Average (psi)	104294	142944	171496	277202	353417	611328	757236	930937
		F Average	33.7	33.2	34.2	34.7	32.8	28.3	24.3	22.7
		|E*| Coeff. of Variation (psi)	0.089	0.167	0.183	0.175	0.172	0.147	0.107	0.118
		F Coeff. of Variation	0.05	0.09	0.06	0.07	0.05	0.08	0.08	0.04
		|E*| Std. Dev. (psi)	9264.5	23889.6	31439.8	48415.8	60943.7	89660.9	81176.9	109630.
		F Std. Dev.	1.624	3.084	2.063	2.287	1.765	2.156	1.906	0.795
54.4	1	|E*| (psi)	51020	53016	46645	61233	75313	137916	184773	268200
		Phase Angle, F (º)	18.0	27.5	25.1	28.7	29.2	29.4	28.4	28.7
		Average Peak Stress (psi)	1	1	2	3	4	7	11	14
		Average Peak Strain (με)	13	20	38	57	59	54	58	54
	2	|E*| (psi)	53439	64852	49905	58699	70673	125265	166257	241766
		Phase Angle, F (º)	24.6	23.5	25.9	26.6	27.3	27.6	26.8	27.5
		Average Peak Stress (psi)	1	1	2	3	4	7	10	13
		Average Peak Strain (με)	11	14	31	52	56	53	58	52
	3	|E*| (psi)		47617	51457	71165	87291	155759	206017	300523
		Phase Angle, F (º)		17.1	19.6	23.9	25.3	26.1	25.6	27.1
		Average Peak Stress (psi)		1	2	4	5	9	13	17
		Average Peak Strain (με)		26	40	57	60	56	62	56
	Avg.	|E*| Average (psi)	52229	55162	49336	63699	77759	139647	185682	270163
		F Average	21.3	22.7	23.5	26.4	27.2	27.7	26.9	27.8
		|E*| Coeff. of Variation (psi)	0.033	0.160	0.050	0.103	0.110	0.110	0.107	0.109
		F Coeff. of Variation	0.22	0.23	0.14	0.09	0.07	0.06	0.05	0.03
		|E*| Std. Dev. (psi)	1710.6	8815.7	2455.9	6588.7	8575.0	15320.4	19895.8	29427.6
		F Std. Dev.	4.659	5.237	3.405	2.408	1.954	1.662	1.411	0.853

Table B-40. B25.0CC – Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	3590928	474441	466048	525127	548695	595329	621913	648452
		Phase Angle, F (º)	12.7	3.4	6.5	7.8	7.9	6.6	5.9	6.0
		Average Peak Stress (psi)	180	213	225	241	245	270	278	301
		Average Peak Strain (με)	50	45	48	46	45	45	45	46
	2	|E*| (psi)	2963789	357960	355247	415844	435730	481917	493291	511807
		Phase Angle, F (º)	9.9	14.7	6.3	5.7	4.5	3.3	2.5	2.1
		Average Peak Stress (psi)	184	217	229	246	253	278	286	319
		Average Peak Strain (με)	62	61	64	59	58	58	58	62
	3	|E*| (psi)	3070915	401601	388517	466265	483455	537450	554077	570528
		Phase Angle, F (º)	14.1	16.4	11.9	8.2	7.9	5.8	5.6	5.1
		Average Peak Stress (psi)	184	217	229	246	253	278	287	319
		Average Peak Strain (με)	60	54	59	53	52	52	52	56
	Avg.	|E*| Average (psi)	3208544	411334	403271	469078	489293	538232	556427	576929
		F Average	12.2	11.5	8.3	7.2	6.8	5.3	4.7	4.4
		|E*| Coeff. of Variation (psi)	0.105	0.143	0.141	0.117	0.116	0.105	0.116	0.119
		F Coeff. of Variation	0.17	0.61	0.38	0.19	0.29	0.33	0.40	0.46
		|E*| Std. Dev. (psi)	335458.0	588475.	568549.	546957.	567083.	567098.	643435.	685470.
		F Std. Dev.	2.128	7.077	3.180	1.371	1.949	1.714	1.879	2.044
10	1	|E*| (psi)	642269	101796	128907	196053	226201	297603	331972	376528
		Phase Angle, F (º)	32.9	28.1	27.6	22.1	20.5	15.7	13.9	12.9
		Average Peak Stress (psi)	41	65	82	102	119	163	184	200
		Average Peak Strain (με)	64	64	63	52	52	55	55	53
	2	|E*| (psi)	530462	886080	109764	159750	185899	248110	274516	310178
		Phase Angle, F (º)	29.6	22.8	25.4	19.3	17.0	12.7	11.1	10.0
		Average Peak Stress (psi)	41	65	82	102	119	163	184	200
		Average Peak Strain (με)	77	74	75	64	64	66	67	65
	3	|E*| (psi)	522838	993738	114967	170161	196565	268767	297318	339695
		Phase Angle, F (º)	34.5	29.3	27.1	23.9	21.8	16.7	14.7	13.2
		Average Peak Stress (psi)	41	65	82	102	119	163	184	200
		Average Peak Strain (με)	78	66	71	60	60	61	62	59
	Avg.	|E*| Average (psi)	565190	965928	117879	175321	202888	271493	301269	342134
		F Average	32.3	26.7	26.7	21.8	19.8	15.0	13.3	12.0
		|E*| Coeff. of Variation (psi)	0.118	0.073	0.084	0.107	0.103	0.092	0.096	0.097
		F Coeff. of Variation	0.08	0.13	0.04	0.11	0.13	0.14	0.14	0.15
		|E*| Std. Dev. (psi)	66861.3	70203.3	98983.6	186935.	208820.	248585.	289307.	332419.
		F Std. Dev.	2.526	3.469	1.194	2.303	2.521	2.100	1.912	1.787
35	1	|E*| (psi)	51923	71794	87023	157221	222053	448602	600891	867180
		Phase Angle, F (º)	25.1	30.1	30.7	35.7	33.6	33.3	31.8	29.6
		Average Peak Stress (psi)	2	4	5	8	16	26	36	60
		Average Peak Strain (με)	47	51	56	52	73	57	59	69
	2	|E*| (psi)	47719	64081	75780	134178	192248	387296	522583	761140
		Phase Angle, F (º)	22.1	26.5	27.3	32.7	31.4	31.6	30.2	27.8
		Average Peak Stress (psi)	2	4	5	8	16	26	36	60
		Average Peak Strain (με)	51	58	65	61	84	66	68	79
	3	|E*| (psi)	41853	59402	74114	131322	184779	374999	501227	740315
		Phase Angle, F (º)	25.1	29.1	30.3	35.4	33.8	34.1	32.9	31.2
		Average Peak Stress (psi)	2	4	5	8	16	26	36	60
		Average Peak Strain (με)	58	62	66	62	87	69	71	81
	Avg.	|E*| Average (psi)	47165	65093	78972	140907	199693	403632	541567	789545
		F Average	24.1	28.5	29.4	34.6	32.9	33.0	31.6	29.5
		|E*| Coeff. of Variation (psi)	0.107	0.096	0.089	0.101	0.099	0.098	0.097	0.086
		F Coeff. of Variation	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.06
		|E*| Std. Dev. (psi)	5058.1	6257.2	7021.5	14200.3	19720.6	39427.1	52474.0	68035.6
		F Std. Dev.	1.714	1.858	1.828	1.656	1.309	1.247	1.360	1.714
54.4	Est.	|E*| (psi)	16969	21176	23641	33069	39305	63091	79481	110519

Table B-41. B25.0CF – Granite (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2398272	274156	306955	332800	348056	381457	393674	412176
		Phase Angle, F (º)	8.3	11.9	5.1	4.9	4.3	3.2	2.6	2.5
		Average Peak Stress (psi)	197	229	238	254	262	286	295	319
		Average Peak Strain (με)	82	84	77	76	75	75	75	77
	2	|E*| (psi)	2499225	303448	319556	345162	366109	403546	419100	436201
		Phase Angle, F (º)	9.5	13.2	6.4	8.5	7.4	6.7	6.4	6.1
		Average Peak Stress (psi)	197	229	238	254	262	286	295	318
		Average Peak Strain (με)	79	76	74	74	72	71	70	73
	3	|E*| (psi)	2391280	287331	307139	333762	345887	383754		
		Phase Angle, F (º)	10.8	13.8	8.5	7.1	7.3	6.7		
		Average Peak Stress (psi)	197	229	238	254	262	286		
		Average Peak Strain (με)	82	80	77	76	76	75		
	Avg.	|E*| Average (psi)	2429592	288312	311217	337241	353351	389586	406387	424189
		F Average	9.5	13.0	6.7	6.8	6.3	5.5	4.5	4.3
		|E*| Coeff. of Variation (psi)	0.025	0.051	0.023	0.020	0.031	0.031	0.044	0.040
		F Coeff. of Variation	0.13	0.08	0.26	0.26	0.28	0.37	0.59	0.61
		|E*| Std. Dev. (psi)	60404.9	146704.	72230.5	68764.8	111024.	121442.	179787.	169887.
		F Std. Dev.	1.239	1.001	1.749	1.794	1.756	2.048	2.676	2.611
10	1	|E*| (psi)	660688	981961	110832	141440	155397	195905	214776	239998
		Phase Angle, F (º)	23.0	23.0	18.0	15.5	14.3	11.0	9.6	9.0
		Average Peak Stress (psi)	41	53	61	82	98	135	151	167
		Average Peak Strain (με)	62	54	55	58	63	69	70	69
	2	|E*| (psi)	693086	987878	116676	148849	166080	208489	228773	255032
		Phase Angle, F (º)	24.7	17.3	20.6	17.7	16.3	13.4	12.5	11.8
		Average Peak Stress (psi)	41	53	61	82	98	135	151	166
		Average Peak Strain (με)	59	54	53	55	59	65	66	65
	3	|E*| (psi)	657181	100334	106563	143092	158756	201416	221163	248266
		Phase Angle, F (º)	26.6	21.3	22.9	18.3	17.2	14.1	12.9	12.5
		Average Peak Stress (psi)	41	53	61	82	98	135	151	167
		Average Peak Strain (με)	62	53	58	57	62	67	68	67
	Avg.	|E*| Average (psi)	670318	991063	111357	144461	160077	201936	221571	247766
		F Average	24.7	20.5	20.5	17.2	15.9	12.8	11.7	11.1
		|E*| Coeff. of Variation (psi)	0.030	0.011	0.046	0.027	0.034	0.031	0.032	0.030
		F Coeff. of Variation	0.07	0.14	0.12	0.09	0.10	0.13	0.15	0.17
		|E*| Std. Dev. (psi)	19795.0	11044.1	50765.7	38895.4	54627.3	63079.8	70074.9	75294.5
		F Std. Dev.	1.794	2.918	2.448	1.503	1.530	1.658	1.801	1.837
35	1	|E*| (psi)	67201	102938	129306	216968	289234	488178	601120	768220
		Phase Angle, F (º)	27.3	28.2	28.1	28.8	26.3	23.5	21.8	20.3
		Average Peak Stress (psi)	3	4	6	10	20	30	40	61
		Average Peak Strain (με)	47	40	48	47	70	62	67	79
	2	|E*| (psi)	74170	111568	132228	219238	282963	484613	591710	751251
		Phase Angle, F (º)	28.2	32.5	30.2	30.8	28.3	24.9	23.5	22.1
		Average Peak Stress (psi)	3	4	6	10	20	30	40	60
		Average Peak Strain (με)	41	37	46	46	72	62	68	80
	3	|E*| (psi)	80382	118582	145863	231943	301784	510141	622719	773175
		Phase Angle, F (º)	27.0	29.7	29.6	30.7	27.8	25.5	24.0	22.7
		Average Peak Stress (psi)	3	4	6	10	20	30	40	61
		Average Peak Strain (με)	38	34	42	44	67	59	64	79
	Avg.	|E*| Average (psi)	73918	111029	135799	222716	291327	494311	605183	764215
		F Average	27.5	30.1	29.3	30.1	27.5	24.6	23.1	21.7
		|E*| Coeff. of Variation (psi)	0.089	0.071	0.065	0.036	0.033	0.028	0.026	0.015
		F Coeff. of Variation	0.02	0.07	0.04	0.04	0.04	0.04	0.05	0.06
		|E*| Std. Dev. (psi)	6594.1	7835.9	8837.0	8071.1	9583.5	13824.7	15898.5	11497.2
		F Std. Dev.	0.660	2.149	1.040	1.140	1.037	0.990	1.145	1.235
54.4	Est.	|E*| (psi)	18420	28572	34954	57435	71794	120816	151274	202618

Table B-42. B25.0CF – Limestone (US Customary Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (psi)	2480003	265750	285740	322241	335609	363701	375195	388753
		Phase Angle, F (º)	5.7	2.2	3.3	2.9	3.0	1.7	1.4	1.5
		Average Peak Stress (psi)	196	229	237	254	262	286	295	319
		Average Peak Strain (με)	79	86	83	79	78	79	79	82
	2	|E*| (psi)	2684916	307046	325949	354769	365671	392327	405322	418787
		Phase Angle, F (º)	11.5	12.5	8.3	7.9	7.6	6.1	5.2	4.5
		Average Peak Stress (psi)	196	229	237	254	262	286	295	318
		Average Peak Strain (με)	73	75	73	72	72	73	73	76
	3	|E*| (psi)	2434297	269880	290717	327150	341410	369392	382843	395698
		Phase Angle, F (º)	11.0	9.7	9.3	8.2	7.9	6.3	6.1	5.7
		Average Peak Stress (psi)	196	229	237	254	262	286	295	319
		Average Peak Strain (με)	81	85	82	78	77	77	77	81
	Avg.	|E*| Average (psi)	2533072	280892	300802	334720	347563	375140	387787	401079
		F Average	9.4	8.1	6.9	6.4	6.2	4.7	4.2	3.9
		|E*| Coeff. of Variation (psi)	0.053	0.081	0.073	0.052	0.046	0.040	0.040	0.039
		F Coeff. of Variation	0.34	0.65	0.46	0.47	0.45	0.56	0.59	0.55
		|E*| Std. Dev. (psi)	133472.1	227442.	219197.	175358.	159477.	151541.	156598.	157234.
		F Std. Dev.	3.209	5.316	3.213	2.990	2.779	2.622	2.496	2.168
10	1	|E*| (psi)	714621	992781	115391	152734	168285	206601	224098	248570
		Phase Angle, F (º)	22.6	15.8	16.9	13.5	12.4	9.0	7.7	7.4
		Average Peak Stress (psi)	41	57	69	90	106	147	168	183
		Average Peak Strain (με)	57	58	60	59	63	71	75	74
	2	|E*| (psi)	806546	119390	128215	168044	186071	224257	242874	267657
		Phase Angle, F (º)	28.7	22.6	22.1	18.0	16.7	12.7	11.4	10.2
		Average Peak Stress (psi)	41	57	70	90	106	147	168	183
		Average Peak Strain (με)	51	48	54	54	57	66	69	68
	3	|E*| (psi)	723868	103548	114310	151988	168743	211283	231854	253145
		Phase Angle, F (º)	27.0	19.3	20.9	17.5	15.7	12.1	11.4	10.4
		Average Peak Stress (psi)	41	57	70	90	106	147	168	183
		Average Peak Strain (με)	56	55	61	59	63	70	72	72
	Avg.	|E*| Average (psi)	748345	107405	119306	157588	174366	214047	232942	256457
		F Average	26.1	19.3	20.0	16.3	14.9	11.3	10.2	9.3
		|E*| Coeff. of Variation (psi)	0.068	0.099	0.065	0.058	0.058	0.043	0.041	0.039
		F Coeff. of Variation	0.12	0.18	0.14	0.15	0.15	0.17	0.21	0.18
		|E*| Std. Dev. (psi)	50615.2	105963.	77348.6	90622.2	101391.	91467.5	94352.8	99653.4
		F Std. Dev.	3.132	3.410	2.714	2.476	2.255	1.967	2.099	1.698
35	1	|E*| (psi)	68921	108592	131028	222276	287715	504849	634741	812091
		Phase Angle, F (º)	28.6	29.6	30.1	31.4	29.5	25.0	21.0	21.1
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	30	38	41	42	49	39	50	69
	2	|E*| (psi)	85559	123765	148248	242367	311886	557087	677929	834229
		Phase Angle, F (º)	31.6	36.8	36.0	37.4	34.6	30.6	26.8	23.6
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	24	33	36	39	45	36	47	67
	3	|E*| (psi)	87370	124085	153787	256077	332789	583653	723594	905336
		Phase Angle, F (º)	33.7	33.9	33.6	35.1	32.7	28.7	25.4	22.9
		Average Peak Stress (psi)	2	4	5	9	14	20	32	56
		Average Peak Strain (με)	24	33	35	36	42	34	44	62
	Avg.	|E*| Average (psi)	80616	118814	144354	240240	310797	548529	678755	850552
		F Average	31.3	33.4	33.2	34.6	32.3	28.1	24.4	22.6
		|E*| Coeff. of Variation (psi)	0.126	0.075	0.082	0.071	0.073	0.073	0.065	0.057
		F Coeff. of Variation	0.08	0.11	0.09	0.09	0.08	0.10	0.12	0.06
		|E*| Std. Dev. (psi)	10169.1	8854.1	11868.4	17000.6	22556.8	40093.1	44432.0	48718.4
		F Std. Dev.	2.547	3.625	2.962	3.034	2.561	2.846	2.994	1.308
54.4	1	|E*| (psi)	22793	28545	31553	50037	63968	122147	166176	245749
		Phase Angle, F (º)	16.9	20.6	21.0	24.7	26.0	26.6	25.6	26.3
		Average Peak Stress (psi)	1	1	2	4	5	9	13	18
		Average Peak Strain (με)	35	43	66	82	83	72	78	72
	2	|E*| (psi)	70323	60071	54111	64482	77693	139272	182092	258832
		Phase Angle, F (º)	27.4	33.0	30.8	32.9	32.5	32.6	30.1	30.0
		Average Peak Stress (psi)	1	1	2	4	5	9	13	17
		Average Peak Strain (με)	12	21	38	63	68	63	71	68
	3	|E*| (psi)	60613	49070	46289	62977	76510	139483	185815	273648
		Phase Angle, F (º)	20.9	22.4	22.6	25.7	26.9	28.9	28.1	28.6
		Average Peak Stress (psi)	0.006	0.009	0.014	0.028	0.036	0.060	0.088	0.118
		Average Peak Strain (με)	13	25	44	65	69	62	68	63
	Avg.	|E*| Average (psi)	51243	45895	43985	59166	72724	133634	178028	259410
		F Average	21.7	25.3	24.8	27.8	28.5	29.3	27.9	28.3
		|E*| Coeff. of Variation (psi)	0.490	0.349	0.260	0.134	0.105	0.074	0.059	0.054
		F Coeff. of Variation	0.24	0.27	0.21	0.16	0.12	0.10	0.08	0.07
		|E*| Std. Dev. (psi)	25112.3	16001.0	11453.9	7940.9	7605.8	9948.3	10431.2	13958.1
		F Std. Dev.	5.294	6.724	5.275	4.483	3.523	3.003	2.221	1.905

Table B-43. S9.5AC–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	20510	24590	26113	29152	30291	33215	34483	36028
		Phase Angle, F (º)	8.8	0.0	3.6	5.1	5.4	4.1	3.5	3.7
		Average Peak Stress (MPa)	1.212	1.438	1.495	1.637	1.691	1.859	1.918	2.078
		Average Peak Strain (με)	59	58	57	56	56	56	56	58
	2	|E*| (MPa)	20399	22271	24169	28465	29611	32353	33721	35061
		Phase Angle, F (º)	8.5	11.9	5.4	5.1	5.3	3.8	3.3	2.9
		Average Peak Stress (MPa)	1.212	1.438	1.495	1.637	1.691	1.859	1.918	2.076
		Average Peak Strain (με)	59	65	62	58	57	57	57	59
	3	|E*| (MPa)	18507	23576	21705	25344	26454	28986	29832	31318
		Phase Angle, F (º)	7.4	2.5	4.8	5.0	4.2	3.1	2.5	3.1
		Average Peak Stress (MPa)	1.212	1.438	1.495	1.637	1.691	1.861	1.921	2.083
		Average Peak Strain (με)	65	61	69	65	64	64	64	66
	Avg.	|E*| Average	19805	23479	23996	27653	28785	31518	32679	34136
		F Average	8.2	4.8	4.6	5.0	5.0	3.7	3.1	3.2
		|E*| Coeff. of Variation	0.057	0.050	0.092	0.073	0.071	0.071	0.076	0.073
		F Coeff. of Variation	0.09	1.32	0.19	0.01	0.14	0.15	0.17	0.12
		|E*| Std. Dev.	1125.9	1162.7	2209.2	2029.5	2047.5	2235.0	2494.5	2487.6
		F Std. Dev.	0.765	6.289	0.882	0.040	0.678	0.546	0.525	0.396
10	1	|E*| (MPa)	4465	7315	7948	11191	12482	16115	17719	
		Phase Angle, F (º)	30.1	20.1	25.6	18.8	17.0	13.7	12.2	
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.506	0.701	0.817	
		Average Peak Strain (με)	32	33	36	35	41	44	46	
	2	|E*| (MPa)	5087	8844	8939	12101	13487	17240	18987	21118
		Phase Angle, F (º)	27.2	25.1	24.1	17.0	15.5	12.2	10.7	9.3
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.506	0.702	0.817	0.919
		Average Peak Strain (με)	28	27	32	33	38	41	43	43
	3	|E*| (MPa)	4314	6211	7809	10071	11557	14703	16197	18057
		Phase Angle, F (º)	27.2	27.9	21.7	17.2	15.1	11.6	10.7	9.7
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.507	0.703	0.819	0.922
		Average Peak Strain (με)	33	39	36	39	44	48	51	51
	Avg.	|E*| Average	4622	7457	8232	11121	12508	16019	17634	19587
		F Average	28.2	24.3	23.8	17.7	15.8	12.5	11.2	9.5
		|E*| Coeff. of Variation	0.089	0.177	0.075	0.091	0.077	0.079	0.079	0.111
		F Coeff. of Variation	0.06	0.16	0.08	0.06	0.06	0.09	0.08	0.03
		|E*| Std. Dev.	409.7	1322.3	616.2	1016.6	965.4	1271.0	1396.5	2164.5
		F Std. Dev.	1.656	3.962	1.965	0.985	1.025	1.095	0.851	0.248
35	1	|E*| (MPa)	384	578	687	1172	1480	2727	3480	
		Phase Angle, F (º)	27.7	28.7	30.2	33.0	33.1	29.5	28.2	
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.036	0.055	0.109	0.135	
		Average Peak Strain (με)	44	39	41	31	37	40	39	
	2	|E*| (MPa)	352	522	661	1163	1473	2861	3581	4782
		Phase Angle, F (º)	29.0	31.1	33.0	34.0	33.1	29.1	27.8	26.4
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.055	0.109	0.135	0.246
		Average Peak Strain (με)	48	43	43	32	37	38	38	51
	3	|E*| (MPa)	335	522	654	1131	1478	2765	3531	4697
		Phase Angle, F (º)	28.9	31.0	31.4	34.2	33.0	28.8	27.3	25.3
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.036	0.055	0.109	0.136	0.248
		Average Peak Strain (? ?)	50	43	43	32	37	40	38	53
	Avg.	|E*| Average	357	541	667	1156	1477	2784	3530	4739
		F Average	28.5	30.3	31.5	33.7	33.1	29.1	27.8	25.8
		|E*| Coeff. of Variation	0.070	0.060	0.026	0.019	0.002	0.025	0.014	0.013
		F Coeff. of Variation	0.02	0.04	0.04	0.02	0.00	0.01	0.02	0.03
		|E*| Std. Dev.	25.0	32.5	17.4	21.6	3.5	68.9	50.3	59.9
		F Std. Dev.	0.682	1.361	1.377	0.611	0.067	0.327	0.439	0.799
54.4	Est.	|E*| (MPa)	112	166	201	327	409	705	896	1231

Table B-44. S9.5AF–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	13885	18204	18946	21527	22778	25732	27016	28556
		Phase Angle, F (º)	11.1	12.8	9.5	6.5	5.9	4.4	3.7	3.3
		Average Peak Stress (MPa)	1.409	1.578	1.636	1.751	1.809	1.862	1.922	2.077
		Average Peak Strain (με)	101	87	86	81	79	72	71	73
	2	|E*| (MPa)	14848		20011	22979	24027	26758	27972	29526
		Phase Angle, F (º)	12.4		7.3	8.4	7.7	5.8	4.9	4.7
		Average Peak Stress (MPa)	1.185		1.468	1.584	1.640	1.810	1.868	2.025
		Average Peak Strain (με)	80		73	69	68	68	67	69
	3	|E*| (MPa)	13578	15502	18721	20763	22007	24942	26218	27754
		Phase Angle, F (º)	12.5	6.7	10.1	8.3	8.0	6.2	5.7	5.3
		Average Peak Stress (MPa)	1.072	1.298	1.411	1.527	1.583	1.752	1.809	1.901
		Average Peak Strain (με)	79	84	75	74	72	70	69	69
	Avg.	|E*| Average	14104	16853	19226	21756	22937	25810	27069	28612
		F Average	12.0	9.8	8.9	7.7	7.2	5.5	4.7	4.5
		|E*| Coeff. of Variation	0.047	0.113	0.036	0.052	0.044	0.035	0.032	0.031
		F Coeff. of Variation	0.06	0.44	0.16	0.14	0.16	0.17	0.21	0.23
		|E*| Std. Dev.	662.6	1910.3	689.2	1125.8	1019.3	910.4	877.9	887.3
		F Std. Dev.	0.766	4.302	1.454	1.065	1.121	0.943	1.001	1.019
10	1	|E*| (MPa)	2441	4156	4797	7076	8362	11448	12946	14916
		Phase Angle, F (º)	29.6	22.7	22.7	20.6	17.8	13.8	12.2	10.5
		Average Peak Stress (MPa)	0.183	0.268	0.310	0.453	0.722	0.889	1.296	1.440
		Average Peak Strain (με)	75	64	65	64	86	78	100	97
	2	|E*| (MPa)	2758	4291	5415	7493	8747	11713	13266	15143
		Phase Angle, F (º)	31.2	22.4	26.8	22.6	20.1	16.5	15.2	14.0
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.397	0.510	0.706	0.822	0.923
		Average Peak Strain (με)	51	56	52	53	58	60	62	61
	3	|E*| (MPa)	2444	3744	4756	6893	8034	10976	12375	14350
		Phase Angle, F (º)	30.9	28.1	23.9	22.3	20.0	15.9	14.5	13.7
		Average Peak Stress (MPa)	0.169	0.268	0.311	0.453	0.566	0.761	0.876	0.979
		Average Peak Strain (με)	69	72	65	66	70	69	71	68
	Avg.	|E*| Average	2548	4064	4989	7154	8381	11379	12862	14803
		F Average	30.6	24.4	24.5	21.8	19.3	15.4	14.0	12.7
		|E*| Coeff. of Variation	0.072	0.070	0.074	0.043	0.043	0.033	0.035	0.028
		F Coeff. of Variation	0.03	0.13	0.09	0.05	0.07	0.09	0.11	0.15
		|E*| Std. Dev.	182.2	284.8	369.3	307.3	356.7	373.1	451.3	408.5
		F Std. Dev.	0.895	3.200	2.146	1.080	1.316	1.408	1.582	1.956
35	1	|E*| (MPa)	221	321	393	646	885	1738	2288	3204
		Phase Angle, F (º)	22.1	26.9	29.3	34.2	32.7	30.2	28.2	27.0
		Average Peak Stress (MPa)	0.011	0.013	0.017	0.029	0.045	0.076	0.107	0.165
		Average Peak Strain (με)	51	42	43	44	51	44	47	52
	2	|E*| (MPa)	206	315	391	650	902	1799	2310	3243
		Phase Angle, F (º)	23.5	27.2	28.4	34.2	32.5	29.7	28.1	26.6
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.057	0.109	0.135	0.243
		Average Peak Strain (με)	82	72	72	57	63	61	58	75
	3	|E*| (MPa)	246	342	412	673	912	1760	2267	3138
		Phase Angle, F (º)	23.1	27.2	29.0	34.6	32.6	30.0	29.0	27.3
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.057	0.110	0.135	0.244
		Average Peak Strain (με)	69	66	68	55	62	62	60	78
	Avg.	|E*| Average	224	326	399	656	900	1766	2289	3195
		F Average	22.9	27.1	28.9	34.3	32.6	30.0	28.4	27.0
		|E*| Coeff. of Variation	0.090	0.043	0.030	0.022	0.015	0.018	0.009	0.017
		F Coeff. of Variation	0.03	0.01	0.02	0.01	0.00	0.01	0.02	0.01
		|E*| Std. Dev.	20.2	14.1	11.8	14.4	13.8	31.0	21.5	52.9
		F Std. Dev.	0.735	0.180	0.437	0.248	0.068	0.267	0.503	0.363
54.4	Est.	|E*| (MPa)	69	94	109	164	199	329	416	572

Table B-45. S9.5AF–Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	13975	17037	16762	19260	20195	22021	22865	23847
		Phase Angle, F (º)	8.3	7.7	6.5	5.5	4.8	3.5	3.0	2.8
		Average Peak Stress (MPa)	1.083	1.264	1.309	1.401	1.446	1.579	1.627	1.754
		Average Peak Strain (με)	77	74	78	73	72	72	71	74
	2	|E*| (MPa)	15199	17842	18323	21279	22325	24204	25180	26321
		Phase Angle, F (º)	8.4	10.9	6.6	5.3	5.0	3.9	3.2	3.3
		Average Peak Stress (MPa)	1.082	1.263	1.308	1.398	1.443	1.577	1.625	1.754
		Average Peak Strain (με)	71	71	71	66	65	65	65	67
	3	|E*| (MPa)	14887	18558	17509	20380	21382	23459	24321	25398
		Phase Angle, F (º)	7.9	9.8	5.6	4.7	4.6	3.0	2.5	2.3
		Average Peak Stress (MPa)	1.084	1.264	1.310	1.401	1.446	1.580	1.628	1.757
		Average Peak Strain (με)	73	68	75	69	68	67	67	69
	Avg.	|E*| Average	14687	17813	17531	20307	21300	23228	24122	25189
		F Average	8.2	9.5	6.3	5.2	4.8	3.5	2.9	2.8
		|E*| Coeff. of Variation	0.043	0.043	0.045	0.050	0.050	0.048	0.049	0.050
		F Coeff. of Variation	0.03	0.17	0.09	0.08	0.04	0.12	0.12	0.18
		|E*| Std. Dev.	635.9	761.1	781.2	1011.4	1067.4	1109.9	1170.4	1250.1
		F Std. Dev.	0.249	1.627	0.546	0.390	0.186	0.436	0.340	0.491
10	1	|E*| (MPa)	3239	4665	5507	7630	8647	11154	12285	13806
		Phase Angle, F (º)	25.3	20.7	19.3	16.4	14.8	11.2	10.0	9.5
		Average Peak Stress (MPa)	0.212	0.296	0.360	0.466	0.551	0.761	0.867	0.947
		Average Peak Strain (με)	65	64	65	61	64	68	71	69
	2	|E*| (MPa)	3417	5076	5993	8032	9217	11812	13006	14758
		Phase Angle, F (º)	26.2	24.6	20.0	17.2	15.8	12.7	10.7	10.2
		Average Peak Stress (MPa)	0.225	0.316	0.383	0.497	0.586	0.811	0.923	1.008
		Average Peak Strain (με)	66	62	64	62	64	69	71	68
	3	|E*| (MPa)	3875	5680	6282	8596	9628	12192	13485	15002
		Phase Angle, F (º)	24.2	17.7	18.2	15.3	14.0	10.6	9.5	8.5
		Average Peak Stress (MPa)	0.226	0.316	0.384	0.498	0.588	0.812	0.924	1.011
		Average Peak Strain (με)	58	56	61	58	61	67	69	67
	Avg.	|E*| Average	3510	5140	5927	8086	9164	11720	12925	14522
		F Average	25.2	21.0	19.2	16.3	14.9	11.5	10.1	9.4
		|E*| Coeff. of Variation	0.093	0.099	0.066	0.060	0.054	0.045	0.047	0.044
		F Coeff. of Variation	0.04	0.16	0.05	0.06	0.06	0.09	0.06	0.09
		|E*| Std. Dev.	327.8	510.2	391.8	485.2	492.9	525.1	604.3	631.9
		F Std. Dev.	0.968	3.445	0.894	0.946	0.901	1.069	0.595	0.846
35	1	|E*| (MPa)	307	458	568	955	1237	2266		3696
		Phase Angle, F (º)	27.5	29.3	30.7	32.2	31.6	28.3		25.0
		Average Peak Stress (MPa)	0.011	0.021	0.028	0.049	0.073	0.101		0.282
		Average Peak Strain (με)	35	46	48	51	59	45		76
	2	|E*| (MPa)	360	478	589	945	1226	2227	2852	3630
		Phase Angle, F (º)	22.6	28.4	29.9	31.9	31.8	28.0	24.8	25.1
		Average Peak Stress (MPa)	0.011	0.022	0.029	0.052	0.077	0.108	0.173	0.301
		Average Peak Strain (με)	32	47	50	55	63	48	61	83
	3	|E*| (MPa)	348	523	655	1107	1456	2622	3325	4302
		Phase Angle, F (º)	27.3	29.6	29.6	30.9	30.8	26.3	23.7	22.9
		Average Peak Stress (MPa)	0.011	0.022	0.029	0.052	0.077	0.108	0.174	0.304
		Average Peak Strain (με)	33	43	45	47	53	41	52	71
	Avg.	|E*| Average	338	486	604	1002	1306	2372	3088	3876
		F Average	25.8	29.1	30.1	31.7	31.4	27.5	24.3	24.3
		|E*| Coeff. of Variation	0.083	0.068	0.075	0.090	0.099	0.092	0.108	0.096
		F Coeff. of Variation	0.11	0.02	0.02	0.02	0.02	0.04	0.03	0.05
		|E*| Std. Dev.	28.1	33.1	45.6	90.4	129.5	217.4	334.7	370.4
		F Std. Dev.	2.759	0.600	0.573	0.686	0.536	1.048	0.766	1.257
54.4	1	|E*| (MPa)		223	199	250	300	534		1043
		Phase Angle, F (º)		19.7	19.9	25.2	26.4	27.3		30.6
		Average Peak Stress (MPa)		0.006	0.011	0.021	0.027	0.044		0.082
		Average Peak Strain (με)		29	54	85	91	83		79
	2	|E*| (MPa)	149	155	169	233	283	516		1010
		Phase Angle, F (º)	14.1	16.9	18.9	23.7	25.7	26.4		28.9
		Average Peak Stress (MPa)	0.004	0.007	0.011	0.023	0.029	0.048		0.087
		Average Peak Strain (με)	28	44	68	97	103	92		86
	3	|E*| (MPa)	158	161	184	261	325	602	811	1195
		Phase Angle, F (º)	16.3	18.2	19.3	23.5	25.0	25.3	24.8	26.7
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.060	0.088	0.117
		Average Peak Strain (με)	36	53	78	109	112	100	108	97
	Avg.	|E*| Average	153	179	184	248	303	551	811	1083
		F Average	15.2	18.3	19.4	24.1	25.7	26.3	24.8	28.7
		|E*| Coeff. of Variation	0.040	0.209	0.080	0.056	0.069	0.082	0.000	0.091
		F Coeff. of Variation	0.10	0.08	0.03	0.04	0.03	0.04	0.00	0.07
		|E*| Std. Dev.	6.2	37.4	14.7	13.9	20.8	45.3	0.0	98.8
		F Std. Dev.	1.517	1.429	0.485	0.968	0.673	1.030	0.000	1.960

Table B-46. S9.5BC–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16718		23110	25887	27253	30146	31629	33125
		Phase Angle, F (º)	10.2		6.7	5.7	5.1	4.0	2.1	2.1
		Average Peak Stress (MPa)	1.241		1.552	1.666	1.693	1.859	1.919	2.077
		Average Peak Strain (με)	74		67	64	62	62	61	63
	2	|E*| (MPa)	13924	18201	18042	21696	23079	25955	27305	28654
		Phase Angle, F (º)	13.6	9.6	11.8	9.4	8.8	7.4	6.8	6.1
		Average Peak Stress (MPa)	1.241	1.465	1.551	1.666	1.693	1.858	1.919	2.077
		Average Peak Strain (με)	89	80	86	77	73	72	70	72
	3	|E*| (MPa)	14142	18586	18929	21809	23207	26247	27363	28876
		Phase Angle, F (º)	10.7	6.6	5.8	6.6	5.6	3.7	3.4	3.1
		Average Peak Stress (MPa)	1.241	1.467	1.552	1.666	1.694	1.858	1.920	2.077
		Average Peak Strain (με)	88	79	82	76	73	71	70	72
	Avg.	|E*| Average	14928	18393	20027	23131	24513	27449	28766	30218
		F Average	11.5	8.1	8.1	7.3	6.5	5.0	4.1	3.8
		|E*| Coeff. of Variation	0.104	0.015	0.135	0.103	0.097	0.085	0.086	0.083
		F Coeff. of Variation	0.16	0.26	0.40	0.27	0.31	0.40	0.59	0.55
		|E*| Std. Dev.	1553.9	272.3	2706.5	2387.5	2373.9	2339.8	2479.8	2519.7
		F Std. Dev.	1.817	2.088	3.222	1.925	2.031	2.038	2.407	2.063
10	1	|E*| (MPa)	2359	4188	5071	7909	9272	12926	14622	17148
		Phase Angle, F (º)	31.1	29.2	24.7	21.2	19.3	14.3	12.8	12.1
		Average Peak Stress (MPa)	0.254	0.395	0.508	0.622	0.733	1.014	1.154	1.263
		Average Peak Strain (με)	108	94	100	79	79	78	79	74
	2	|E*| (MPa)	2605	4524	5334	7674	8945	12400	14043	15994
		Phase Angle, F (º)	33.8	27.0	27.6	22.6	20.6	16.4	15.0	13.6
		Average Peak Stress (MPa)	0.169	0.311	0.423	0.622	0.734	1.011	1.153	1.262
		Average Peak Strain (με)	65	69	79	81	82	82	82	79
	3	|E*| (MPa)	2337	4212	4913	7374	8630	11931	13433	15450
		Phase Angle, F (º)	30.8	25.9	23.2	20.0	18.0	13.9	12.4	11.3
		Average Peak Stress (MPa)	0.170	0.310	0.423	0.621	0.733	1.015	1.155	1.264
		Average Peak Strain (με)	73	74	86	84	85	85	86	82
	Avg.	|E*| Average	2434	4308	5106	7652	8949	12419	14033	16197
		F Average	31.9	27.4	25.2	21.3	19.3	14.9	13.4	12.3
		|E*| Coeff. of Variation	0.061	0.044	0.042	0.035	0.036	0.040	0.042	0.054
		F Coeff. of Variation	0.05	0.06	0.09	0.06	0.07	0.09	0.10	0.10
		|E*| Std. Dev.	149.0	187.6	212.5	268.4	321.0	497.9	594.8	867.1
		F Std. Dev.	1.634	1.663	2.247	1.287	1.295	1.362	1.378	1.175
35	1	|E*| (MPa)		328	411	763	1067	2149	2815	3966
		Phase Angle, F (º)		30.5	31.7	34.7	33.0	30.8	28.9	27.3
		Average Peak Stress (MPa)		0.023	0.028	0.051	0.097	0.164	0.217	0.356
		Average Peak Strain (με)		70	69	67	91	77	77	90
	2	|E*| (MPa)	237	368	454	811	1082	2216	2853	3982
		Phase Angle, F (º)	27.3	31.7	33.4	37.1	36.2	32.4	30.8	29.0
		Average Peak Stress (MPa)	0.013	0.022	0.028	0.045	0.070	0.138	0.189	0.299
		Average Peak Strain (με)	56	61	62	56	64	62	66	75
	3	|E*| (MPa)	180	281	364	681	927	1899	2518	3557
		Phase Angle, F (º)	24.3	28.2	29.7	33.4	33.1	29.1	28.5	27.2
		Average Peak Stress (MPa)	0.014	0.022	0.028	0.045	0.070	0.135	0.190	0.299
		Average Peak Strain (με)	81	79	77	66	75	71	75	84
	Avg.	|E*| Average	208	326	410	752	1025	2088	2729	3835
		F Average	25.8	30.1	31.6	35.1	34.1	30.8	29.4	27.8
		|E*| Coeff. of Variation	0.194	0.134	0.110	0.087	0.083	0.080	0.067	0.063
		F Coeff. of Variation	0.08	0.06	0.06	0.05	0.05	0.05	0.04	0.04
		|E*| Std. Dev.	40.3	43.8	45.0	65.6	85.2	167.2	183.4	241.0
		F Std. Dev.	2.096	1.746	1.887	1.864	1.798	1.684	1.261	0.979
54.4	Est.	|E*| (MPa)	52	72	84	128	158	271	349	494

Table B-47. S9.5B0F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	14329	16304	18422	20193	21225	23377	24287	25375
		Phase Angle, F (º)	8.8	11.5	4.7	5.1	4.9	3.4	3.1	2.8
		Average Peak Stress (MPa)	1.212	1.438	1.495	1.637	1.691	1.861	1.921	2.082
		Average Peak Strain (με)	85	88	81	81	80	80	79	82
	2	|E*| (MPa)	13313	15130	16051	18875	19790	22059	23042	24160
		Phase Angle, F (º)	9.5	12.6	8.9	5.6	6.1	4.6	4.3	3.6
		Average Peak Stress (MPa)	1.212	1.438	1.495	1.637	1.692	1.861	1.922	2.082
		Average Peak Strain (με)	91	95	93	87	85	84	83	86
	3	|E*| (MPa)	14570	15961	17733	20645	21634	23881	24764	26020
		Phase Angle, F (º)	8.0	8.4	4.1	4.3	4.0	2.7	2.2	2.2
		Average Peak Stress (MPa)	1.212	1.438	1.495	1.637	1.691	1.860	1.919	2.077
		Average Peak Strain (με)	83	90	84	79	78	78	77	80
	Avg.	|E*| Average	14071	15798	17402	19904	20883	23106	24031	25185
		F Average	8.8	10.8	5.9	5.0	5.0	3.6	3.2	2.9
		|E*| Coeff. of Variation	0.047	0.038	0.070	0.046	0.046	0.041	0.037	0.038
		F Coeff. of Variation	0.09	0.20	0.44	0.14	0.20	0.26	0.33	0.25
		|E*| Std. Dev.	667.3	603.6	1219.5	919.7	968.7	940.7	889.0	944.6
		F Std. Dev.	0.753	2.181	2.623	0.695	1.022	0.938	1.055	0.714
10	1	|E*| (MPa)	3150	4699	5629	7659	8670	11262	12433	14003
		Phase Angle, F (º)	26.7	26.8	18.0	17.2	15.5	12.4	11.1	10.5
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.507	0.703	0.819	0.921
		Average Peak Strain (με)	45	51	50	52	58	62	66	66
	2	|E*| (MPa)	3299	4538	5605	7751	8683	11161	12349	13905
		Phase Angle, F (º)	28.0	24.7	18.9	17.9	16.3	13.2	11.6	11.1
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.507	0.703	0.819	0.921
		Average Peak Strain (με)	43	53	50	51	58	63	66	66
	3	|E*| (MPa)	3288	5227	5905	7827	8865			
		Phase Angle, F (º)	26.2	24.2	19.4	16.0	14.7			
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.506			
		Average Peak Strain (με)	43	46	48	50	57			
	Avg.	|E*| Average	3246	4821	5713	7746	8739	11211	12391	13954
		F Average	27.0	25.2	18.8	17.0	15.5	12.8	11.4	10.8
		|E*| Coeff. of Variation	0.026	0.075	0.029	0.011	0.012	0.006	0.005	0.005
		F Coeff. of Variation	0.03	0.05	0.04	0.06	0.05	0.05	0.03	0.04
		|E*| Std. Dev.	82.9	360.4	166.5	84.5	109.0	71.5	59.3	69.2
		F Std. Dev.	0.911	1.379	0.710	0.966	0.804	0.597	0.333	0.472
35	1	|E*| (MPa)	220	345	445	778	1019	1928	2461	3284
		Phase Angle, F (º)	31.1	33.4	33.7	34.1	33.5	29.4	27.9	26.2
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.036	0.056	0.109	0.135	0.245
		Average Peak Strain (με)	77	65	63	47	54	56	55	75
	2	|E*| (MPa)	261	416	521	891	1153	2104	2658	3474
		Phase Angle, F (º)	31.5	31.8	33.3	34.5	33.3	29.5	27.5	25.9
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.036	0.055	0.109	0.136	0.247
		Average Peak Strain (με)	65	54	54	41	48	52	51	71
	3	|E*| (MPa)	243	393	489	842	1078	1966	2467	3240
		Phase Angle, F (º)	29.8	30.5	31.6	32.5	32.0	27.9	26.4	25.3
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.036	0.055	0.108	0.135	0.244
		Average Peak Strain (με)	69	57	58	43	51	55	55	75
	Avg.	|E*| Average	241	385	485	837	1083	2000	2529	3332
		F Average	30.8	31.9	32.9	33.7	32.9	28.9	27.3	25.8
		|E*| Coeff. of Variation	0.085	0.095	0.078	0.068	0.062	0.046	0.044	0.037
		F Coeff. of Variation	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.02
		|E*| Std. Dev.	20.5	36.4	38.0	56.8	67.4	92.9	112.0	124.4
		F Std. Dev.	0.900	1.433	1.093	1.081	0.838	0.918	0.765	0.433
54.4	Est.	|E*| (MPa)	63	101	126	215	274	484	620	855

Table B-48. S9.5B1F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16441	19860	21429	24373	25802	28989	30300	31887
		Phase Angle, F (º)	14.5	7.4	14.9	11.1	11.1	10.0	9.3	9.0
		Average Peak Stress (MPa)	1.213	1.439	1.496	1.638	1.692	1.862	1.921	2.080
		Average Peak Strain (με)	74	72	70	67	66	64	63	65
	2	|E*| (MPa)	15704	17301	20771	22883	24169	27015	28138	29511
		Phase Angle, F (º)	9.7	10.4	10.0	6.7	5.7	4.6	4.2	4.1
		Average Peak Stress (MPa)	1.213	1.439	1.496	1.638	1.692	1.862	1.920	2.080
		Average Peak Strain (με)	77	83	72	72	70	69	68	70
	3	|E*| (MPa)	16173	19630	21306	23846	24799	27784		
		Phase Angle, F (º)	10.0	13.9	8.0	6.4	6.6	5.0		
		Average Peak Stress (MPa)	1.213	1.439	1.496	1.638	1.693	1.862		
		Average Peak Strain (με)	75	73	70	69	68	67		
	Avg.	|E*| Average	16106	18930	21169	23701	24924	27929	29219	30699
		F Average	11.4	10.6	11.0	8.1	7.8	6.6	6.8	6.6
		|E*| Coeff. of Variation	0.023	0.075	0.017	0.032	0.033	0.036	0.052	0.055
		F Coeff. of Variation	0.23	0.31	0.32	0.33	0.37	0.46	0.54	0.54
		|E*| Std. Dev.	372.8	1415.8	349.7	755.7	823.5	994.9	1529.1	1680.3
		F Std. Dev.	2.678	3.263	3.550	2.643	2.866	3.012	3.630	3.510
10	1	|E*| (MPa)	3550	5033	6532	8838	10046	13676	15452	17359
		Phase Angle, F (º)	36.3	28.0	28.1	26.0	24.1	20.9	19.0	17.8
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.507	0.703	0.818	0.918
		Average Peak Strain (με)	40	48	43	45	50	51	53	53
	2	|E*| (MPa)	3176	4689	5582	8185	9323	12440	13892	15713
		Phase Angle, F (º)	28.3	20.7	22.9	19.3	17.4	14.4	12.9	12.4
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.507	0.703	0.818	0.918
		Average Peak Strain (με)	44	51	51	48	54	57	59	58
	3	|E*| (MPa)	3266	4677	5972	8509	9676	12928	14453	16438
		Phase Angle, F (º)	27.8	25.9	24.9	19.6	18.0	14.6	13.4	12.4
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.507	0.703	0.818	0.917
		Average Peak Strain (με)	43	51	47	46	52	54	57	56
	Avg.	|E*| Average	3331	4800	6029	8511	9681	13015	14599	16503
		F Average	30.8	24.9	25.3	21.6	19.8	16.6	15.1	14.2
		|E*| Coeff. of Variation	0.059	0.042	0.079	0.038	0.037	0.048	0.054	0.050
		F Coeff. of Variation	0.16	0.15	0.10	0.18	0.19	0.22	0.23	0.22
		|E*| Std. Dev.	195.2	201.8	477.3	326.6	361.2	622.3	790.1	825.0
		F Std. Dev.	4.778	3.799	2.607	3.782	3.687	3.678	3.415	3.139
35	1	|E*| (MPa)	312	453	559	938	1211	2271	2891	3890
		Phase Angle, F (º)	27.7	30.4	31.4	35.2	34.1	30.8	29.1	27.3
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.036	0.055	0.109	0.135	0.243
		Average Peak Strain (με)	54	50	50	39	46	48	47	62
	2	|E*| (MPa)	266	401	489	840	1105	2109	2712	3720
		Phase Angle, F (º)	23.7	28.4	28.2	32.2	31.6	28.7	27.2	25.5
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.036	0.055	0.109	0.135	0.243
		Average Peak Strain (με)	63	56	58	43	50	52	50	65
	3	|E*| (MPa)	269	420	526	906	1189	2269	2933	3971
		Phase Angle, F (º)	25.1	27.7	29.7	33.0	32.8	29.3	27.2	25.2
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.036	0.055	0.109	0.135	0.243
		Average Peak Strain (με)	63	54	54	40	47	48	46	61
	Avg.	|E*| Average	282	425	525	895	1169	2216	2845	3860
		F Average	25.5	28.8	29.8	33.5	32.8	29.6	27.8	26.0
		|E*| Coeff. of Variation	0.091	0.061	0.066	0.056	0.048	0.042	0.041	0.033
		F Coeff. of Variation	0.08	0.05	0.06	0.05	0.04	0.04	0.04	0.04
		|E*| Std. Dev.	25.7	26.0	34.7	50.0	56.1	93.2	117.2	127.9
		F Std. Dev.	2.020	1.408	1.640	1.532	1.224	1.108	1.089	1.131
54.4	1	|E*| (MPa)		246	211	254	295	473	618	917
		Phase Angle, F (º)		17.6	12.6	19.5	21.6	27.2	29.2	32.2
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.016	0.020	0.023	0.026
		Average Peak Strain (με)		23	41	44	56	43	38	28
	2	|E*| (MPa)		173	189	224	262	420	551	815
		Phase Angle, F (º)		16.6	15.2	20.4	21.7	27.0	28.6	31.2
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.020	0.023	0.026
		Average Peak Strain (με)		32	45	50	63	48	42	32
	3	|E*| (MPa)		143	160	209	256	441	581	889
		Phase Angle, F (º)		13.3	14.8	21.1	23.2	27.0	29.0	31.7
		Average Peak Stress (MPa)		0.006	0.008	0.011	0.017	0.020	0.023	0.026
		Average Peak Strain (με)		39	53	54	65	46	40	29
	Avg.	|E*| Average		187	187	229	271	444	583	873
		F Average		15.8	14.2	20.3	22.2	27.1	28.9	31.7
		|E*| Coeff. of Variation		0.281	0.138	0.100	0.077	0.060	0.057	0.060
		F Coeff. of Variation		0.14	0.10	0.04	0.04	0.00	0.01	0.02
		|E*| Std. Dev.		52.6	25.7	22.9	20.9	26.6	33.2	52.8
		F Std. Dev.		2.261	1.371	0.783	0.869	0.124	0.322	0.507

Table B-49. S9.5B2F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16190	17892	19428	22276	23172	25738	26679	
		Phase Angle, F (º)	11.0	5.5	7.0	7.2	7.4	6.1	5.7	
		Average Peak Stress (MPa)	1.214	1.440	1.497	1.639	1.694	1.863	1.922	
		Average Peak Strain (με)	75	81	77	74	73	72	72	
	2	|E*| (MPa)	15879	20026	20114	21949	22740	25170	26066	27224
		Phase Angle, F (º)	10.7	9.3	9.0	7.3	6.9	5.9	5.3	4.9
		Average Peak Stress (MPa)	1.214	1.440	1.497	1.639	1.694	1.863	1.922	2.079
		Average Peak Strain (με)	76	72	74	75	74	74	74	76
	3	|E*| (MPa)	15421	18913	19168	21383	22179	24491	25348	26589
		Phase Angle, F (º)	9.5	4.9	6.0	6.0	5.9	4.4	4.0	3.8
		Average Peak Stress (MPa)	1.214	1.440	1.497	1.640	1.694	1.863	1.922	2.077
		Average Peak Strain (με)	79	76	78	77	76	76	76	78
	Avg.	|E*| Average	15830	18944	19570	21869	22697	25133	26031	26906
		F Average	10.4	6.6	7.3	6.8	6.7	5.5	5.0	4.4
		|E*| Coeff. of Variation	0.024	0.056	0.025	0.021	0.022	0.025	0.026	0.017
		F Coeff. of Variation	0.08	0.36	0.21	0.11	0.12	0.17	0.18	0.16
		|E*| Std. Dev.	387.2	1067.4	489.1	452.0	498.3	624.3	666.0	449.6
		F Std. Dev.	0.814	2.374	1.510	0.746	0.776	0.932	0.919	0.714
10	1	|E*| (MPa)	5397	7947	8434	10300	11117	13655	14940	16724
		Phase Angle, F (º)	29.7	24.5	23.3	18.7	17.5	14.4	12.9	11.3
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.507	0.703	0.819	0.918
		Average Peak Strain (με)	26	30	33	38	46	51	55	55
	2	|E*| (MPa)	4816	6079	7793	9800	10713	13373	14543	16228
		Phase Angle, F (º)	28.8	21.8	24.0	19.4	17.4	14.6	13.3	12.3
		Average Peak Stress (MPa)	0.141	0.240	0.283	0.395	0.507	0.703	0.819	0.918
		Average Peak Strain (με)	29	40	36	40	47	53	56	57
	3	|E*| (MPa)	4685	6181	7149	9485	10443	13073	14337	16089
		Phase Angle, F (º)	26.7	25.9	18.6	17.7	16.0	13.2	12.5	11.9
		Average Peak Stress (MPa)	0.141	0.240	0.283	0.396	0.508	0.703	0.817	0.917
		Average Peak Strain (με)	30	39	40	42	49	54	57	57
	Avg.	|E*| Average	4966	6736	7792	9862	10758	13367	14607	16347
		F Average	28.4	24.1	21.9	18.6	17.0	14.1	12.9	11.8
		|E*| Coeff. of Variation	0.076	0.156	0.082	0.042	0.032	0.022	0.021	0.020
		F Coeff. of Variation	0.05	0.09	0.13	0.05	0.05	0.05	0.03	0.04
		|E*| Std. Dev.	379.0	1050.2	642.1	411.0	339.2	291.1	306.7	333.7
		F Std. Dev.	1.558	2.096	2.947	0.859	0.845	0.740	0.438	0.492
35	1	|E*| (MPa)	476	724	904	1480	1851	3172	3856	4795
		Phase Angle, F (º)	36.3	35.2	35.5	35.3	33.6	27.9	26.3	23.7
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.055	0.109	0.136	0.245
		Average Peak Strain (με)	36	31	31	25	30	34	35	51
	2	|E*| (MPa)	451	715	856	1414	1736	3014	3762	4658
		Phase Angle, F (º)	34.8	35.1	36.3	37.6	35.7	30.3	28.9	25.7
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.055	0.110	0.136	0.246
		Average Peak Strain (με)	38	32	33	26	32	36	36	53
	3	|E*| (MPa)	526	791	932	1522	1829	3039	3756	4670
		Phase Angle, F (º)	34.7	34.2	34.7	35.7	33.5	28.6	26.6	24.0
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.056	0.110	0.136	0.245
		Average Peak Strain (με)	32	29	30	24	30	36	36	52
	Avg.	|E*| Average	484	743	897	1472	1805	3075	3791	4708
		F Average	35.3	34.8	35.5	36.2	34.3	28.9	27.3	24.5
		|E*| Coeff. of Variation	0.079	0.056	0.043	0.037	0.034	0.028	0.015	0.016
		F Coeff. of Variation	0.02	0.02	0.02	0.03	0.04	0.04	0.05	0.04
		|E*| Std. Dev.	38.4	41.9	38.4	54.6	61.3	85.1	55.9	76.1
		F Std. Dev.	0.879	0.548	0.827	1.251	1.260	1.236	1.427	1.072
54.4	1	|E*| (MPa)		219	248	349	425	747	973	1369
		Phase Angle, F (º)		22.5	25.0	29.0	29.9	31.0	31.2	32.6
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.024	0.027
		Average Peak Strain (με)		26	35	32	39	28	25	20
	2	|E*| (MPa)		255	256	335	395	697	897	1328
		Phase Angle, F (º)		33.5	26.4	30.5	31.3	32.7	33.0	35.8
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.025	0.029
		Average Peak Strain (με)		22	34	34	42	30	28	22
	3	|E*| (MPa)		334	297	398	467	777	982	1345
		Phase Angle, F (º)		23.5	21.6	26.3	28.5	29.3	30.0	32.7
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.024	0.028
		Average Peak Strain (με)		17	29	28	36	27	25	21
	Avg.	|E*| Average		269	267	360	429	740	950	1347
		F Average		26.5	24.3	28.6	29.9	31.0	31.4	33.7
		|E*| Coeff. of Variation		0.219	0.099	0.091	0.085	0.055	0.049	0.015
		F Coeff. of Variation		0.23	0.10	0.07	0.05	0.06	0.05	0.05
		|E*| Std. Dev.		59.1	26.5	32.8	36.2	40.7	46.8	20.6
		F Std. Dev.		6.057	2.464	2.091	1.374	1.717	1.510	1.841

Table B-50. S9.5B3F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16924	19704	20490	23895	25075	27547	28568	
		Phase Angle, F (º)	8.0	11.2	4.2	4.6	3.7	2.6	1.9	
		Average Peak Stress (MPa)	1.240	1.494	1.579	1.637	1.691	1.859	1.919	
		Average Peak Strain (με)	73	76	77	69	67	67	67	
	2	|E*| (MPa)	15643	17188	19974	22179	23315	25783	26767	
		Phase Angle, F (º)	8.1	6.5	6.7	4.7	4.7	3.1	2.2	
		Average Peak Stress (MPa)	1.241	1.494	1.579	1.637	1.691	1.859	1.919	
		Average Peak Strain (με)	79	87	79	74	73	72	72	
	3	|E*| (MPa)	16974	21501	21215	23529	24561	26895	27920	
		Phase Angle, F (º)	9.8	5.3	9.3	6.3	6.0	4.2	3.6	
		Average Peak Stress (MPa)	1.240	1.494	1.579	1.637	1.691	1.860	1.919	
		Average Peak Strain (με)	73	69	74	70	69	69	69	
	Avg.	|E*| Average	16514	19464	20560	23201	24317	26742	27752	
		F Average	8.6	7.7	6.7	5.2	4.8	3.3	2.6	
		|E*| Coeff. of Variation	0.046	0.111	0.030	0.039	0.037	0.033	0.033	
		F Coeff. of Variation	0.12	0.41	0.38	0.19	0.24	0.25	0.35	
		|E*| Std. Dev.	754.4	2166.5	623.5	903.8	904.7	892.1	912.5	
		F Std. Dev.	1.028	3.138	2.529	0.997	1.146	0.818	0.922	
10	1	|E*| (MPa)	3872	5790	6590	9251	10446	13443	14811	
		Phase Angle, F (º)	24.3	23.8	19.2	16.4	14.8	11.5	10.1	
		Average Peak Stress (MPa)	0.310	0.395	0.479	0.621	0.733	1.013	1.154	
		Average Peak Strain (με)	80	68	73	67	70	75	78	
	2	|E*| (MPa)	3992	6075	6862	9051	10243	13021	14310	16088
		Phase Angle, F (º)	23.6	18.2	17.6	15.1	13.9	10.8	9.6	8.5
		Average Peak Stress (MPa)	0.310	0.395	0.479	0.621	0.733	1.013	1.155	1.264
		Average Peak Strain (με)	78	65	70	69	72	78	81	79
	3	|E*| (MPa)	4446	6265	7121	9712	10797	13634	14994	16767
		Phase Angle, F (º)	24.4	24.5	18.8	16.1	14.9	11.8	10.6	10.0
		Average Peak Stress (MPa)	0.310	0.395	0.479	0.621	0.733	1.013	1.155	1.264
		Average Peak Strain (με)	70	63	67	64	68	74	77	75
	Avg.	|E*| Average	4103	6043	6858	9338	10495	13366	14705	16427
		F Average	24.1	22.2	18.5	15.9	14.5	11.4	10.1	9.3
		|E*| Coeff. of Variation	0.074	0.040	0.039	0.036	0.027	0.023	0.024	0.029
		F Coeff. of Variation	0.02	0.16	0.05	0.04	0.04	0.04	0.05	0.11
		|E*| Std. Dev.	303.0	239.1	265.3	339.1	280.3	313.9	354.4	480.5
		F Std. Dev.	0.434	3.461	0.862	0.680	0.555	0.500	0.496	1.031
35	1	|E*| (MPa)	305	495	627	1097	1441	2628	3299	4332
		Phase Angle, F (º)	26.4	29.0	29.8	31.0	29.9	25.9	23.9	22.6
		Average Peak Stress (MPa)	0.025	0.034	0.042	0.078	0.111	0.165	0.248	0.388
		Average Peak Strain (με)	83	68	68	71	77	63	75	90
	2	|E*| (MPa)	340	550	683	1169	1498	2670	3309	4317
		Phase Angle, F (º)	29.3	29.4	30.7	31.8	30.4	26.3	24.3	22.4
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.165	0.248	0.389
		Average Peak Strain (με)	58	61	62	67	74	62	75	90
	3	|E*| (MPa)	398	615	759	1272	1633	2869	3609	4604
		Phase Angle, F (º)	29.4	30.1	30.7	31.3	30.5	26.4	24.1	22.9
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.166	0.249	0.390
		Average Peak Strain (με)	50	55	56	61	68	58	69	85
	Avg.	|E*| Average	348	554	690	1179	1524	2722	3406	4418
		F Average	28.4	29.5	30.4	31.4	30.3	26.2	24.1	22.6
		|E*| Coeff. of Variation	0.136	0.108	0.096	0.074	0.065	0.047	0.052	0.037
		F Coeff. of Variation	0.06	0.02	0.02	0.01	0.01	0.01	0.01	0.01
		|E*| Std. Dev.	47.4	60.0	66.2	87.7	98.5	129.1	176.1	161.4
		F Std. Dev.	1.706	0.557	0.490	0.389	0.312	0.259	0.232	0.252
54.4	1	|E*| (MPa)		162	170	236	287	492	660	966
		Phase Angle, F (º)		14.1	19.0	23.8	25.5	28.5	29.1	33.0
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.020	0.024	0.027
		Average Peak Strain (με)		34	50	48	58	42	36	28
	2	|E*| (MPa)		184	186	264	320	571	739	1077
		Phase Angle, F (º)		18.4	20.7	24.9	27.0	29.8	30.2	32.9
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.024	0.028
		Average Peak Strain (με)		30	46	43	52	36	33	26
	3	|E*| (MPa)		217	217	296	352	607	793	1138
		Phase Angle, F (º)		25.4	22.1	24.8	26.0	29.6	30.2	34.0
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.024	0.028
		Average Peak Strain (με)		26	39	38	47	34	31	25
	Avg.	|E*| Average		187	191	265	320	557	731	1061
		F Average		19.3	20.6	24.5	26.1	29.3	29.8	33.3
		|E*| Coeff. of Variation		0.147	0.124	0.113	0.101	0.106	0.092	0.082
		F Coeff. of Variation		0.30	0.08	0.03	0.03	0.02	0.02	0.02
		|E*| Std. Dev.		27.6	23.8	29.9	32.4	58.7	66.9	87.2
		F Std. Dev.		5.699	1.549	0.643	0.763	0.712	0.667	0.601

Table B-51. S9.5B4F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16683	18364	22529	24721	25907	28540	29498	
		Phase Angle, F (º)	13.5	9.8	10.6	9.3	9.1	7.3	6.6	
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.752	1.808	1.975	2.035	
		Average Peak Strain (με)	81	86	73	71	70	69	69	
	2	|E*| (MPa)	17117	21920	22534	24733	26028	28795	29947	31256
		Phase Angle, F (º)	10.0	12.6	9.6	6.1	5.6	4.3	3.6	2.5
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.752	1.808	1.975	2.036	2.197
		Average Peak Strain (με)	79	72	73	71	69	69	68	70
	3	|E*| (MPa)	16011	17555	19929	23027	24065	26434	27391	
		Phase Angle, F (º)	9.5	7.2	8.4	6.1	5.2	3.6	2.8	
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.752	1.808	1.976	2.036	
		Average Peak Strain (με)	85	90	82	76	75	75	74	
	Avg.	|E*| Average	16604	19279	21664	24160	25333	27923	28945	31256
		F Average	11.0	9.9	9.5	7.2	6.7	5.1	4.3	2.5
		|E*| Coeff. of Variation	0.034	0.120	0.069	0.041	0.043	0.046	0.047	
		F Coeff. of Variation	0.20	0.27	0.12	0.26	0.33	0.39	0.46	
		|E*| Std. Dev.	557.1	2322.3	1502.7	981.2	1100.1	1295.7	1364.5	
		F Std. Dev.	2.164	2.683	1.099	1.842	2.175	1.966	1.982	
10	1	|E*| (MPa)	3543	5825	6614	9250	10630	13946	15297	17301
		Phase Angle, F (º)	32.8	30.0	27.2	22.0	20.7	16.6	14.8	
		Average Peak Stress (MPa)	0.283	0.395	0.480	0.622	0.735	1.016	1.158	1.264
		Average Peak Strain (με)	80	68	73	67	69	73	76	73
	2	|E*| (MPa)	3522	5247	6700	9343	10604	13882	15434	17524
		Phase Angle, F (º)	28.2	23.5	21.4	18.3	16.9	12.9	11.5	10.6
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.622	0.735	1.015	1.157	1.270
		Average Peak Strain (με)	80	75	72	67	69	73	75	72
	3	|E*| (MPa)	3375	5085	6039	8572	9783	12750	14126	15996
		Phase Angle, F (º)	27.3	26.4	20.6	17.7	16.2	12.4	10.9	10.0
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.622	0.735	1.016	1.157	1.267
		Average Peak Strain (με)	84	78	80	73	75	80	82	79
	Avg.	|E*| Average	3480	5385	6451	9055	10339	13526	14953	16941
		F Average	29.4	26.6	23.0	19.4	17.9	14.0	12.4	10.3
		|E*| Coeff. of Variation	0.026	0.072	0.056	0.046	0.047	0.050	0.048	0.049
		F Coeff. of Variation	0.10	0.12	0.16	0.12	0.13	0.16	0.17	0.04
		|E*| Std. Dev.	91.9	389.0	359.5	420.7	481.8	672.7	718.8	825.7
		F Std. Dev.	2.937	3.241	3.631	2.337	2.405	2.303	2.066	0.457
35	1	|E*| (MPa)	281	406	512	915	1241	2382	3098	4208
		Phase Angle, F (º)	27.4	30.2	31.6	34.2	33.0	30.5	28.3	25.9
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.065	0.097	0.137	0.219	0.388
		Average Peak Strain (με)	51	69	72	71	78	58	71	92
	2	|E*| (MPa)	244	378	483	882	1195	2288	2980	4096
		Phase Angle, F (º)	27.0	29.9	31.0	33.5	32.5	29.3	26.9	24.8
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.219	0.388
		Average Peak Strain (με)	58	74	76	73	81	60	74	95
	3	|E*| (MPa)	253	388	490	883	1178	2217	2847	3872
		Phase Angle, F (º)	25.4	28.5	30.0	32.8	31.8	29.1	26.5	24.5
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.220	0.387
		Average Peak Strain (με)	56	72	75	73	82	62	77	100
	Avg.	|E*| Average	259	391	495	893	1205	2296	2975	4059
		F Average	26.6	29.6	30.9	33.5	32.4	29.6	27.2	25.1
		|E*| Coeff. of Variation	0.074	0.037	0.030	0.021	0.027	0.036	0.042	0.042
		F Coeff. of Variation	0.04	0.03	0.03	0.02	0.02	0.03	0.04	0.03
		|E*| Std. Dev.	19.2	14.3	14.9	18.8	32.7	82.9	125.7	171.1
		F Std. Dev.	1.070	0.901	0.811	0.718	0.602	0.755	0.965	0.727
54.4	1	|E*| (MPa)		138	143	195	244	455	629	965
		Phase Angle, F (º)		18.6	16.4	22.0	23.9	27.0	27.5	29.3
		Average Peak Stress (MPa)		0.009	0.014	0.028	0.036	0.059	0.086	0.114
		Average Peak Strain (με)		62	100	146	148	131	136	118
	2	|E*| (MPa)		125	130	181	226	423	581	904
		Phase Angle, F (º)		16.0	17.4	22.4	24.4	26.7	27.1	29.2
		Average Peak Stress (MPa)		0.009	0.014	0.028	0.036	0.059	0.085	0.113
		Average Peak Strain (με)		68	110	157	160	139	147	125
	3	|E*| (MPa)		151	143	189	230	420	571	875
		Phase Angle, F (º)		15.9	16.5	20.6	22.7	26.0	26.5	28.6
		Average Peak Stress (MPa)		0.009	0.014	0.028	0.036	0.059	0.085	0.113
		Average Peak Strain (με)		56	100	150	157	140	149	129
	Avg.	|E*| Average		138	139	188	233	433	594	915
		F Average		16.9	16.8	21.7	23.7	26.5	27.0	29.0
		|E*| Coeff. of Variation		0.096	0.053	0.038	0.040	0.045	0.052	0.050
		F Coeff. of Variation		0.09	0.03	0.04	0.04	0.02	0.02	0.01
		|E*| Std. Dev.		13.2	7.4	7.2	9.3	19.5	30.7	45.6
		F Std. Dev.		1.544	0.528	0.961	0.891	0.522	0.479	0.386

Table B-52. S9.5BF–Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	17764	21823	21583	23926	24801	26983	27905	
		Phase Angle, F (º)	11.0	7.0	7.0	7.6	7.4	6.2	5.9	
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.752	1.808	1.977	2.037	
		Average Peak Strain (με)	76	72	76	73	73	73	73	
	2	|E*| (MPa)	17096	20233	19997	22643	23472	25139	25917	27022
		Phase Angle, F (º)	7.6	10.0	4.8	5.4	4.9	3.2	2.7	2.3
		Average Peak Stress (MPa)	1.151	1.343	1.391	1.487	1.535	1.678	1.728	1.872
		Average Peak Strain (με)	67	66	70	66	65	67	67	69
	3	|E*| (MPa)	17684	22033	21034	23589	24404	26565	27505	28570
		Phase Angle, F (º)	10.5	13.8	8.0	8.6	8.8	7.6	6.8	6.4
		Average Peak Stress (MPa)	1.151	1.343	1.391	1.488	1.536	1.678	1.730	1.872
		Average Peak Strain (με)	65	61	66	63	63	63	63	66
	Avg.	|E*| Average	17515	21363	20871	23386	24226	26229	27109	27796
		F Average	9.7	10.3	6.6	7.2	7.0	5.7	5.1	4.4
		|E*| Coeff. of Variation	0.021	0.046	0.039	0.028	0.028	0.037	0.039	0.039
		F Coeff. of Variation	0.19	0.33	0.25	0.23	0.28	0.39	0.42	0.66
		|E*| Std. Dev.	364.7	984.5	805.3	665.2	682.5	966.6	1051.2	1095.1
		F Std. Dev.	1.846	3.405	1.657	1.640	1.969	2.218	2.147	2.873
10	1	|E*| (MPa)	5219	7353	8162	10838	12017	15034	16359	17851
		Phase Angle, F (º)	28.2	26.7	22.1	18.7	16.9	13.5	11.9	11.2
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.622	0.735	1.016	1.159	1.271
		Average Peak Strain (με)	54	54	59	57	61	68	71	71
	2	|E*| (MPa)	5777	7588	8943	11528	12522	15266	16437	18133
		Phase Angle, F (º)	24.9	22.9	18.7	15.0	14.0	11.1	10.0	9.6
		Average Peak Stress (MPa)	0.240	0.336	0.408	0.528	0.624	0.862	0.983	1.075
		Average Peak Strain (με)	41	44	46	46	50	56	60	59
	3	|E*| (MPa)	5820	7806	8823	11443	12452	15068	16336	18030
		Phase Angle, F (º)	25.7	18.3	20.2	17.7	16.2	13.2	12.2	11.5
		Average Peak Stress (MPa)	0.240	0.336	0.408	0.528	0.624	0.862	0.983	1.078
		Average Peak Strain (με)	41	43	46	46	50	57	60	60
	Avg.	|E*| Average	5606	7582	8643	11270	12330	15123	16377	18005
		F Average	26.2	22.6	20.3	17.1	15.7	12.6	11.4	10.8
		|E*| Coeff. of Variation	0.060	0.030	0.049	0.033	0.022	0.008	0.003	0.008
		F Coeff. of Variation	0.07	0.18	0.08	0.11	0.10	0.10	0.11	0.10
		|E*| Std. Dev.	335.3	226.7	420.7	375.9	273.7	125.0	53.4	143.0
		F Std. Dev.	1.710	4.178	1.689	1.935	1.508	1.320	1.207	1.058
35	1	|E*| (MPa)	808	946	1110	1741	2148	3872	4677	5830
		Phase Angle, F (º)	30.2	36.3	35.6	36.2	35.0	30.6	26.5	24.3
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.138	0.221	0.392
		Average Peak Strain (με)	18	30	33	37	45	36	47	67
	2	|E*| (MPa)	785	1075	1247	1962	2430	4193	4969	6009
		Phase Angle, F (º)	29.6	32.8	35.3	35.4	33.5	29.1	25.3	23.1
		Average Peak Stress (MPa)	0.012	0.024	0.031	0.055	0.082	0.115	0.186	0.331
		Average Peak Strain (με)	15	22	25	28	34	28	37	55
	3	|E*| (MPa)	1077	1197	1385	2084	2484	4069	4812	5782
		Phase Angle, F (º)	35.2	36.1	35.7	35.3	32.2	28.0	24.8	22.1
		Average Peak Stress (MPa)	0.012	0.024	0.031	0.055	0.082	0.116	0.187	0.331
		Average Peak Strain (με)	11	20	22	26	33	29	39	57
	Avg.	|E*| Average	890	1073	1247	1929	2354	4045	4820	5874
		F Average	31.7	35.1	35.6	35.6	33.6	29.2	25.5	23.2
		|E*| Coeff. of Variation	0.182	0.117	0.110	0.090	0.077	0.040	0.030	0.020
		F Coeff. of Variation	0.10	0.06	0.01	0.01	0.04	0.04	0.04	0.05
		|E*| Std. Dev.	162.3	125.6	137.5	173.8	180.6	161.7	146.2	119.6
		F Std. Dev.	3.099	1.946	0.208	0.500	1.368	1.270	0.896	1.066
54.4	1	|E*| (MPa)	373	388	377	456	531	929	1198	1714
		Phase Angle, F (º)	26.0	20.2	23.8	29.8	31.1	30.7	29.3	30.1
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.090	0.124
		Average Peak Strain (με)	15	22	38	62	68	66	75	72
	2	|E*| (MPa)	277	282	343	480	584	1083	1395	1928
		Phase Angle, F (º)	18.6	19.6	23.6	30.2	31.2	31.2	29.6	29.7
		Average Peak Stress (MPa)	0.005	0.007	0.012	0.024	0.031	0.052	0.076	0.103
		Average Peak Strain (με)	17	26	35	50	53	48	54	53
	3	|E*| (MPa)	419	330	349	484	585	1011	1309	1838
		Phase Angle, F (º)	28.4	22.5	23.2	25.9	27.0	27.5	26.3	26.8
		Average Peak Stress (MPa)	0.005	0.007	0.012	0.024	0.031	0.052	0.077	0.104
		Average Peak Strain (με)	11	22	35	50	53	51	59	57
	Avg.	|E*| Average	356	333	357	473	567	1008	1301	1827
		F Average	24.3	20.8	23.5	28.7	29.7	29.8	28.4	28.9
		|E*| Coeff. of Variation	0.203	0.159	0.050	0.033	0.055	0.076	0.076	0.059
		F Coeff. of Variation	0.21	0.07	0.01	0.08	0.08	0.07	0.06	0.06
		|E*| Std. Dev.	72.2	53.0	17.9	15.4	30.9	76.9	98.7	107.6
		F Std. Dev.	5.092	1.520	0.321	2.373	2.413	1.993	1.810	1.798

Table B-53. S9.5CC–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	17530	19120	22228	23719	24726	27021	28189	28566
		Phase Angle, F (º)	6.9	10.0	5.6	4.3	2.6	3.0	2.6	0.0
		Average Peak Stress (MPa)	1.354	1.580	1.637	1.751	1.806	1.974	2.035	2.201
		Average Peak Strain (με)	77	83	74	74	73	73	72	77
	2	|E*| (MPa)	18615		21988	25581	26360	28884	30241	31646
		Phase Angle, F (º)	10.0		6.4	7.6	6.3	5.7	5.7	5.4
		Average Peak Stress (MPa)	1.242		1.581	1.640	1.694	1.860	1.728	1.871
		Average Peak Strain (με)	67		72	64	64	64	57	59
	3	|E*| (MPa)	18056	19554	22899	24162	25330	27685	28663	29740
		Phase Angle, F (º)	8.2	2.8	5.6	6.4	4.6	4.1	3.5	3.2
		Average Peak Stress (MPa)	1.242	1.496	1.581	1.640	1.694	1.865	1.923	2.083
		Average Peak Strain (με)	69	77	69	68	67	67	67	70
	Avg.	|E*| Average	18067	19337	22372	24487	25472	27863	29031	29984
		F Average	8.4	6.4	5.9	6.1	4.5	4.3	3.9	2.9
		|E*| Coeff. of Variation	0.030	0.016	0.021	0.040	0.032	0.034	0.037	0.052
		F Coeff. of Variation	0.19	0.80	0.08	0.28	0.41	0.32	0.40	0.94
		|E*| Std. Dev.	542.7	307.5	472.0	973.0	826.0	943.8	1074.3	1554.3
		F Std. Dev.	1.600	5.088	0.457	1.703	1.843	1.385	1.585	2.699
10	1	|E*| (MPa)	5527	7883	9015	11378	12516	15346	16839	18509
		Phase Angle, F (º)	21.2	13.1	15.2	13.3	11.4	10.0	8.9	6.4
		Average Peak Stress (MPa)	0.254	0.355	0.432	0.559	0.661	0.911	1.157	1.267
		Average Peak Strain (με)	46	45	48	49	53	59	69	68
	2	|E*| (MPa)	5983	8037	9665	12038	13356	16185	17452	19493
		Phase Angle, F (º)	24.3	16.4	20.6	16.7	14.1	12.5	11.1	10.7
		Average Peak Stress (MPa)	0.282	0.396	0.480	0.622	0.734	1.015	1.158	1.269
		Average Peak Strain (με)	47	49	50	52	55	63	66	65
	3	|E*| (MPa)	5515	8080	8690	11393	12608	15536	16719	18725
		Phase Angle, F (º)	22.8	15.1	19.9	14.5	12.4	10.6	9.6	9.0
		Average Peak Stress (MPa)	0.311	0.395	0.480	0.622	0.734	1.014	1.156	1.268
		Average Peak Strain (με)	56	49	55	55	58	65	69	68
	Avg.	|E*| Average	5675	8000	9124	11603	12827	15689	17003	18909
		F Average	22.7	14.9	18.6	14.9	12.7	11.0	9.9	8.7
		|E*| Coeff. of Variation	0.047	0.013	0.054	0.032	0.036	0.028	0.023	0.027
		F Coeff. of Variation	0.07	0.11	0.16	0.12	0.11	0.11	0.12	0.25
		|E*| Std. Dev.	267.2	103.7	496.5	376.6	460.5	439.9	393.0	517.3
		F Std. Dev.	1.562	1.628	2.902	1.725	1.370	1.264	1.150	2.175
35	1	|E*| (MPa)	453	732	923	1592	2025	3564	4349	5534
		Phase Angle, F (º)	30.1	31.2	30.7	31.1	28.3	25.9	23.5	21.3
		Average Peak Stress (MPa)	0.013	0.025	0.033	0.058	0.088	0.125	0.198	0.353
		Average Peak Strain (με)	29	34	36	37	44	35	45	64
	2	|E*| (MPa)	550	817	1019	1708	2154	3791	4514	5683
		Phase Angle, F (º)	35.7	34.0	33.5	33.3	30.0	28.5	25.5	23.0
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.065	0.098	0.140	0.221	0.393
		Average Peak Strain (με)	26	35	36	38	46	37	49	69
	3	|E*| (MPa)	498	776	934	1595	2047	3516	4381	5565
		Phase Angle, F (º)	30.7	29.6	30.5	31.0	29.1	26.7	23.9	22.1
		Average Peak Stress (MPa)	0.020	0.033	0.042	0.079	0.111	0.166	0.249	0.393
		Average Peak Strain (με)	40	43	45	50	54	47	57	71
	Avg.	|E*| Average	500	775	958	1632	2076	3624	4415	5594
		F Average	32.2	31.6	31.6	31.8	29.1	27.0	24.3	22.1
		|E*| Coeff. of Variation	0.097	0.055	0.055	0.041	0.033	0.040	0.020	0.014
		F Coeff. of Variation	0.10	0.07	0.05	0.04	0.03	0.05	0.04	0.04
		|E*| Std. Dev.	48.5	42.8	52.6	66.4	69.1	146.7	87.7	78.4
		F Std. Dev.	3.059	2.208	1.699	1.290	0.870	1.351	1.047	0.842
54.4	Est.	|E*| (MPa)	129	208	259	438	553	954	1202	1623

Table B-54. S9.5C0F-Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	20546	21227	23751	27519	28751	31026	31956	33053
		Phase Angle, F (º)	7.7	8.2	6.7	5.5	5.0	3.9	3.5	2.9
		Average Peak Stress (MPa)	1.412	1.582	1.639	1.755	1.814	1.873	1.932	2.083
		Average Peak Strain (με)	69	75	69	64	63	60	60	63
	2	|E*| (MPa)	18853	23966	23602	25533	26620	28987	29878	31102
		Phase Angle, F (º)	8.1	9.5	7.6	5.3	4.6	3.5	3.1	2.8
		Average Peak Stress (MPa)	1.412	1.582	1.639	1.755	1.814	1.871	1.932	2.096
		Average Peak Strain (με)	75	66	69	69	68	65	65	67
	3	|E*| (MPa)	20640		26388	28111	29379	32012	33140	34435
		Phase Angle, F (º)	8.6		5.4	6.7	5.9	4.1	3.4	3.8
		Average Peak Stress (MPa)	1.412		1.636	1.755	1.814	1.873	1.931	2.094
		Average Peak Strain (με)	68		62	62	62	59	58	61
	Avg.	|E*| Average	20013	22597	24580	27054	28250	30675	31658	32863
		F Average	8.1	8.9	6.6	5.8	5.2	3.8	3.3	3.1
		|E*| Coeff. of Variation	0.050	0.086	0.064	0.050	0.051	0.050	0.052	0.051
		F Coeff. of Variation	0.05	0.10	0.17	0.12	0.13	0.08	0.06	0.17
		|E*| Std. Dev.	1005.6	1936.9	1566.8	1350.2	1446.2	1542.5	1651.7	1674.5
		F Std. Dev.	0.445	0.918	1.105	0.720	0.662	0.298	0.205	0.532
10	1	|E*| (MPa)	6165	9168	9702	12752	14095	17376	18752	20796
		Phase Angle, F (º)	21.4	19.7	14.5	13.1	11.8	9.3	8.3	7.1
		Average Peak Stress (MPa)	0.367	0.537	0.622	0.907	0.965	1.192	1.305	1.452
		Average Peak Strain (με)	60	59	64	71	68	69	70	70
	2	|E*| (MPa)	5673	8367	9072	11472	12800	16040	17442	19292
		Phase Angle, F (º)	22.3	17.3	17.3	13.9	12.9	10.0	9.4	8.4
		Average Peak Stress (MPa)	0.367	0.537	0.622	0.907	0.965	1.193	1.305	1.451
		Average Peak Strain (με)	65	64	69	79	75	74	75	75
	3	|E*| (MPa)	5765	8878	9685	12457	13909	17438	18951	21126
		Phase Angle, F (º)	23.5	18.6	16.8	15.1	13.6	11.3	10.1	9.4
		Average Peak Stress (MPa)	0.367	0.537	0.623	0.907	0.965	1.193	1.304	1.448
		Average Peak Strain (με)	64	60	64	73	69	68	69	69
	Avg.	|E*| Average	5868	8804	9486	12227	13601	16951	18381	20404
		F Average	22.4	18.5	16.2	14.0	12.8	10.2	9.3	8.3
		|E*| Coeff. of Variation	0.045	0.046	0.038	0.055	0.052	0.047	0.045	0.048
		F Coeff. of Variation	0.05	0.06	0.09	0.07	0.07	0.10	0.10	0.14
		|E*| Std. Dev.	261.5	405.7	358.8	670.2	700.5	790.1	819.9	977.4
		F Std. Dev.	1.047	1.201	1.516	1.037	0.907	1.013	0.937	1.170
35	1	|E*| (MPa)	566	916	1138	1898	2383	4066	4948	6233
		Phase Angle, F (º)	30.8	31.7	32.3	32.0	29.8	25.0	22.6	20.7
		Average Peak Stress (MPa)	0.023	0.034	0.042	0.071	0.114	0.195	0.280	0.453
		Average Peak Strain (με)	40	37	37	37	48	48	56	73
	2	|E*| (MPa)	469	782	990	1671	2143	3785	4743	6001
		Phase Angle, F (º)	30.9	32.8	34.6	32.8	31.0	26.1	23.4	21.8
		Average Peak Stress (MPa)	0.022	0.034	0.043	0.071	0.114	0.196	0.279	0.451
		Average Peak Strain (με)	48	43	43	43	53	52	59	75
	3	|E*| (MPa)	466	754	948	1592	2049	3641	4535	5829
		Phase Angle, F (º)	33.0	33.8	40.9	35.0	32.8	26.7	24.6	22.7
		Average Peak Stress (MPa)	0.023	0.034	0.044	0.071	0.114	0.195	0.279	0.451
		Average Peak Strain (με)	48	45	46	45	56	54	61	77
	Avg.	|E*| Average	500	817	1025	1720	2192	3831	4742	6021
		F Average	31.6	32.8	36.0	33.3	31.2	25.9	23.6	21.7
		|E*| Coeff. of Variation	0.114	0.106	0.097	0.092	0.079	0.056	0.044	0.034
		F Coeff. of Variation	0.04	0.03	0.12	0.05	0.05	0.03	0.04	0.05
		|E*| Std. Dev.	57.0	86.8	99.8	159.0	172.4	216.1	206.4	202.6
		F Std. Dev.	1.208	1.065	4.454	1.569	1.512	0.862	0.992	1.001
54.4	Est.	|E*| (MPa)	118	196	247	430	549	966	1226	1669

Table B-55. S9.5C1F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	18465	23352	21716	24796	25814	28144	29177	30285
		Phase Angle, F (º)	9.9	6.6	6.9	6.9	6.5	5.1	4.7	4.4
		Average Peak Stress (MPa)	1.240	1.494	1.578	1.636	1.690	1.857	1.916	2.070
		Average Peak Strain (με)	67	64	73	66	65	66	66	68
	2	|E*| (MPa)	19247	19781	23913	25646	26553	28836	29775	30921
		Phase Angle, F (º)	5.9	5.9	4.8	3.5	3.1	2.2	1.6	1.3
		Average Peak Stress (MPa)	1.240	1.494	1.578	1.636	1.690	1.858	1.916	2.068
		Average Peak Strain (με)	64	76	66	64	64	64	64	67
	3	|E*| (MPa)	17484	18606	21881	23480	24615	26877	27726	
		Phase Angle, F (º)	7.4	3.9	7.2	4.8	4.8	3.2	2.9	
		Average Peak Stress (MPa)	1.240	1.494	1.578	1.636	1.690	1.857	1.917	
		Average Peak Strain (με)	71	80	72	70	69	69	69	
	Avg.	|E*| Average	18399	20580	22503	24641	25660	27952	28893	30603
		F Average	7.7	5.5	6.3	5.1	4.8	3.5	3.0	2.8
		|E*| Coeff. of Variation	0.048	0.120	0.054	0.044	0.038	0.036	0.036	0.015
		F Coeff. of Variation	0.26	0.25	0.21	0.34	0.35	0.42	0.51	0.78
		|E*| Std. Dev.	883.4	2471.7	1223.5	1091.2	978.0	993.5	1054.2	450.0
		F Std. Dev.	1.996	1.385	1.291	1.748	1.698	1.491	1.546	2.210
10	1	|E*| (MPa)	6126	9101	9191	11883	13067	15992	17346	19145
		Phase Angle, F (º)	23.5	19.5	17.4	15.8	14.3	11.6	10.6	9.7
		Average Peak Stress (MPa)	0.310	0.395	0.479	0.620	0.732	1.012	1.153	1.260
		Average Peak Strain (με)	51	43	52	52	56	63	66	66
	2	|E*| (MPa)	6139	7866	9253	11957	13165	16012	17299	19149
		Phase Angle, F (º)	18.6	12.6	15.4	11.9	10.8	8.8	7.9	7.6
		Average Peak Stress (MPa)	0.310	0.395	0.479	0.620	0.732	1.012	1.153	1.260
		Average Peak Strain (με)	51	50	52	52	56	63	67	66
	3	|E*| (MPa)	5411	7034	8609	10950	12013	14895	16190	17810
		Phase Angle, F (º)	21.1	15.3	16.7	13.5	12.2	9.6	8.8	8.3
		Average Peak Stress (MPa)	0.310	0.395	0.479	0.620	0.732	1.012	1.153	1.260
		Average Peak Strain (με)	57	56	56	57	61	68	71	71
	Avg.	|E*| Average	5892	8001	9017	11597	12748	15633	16945	18701
		F Average	21.1	15.8	16.5	13.7	12.5	10.0	9.1	8.5
		|E*| Coeff. of Variation	0.071	0.130	0.039	0.048	0.050	0.041	0.039	0.041
		F Coeff. of Variation	0.12	0.22	0.06	0.14	0.14	0.15	0.15	0.13
		|E*| Std. Dev.	416.5	1040.2	355.4	561.5	638.5	639.1	654.6	771.6
		F Std. Dev.	2.471	3.459	1.042	1.987	1.752	1.468	1.395	1.084
35	1	|E*| (MPa)	615	895	1103	1765	2188	3699	4436	5600
		Phase Angle, F (º)	34.8	34.5	34.3	32.7	30.6	26.6	24.2	22.2
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.166	0.248	0.390
		Average Peak Strain (με)	32	38	38	44	51	45	56	70
	2	|E*| (MPa)	530	842	1088	1805	2280	3835	4686	5893
		Phase Angle, F (º)	31.1	31.2	31.0	29.9	28.0	23.6	21.6	20.1
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.166	0.249	0.390
		Average Peak Strain (με)	37	40	39	43	49	43	53	66
	3	|E*| (MPa)	529	782	971	1581	1955	3356	4150	5254
		Phase Angle, F (º)	30.0	30.7	30.9	30.6	28.8	25.0	22.3	21.1
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.165	0.248	0.388
		Average Peak Strain (με)	38	43	44	49	57	49	60	74
	Avg.	|E*| Average	558	840	1054	1717	2141	3630	4424	5582
		F Average	32.0	32.1	32.0	31.1	29.1	25.1	22.7	21.2
		|E*| Coeff. of Variation	0.088	0.067	0.068	0.070	0.078	0.068	0.061	0.057
		F Coeff. of Variation	0.08	0.07	0.06	0.05	0.05	0.06	0.06	0.05
		|E*| Std. Dev.	49.2	56.1	72.2	119.4	167.5	247.0	268.3	320.0
		F Std. Dev.	2.503	2.095	1.915	1.441	1.320	1.531	1.303	1.074
54.4	1	|E*| (MPa)		403	326	467	556	963	1247	1745
		Phase Angle, F (º)		28.5	27.7	29.5	30.4	31.3	31.7	32.9
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.025	0.030
		Average Peak Strain (με)		14	26	24	30	22	20	17
	2	|E*| (MPa)		285	289	439	542	934	1196	1707
		Phase Angle, F (º)		26.2	23.4	26.1	27.4	28.3	27.7	27.2
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.025	0.030
		Average Peak Strain (με)		20	30	26	31	23	21	18
	3	|E*| (MPa)		226	266	395	489	833	1078	1505
		Phase Angle, F (º)		18.6	19.9	24.8	25.9	27.8	27.9	30.0
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.025	0.030
		Average Peak Strain (με)		25	32	28	34	25	23	20
	Avg.	|E*| Average		305	294	434	529	910	1174	1652
		F Average		24.5	23.7	26.8	27.9	29.1	29.1	30.0
		|E*| Coeff. of Variation		0.296	0.104	0.085	0.066	0.075	0.074	0.078
		F Coeff. of Variation		0.21	0.16	0.09	0.08	0.07	0.08	0.10
		|E*| Std. Dev.		90.2	30.5	36.7	35.0	68.1	86.8	128.7
		F Std. Dev.		5.169	3.878	2.411	2.294	1.930	2.265	2.854

Table B-56. S9.5C2F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	19553	25402	24454	26578	27798	30536	31908	
		Phase Angle, F (º)	9.0	8.0	4.4	5.9	5.4	4.3	4.1	
		Average Peak Stress (MPa)	1.240	1.494	1.578	1.636	1.690	1.858	1.916	
		Average Peak Strain (με)	63	59	65	62	61	61	60	
	2	|E*| (MPa)	19502	20558	24180	26293	27362	29685	30542	32016
		Phase Angle, F (º)	8.7	8.0	8.5	5.2	5.0	3.7	3.0	3.0
		Average Peak Stress (MPa)	1.240	1.494	1.579	1.636	1.690	1.857	1.915	2.068
		Average Peak Strain (με)	64	73	65	62	62	63	63	65
	3	|E*| (MPa)	19010	24090	24041	25714	27004	29585	30546	31718
		Phase Angle, F (º)	7.9	5.9	6.4	5.2	5.0	4.2	3.6	3.3
		Average Peak Stress (MPa)	1.240	1.494	1.579	1.636	1.690	1.857	1.916	2.066
		Average Peak Strain (με)	65	62	66	64	63	63	63	65
	Avg.	|E*| Average	19355	23350	24225	26195	27388	29935	30999	31867
		F Average	8.5	7.3	6.4	5.4	5.1	4.1	3.6	3.1
		|E*| Coeff. of Variation	0.016	0.107	0.009	0.017	0.015	0.017	0.025	0.007
		F Coeff. of Variation	0.06	0.17	0.32	0.07	0.05	0.09	0.14	0.06
		|E*| Std. Dev.	300.1	2505.4	210.1	440.2	397.7	522.4	787.2	210.4
		F Std. Dev.	0.533	1.239	2.055	0.387	0.247	0.348	0.514	0.199
10	1	|E*| (MPa)	6396	8245	9946	12835	14165	17408	18883	
		Phase Angle, F (º)	23.2	21.8	19.3	15.0	13.4	10.9	10.1	
		Average Peak Stress (MPa)	0.310	0.395	0.479	0.620	0.732	1.012	1.153	
		Average Peak Strain (με)	48	48	48	48	52	58	61	
	2	|E*| (MPa)	5849	7873	9169	12063	13258	16318	17753	19765
		Phase Angle, F (º)	24.0	16.7	16.9	15.0	13.2	10.7	9.5	8.7
		Average Peak Stress (MPa)	0.310	0.395	0.479	0.620	0.732	1.011	1.152	1.256
		Average Peak Strain (με)	53	50	52	51	55	62	65	64
	3	|E*| (MPa)	5724	7524	9140	11862	13256	16599	18253	20053
		Phase Angle, F (º)	22.8	17.0	19.2	14.5	13.3	11.0	10.4	9.5
		Average Peak Stress (MPa)	0.310	0.395	0.479	0.620	0.732	1.012	1.153	1.258
		Average Peak Strain (με)	54	52	52	52	55	61	63	63
	Avg.	|E*| Average	5990	7881	9418	12254	13560	16775	18296	19909
		F Average	23.4	18.5	18.5	14.8	13.3	10.8	10.0	9.1
		|E*| Coeff. of Variation	0.060	0.046	0.049	0.042	0.039	0.034	0.031	0.010
		F Coeff. of Variation	0.03	0.16	0.07	0.02	0.01	0.02	0.05	0.06
		|E*| Std. Dev.	357.1	360.9	457.3	513.7	524.3	566.2	566.6	203.5
		F Std. Dev.	0.596	2.898	1.363	0.312	0.094	0.174	0.471	0.561
35	1	|E*| (MPa)	523	825	1055	1809	2332	4096	5082	6402
		Phase Angle, F (º)	33.5	34.5	33.1	33.3	31.7	27.2	24.1	22.1
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.166	0.249	0.391
		Average Peak Strain (με)	38	41	40	43	48	41	49	61
	2	|E*| (MPa)	485	770	928	1575	2011	3592	4444	5703
		Phase Angle, F (º)	33.5	33.3	34.6	33.1	31.8	27.1	24.8	22.6
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.165	0.247	0.389
		Average Peak Strain (με)	41	44	46	49	55	46	56	68
	3	|E*| (MPa)	436	707	899	1544	2006	3584	4485	5730
		Phase Angle, F (º)	30.6	31.5	31.7	31.2	30.3	26.3	23.8	22.1
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.166	0.249	0.390
		Average Peak Strain (με)	45	48	47	51	55	46	55	68
	Avg.	|E*| Average	481	767	961	1643	2117	3757	4671	5945
		F Average	32.6	33.1	33.2	32.5	31.3	26.9	24.2	22.3
		|E*| Coeff. of Variation	0.090	0.077	0.087	0.088	0.088	0.078	0.076	0.067
		F Coeff. of Variation	0.05	0.05	0.04	0.04	0.03	0.02	0.02	0.01
		|E*| Std. Dev.	43.5	59.3	83.2	145.0	186.7	293.3	357.1	395.9
		F Std. Dev.	1.680	1.499	1.416	1.148	0.832	0.464	0.531	0.284
54.4	1	|E*| (MPa)		314	309	436	514	920	1189	1676
		Phase Angle, F (º)		20.0	22.5	29.0	29.7	31.8	32.1	33.9
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.025	0.030
		Average Peak Strain (με)		18	28	26	32	23	21	18
	2	|E*| (MPa)		265	253	362	447	810	1073	1528
		Phase Angle, F (º)		29.1	25.4	28.8	30.3	32.6	32.7	34.2
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.025	0.029
		Average Peak Strain (με)		21	34	31	37	26	23	19
	3	|E*| (MPa)		234	268	385	465	830	1072	1552
		Phase Angle, F (º)		17.2	21.9	26.7	27.9	30.3	30.2	31.6
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.025	0.030
		Average Peak Strain (με)		24	32	29	36	26	23	19
	Avg.	|E*| Average		271	277	394	475	853	1111	1585
		F Average		22.1	23.3	28.2	29.3	31.6	31.7	33.2
		|E*| Coeff. of Variation		0.148	0.104	0.096	0.073	0.069	0.061	0.050
		F Coeff. of Variation		0.28	0.08	0.05	0.04	0.04	0.04	0.04
		|E*| Std. Dev.		40.1	28.8	37.7	34.6	58.6	67.3	79.6
		F Std. Dev.		6.219	1.908	1.272	1.257	1.134	1.302	1.429

Table B-57. S9.5C3F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	18894	20468	24258	27222	28489	31624	33020	34607
		Phase Angle, F (º)	14.3	13.7	9.1	10.4	9.7	7.9	7.6	7.4
		Average Peak Stress (MPa)	1.241	1.495	1.580	1.638	1.692	1.861	1.920	2.077
		Average Peak Strain (με)	66	73	65	60	59	59	58	60
	2	|E*| (MPa)	16945	21414	20905	24734	25709	28566	29728	31029
		Phase Angle, F (º)	9.7	12.0	8.0	5.1	5.0	3.3	2.8	2.4
		Average Peak Stress (MPa)	1.241	1.495	1.580	1.638	1.692	1.861	1.920	2.078
		Average Peak Strain (με)	73	70	76	66	66	65	65	67
	3	|E*| (MPa)	16703	20769	21366	24281	25467	28393	29314	
		Phase Angle, F (º)	8.5	11.8	3.5	4.8	4.3	2.7	2.1	
		Average Peak Stress (MPa)	1.241	1.495	1.580	1.638	1.692	1.862	1.921	
		Average Peak Strain (με)	74	72	74	67	66	66	66	
	Avg.	|E*| Average	17514	20884	22176	25412	26555	29528	30688	32818
		F Average	10.8	12.5	6.9	6.8	6.4	4.6	4.2	4.9
		|E*| Coeff. of Variation	0.069	0.023	0.082	0.062	0.063	0.062	0.066	0.077
		F Coeff. of Variation	0.28	0.09	0.43	0.47	0.46	0.61	0.73	0.71
		|E*| Std. Dev.	1200.9	483.1	1817.7	1583.7	1679.3	1817.7	2030.7	2530.0
		F Std. Dev.	3.046	1.084	2.967	3.165	2.947	2.824	3.038	3.504
10	1	|E*| (MPa)	3955	6136	7241	10500	11970	15548	17229	19679
		Phase Angle, F (º)	33.0	25.3	26.5	22.4	20.7	16.8	15.7	14.6
		Average Peak Stress (MPa)	0.310	0.395	0.480	0.621	0.733	1.014	1.156	1.265
		Average Peak Strain (με)	78	64	66	59	61	65	67	64
	2	|E*| (MPa)	3123	4701	6056	8579	9909	13310	14877	16959
		Phase Angle, F (º)	29.3	25.3	24.1	18.8	17.1	13.0	11.7	10.6
		Average Peak Stress (MPa)	0.310	0.395	0.480	0.621	0.733	1.014	1.157	1.264
		Average Peak Strain (με)	99	84	79	72	74	76	78	75
	3	|E*| (MPa)	3351	5440	6230	8947	10244	13497	14994	17075
		Phase Angle, F (º)	27.2	22.2	22.0	17.3	15.6	11.7	10.4	9.5
		Average Peak Stress (MPa)	0.310	0.395	0.480	0.621	0.733	1.014	1.156	1.265
		Average Peak Strain (με)	93	73	77	69	72	75	77	74
	Avg.	|E*| Average	3476	5426	6509	9342	10708	14119	15700	17904
		F Average	29.8	24.3	24.2	19.5	17.8	13.8	12.6	11.6
		|E*| Coeff. of Variation	0.124	0.132	0.098	0.109	0.103	0.088	0.084	0.086
		F Coeff. of Variation	0.10	0.07	0.09	0.13	0.15	0.19	0.22	0.23
		|E*| Std. Dev.	430.2	717.2	640.2	1019.8	1105.8	1241.5	1325.6	1537.9
		F Std. Dev.	2.923	1.820	2.277	2.609	2.627	2.654	2.768	2.656
35	1	|E*| (MPa)	250	395	504	927	1260	2502	3262	4399
		Phase Angle, F (º)	28.2	31.4	32.9	35.4	34.4	31.7	29.3	27.1
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.166	0.248	0.389
		Average Peak Strain (με)	79	85	84	84	88	66	76	89
	2	|E*| (MPa)	220	346	440	806	1088	2120	2807	3910
		Phase Angle, F (º)	24.2	27.4	28.7	32.1	31.4	28.6	26.8	25.6
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.165	0.246	0.387
		Average Peak Strain (με)	90	97	96	97	102	78	88	99
	3	|E*| (MPa)	213	352	455	845	1137	2184	2837	3931
		Phase Angle, F (º)	24.8	28.0	29.1	32.1	31.2	27.7	25.5	24.7
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.165	0.247	0.388
		Average Peak Strain (με)	93	96	93	92	98	76	87	99
	Avg.	|E*| Average	228	364	466	859	1162	2269	2969	4080
		F Average	25.7	28.9	30.2	33.2	32.3	29.3	27.2	25.8
		|E*| Coeff. of Variation	0.086	0.074	0.072	0.072	0.076	0.090	0.086	0.068
		F Coeff. of Variation	0.08	0.07	0.08	0.06	0.06	0.07	0.07	0.05
		|E*| Std. Dev.	19.6	26.8	33.4	62.1	88.7	204.9	253.9	276.5
		F Std. Dev.	2.146	2.166	2.322	1.916	1.826	2.097	1.904	1.216
54.4	1	|E*| (MPa)		167	166	206	244	434	585	922
		Phase Angle, F (º)		13.3	19.2	25.1	26.7	32.1	33.5	36.0
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.020	0.024	0.027
		Average Peak Strain (με)		33	52	55	68	47	40	29
	2	|E*| (MPa)		142	141	183	222	388	530	816
		Phase Angle, F (º)		17.2	15.9	22.1	23.9	28.5	30.4	32.7
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.020	0.023	0.026
		Average Peak Strain (με)		39	61	62	74	52	44	32
	3	|E*| (MPa)		109	120	166	209	367	494	754
		Phase Angle, F (º)		10.5	14.3	21.9	23.8	27.7	28.7	32.6
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.020	0.024	0.027
		Average Peak Strain (με)		51	71	68	79	55	48	36
	Avg.	|E*| Average		139	142	185	225	396	536	831
		F Average		13.7	16.5	23.0	24.8	29.4	30.9	33.8
		|E*| Coeff. of Variation		0.209	0.160	0.109	0.079	0.086	0.086	0.103
		F Coeff. of Variation		0.24	0.15	0.08	0.07	0.08	0.08	0.06
		|E*| Std. Dev.		29.1	22.7	20.2	17.7	34.2	46.0	85.1
		F Std. Dev.		3.333	2.454	1.773	1.614	2.360	2.462	1.975

Table B-58. S9.5CF–Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16617	19935	19186	21850	22535	24289	25006	25935
		Phase Angle, F (º)	5.6	2.2	3.0	3.4	3.0	2.0	1.5	1.6
		Average Peak Stress (MPa)	1.083	1.264	1.309	1.400	1.444	1.579	1.625	1.757
		Average Peak Strain (με)	65	63	68	64	64	65	65	68
	2	|E*| (MPa)	17247	20306	21020	22426	23324	25190	25936	26799
		Phase Angle, F (º)	7.0	3.8	5.3	4.5	4.3	3.6	3.0	2.8
		Average Peak Stress (MPa)	1.354	1.579	1.636	1.750	1.806	1.975	2.035	2.202
		Average Peak Strain (με)	78	78	78	78	77	78	78	82
	3	|E*| (MPa)	15163	17282	17542	19801	20415	22359	23008	23862
		Phase Angle, F (º)	7.4	2.6	5.0	4.8	4.7	3.8	3.3	3.2
		Average Peak Stress (MPa)	1.082	1.263	1.309	1.400	1.445	1.579	1.628	1.757
		Average Peak Strain (με)	71	73	75	71	71	71	71	74
	Avg.	|E*| Average	16342	19174	19249	21359	22091	23946	24650	25532
		F Average	6.7	2.8	4.4	4.3	4.0	3.1	2.6	2.5
		|E*| Coeff. of Variation	0.065	0.086	0.090	0.065	0.068	0.060	0.061	0.059
		F Coeff. of Variation	0.14	0.29	0.27	0.17	0.22	0.32	0.38	0.34
		|E*| Std. Dev.	1068.6	1649.0	1739.6	1379.8	1504.5	1446.4	1496.3	1509.3
		F Std. Dev.	0.955	0.823	1.220	0.712	0.888	0.991	0.967	0.869
10	1	|E*| (MPa)	5748	7511	8789	11248	12309	14836	16054	17452
		Phase Angle, F (º)	19.4	14.0	15.7	12.3	11.1	8.7	7.4	6.7
		Average Peak Stress (MPa)	0.226	0.316	0.383	0.497	0.587	0.812	0.925	1.014
		Average Peak Strain (με)	39	42	44	44	48	55	58	58
	2	|E*| (MPa)	6067	8555	9201	11597	12579	15037	16041	17643
		Phase Angle, F (º)	22.2	20.4	15.0	13.7	12.6	9.9	8.7	8.0
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.621	0.734	1.015	1.157	1.270
		Average Peak Strain (με)	46	46	52	54	58	68	72	72
	3	|E*| (MPa)	5498	7672	8066	10215	11131	13574	14774	16057
		Phase Angle, F (º)	21.4	19.7	17.0	13.7	12.6	10.4	9.5	10.1
		Average Peak Stress (MPa)	0.226	0.316	0.384	0.497	0.588	0.811	0.924	1.010
		Average Peak Strain (με)	41	41	48	49	53	60	63	63
	Avg.	|E*| Average	5771	7913	8685	11020	12006	14482	15623	17051
		F Average	21.0	18.1	15.9	13.3	12.1	9.7	8.5	8.3
		|E*| Coeff. of Variation	0.049	0.071	0.066	0.065	0.064	0.055	0.047	0.051
		F Coeff. of Variation	0.07	0.19	0.06	0.06	0.07	0.09	0.13	0.20
		|E*| Std. Dev.	285.0	562.2	574.4	718.5	769.7	793.0	735.6	865.5
		F Std. Dev.	1.453	3.510	1.018	0.801	0.834	0.834	1.075	1.690
35	1	|E*| (MPa)	613	858	1046	1687	2147	3620	4402	5484
		Phase Angle, F (º)	29.9	31.9	30.6	31.9	29.5	24.7	22.0	19.6
		Average Peak Stress (MPa)	0.011	0.022	0.029	0.052	0.077	0.109	0.176	0.308
		Average Peak Strain (με)	19	26	28	31	36	30	40	56
	2	|E*| (MPa)	671	967	1176	1901	2370	3967	4717	5777
		Phase Angle, F (º)	35.3	34.1	33.8	33.0	30.6	25.9	22.6	20.4
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.221	0.391
		Average Peak Strain (με)	21	29	31	34	41	35	47	68
	3	|E*| (MPa)	617	966	1173	1869	2325	3906	4668	5664
		Phase Angle, F (º)	26.4	30.2	31.7	32.7	30.5	26.2	22.7	20.6
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.220	0.389
		Average Peak Strain (με)	23	29	31	34	42	35	47	69
	Avg.	|E*| Average	634	930	1132	1819	2281	3831	4596	5642
		F Average	30.5	32.0	32.0	32.5	30.2	25.6	22.4	20.2
		|E*| Coeff. of Variation	0.051	0.067	0.066	0.063	0.052	0.048	0.037	0.026
		F Coeff. of Variation	0.15	0.06	0.05	0.02	0.02	0.03	0.02	0.03
		|E*| Std. Dev.	32.2	62.4	74.3	115.2	118.1	185.1	169.2	148.1
		F Std. Dev.	4.488	1.975	1.636	0.550	0.589	0.799	0.382	0.560
54.4	1	|E*| (MPa)	276	286	302	438	547	981	1298	1788
		Phase Angle, F (º)	18.5	25.6	23.7	26.9	27.3	26.3	25.2	25.7
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.091	0.124
		Average Peak Strain (με)	20	30	47	64	66	62	70	70
	2	|E*| (MPa)	272	301	309	450	567	1028	1338	1879
		Phase Angle, F (º)	27.3	24.8	27.2	28.4	28.5	27.3	26.2	26.2
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.091	0.124
		Average Peak Strain (με)	21	28	46	63	64	60	68	66
	3	|E*| (MPa)	300	335	336	460	573	1010	1315	1795
		Phase Angle, F (º)	13.9	22.0	22.4	26.3	27.1	27.2	25.6	25.8
		Average Peak Stress (MPa)	0.006	0.008	0.014	0.028	0.036	0.061	0.090	0.122
		Average Peak Strain (με)	19	25	42	62	63	60	68	68
	Avg.	|E*| Average	283	308	316	449	562	1006	1317	1821
		F Average	19.9	24.1	24.4	27.2	27.6	26.9	25.7	25.9
		|E*| Coeff. of Variation	0.053	0.082	0.056	0.023	0.024	0.024	0.016	0.028
		F Coeff. of Variation	0.34	0.08	0.10	0.04	0.03	0.02	0.02	0.01
		|E*| Std. Dev.	15.1	25.1	17.7	10.5	13.7	23.8	20.4	50.8
		F Std. Dev.	6.813	1.925	2.459	1.045	0.773	0.545	0.539	0.251

Table B-59. S12.5BC–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	17425	22872	23478	25710	27007	29979	31180	32744
		Phase Angle, F (º)	9.8	5.8	6.7	5.6	4.6	4.5	3.9	3.2
		Average Peak Stress (MPa)	1.241	1.467	1.552	1.666	1.694	1.862	1.919	2.077
		Average Peak Strain (με)	71	64	66	65	63	62	62	63
	2	|E*| (MPa)	16092	21453	21700	23896	25179	27874	29043	30522
		Phase Angle, F (º)	11.9	7.9	7.4	7.0	5.6	5.1	4.6	4.3
		Average Peak Stress (MPa)	1.241	1.467	1.552	1.666	1.693	1.862	1.920	2.077
		Average Peak Strain (με)	77	68	72	70	67	67	66	68
	3	|E*| (MPa)	16977	22516	21588	24791	25990	28772	29914	31346
		Phase Angle, F (º)	10.5	9.8	5.1	6.9	5.0	4.5	4.0	3.5
		Average Peak Stress (MPa)	1.240	1.466	1.551	1.666	1.693	1.862	1.921	2.082
		Average Peak Strain (με)	73	65	72	67	65	65	64	66
	Avg.	|E*| Average	16831	22280	22255	24799	26059	28875	30046	31537
		F Average	10.7	7.8	6.4	6.5	5.1	4.7	4.1	3.6
		|E*| Coeff. of Variation	0.040	0.033	0.048	0.037	0.035	0.037	0.036	0.036
		F Coeff. of Variation	0.10	0.25	0.19	0.12	0.10	0.07	0.09	0.15
		|E*| Std. Dev.	678.5	738.2	1060.3	906.7	915.7	1056.3	1074.5	1123.0
		F Std. Dev.	1.046	1.999	1.182	0.759	0.509	0.319	0.369	0.548
10	1	|E*| (MPa)	2869	5054	5691	8579	9986	13681	15345	17636
		Phase Angle, F (º)	31.3	24.9	24.3	20.6	17.8	14.7	12.8	11.9
		Average Peak Stress (MPa)	0.169	0.310	0.423	0.622	0.734	1.014	1.155	1.260
		Average Peak Strain (με)	59	61	74	72	74	74	75	71
	2	|E*| (MPa)	2699	4551	5482	8285	9649	13113	14839	17125
		Phase Angle, F (º)	32.7	24.9	26.0	21.6	18.6	14.9	13.0	13.0
		Average Peak Stress (MPa)	0.169	0.310	0.423	0.622	0.734	1.014	1.155	1.262
		Average Peak Strain (με)	63	68	77	75	76	77	78	74
	3	|E*| (MPa)	3181	4892	6421	9036	10404	13983	15558	17621
		Phase Angle, F (º)	30.4	28.0	24.6	19.2	16.2	14.0	12.3	10.9
		Average Peak Stress (MPa)	0.169	0.310	0.423	0.622	0.734	0.986	1.155	1.265
		Average Peak Strain (με)	53	63	66	69	71	70	74	72
	Avg.	|E*| Average	2917	4832	5865	8633	10013	13593	15248	17461
		F Average	31.4	25.9	25.0	20.5	17.5	14.6	12.7	11.9
		|E*| Coeff. of Variation	0.084	0.053	0.084	0.044	0.038	0.032	0.024	0.017
		F Coeff. of Variation	0.04	0.07	0.04	0.06	0.07	0.03	0.03	0.09
		|E*| Std. Dev.	244.6	256.5	493.2	378.2	378.1	441.7	369.2	290.9
		F Std. Dev.	1.149	1.781	0.877	1.209	1.250	0.489	0.371	1.080
35	1	|E*| (MPa)	216	350	447	846	1141	2316	3030	4216
		Phase Angle, F (º)	27.0	30.0	31.3	34.8	33.1	30.8	29.1	27.6
		Average Peak Stress (MPa)	0.014	0.023	0.028	0.045	0.070	0.136	0.189	0.298
		Average Peak Strain (με)	66	65	63	53	61	59	62	71
	2	|E*| (MPa)	191	313	402	742	1023	2118	2807	3982
		Phase Angle, F (º)	24.1	26.4	28.7	33.1	31.8	30.5	29.4	27.8
		Average Peak Stress (MPa)	0.014	0.023	0.028	0.045	0.069	0.135	0.189	0.298
		Average Peak Strain (με)	74	72	70	61	68	64	67	75
	3	|E*| (MPa)	260	393	498	894	1214	2382	3120	4293
		Phase Angle, F (º)	25.1	28.8	30.0	34.1	31.6	29.8	28.3	26.7
		Average Peak Stress (MPa)	0.014	0.022	0.028	0.045	0.070	0.136	0.189	0.300
		Average Peak Strain (με)	55	57	56	50	57	57	61	70
	Avg.	|E*| Average	223	352	449	827	1126	2272	2986	4164
		F Average	25.4	28.4	30.0	34.0	32.2	30.4	28.9	27.3
		|E*| Coeff. of Variation	0.157	0.114	0.107	0.094	0.086	0.060	0.054	0.039
		F Coeff. of Variation	0.06	0.07	0.04	0.03	0.03	0.02	0.02	0.02
		|E*| Std. Dev.	34.8	40.2	48.2	77.5	96.5	137.3	160.9	161.6
		F Std. Dev.	1.477	1.848	1.258	0.853	0.825	0.505	0.532	0.579
54.4	Est.	|E*| (MPa)	57	79	93	146	181	316	409	582

Table B-60. S12.5BF–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16442	21370	21706	23599	24858	27280	28352	29497
		Phase Angle, F (º)	9.9	6.7	6.6	6.5	5.1	5.0	4.0	3.6
		Average Peak Stress (MPa)	1.354	1.580	1.637	1.751	1.806	1.969	2.031	2.191
		Average Peak Strain (με)	82	74	75	74	73	72	72	74
	2	|E*| (MPa)	17306		20612	24494	25585	28208	29032	30464
		Phase Angle, F (º)	8.6		6.8	5.4	4.0	3.9	3.1	3.5
		Average Peak Stress (MPa)	1.354		1.637	1.750	1.806	1.975	2.032	2.196
		Average Peak Strain (με)	78		79	71	71	70	70	72
	3	|E*| (MPa)	17315	18594	21742	24545	25700	28349	29123	30436
		Phase Angle, F (º)	9.1	4.7	4.1	5.2	4.0	3.3	2.9	2.5
		Average Peak Stress (MPa)	1.354	1.580	1.637	1.751	1.806	1.972	2.033	2.193
		Average Peak Strain (με)	78	85	75	71	70	70	70	72
	Avg.	|E*| Average	17021	19982	21353	24213	25381	27946	28836	30132
		F Average	9.2	5.7	5.8	5.7	4.4	4.1	3.3	3.2
		|E*| Coeff. of Variation	0.029	0.098	0.030	0.022	0.018	0.021	0.015	0.018
		F Coeff. of Variation	0.07	0.25	0.26	0.13	0.15	0.22	0.18	0.19
		|E*| Std. Dev.	501.2	1963.3	642.3	531.9	456.4	580.5	421.3	550.3
		F Std. Dev.	0.678	1.393	1.488	0.722	0.642	0.897	0.586	0.599
10	1	|E*| (MPa)	3485	5708	6584	9069	10273	13366	14816	16925
		Phase Angle, F (º)	27.5	24.0	22.1	17.9	15.6	12.9	11.1	10.9
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.707	0.819	1.098	1.265	1.373
		Average Peak Strain (με)	105	84	86	78	80	82	85	81
	2	|E*| (MPa)	3981	6090	7056	9864	11099	14338	15801	17990
		Phase Angle, F (º)	25.9	18.9	21.6	17.2	14.4	12.3	11.1	10.5
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.706	0.819	1.098	1.267	1.380
		Average Peak Strain (με)	92	79	80	72	74	77	80	77
	3	|E*| (MPa)	3567	5643	6511	9187	10486	13778	15146	17202
		Phase Angle, F (º)	26.3	20.1	22.2	17.2	14.8	11.7	10.5	9.8
		Average Peak Stress (MPa)	0.367	0.479	0.564	0.707	0.819	1.097	1.268	1.380
		Average Peak Strain (με)	103	85	87	77	78	80	84	80
	Avg.	|E*| Average	3678	5814	6717	9373	10620	13827	15254	17372
		F Average	26.6	21.0	22.0	17.5	14.9	12.3	10.9	10.4
		|E*| Coeff. of Variation	0.072	0.042	0.044	0.046	0.040	0.035	0.033	0.032
		F Coeff. of Variation	0.03	0.13	0.01	0.02	0.04	0.05	0.03	0.05
		|E*| Std. Dev.	266.0	241.7	296.1	429.0	429.0	487.7	501.4	552.8
		F Std. Dev.	0.800	2.690	0.311	0.421	0.603	0.582	0.363	0.562
35	1	|E*| (MPa)	261	434	542	987	1332	2475	3173	4339
		Phase Angle, F (º)	29.2	32.2	32.2	32.9	29.5	28.4	26.0	24.5
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.079	0.140	0.218	0.301	0.442
		Average Peak Strain (με)	76	77	78	80	105	88	95	102
	2	|E*| (MPa)	277	487	617	1138	1557	2855	3620	4784
		Phase Angle, F (º)	27.1	29.7	30.4	31.9	28.5	27.1	24.6	23.2
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.079	0.140	0.219	0.303	0.446
		Average Peak Strain (με)	71	71	69	69	90	77	84	93
	3	|E*| (MPa)	251	424	525	991	1375	2576	3333	4589
		Phase Angle, F (º)	26.0	26.1	30.1	31.7	28.7	26.6	25.7	24.4
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.079	0.140	0.219	0.303	0.445
		Average Peak Strain (με)	79	81	81	80	102	85	91	97
	Avg.	|E*| Average	263	448	561	1039	1421	2635	3375	4571
		F Average	27.4	29.3	30.9	32.2	28.9	27.4	25.4	24.0
		|E*| Coeff. of Variation	0.051	0.075	0.087	0.083	0.084	0.075	0.067	0.049
		F Coeff. of Variation	0.06	0.10	0.04	0.02	0.02	0.03	0.03	0.03
		|E*| Std. Dev.	13.5	33.6	49.1	86.1	119.6	197.0	226.7	223.2
		F Std. Dev.	1.630	3.038	1.154	0.637	0.503	0.898	0.742	0.720
54.4	Est.	|E*| (MPa)	54	86	107	188	243	450	590	842

Table B-61. S12.5CC–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	19461	22854	24888	26583	27834	30844	32098	33640
		Phase Angle, F (º)	6.9	12.3	7.0	4.4	4.5	3.8	3.2	3.3
		Average Peak Stress (MPa)	1.354	1.581	1.637	1.750	1.805	1.972	2.033	2.197
		Average Peak Strain (με)	70	69	66	66	65	64	63	65
	2	|E*| (MPa)	17766	19588	22555	24262	25713	28163	29172	30688
		Phase Angle, F (º)	7.1		6.4	4.3	4.0	3.1	2.4	2.6
		Average Peak Stress (MPa)	1.354	1.580	1.637	1.750	1.805	1.973	2.033	2.200
		Average Peak Strain (με)	76	81	73	72	70	70	70	72
	3	|E*| (MPa)	19045	23841	23237	26048	27199	30114	31415	33033
		Phase Angle, F (º)	6.6	7.9	2.4	4.8	3.1	2.8	2.4	2.4
		Average Peak Stress (MPa)	1.354	1.580	1.637	1.749	1.804	1.972	2.032	2.198
		Average Peak Strain (με)	71	66	70	67	66	66	65	67
	Avg.	|E*| Average	18758	22095	23560	25631	26915	29707	30895	32454
		F Average	6.9	10.1	5.3	4.5	3.9	3.2	2.7	2.8
		|E*| Coeff. of Variation	0.047	0.101	0.051	0.047	0.040	0.047	0.050	0.048
		F Coeff. of Variation	0.03	0.31	0.47	0.05	0.19	0.16	0.18	0.18
		|E*| Std. Dev.	883.2	2226.0	1199.5	1215.4	1088.5	1386.0	1530.9	1559.4
		F Std. Dev.	0.218	3.089	2.484	0.217	0.734	0.517	0.474	0.492
10	1	|E*| (MPa)	5258	6942	8154	10993	12245	15221	16803	18863
		Phase Angle, F (º)	21.9	20.6	16.8	14.6	13.8	10.9	9.9	9.2
		Average Peak Stress (MPa)	0.367	0.479	0.565	0.706	0.818	1.098	1.211	1.324
		Average Peak Strain (με)	70	69	69	64	67	72	72	70
	2	|E*| (MPa)	5105	6985	8124	10477	11504	14412	15835	17609
		Phase Angle, F (º)	20.4	20.8	17.1	13.3	12.4	9.9	8.8	8.3
		Average Peak Stress (MPa)	0.366	0.480	0.565	0.706	0.819	1.098	1.211	1.325
		Average Peak Strain (με)	72	69	70	67	71	76	76	75
	3	|E*| (MPa)	5478	7378	8340	11112	12340	15597	17011	19084
		Phase Angle, F (º)	19.8	20.3	16.3	12.9	12.1	9.8	8.8	8.3
		Average Peak Stress (MPa)	0.367	0.480	0.564	0.706	0.818	1.099	1.210	1.324
		Average Peak Strain (με)	67	65	68	63	66	70	71	69
	Avg.	|E*| Average	5280	7101	8206	10861	12030	15077	16550	18519
		F Average	20.7	20.6	16.8	13.6	12.8	10.2	9.2	8.6
		|E*| Coeff. of Variation	0.036	0.034	0.014	0.031	0.038	0.040	0.038	0.043
		F Coeff. of Variation	0.05	0.01	0.02	0.06	0.07	0.06	0.07	0.06
		|E*| Std. Dev.	187.6	240.3	117.1	337.9	457.6	605.6	627.5	795.7
		F Std. Dev.	1.098	0.264	0.387	0.855	0.885	0.603	0.623	0.530
35	1	|E*| (MPa)	781	1084	1211	1901	2342	3824	4568	5721
		Phase Angle, F (º)	28.2	26.6	28.0	28.6	26.3	22.7	21.0	20.2
		Average Peak Stress (MPa)	0.025	0.034	0.050	0.078	0.168	0.222	0.305	0.447
		Average Peak Strain (με)	33	31	42	41	72	58	67	78
	2	|E*| (MPa)	741	1171	1240	1880	2342	3749	4505	5549
		Phase Angle, F (º)	28.6	27.3	27.4	27.7	25.3	22.0	20.2	19.7
		Average Peak Stress (MPa)	0.025	0.036	0.051	0.078	0.168	0.221	0.305	0.448
		Average Peak Strain (με)	34	31	41	42	72	59	68	81
	3	|E*| (MPa)	890	1256	1397	2119	2600	4165	4994	6147
		Phase Angle, F (º)	27.5	26.7	28.1	27.6	25.3	22.4	20.7	19.8
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.078	0.168	0.221	0.305	0.449
		Average Peak Strain (με)	29	27	36	37	65	53	61	73
	Avg.	|E*| Average	804	1171	1283	1967	2428	3913	4689	5805
		F Average	28.1	26.8	27.8	27.9	25.7	22.4	20.7	19.9
		|E*| Coeff. of Variation	0.096	0.073	0.078	0.067	0.061	0.057	0.057	0.053
		F Coeff. of Variation	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.01
		|E*| Std. Dev.	77.2	85.9	100.3	132.5	148.7	221.7	266.3	307.8
		F Std. Dev.	0.580	0.366	0.375	0.567	0.584	0.354	0.397	0.294
54.4	Est.	|E*| (MPa)	280	383	444	643	762	1147	1374	1748

Table B-62. S12.5CF–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	22539		25985	29425	30824	33479	34825	36061
		Phase Angle, F (º)	7.2		3.0	4.4	4.3	3.1	2.2	2.2
		Average Peak Stress (MPa)	1.212		1.468	1.640	1.750	1.863	1.953	2.082
		Average Peak Strain (με)	54		56	56	57	56	56	58
	2	|E*| (MPa)	20229	21630	25149	28083	29294	32103	33078	34344
		Phase Angle, F (º)	12.2	7.2	7.0	9.0	8.5	7.3	6.8	6.3
		Average Peak Stress (MPa)	1.356	1.525	1.582	1.753	1.808	1.975	2.034	2.200
		Average Peak Strain (με)	67	71	63	62	62	62	61	64
	3	|E*| (MPa)	22679	26985	27808	30896	31868	34691	35951	37288
		Phase Angle, F (º)	9.8	2.2	11.0	7.3	6.8	5.5	4.6	3.8
		Average Peak Stress (MPa)	1.356	1.525	1.582	1.753	1.809	1.973	2.033	2.191
		Average Peak Strain (με)	60	57	57	57	57	57	57	59
	Avg.	|E*| Average	21815	24307	26314	29468	30662	33424	34618	35898
		F Average	9.8	4.7	7.0	6.9	6.5	5.3	4.5	4.1
		|E*| Coeff. of Variation	0.063	0.156	0.052	0.048	0.042	0.039	0.042	0.041
		F Coeff. of Variation	0.26	0.74	0.57	0.34	0.33	0.41	0.50	0.49
		|E*| Std. Dev.	1375.5	3786.2	1359.9	1407.2	1294.5	1295.1	1447.8	1478.7
		F Std. Dev.	2.493	3.519	3.967	2.306	2.114	2.152	2.258	2.039
10	1	|E*| (MPa)	6662	8445	10798	13906	15072	18516	20024	22163
		Phase Angle, F (º)	21.4	18.0	18.4	13.8	12.2	9.9	8.7	8.3
		Average Peak Stress (MPa)	0.310	0.395	0.452	0.594	0.706	0.931	1.073	1.151
		Average Peak Strain (με)	47	47	42	43	47	50	54	52
	2	|E*| (MPa)	6242	8211	9710	13195	14654	18295	19859	22313
		Phase Angle, F (º)	27.3	22.5	19.9	18.3	16.2	13.9	12.9	12.1
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.707	0.820	1.099	1.213	1.324
		Average Peak Strain (με)	59	58	58	54	56	60	61	59
	3	|E*| (MPa)	6866	9942	11508	14655	16135	19436	21251	23557
		Phase Angle, F (º)	25.4	24.8	20.3	16.5	15.3	12.6	12.0	11.5
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.708	0.820	1.099	1.209	1.322
		Average Peak Strain (με)	54	48	49	48	51	57	57	56
	Avg.	|E*| Average	6590	8866	10672	13919	15287	18749	20378	22678
		F Average	24.7	21.8	19.5	16.2	14.6	12.1	11.2	10.6
		|E*| Coeff. of Variation	0.048	0.106	0.085	0.052	0.050	0.032	0.037	0.034
		F Coeff. of Variation	0.12	0.16	0.05	0.14	0.14	0.17	0.20	0.19
		|E*| Std. Dev.	318.3	939.5	905.8	729.6	763.7	605.0	760.2	765.3
		F Std. Dev.	3.015	3.444	0.980	2.263	2.072	2.028	2.205	2.029
35	1	|E*| (MPa)	558	949	1199	1885	2491	4238	5106	6481
		Phase Angle, F (º)	27.8	28.4	28.6	31.0	27.8	24.0	22.4	20.9
		Average Peak Stress (MPa)	0.028	0.057	0.085	0.113	0.169	0.250	0.305	0.392
		Average Peak Strain (με)	50	60	71	60	68	59	60	60
	2	|E*| (MPa)	695	974	1159	1802	2426	4154	5050	6332
		Phase Angle, F (º)	33.2	36.0	32.2	34.7	29.7	26.6	24.3	22.7
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.079	0.169	0.223	0.305	0.448
		Average Peak Strain (με)	37	35	44	44	70	54	60	71
	3	|E*| (MPa)	646	1017	1261	2054	2810	4732	5868	7399
		Phase Angle, F (º)	30.3	30.0	31.6	33.2	29.1	25.7	23.3	21.7
		Average Peak Stress (MPa)	0.034	0.042	0.057	0.085	0.168	0.219	0.302	0.443
		Average Peak Strain (με)	52	41	45	41	60	46	51	60
	Avg.	|E*| Average	633	980	1206	1914	2576	4375	5341	6737
		F Average	30.4	31.5	30.8	33.0	28.9	25.4	23.4	21.8
		|E*| Coeff. of Variation	0.109	0.035	0.043	0.067	0.080	0.071	0.086	0.086
		F Coeff. of Variation	0.09	0.13	0.06	0.06	0.03	0.05	0.04	0.04
		|E*| Std. Dev.	69.2	34.4	51.5	128.5	205.2	312.6	457.0	577.9
		F Std. Dev.	2.691	3.967	1.927	1.888	0.959	1.324	0.968	0.928
54.4	Est.	|E*| (MPa)	175	264	321	519	645	1084	1357	1823

Table B-63. S12.5CF–Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16085	19423	18827	21101	21971	23583	24343	25208
		Phase Angle, F (º)	5.5	4.6	2.9	3.8	3.0	2.4	1.7	1.9
		Average Peak Stress (MPa)	1.351	1.577	1.634	1.747	1.802	1.970	2.031	2.195
		Average Peak Strain (με)	84	81	87	83	82	84	83	87
	2	|E*| (MPa)	17149	18331	20053	22556	23324	25149	25879	26425
		Phase Angle, F (º)	8.4	9.7	4.5	5.6	5.2	4.4	3.8	3.7
		Average Peak Stress (MPa)	1.083	1.264	1.309	1.400	1.445	1.579	1.627	1.758
		Average Peak Strain (με)	63	69	65	62	62	63	63	67
	3	|E*| (MPa)	13243	17068	19071	21580	22773	24708	25437	26260
		Phase Angle, F (º)	12.4	9.2	8.0	7.6	7.0	6.1	5.1	4.6
		Average Peak Stress (MPa)	1.083	1.264	1.309	1.400	1.444	1.578	1.629	1.756
		Average Peak Strain (με)	82	74	69	65	63	64	64	67
	Avg.	|E*| Average	15492	18274	19317	21746	22690	24480	25220	25964
		F Average	8.8	7.8	5.1	5.7	5.1	4.3	3.6	3.4
		|E*| Coeff. of Variation	0.130	0.065	0.034	0.034	0.030	0.033	0.031	0.025
		F Coeff. of Variation	0.39	0.36	0.51	0.33	0.39	0.43	0.48	0.39
		|E*| Std. Dev.	2018.9	1179.0	648.7	741.7	680.3	807.6	790.7	660.2
		F Std. Dev.	3.443	2.830	2.620	1.882	1.993	1.854	1.700	1.339
10	1	|E*| (MPa)	5228	7027	8125	10395	11312	13806	15039	16427
		Phase Angle, F (º)	20.4	19.7	13.4	12.4	10.9	8.8	7.8	7.6
		Average Peak Stress (MPa)	0.226	0.316	0.384	0.497	0.587	0.811	0.924	1.010
		Average Peak Strain (με)	43	45	47	48	52	59	61	61
	2	|E*| (MPa)	5511	8188	8819	10954	12125	14957	16063	17474
		Phase Angle, F (º)	22.8	19.1	18.8	14.4	13.3	11.2	10.2	9.6
		Average Peak Stress (MPa)	0.226	0.316	0.384	0.497	0.587	0.812	0.924	1.014
		Average Peak Strain (με)	41	39	43	45	48	54	58	58
	3	|E*| (MPa)	5609	8147	8983	11257	12282	14796	15977	17450
		Phase Angle, F (º)	28.6	27.1	19.9	18.4	15.9	12.9	11.8	11.3
		Average Peak Stress (MPa)	0.226	0.316	0.384	0.497	0.587	0.811	0.925	1.012
		Average Peak Strain (με)	40	39	43	44	48	55	58	58
	Avg.	|E*| Average	5450	7787	8642	10869	11906	14520	15693	17117
		F Average	24.0	22.0	17.4	15.1	13.3	11.0	10.0	9.5
		|E*| Coeff. of Variation	0.036	0.085	0.053	0.040	0.044	0.043	0.036	0.035
		F Coeff. of Variation	0.18	0.20	0.20	0.20	0.19	0.19	0.20	0.19
		|E*| Std. Dev.	197.9	658.8	455.1	437.1	520.9	623.4	568.1	597.7
		F Std. Dev.	4.234	4.447	3.469	3.031	2.537	2.036	2.036	1.828
35	1	|E*| (MPa)	524	830	1047	1706	2173	3741	4599	5658
		Phase Angle, F (º)	26.2	28.1	28.5	29.8	27.6	22.4	20.5	19.9
		Average Peak Stress (MPa)	0.022	0.034	0.059	0.090	0.134	0.222	0.310	0.353
		Average Peak Strain (με)	43	41	56	53	62	59	67	62
	2	|E*| (MPa)	729	987	1140	1734	2205	3811	4613	5691
		Phase Angle, F (º)	23.5	27.5	30.1	31.9	29.6	25.7	22.9	22.4
		Average Peak Stress (MPa)	0.022	0.034	0.056	0.090	0.134	0.222	0.311	0.355
		Average Peak Strain (με)	31	34	50	52	61	58	67	62
	3	|E*| (MPa)	716	955	1135	1729	2196	3752	4570	5617
		Phase Angle, F (º)	31.5	31.8	30.1	32.2	30.1	25.6	23.1	22.1
		Average Peak Stress (MPa)	0.023	0.034	0.059	0.090	0.134	0.222	0.311	0.355
		Average Peak Strain (με)	32	35	52	52	61	59	68	63
	Avg.	|E*| Average	656	924	1107	1723	2191	3768	4594	5655
		F Average	27.1	29.1	29.6	31.3	29.1	24.6	22.1	21.5
		|E*| Coeff. of Variation	0.174	0.090	0.047	0.009	0.008	0.010	0.005	0.007
		F Coeff. of Variation	0.15	0.08	0.03	0.04	0.05	0.08	0.07	0.06
		|E*| Std. Dev.	114.4	83.0	52.2	15.2	16.6	37.4	21.8	37.4
		F Std. Dev.	4.083	2.311	0.900	1.305	1.332	1.855	1.454	1.350
54.4	1	|E*| (MPa)	247	296	320	447	551	976	1278	1798
		Phase Angle, F (º)	10.5	11.5	20.8	23.8	25.0	25.9	25.0	25.9
		Average Peak Stress (MPa)	0.004	0.007	0.011	0.023	0.029	0.049	0.071	0.095
		Average Peak Strain (με)	18	23	36	51	53	50	56	53
	2	|E*| (MPa)		448	489	556	641	1049	1325	1800
		Phase Angle, F (º)		14.7	15.4	22.0	24.9	27.1	26.2	27.3
		Average Peak Stress (MPa)		0.007	0.011	0.023	0.029	0.049	0.071	0.095
		Average Peak Strain (με)		15	23	41	46	47	54	53
	3	|E*| (MPa)	516	473	416	511	603	998	1316	1815
		Phase Angle, F (º)	20.0	25.4	24.2	26.3	27.1	28.1	26.6	28.2
		Average Peak Stress (MPa)	0.005	0.007	0.011	0.023	0.029	0.049	0.072	0.094
		Average Peak Strain (με)	9	14	27	44	48	49	54	52
	Avg.	|E*| Average	382	406	408	505	598	1008	1306	1804
		F Average	15.3	17.2	20.1	24.0	25.7	27.0	26.0	27.1
		|E*| Coeff. of Variation	0.498	0.237	0.208	0.109	0.075	0.037	0.019	0.005
		F Coeff. of Variation	0.44	0.42	0.22	0.09	0.05	0.04	0.03	0.04
		|E*| Std. Dev.	190.1	96.0	84.8	54.9	45.0	37.1	24.9	9.6
		F Std. Dev.	6.731	7.292	4.434	2.160	1.270	1.079	0.827	1.175

Table B-64. S12.5DC–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	20674	21519	27178	29179	30302	32928	34041	35616
		Phase Angle, F (º)	12.2	13.7	11.9	8.8	8.1	6.7	6.2	6.0
		Average Peak Stress (MPa)	1.270	1.467	1.524	1.696	1.806	1.918	2.004	2.134
		Average Peak Strain (με)	61	68	56	58	60	58	59	60
	2	|E*| (MPa)	20772	22398	25808	29546	31089	33935	35201	36661
		Phase Angle, F (º)	8.5	4.6	5.8	5.8	5.2	4.0	3.7	3.7
		Average Peak Stress (MPa)	1.213	1.411	1.468	1.639	1.748	1.859	1.948	2.072
		Average Peak Strain (με)	58	63	57	55	56	55	55	57
	3	|E*| (MPa)	21144		24997	29721	30696	34081	35283	36758
		Phase Angle, F (º)	7.9		6.4	5.1	4.4	3.4	2.6	2.9
		Average Peak Stress (MPa)	1.269		1.524	1.696	1.805	1.917	2.005	2.134
		Average Peak Strain (με)	60		61	57	59	56	57	58
	Avg.	|E*| Average	20863	21958	25994	29482	30695	33648	34842	36345
		F Average	9.5	9.2	8.0	6.6	5.9	4.7	4.2	4.2
		|E*| Coeff. of Variation	0.012	0.028	0.042	0.009	0.013	0.019	0.020	0.017
		F Coeff. of Variation	0.25	0.70	0.42	0.30	0.33	0.38	0.44	0.39
		|E*| Std. Dev.	247.9	621.6	1102.2	276.8	393.5	627.8	694.8	633.3
		F Std. Dev.	2.345	6.439	3.361	1.963	1.978	1.775	1.814	1.615
10	1	|E*| (MPa)	5360	7877	9248	12440	13835	17138	18871	19845
		Phase Angle, F (º)	27.0	18.3	18.7	18.0	16.1	12.7	11.6	9.6
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.706	0.818	1.071	1.241	1.325
		Average Peak Strain (με)	68	61	61	57	59	62	66	67
	2	|E*| (MPa)	5841	9157	10405	13350	14682	18209	19830	22215
		Phase Angle, F (º)	23.5	23.5	18.9	15.4	14.5	11.4	10.6	10.1
		Average Peak Stress (MPa)	0.310	0.395	0.452	0.593	0.705	0.929	1.071	1.150
		Average Peak Strain (με)	53	43	43	44	48	51	54	52
	3	|E*| (MPa)								
		Phase Angle, F (º)								
		Average Peak Stress (MPa)								
		Average Peak Strain (με)								
	Avg.	|E*| Average	5600	8517	9827	12895	14258	17674	19351	21030
		F Average	25.2	20.9	18.8	16.7	15.3	12.1	11.1	9.8
		|E*| Coeff. of Variation	0.061	0.106	0.083	0.050	0.042	0.043	0.035	0.080
		F Coeff. of Variation	0.10	0.18	0.01	0.11	0.07	0.08	0.06	0.04
		|E*| Std. Dev.	340.3	905.7	818.0	643.4	598.8	757.6	678.1	1675.4
		F Std. Dev.	2.529	3.662	0.161	1.796	1.139	0.959	0.693	0.399
35	1	|E*| (MPa)	524	827	1067	1586	2186	3773	4719	6154
		Phase Angle, F (º)	25.1	25.6	26.2	31.8	28.3	26.1	24.7	23.6
		Average Peak Stress (MPa)	0.071	0.113	0.169	0.198	0.281	0.390	0.446	0.565
		Average Peak Strain (με)	135	136	159	125	128	103	94	92
	2	|E*| (MPa)	472	747	947	1481	2034	3635	4570	6001
		Phase Angle, F (º)	25.2	26.8	26.5	31.1	28.3	24.9	23.6	22.7
		Average Peak Stress (MPa)	0.042	0.071	0.113	0.141	0.196	0.305	0.361	0.450
		Average Peak Strain (με)	89	94	119	95	97	84	79	75
	3	|E*| (MPa)	505	818	1076	1655	2290	3951	4941	6457
		Phase Angle, F (º)	23.9	25.4	25.3	30.7	27.1	24.2	23.1	22.2
		Average Peak Stress (MPa)	0.070	0.113	0.169	0.198	0.281	0.390	0.445	0.563
		Average Peak Strain (με)	140	138	157	119	123	99	90	87
	Avg.	|E*| Average	500	797	1030	1574	2170	3786	4743	6204
		F Average	24.7	25.9	26.0	31.2	27.9	25.1	23.8	22.9
		|E*| Coeff. of Variation	0.053	0.055	0.070	0.056	0.059	0.042	0.039	0.037
		F Coeff. of Variation	0.03	0.03	0.02	0.02	0.02	0.04	0.03	0.03
		|E*| Std. Dev.	26.4	43.9	72.3	87.9	129.1	158.7	186.6	232.2
		F Std. Dev.	0.697	0.754	0.586	0.598	0.694	0.931	0.790	0.696
54.4	Est.	|E*| (MPa)	127.4	198.3	243.9	406.5	511.7	884.1	1120.2	1526.9

Table B-65. S12.5DF–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	21274	23784	24782	28509	29395	31576	32765	34053
		Phase Angle, F (º)	9.8	1.0	5.1	7.2	7.4	6.1	5.4	5.4
		Average Peak Stress (MPa)	1.214	1.440	1.497	1.640	1.694	1.863	1.921	2.079
		Average Peak Strain (με)	57	61	60	58	58	59	59	61
	2	|E*| (MPa)		20914	23869	28057	29116	31507	32542	
		Phase Angle, F (º)		5.7	6.9	4.8	4.9	3.9	4.0	
		Average Peak Stress (MPa)		1.440	1.497	1.639	1.693	1.863	1.918	
		Average Peak Strain (με)		69	63	58	58	59	59	
	3	|E*| (MPa)	20390	21438	24408	26198	27289	29516	30370	
		Phase Angle, F (º)	6.8	1.2	2.8	4.9	4.8	3.6	3.3	
		Average Peak Stress (MPa)	1.214	1.440	1.497	1.640	1.694	1.863	1.924	
		Average Peak Strain (με)	60	67	61	63	62	63	63	
	Avg.	|E*| Average	20832	22045	24353	27588	28600	30866	31892	34053
		F Average	8.3	2.6	4.9	5.6	5.7	4.5	4.2	5.4
		|E*| Coeff. of Variation	0.030	0.069	0.019	0.044	0.040	0.038	0.041	
		F Coeff. of Variation	0.25	1.01	0.42	0.25	0.25	0.31	0.26	
		|E*| Std. Dev.	625.0	1528.2	459.2	1225.1	1144.2	1169.6	1323.3	
		F Std. Dev.	2.108	2.664	2.055	1.403	1.435	1.387	1.096	
10	1	|E*| (MPa)	7460	8894	10338	14074	15080	18097	19466	21420
		Phase Angle, F (º)	28.6	16.3	23.1	17.5	15.7	13.7	12.2	12.1
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.507	0.704	0.819	0.919
		Average Peak Strain (με)	19	27	27	28	34	39	42	43
	2	|E*| (MPa)	7022	9168	11641	13661	15042	18138	19642	21599
		Phase Angle, F (º)	23.8	28.0	15.6	14.0	13.3	10.5	9.1	8.6
		Average Peak Stress (MPa)	0.141	0.240	0.282	0.395	0.507	0.703	0.819	0.919
		Average Peak Strain (με)	20	26	24	29	34	39	42	43
	3	|E*| (MPa)	7775	11148	10855	13845	14851	17582	18963	20573
		Phase Angle, F (º)	23.1	27.6	13.5	14.8	12.7	10.0	9.3	8.8
		Average Peak Stress (MPa)	0.141	0.240	0.283	0.396	0.508	0.703	0.820	0.921
		Average Peak Strain (με)	18	22	26	29	34	40	43	45
	Avg.	|E*| Average	7419	9737	10945	13860	14991	17939	19357	21197
		F Average	25.2	24.0	17.4	15.4	13.9	11.4	10.2	9.8
		|E*| Coeff. of Variation	0.051	0.126	0.060	0.015	0.008	0.017	0.018	0.026
		F Coeff. of Variation	0.12	0.28	0.29	0.12	0.11	0.18	0.17	0.20
		|E*| Std. Dev.	378.2	1229.9	656.1	206.7	122.8	309.4	352.4	547.9
		F Std. Dev.	2.960	6.656	5.043	1.850	1.570	2.009	1.749	1.977
35	1	|E*| (MPa)	628	1027	1257	2136	2602	4259	5344	6505
		Phase Angle, F (º)	35.9	37.2	37.9	37.4	35.2	29.9	28.1	24.8
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.056	0.110	0.137	0.249
		Average Peak Strain (με)	27	22	22	17	21	26	26	38
	2	|E*| (MPa)	608	953	1156	1905	2349	4077	5003	6231
		Phase Angle, F (º)	32.7	32.1	34.9	34.4	33.1	27.6	26.3	23.0
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.036	0.055	0.110	0.136	0.247
		Average Peak Strain (με)	28	24	24	19	24	27	27	40
	3	|E*| (MPa)	670	1072	1343	2261	2721	4452	5394	6580
		Phase Angle, F (º)	34.7	34.8	34.6	34.4	32.4	26.5	24.5	22.1
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.056	0.110	0.137	0.249
		Average Peak Strain (με)	25	21	21	16	21	25	25	38
	Avg.	|E*| Average	636	1018	1252	2101	2557	4263	5247	6439
		F Average	34.4	34.7	35.8	35.4	33.6	28.0	26.3	23.3
		|E*| Coeff. of Variation	0.050	0.059	0.075	0.086	0.074	0.044	0.041	0.029
		F Coeff. of Variation	0.05	0.07	0.05	0.05	0.04	0.06	0.07	0.06
		|E*| Std. Dev.	31.6	60.2	93.4	180.5	189.9	187.3	212.9	183.7
		F Std. Dev.	1.653	2.528	1.813	1.773	1.462	1.729	1.792	1.390

Table B-66. I19.0BC–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	15957	17773	19485	23351	24588	27439	28730	30202
		Phase Angle, F (º)	10.5	11.9	7.5	6.8	6.3	5.3	4.9	4.6
		Average Peak Stress (MPa)	1.353	1.579	1.636	1.749	1.804	1.970	2.029	2.190
		Average Peak Strain (με)	85	89	84	75	73	72	71	73
	2	|E*| (MPa)	15141	19635	19685	22179	23379	26174	27318	28733
		Phase Angle, F (º)	8.9	5.0	4.2	4.7	4.3	3.2	2.4	2.4
		Average Peak Stress (MPa)	1.353	1.579	1.636	1.749	1.804	1.970	2.030	2.191
		Average Peak Strain (με)	89	80	83	79	77	75	74	76
	3	|E*| (MPa)	17376	23261	21816	26005	27572	30807	32332	34190
		Phase Angle, F (º)	11.7	10.8	10.4	8.0	7.2	6.0	5.4	5.6
		Average Peak Stress (MPa)	1.353	1.579	1.636	1.749	1.804	1.970	2.030	2.193
		Average Peak Strain (με)	78	68	75	67	65	64	63	64
	Avg.	|E*| Average	16158	20223	20328	23845	25180	28140	29460	31042
		F Average	10.4	9.2	7.4	6.5	6.0	4.8	4.2	4.2
		|E*| Coeff. of Variation	0.070	0.138	0.064	0.082	0.086	0.085	0.088	0.091
		F Coeff. of Variation	0.14	0.40	0.43	0.26	0.25	0.30	0.37	0.39
		|E*| Std. Dev.	1130.8	2790.9	1292.3	1960.4	2158.3	2394.6	2585.3	2823.6
		F Std. Dev.	1.415	3.700	3.146	1.675	1.477	1.462	1.576	1.616
10	1	|E*| (MPa)	3315	5307	6153	8556	9846	13154	14698	16783
		Phase Angle, F (º)	27.0	22.9	21.9	19.0	17.5	14.0	12.6	11.8
		Average Peak Stress (MPa)	0.367	0.479	0.564	0.706	0.817	1.097	1.208	1.319
		Average Peak Strain (με)	111	90	92	82	83	83	82	79
	2	|E*| (MPa)	2888	4385	5381	7744	8974	12185	13717	15580
		Phase Angle, F (º)	26.6	25.1	20.7	18.3	16.6	12.8	11.5	10.5
		Average Peak Stress (MPa)	0.367	0.479	0.564	0.706	0.817	1.097	1.208	1.320
		Average Peak Strain (με)	127	109	105	91	91	90	88	85
	3	|E*| (MPa)	3527	5512	6697	9387	10765	14396	16188	18624
		Phase Angle, F (º)	28.0	27.4	23.0	20.2	18.6	14.9	13.5	12.5
		Average Peak Stress (MPa)	0.367	0.479	0.564	0.705	0.817	1.097	1.208	1.321
		Average Peak Strain (με)	104	87	84	75	76	76	75	71
	Avg.	|E*| Average	3244	5068	6077	8562	9862	13245	14868	16996
		F Average	27.2	25.1	21.9	19.2	17.5	13.9	12.5	11.6
		|E*| Coeff. of Variation	0.100	0.118	0.109	0.096	0.091	0.084	0.084	0.090
		F Coeff. of Variation	0.03	0.09	0.05	0.05	0.06	0.08	0.08	0.08
		|E*| Std. Dev.	325.5	600.1	661.1	821.1	895.6	1108.4	1244.3	1532.9
		F Std. Dev.	0.717	2.290	1.175	0.976	1.008	1.048	1.015	0.974
35	1	|E*| (MPa)	298	449	563	971	1370	2438	3108	4220
		Phase Angle, F (º)	26.3	29.5	28.7	31.7	28.5	27.8	26.4	25.5
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.078	0.168	0.221	0.302	0.441
		Average Peak Strain (με)	85	75	90	81	122	90	97	104
	2	|E*| (MPa)	253	390	494	850	1209	2123	2738	3744
		Phase Angle, F (º)	22.3	25.1	25.5	29.1	26.8	26.4	25.2	24.8
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.079	0.168	0.220	0.302	0.440
		Average Peak Strain (με)	100	87	103	92	139	104	110	117
	3	|E*| (MPa)	327	490	590	989	1363	2400	3080	4185
		Phase Angle, F (º)	26.6	28.8	29.1	31.5	28.3	27.6	26.8	25.5
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.078	0.168	0.220	0.302	0.440
		Average Peak Strain (με)	78	69	86	79	123	92	98	105
	Avg.	|E*| Average	293	443	549	937	1314	2320	2976	4050
		F Average	25.1	27.8	27.8	30.8	27.9	27.2	26.1	25.3
		|E*| Coeff. of Variation	0.127	0.113	0.091	0.081	0.070	0.074	0.069	0.065
		F Coeff. of Variation	0.10	0.08	0.07	0.05	0.03	0.03	0.03	0.02
		|E*| Std. Dev.	37.2	50.2	49.8	75.7	91.3	171.8	205.9	265.0
		F Std. Dev.	2.433	2.360	1.984	1.461	0.945	0.779	0.821	0.384
54.4	Est.	|E*| (MPa)	78	110	131	203	250	422	534	735

Table B-67. I19.0BC-Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	22909	25635	27922	29251	29794	31626	32320	33399
		Phase Angle, F (º)	8.4	13.3	5.8	6.2	5.6	3.8	2.9	3.1
		Average Peak Stress (MPa)	1.353	1.578	1.635	1.748	1.803	1.970	2.031	2.192
		Average Peak Strain (με)	59	62	59	60	61	62	63	66
	2	|E*| (MPa)	19329	20766	23867	25990	26833	28871	29730	30791
		Phase Angle, F (º)	9.0	8.9	9.0	5.6	5.0	4.4	3.9	3.8
		Average Peak Stress (MPa)	1.353	1.578	1.635	1.748	1.803	1.970	2.030	2.192
		Average Peak Strain (με)	70	76	69	67	67	68	68	71
	3	|E*| (MPa)	20059	24242	24683	25912	26839	29023	29851	30691
		Phase Angle, F (º)	7.5	10.5	6.2	4.7	4.4	2.9	2.4	2.8
		Average Peak Stress (MPa)	1.353	1.579	1.635	1.748	1.803	1.970	2.031	2.194
		Average Peak Strain (με)	67	65	66	67	67	68	68	71
	Avg.	|E*| Average	20766	23548	25491	27051	27822	29840	30634	31627
		F Average	8.3	10.9	7.0	5.5	5.0	3.7	3.1	3.2
		|E*| Coeff. of Variation	0.091	0.106	0.084	0.070	0.061	0.052	0.048	0.049
		F Coeff. of Variation	0.09	0.20	0.25	0.14	0.13	0.21	0.24	0.16
		|E*| Std. Dev.	1891.5	2507.6	2144.4	1905.4	1708.0	1548.3	1461.6	1535.6
		F Std. Dev.	0.764	2.224	1.733	0.759	0.642	0.779	0.743	0.521
10	1	|E*| (MPa)	5733	8094	9598	13010	14469	17732	19239	21424
		Phase Angle, F (º)	29.4	26.6	23.2	18.7	16.5	12.3	11.0	10.3
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.620	0.733	1.011	1.154	1.264
		Average Peak Strain (με)	49	49	50	48	51	57	60	59
	2	|E*| (MPa)	5400	8241	8531	11508	12553	15812	17560	19447
		Phase Angle, F (º)	26.8	20.9	19.9	17.1	15.3	11.6	10.9	9.9
		Average Peak Stress (MPa)	0.282	0.395	0.479	0.620	0.733	1.013	1.153	1.263
		Average Peak Strain (με)	52	48	56	54	58	64	66	65
	3	|E*| (MPa)	5692	7680	9438	12395	13668	16938	18399	20251
		Phase Angle, F (º)	26.7	20.6	17.5	16.0	13.7	10.5	9.1	8.5
		Average Peak Stress (MPa)	0.282	0.395	0.479	0.620	0.733	1.012	1.155	1.267
		Average Peak Strain (με)	50	51	51	50	54	60	63	63
	Avg.	|E*| Average	5608	8005	9189	12304	13563	16827	18400	20374
		F Average	27.6	22.7	20.2	17.3	15.2	11.5	10.3	9.6
		|E*| Coeff. of Variation	0.032	0.036	0.063	0.061	0.071	0.057	0.046	0.049
		F Coeff. of Variation	0.05	0.15	0.14	0.08	0.09	0.08	0.10	0.10
		|E*| Std. Dev.	181.3	290.9	575.7	754.9	962.1	964.8	839.4	994.0
		F Std. Dev.	1.508	3.358	2.864	1.351	1.415	0.900	1.048	0.974
35	1	|E*| (MPa)	503	772	997	1780	2400	4367	5443	6999
		Phase Angle, F (º)	31.4	33.0	33.0	36.1	33.6	29.9	26.4	24.1
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.221	0.393
		Average Peak Strain (με)	28	36	37	36	41	31	41	56
	2	|E*| (MPa)	478	751	961	1703	2276	4052	5118	6514
		Phase Angle, F (º)	29.3	31.2	31.7	33.6	30.9	27.8	24.4	22.0
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.221	0.394
		Average Peak Strain (με)	30	37	38	38	43	34	43	60
	3	|E*| (MPa)	503	787	984	1741	2302	4046	5140	6660
		Phase Angle, F (º)	29.9	32.2	31.9	33.5	31.2	28.4	24.4	21.8
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.221	0.395
		Average Peak Strain (με)	28	36	37	37	42	34	43	59
	Avg.	|E*| Average	494	770	980	1741	2326	4155	5234	6724
		F Average	30.2	32.1	32.2	34.4	31.9	28.7	25.1	22.6
		|E*| Coeff. of Variation	0.029	0.023	0.019	0.022	0.028	0.044	0.035	0.037
		F Coeff. of Variation	0.04	0.03	0.02	0.04	0.05	0.04	0.05	0.06
		|E*| Std. Dev.	14.1	18.0	18.2	38.1	65.6	183.7	181.4	248.7
		F Std. Dev.	1.097	0.910	0.743	1.469	1.504	1.078	1.172	1.247
54.4	1	|E*| (MPa)	290	284	260	369	463	871	1218	1831
		Phase Angle, F (º)	17.4	19.4	21.0	23.9	25.3	27.6	26.6	27.4
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.092	0.128
		Average Peak Strain (με)	20	30	54	76	78	70	75	70
	2	|E*| (MPa)	259	260	269	378	472	873	1211	1818
		Phase Angle, F (º)	15.2	17.6	21.6	24.8	26.0	28.1	27.0	27.9
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.091	0.127
		Average Peak Strain (με)	22	33	53	74	76	70	75	70
	3	|E*| (MPa)	231	268	285	400	496	920	1257	1890
		Phase Angle, F (º)	13.4	19.0	19.5	23.5	24.7	26.9	26.6	27.8
		Average Peak Stress (MPa)	0.006	0.008	0.014	0.028	0.036	0.062	0.091	0.127
		Average Peak Strain (με)	24	32	50	70	73	67	73	67
	Avg.	|E*| Average	260	271	272	382	477	888	1229	1846
		F Average	15.3	18.6	20.7	24.1	25.3	27.6	26.8	27.7
		|E*| Coeff. of Variation	0.113	0.046	0.047	0.042	0.035	0.031	0.020	0.021
		F Coeff. of Variation	0.13	0.05	0.05	0.03	0.03	0.02	0.01	0.01
		|E*| Std. Dev.	29.5	12.5	12.9	16.1	16.6	27.8	25.1	38.4
		F Std. Dev.	2.037	0.949	1.077	0.658	0.640	0.617	0.241	0.233

Table B-68. I19.0B0F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16608	21479	21280	24785	26011	28798	29930	31413
		Phase Angle, F (º)	11.3	4.5	9.9	6.5	5.2	4.1	3.6	3.6
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.752	1.808	1.976	2.034	2.196
		Average Peak Strain (με)	82	74	77	71	69	69	68	70
	2	|E*| (MPa)	19383		26073	28731	30061	33060	34365	35949
		Phase Angle, F (º)	12.1		6.4	7.1	5.5	5.6	3.9	4.0
		Average Peak Stress (MPa)	1.218		1.473	1.575	1.624	1.773	1.826	1.969
		Average Peak Strain (με)	63		56	55	54	54	53	55
	3	|E*| (MPa)	16943	18102	21600	24902	26275	28823	29731	30942
		Phase Angle, F (º)	9.7	11.2	3.1	4.9	4.6	3.2	2.7	2.8
		Average Peak Stress (MPa)	0.947	1.105	1.145	1.225	1.263	1.378	1.420	1.530
		Average Peak Strain (με)	56	61	53	49	48	48	48	49
	Avg.	|E*| Average	17645	19791	22984	26139	27449	30227	31342	32768
		F Average	11.0	7.9	6.5	6.2	5.1	4.3	3.4	3.5
		|E*| Coeff. of Variation	0.086	0.121	0.117	0.086	0.083	0.081	0.084	0.084
		F Coeff. of Variation	0.11	0.60	0.52	0.18	0.09	0.29	0.19	0.18
		|E*| Std. Dev.	1514.7	2388.1	2679.6	2245.6	2266.0	2453.7	2619.5	2764.9
		F Std. Dev.	1.225	4.685	3.396	1.111	0.465	1.243	0.636	0.623
10	1	|E*| (MPa)	2767	4529	5642	8417	9822	13556	15331	17274
		Phase Angle, F (º)	31.7	28.7	25.3	21.8	18.4	15.2	15.3	12.2
		Average Peak Stress (MPa)	0.257	0.336	0.395	0.494	0.573	0.767	0.844	1.322
		Average Peak Strain (με)	93	74	70	59	58	57	55	77
	2	|E*| (MPa)	3454	6158	6820	10217	11787	15577	17247	19541
		Phase Angle, F (º)	31.6	25.9	25.7	21.4	18.4	14.9	13.2	12.4
		Average Peak Stress (MPa)	0.257	0.334	0.395	0.495	0.573	0.767	0.883	0.961
		Average Peak Strain (με)	74	54	58	48	49	49	51	49
	3	|E*| (MPa)	3002	5125	6056	8926	10368	13828	15434	17597
		Phase Angle, F (º)	31.0	24.0	24.9	19.1	15.9	13.2	11.6	10.8
		Average Peak Stress (MPa)	0.257	0.335	0.395	0.495	0.574	0.767	0.885	0.962
		Average Peak Strain (με)	85	65	65	55	55	55	57	55
	Avg.	|E*| Average	3074	5270	6173	9187	10659	14320	16004	18137
		F Average	31.4	26.2	25.3	20.7	17.6	14.5	13.4	11.8
		|E*| Coeff. of Variation	0.114	0.156	0.097	0.101	0.095	0.077	0.067	0.068
		F Coeff. of Variation	0.01	0.09	0.01	0.07	0.08	0.07	0.14	0.08
		|E*| Std. Dev.	349.4	824.2	597.5	927.6	1014.0	1096.3	1077.5	1226.1
		F Std. Dev.	0.407	2.355	0.372	1.458	1.462	1.074	1.851	0.890
35	1	|E*| (MPa)	188		353	676	1012	1960	2662	3833
		Phase Angle, F (º)	19.3		30.7	35.3	31.3	31.4	29.9	28.8
		Average Peak Stress (MPa)	0.016		0.031	0.047	0.100	0.128	0.178	0.259
		Average Peak Strain (με)	86		87	70	99	65	67	68
	2	|E*| (MPa)		311	416	790	1123	2194	2964	4243
		Phase Angle, F (º)		30.0	30.6	33.8	31.2	31.3	28.8	27.5
		Average Peak Stress (MPa)		0.023	0.030	0.055	0.098	0.151	0.208	0.305
		Average Peak Strain (με)		73	71	70	87	69	70	72
	3	|E*| (MPa)	168	262	349	674	984	2031	2653	3773
		Phase Angle, F (º)	26.1	28.1	30.2	33.9	31.1	30.1	28.6	27.2
		Average Peak Stress (MPa)	0.014	0.023	0.030	0.055	0.097	0.155	0.208	0.305
		Average Peak Strain (με)	86	89	85	82	99	76	78	81
	Avg.	|E*| Average	178	287	373	713	1040	2062	2759	3950
		F Average	22.7	29.0	30.5	34.3	31.2	30.9	29.1	27.8
		|E*| Coeff. of Variation	0.078	0.120	0.102	0.093	0.070	0.058	0.064	0.065
		F Coeff. of Variation	0.21	0.05	0.01	0.02	0.00	0.02	0.02	0.03
		|E*| Std. Dev.	13.9	34.4	38.0	66.6	73.1	119.9	176.8	255.9
		F Std. Dev.	4.817	1.347	0.241	0.802	0.126	0.697	0.661	0.865
54.4	Est.	|E*| (MPa)	41	61	75	125	160	298	395	579

Table B-69. I19.0B1F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	21830	26843	25994	30727	32256	35426	36482	38083
		Phase Angle, F (º)	7.4	-1.2	2.5	3.7	3.3	2.4	1.9	2.0
		Average Peak Stress (MPa)	1.214	1.440	1.497	1.640	1.695	1.863	1.922	2.078
		Average Peak Strain (με)	56	54	58	53	53	53	53	55
	2	|E*| (MPa)	21336	23309	29176	31219	32658	36331		
		Phase Angle, F (º)	13.7	7.5	9.0	9.9	10.0	9.1		
		Average Peak Stress (MPa)	1.214	1.440	1.497	1.640	1.694	1.863		
		Average Peak Strain (με)	57	62	51	53	52	51		
	3	|E*| (MPa)	22319	23547	28243	31443	32955	36356	37115	39189
		Phase Angle, F (º)	11.9	11.4	13.4	9.1	8.6	7.9	6.8	6.7
		Average Peak Stress (MPa)	1.214	1.440	1.497	1.640	1.694	1.862	1.921	2.076
		Average Peak Strain (με)	54	61	53	52	51	51	52	53
	Avg.	|E*| Average	21828	24567	27804	31130	32623	36038	36798	38636
		F Average	11.0	5.9	8.3	7.6	7.3	6.5	4.4	4.3
		|E*| Coeff. of Variation	0.023	0.080	0.059	0.012	0.011	0.015	0.012	0.020
		F Coeff. of Variation	0.29	1.09	0.66	0.44	0.49	0.55	0.79	0.77
		|E*| Std. Dev.	491.6	1975.5	1636.1	366.4	350.5	529.9	447.8	782.0
		F Std. Dev.	3.239	6.450	5.481	3.352	3.566	3.526	3.466	3.331
10	1	|E*| (MPa)	5100	8578	9059	12710	14249	18437	20257	22823
		Phase Angle, F (º)	26.8	29.6	23.7	17.5	14.8	11.7	10.4	9.5
		Average Peak Stress (MPa)	0.141	0.240	0.283	0.395	0.508	0.704	0.819	0.919
		Average Peak Strain (με)	28	28	31	31	36	38	40	40
	2	|E*| (MPa)	5290	9538	8901	13391	14709	19086	21129	23643
		Phase Angle, F (º)	35.2	28.4	27.7	24.4	22.6	18.7	17.5	16.0
		Average Peak Stress (MPa)	0.141	0.240	0.283	0.395	0.508	0.704	0.820	0.921
		Average Peak Strain (με)	27	25	32	30	35	37	39	39
	3	|E*| (MPa)	5816	7865	10293	13724	15033	19219	21163	23764
		Phase Angle, F (º)	34.9	33.1	29.7	22.7	21.6	17.8	17.0	15.2
		Average Peak Stress (MPa)	0.141	0.240	0.283	0.395	0.507	0.704	0.819	0.918
		Average Peak Strain (με)	24	31	27	29	34	37	39	39
	Avg.	|E*| Average	5402	8660	9418	13275	14664	18914	20850	23410
		F Average	32.3	30.4	27.0	21.6	19.7	16.1	15.0	13.6
		|E*| Coeff. of Variation	0.069	0.097	0.081	0.039	0.027	0.022	0.025	0.022
		F Coeff. of Variation	0.15	0.08	0.11	0.17	0.22	0.24	0.26	0.26
		|E*| Std. Dev.	371.1	839.7	762.2	516.9	394.4	418.6	513.6	512.1
		F Std. Dev.	4.758	2.435	3.082	3.608	4.244	3.804	3.961	3.509
35	1	|E*| (MPa)	357	603	763	1403	1863	3575	4509	6053
		Phase Angle, F (º)	25.3	29.3	30.6	33.3	32.4	27.7	25.9	23.8
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.056	0.110	0.136	0.247
		Average Peak Strain (με)	47	37	37	26	30	31	30	41
	2	|E*| (MPa)	551	753	921	1577	1980	3661		
		Phase Angle, F (º)	30.2	32.1	34.0	38.1	36.1	33.5		
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.056	0.110		
		Average Peak Strain (με)	31	30	31	23	28	30		
	3	|E*| (MPa)	586	842	1066	1874	2309	4080	5330	6674
		Phase Angle, F (º)	31.0	33.8	36.2	40.3	37.9	33.9	33.0	29.2
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.037	0.056	0.110	0.137	0.247
		Average Peak Strain (με)	29	27	26	20	24	27	26	37
	Avg.	|E*| Average	498	733	917	1618	2051	3772	4920	6364
		F Average	28.8	31.7	33.6	37.2	35.5	31.7	29.5	26.5
		|E*| Coeff. of Variation	0.248	0.165	0.165	0.147	0.113	0.072	0.118	0.069
		F Coeff. of Variation	0.11	0.07	0.08	0.10	0.08	0.11	0.17	0.14
		|E*| Std. Dev.	123.4	120.9	151.7	237.8	231.2	270.6	580.6	438.9
		F Std. Dev.	3.122	2.252	2.818	3.564	2.807	3.485	4.971	3.807
54.4	1	|E*| (MPa)		197	212	295	362	658	867	1302
		Phase Angle, F (º)		19.1	17.2	22.0	24.4	29.4	30.7	32.1
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.024	0.028
		Average Peak Strain (με)		28	40	38	46	32	28	21
	2	|E*| (MPa)		535	521	499	520	777	1002	1508
		Phase Angle, F (º)		6.7	12.6	21.8	24.2	30.3	32.3	35.5
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.024	0.027
		Average Peak Strain (με)		10	16	22	32	27	24	18
	3	|E*| (MPa)		611	501	514	550	870	1137	1698
		Phase Angle, F (º)		21.2	13.8	22.5	24.1	31.8	32.6	35.7
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.024	0.028
		Average Peak Strain (με)		9	17	22	30	24	21	16
	Avg.	|E*| Average		448	411	436	478	768	1002	1503
		F Average		15.7	14.5	22.1	24.2	30.5	31.9	34.5
		|E*| Coeff. of Variation		0.492	0.421	0.280	0.211	0.138	0.135	0.132
		F Coeff. of Variation		0.50	0.16	0.02	0.01	0.04	0.03	0.06
		|E*| Std. Dev.		220.6	173.0	122.1	100.9	106.3	134.8	198.1
		F Std. Dev.		7.853	2.378	0.362	0.176	1.204	1.011	2.025

Table B-70. I19.0B2F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	17253	18971	21945	23616	24612	26910	27822	28992
		Phase Angle, F (º)	7.5	10.6	5.9	5.1	4.8	3.5	3.0	2.7
		Average Peak Stress (MPa)	1.214	1.440	1.497	1.640	1.694	1.862	1.920	2.078
		Average Peak Strain (με)	70	76	68	69	69	69	69	72
	2	|E*| (MPa)	18197	22739	22714	24634	25591	27965	28846	30155
		Phase Angle, F (º)	7.8	9.7	7.7	5.1	4.7	3.8	3.2	3.0
		Average Peak Stress (MPa)	1.355	1.581	1.638	1.750	1.806	1.975	2.034	2.195
		Average Peak Strain (με)	74	70	72	71	71	71	71	73
	3	|E*| (MPa)	17891	20888	20925	23871	24994	27238	28705	29638
		Phase Angle, F (º)	8.0	11.4	6.3	5.1	4.9	3.7	3.5	2.8
		Average Peak Stress (MPa)	1.355	1.581	1.638	1.751	1.806	1.974	2.034	2.195
		Average Peak Strain (με)	76	76	78	73	72	72	71	74
	Avg.	|E*| Average	17780	20866	21861	24040	25066	27371	28458	29595
		F Average	7.8	10.6	6.6	5.1	4.8	3.6	3.3	2.9
		|E*| Coeff. of Variation	0.027	0.090	0.041	0.022	0.020	0.020	0.019	0.020
		F Coeff. of Variation	0.03	0.08	0.15	0.01	0.02	0.05	0.08	0.05
		|E*| Std. Dev.	481.9	1884.1	897.4	529.5	493.3	540.0	554.8	582.6
		F Std. Dev.	0.236	0.851	0.989	0.043	0.097	0.179	0.267	0.134
10	1	|E*| (MPa)	4865	7416	7706	10253	11448	14226	15584	
		Phase Angle, F (º)	22.1	18.8	18.3	14.3	13.6	10.5	9.6	
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.621	0.734	1.014	1.156	
		Average Peak Strain (με)	58	53	62	61	64	71	74	
	2	|E*| (MPa)	5434	7996	8404	11223	12425	15258	16536	18479
		Phase Angle, F (º)	22.5	16.9	16.1	14.5	13.4	11.1	10.1	9.4
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.621	0.734	1.014	1.156	1.264
		Average Peak Strain (με)	52	49	57	55	59	66	70	68
	3	|E*| (MPa)	5524	7118	8882	11159	12229	15025	16311	18134
		Phase Angle, F (º)	21.8	19.3	16.6	14.3	12.8	10.5	9.5	8.9
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.621	0.734	1.014	1.156	1.264
		Average Peak Strain (με)	51	56	54	56	60	68	71	70
	Avg.	|E*| Average	5275	7510	8330	10879	12034	14836	16143	18306
		F Average	22.1	18.3	17.0	14.4	13.3	10.7	9.7	9.2
		|E*| Coeff. of Variation	0.068	0.059	0.071	0.050	0.043	0.036	0.031	0.013
		F Coeff. of Variation	0.02	0.07	0.07	0.01	0.03	0.03	0.03	0.04
		|E*| Std. Dev.	357.3	446.3	591.6	542.5	517.1	540.9	497.6	243.8
		F Std. Dev.	0.358	1.280	1.166	0.137	0.402	0.347	0.305	0.363
35	1	|E*| (MPa)	470	748	942	1590	2028	3504	4311	5474
		Phase Angle, F (º)	32.7	33.1	32.1	31.5	29.8	25.5	23.1	20.9
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.098	0.138	0.220	0.389
		Average Peak Strain (με)	30	38	39	40	48	39	51	71
	2	|E*| (MPa)	544	835	1040	1729	2160	3685	4523	5654
		Phase Angle, F (º)	32.7	32.2	32.5	32.2	30.2	26.5	23.7	21.5
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.098	0.138	0.220	0.390
		Average Peak Strain (με)	26	34	35	37	45	37	49	69
	3	|E*| (MPa)	659	989	1172	1868	2282	3842	4604	5781
		Phase Angle, F (º)	35.7	33.7	33.5	31.5	29.7	26.0	22.5	21.5
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.098	0.138	0.220	0.389
		Average Peak Strain (με)	22	28	31	34	43	36	48	67
	Avg.	|E*| Average	558	858	1051	1729	2157	3677	4479	5636
		F Average	33.7	33.0	32.7	31.8	29.9	26.0	23.1	21.3
		|E*| Coeff. of Variation	0.171	0.142	0.110	0.080	0.059	0.046	0.034	0.027
		F Coeff. of Variation	0.05	0.02	0.02	0.01	0.01	0.02	0.03	0.02
		|E*| Std. Dev.	95.6	121.9	115.4	138.8	126.9	168.9	151.1	154.3
		F Std. Dev.	1.691	0.738	0.724	0.392	0.293	0.524	0.589	0.364
54.4	1	|E*| (MPa)	151	191	217	343	444	824	1101	1587
		Phase Angle, F (º)	20.2	24.9	23.0	25.7	27.0	27.1	26.4	27.2
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.091	0.124
		Average Peak Strain (με)	37	45	66	81	81	74	82	78
	2	|E*| (MPa)	174		231	367	465	853	1131	1628
		Phase Angle, F (º)	23.4		23.2	25.6	26.8	26.9	26.3	27.3
		Average Peak Stress (MPa)	0.006		0.014	0.028	0.036	0.061	0.091	0.125
		Average Peak Strain (με)	32		62	76	77	71	80	77
	3	|E*| (MPa)	276	287	295	437	546	977	1275	1790
		Phase Angle, F (º)	28.2	26.1	27.1	28.8	29.3	29.1	28.1	28.2
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.091	0.125
		Average Peak Strain (με)	20	30	48	64	66	63	72	70
	Avg.	|E*| Average	201	239	248	382	485	885	1169	1668
		F Average	23.9	25.5	24.4	26.7	27.7	27.7	26.9	27.5
		|E*| Coeff. of Variation	0.331	0.285	0.168	0.127	0.112	0.092	0.079	0.064
		F Coeff. of Variation	0.17	0.03	0.09	0.07	0.05	0.04	0.04	0.02
		|E*| Std. Dev.	66.4	68.1	41.7	48.6	54.1	81.1	92.7	107.3
		F Std. Dev.	4.036	0.813	2.305	1.824	1.361	1.236	1.000	0.538

Table B-71. I19.0B3F–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	20586	22194	24879	28506	29891	32684	33962	
		Phase Angle, F (º)	7.1	10.3	7.6	3.8	4.1	2.7	2.3	
		Average Peak Stress (MPa)	1.241	1.495	1.580	1.638	1.692	1.859	1.917	
		Average Peak Strain (με)	60	67	63	57	57	57	56	
	2	|E*| (MPa)	18537	23573	22168	25487	26404	28985	29930	
		Phase Angle, F (º)	8.2	6.1	3.9	5.4	5.0	3.6	3.0	
		Average Peak Stress (MPa)	1.241	1.495	1.580	1.638	1.692	1.859	1.918	
		Average Peak Strain (με)	67	63	71	64	64	64	64	
	3	|E*| (MPa)	18618	22091	22821	26097	27393	30003	31142	32534
		Phase Angle, F (º)	8.2	12.0	8.2	4.6	4.4	3.1	2.2	2.3
		Average Peak Stress (MPa)	1.241	1.495	1.580	1.638	1.692	1.860	1.918	2.077
		Average Peak Strain (με)	67	68	69	63	62	62	62	64
	Avg.	|E*| Average	19247	22619	23289	26697	27896	30557	31678	32534
		F Average	7.8	9.5	6.6	4.6	4.5	3.1	2.5	2.3
		|E*| Coeff. of Variation	0.060	0.037	0.061	0.060	0.064	0.063	0.065	
		F Coeff. of Variation	0.08	0.32	0.36	0.17	0.10	0.14	0.18	
		|E*| Std. Dev.	1160.7	827.7	1414.8	1596.3	1796.9	1910.8	2069.0	
		F Std. Dev.	0.627	3.057	2.371	0.810	0.442	0.452	0.463	
10	1	|E*| (MPa)	5748	8341	9488	12349	13771	17127	18748	20933
		Phase Angle, F (º)	21.7	21.9	15.1	13.7	12.5	10.1	9.1	8.6
		Average Peak Stress (MPa)	0.310	0.395	0.480	0.621	0.733	1.013	1.154	1.260
		Average Peak Strain (με)	54	47	51	50	53	59	62	60
	2	|E*| (MPa)	5247	7366	8673	11107	12290	15399	16759	18690
		Phase Angle, F (º)	22.3	21.9	17.6	14.5	13.4	10.6	9.3	8.8
		Average Peak Stress (MPa)	0.310	0.395	0.480	0.621	0.733	1.012	1.154	1.261
		Average Peak Strain (με)	59	54	55	56	60	66	69	67
	3	|E*| (MPa)	4872	6576	8049	10626	11930	15208	16719	
		Phase Angle, F (º)	23.0	19.8	16.8	15.0	13.8	10.8	9.7	
		Average Peak Stress (MPa)	0.310	0.395	0.480	0.621	0.733	1.014	1.154	
		Average Peak Strain (με)	64	60	60	58	61	67	69	
	Avg.	|E*| Average	5289	7428	8737	11361	12664	15911	17409	19812
		F Average	22.3	21.2	16.5	14.4	13.2	10.5	9.4	8.7
		|E*| Coeff. of Variation	0.083	0.119	0.083	0.078	0.077	0.066	0.067	0.080
		F Coeff. of Variation	0.03	0.06	0.08	0.04	0.05	0.04	0.04	0.02
		|E*| Std. Dev.	439.3	884.1	721.3	888.9	976.0	1057.3	1160.4	1586.1
		F Std. Dev.	0.642	1.256	1.241	0.641	0.671	0.375	0.328	0.166
35	1	|E*| (MPa)	572	882	1103	1818	2299	3918	4829	6148
		Phase Angle, F (º)	27.8	27.7	29.1	29.7	28.3	24.3	22.2	20.9
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.166	0.248	0.388
		Average Peak Strain (με)	35	38	38	43	48	42	51	63
	2	|E*| (MPa)	559	878	1089	1792	2246	3847	4701	5863
		Phase Angle, F (º)	33.5	31.8	32.4	31.7	30.0	25.7	23.2	21.5
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.166	0.248	0.389
		Average Peak Strain (με)	35	38	39	44	50	43	53	66
	3	|E*| (MPa)	529	789	963	1605	2022	3474	4255	5451
		Phase Angle, F (º)	29.8	30.1	30.9	30.6	29.3	25.1	23.0	21.8
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.078	0.111	0.165	0.248	0.390
		Average Peak Strain (με)	37	43	44	49	55	48	58	71
	Avg.	|E*| Average	553	850	1052	1738	2189	3746	4595	5820
		F Average	30.4	29.9	30.8	30.7	29.2	25.1	22.8	21.4
		|E*| Coeff. of Variation	0.040	0.062	0.073	0.067	0.067	0.064	0.066	0.060
		F Coeff. of Variation	0.10	0.07	0.05	0.03	0.03	0.03	0.02	0.02
		|E*| Std. Dev.	22.1	52.6	77.1	116.3	147.1	238.4	301.4	350.5
		F Std. Dev.	2.938	2.031	1.666	1.036	0.855	0.680	0.520	0.457
54.4	1	|E*| (MPa)		272	319	457	556	942	1240	1750
		Phase Angle, F (º)		26.0	19.8	24.7	25.9	27.3	27.8	29.6
		Average Peak Stress (MPa)		0.005	0.008	0.011	0.017	0.021	0.025	0.028
		Average Peak Strain (με)		20	27	25	30	22	20	16
	2	|E*| (MPa)		455		463	546	965	1267	1799
		Phase Angle, F (º)		30.4		29.3	31.1	32.4	32.4	32.6
		Average Peak Stress (MPa)		0.007		0.011	0.017	0.021	0.025	0.028
		Average Peak Strain (με)		15		24	31	22	20	16
	3	|E*| (MPa)		259	283	396	483	828	1085	1554
		Phase Angle, F (º)		16.0	21.2	26.5	27.1	29.0	29.2	30.9
		Average Peak Stress (MPa)		0.006	0.009	0.011	0.017	0.021	0.025	0.028
		Average Peak Strain (με)		22	30	29	35	25	23	18
	Avg.	|E*| Average		329	301	439	528	912	1197	1701
		F Average		24.2	20.5	26.8	28.0	29.6	29.8	31.0
		|E*| Coeff. of Variation		0.333	0.086	0.085	0.075	0.081	0.082	0.076
		F Coeff. of Variation		0.31	0.05	0.09	0.10	0.09	0.08	0.05
		|E*| Std. Dev.		109.5	25.8	37.2	39.8	73.6	98.5	129.4
		F Std. Dev.		7.378	1.013	2.345	2.746	2.573	2.352	1.481

Table B-72. I19.0BF–Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	17827	20329	20807	23640	24402	26360	27153	28187
		Phase Angle, F (º)	8.4	11.9	5.6	5.9	5.4	4.1	3.5	3.2
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.752	1.808	1.976	2.037	2.207
		Average Peak Strain (με)	76	78	79	74	74	75	75	78
	2	|E*| (MPa)	18756	19803	22730	25122	25850	28155	29220	29734
		Phase Angle, F (º)	7.8	5.9	7.6	5.1	4.9	3.6	3.2	2.9
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.753	1.808	1.977	2.037	2.203
		Average Peak Strain (με)	72	80	72	70	70	70	70	74
	3	|E*| (MPa)	18564	22298	22275	24441	25513	27533	28339	29502
		Phase Angle, F (º)	10.3	5.0	6.3	7.3	7.2	6.1	5.8	5.0
		Average Peak Stress (MPa)	1.355	1.582	1.638	1.752	1.808	1.976	2.036	2.200
		Average Peak Strain (με)	73	71	74	72	71	72	72	75
	Avg.	|E*| Average	18382	20810	21937	24401	25255	27350	28238	29141
		F Average	8.8	7.6	6.5	6.1	5.8	4.6	4.2	3.7
		|E*| Coeff. of Variation	0.027	0.063	0.046	0.030	0.030	0.033	0.037	0.029
		F Coeff. of Variation	0.15	0.49	0.16	0.18	0.20	0.29	0.33	0.30
		|E*| Std. Dev.	490.7	1314.9	1005.0	741.8	757.7	911.4	1037.3	834.4
		F Std. Dev.	1.314	3.745	1.043	1.111	1.178	1.311	1.383	1.136
10	1	|E*| (MPa)	5358	7978	8344	11146	12225	15021	16330	18038
		Phase Angle, F (º)	25.5	20.3	18.8	16.4	15.0	11.1	10.0	9.3
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.622	0.735	1.016	1.158	1.267
		Average Peak Strain (με)	53	50	58	56	60	68	71	70
	2	|E*| (MPa)	5586	7468	8701	11556	12789	15859	17168	18899
		Phase Angle, F (º)	25.3	17.6	18.3	15.5	14.3	11.0	9.7	8.7
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.622	0.735	1.016	1.158	1.269
		Average Peak Strain (με)	51	53	55	54	57	64	67	67
	3	|E*| (MPa)	5940	7921	8906	11761	12933	15779	16949	18671
		Phase Angle, F (º)	27.7	26.6	20.8	17.8	16.2	13.3	11.8	11.0
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.622	0.735	1.016	1.158	1.264
		Average Peak Strain (με)	48	50	54	53	57	64	68	68
	Avg.	|E*| Average	5628	7789	8650	11488	12649	15553	16816	18536
		F Average	26.2	21.5	19.3	16.6	15.2	11.8	10.5	9.7
		|E*| Coeff. of Variation	0.052	0.036	0.033	0.027	0.030	0.030	0.026	0.024
		F Coeff. of Variation	0.05	0.21	0.07	0.07	0.06	0.11	0.11	0.12
		|E*| Std. Dev.	293.3	279.2	284.8	313.0	374.2	462.2	434.9	446.3
		F Std. Dev.	1.299	4.583	1.362	1.153	0.964	1.275	1.130	1.186
35	1	|E*| (MPa)	570	865	1073	1779	2287	3862	4777	5946
		Phase Angle, F (º)	32.4	33.2	32.0	32.5	30.2	27.0	24.1	21.8
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.065	0.097	0.137	0.221	0.392
		Average Peak Strain (με)	25	33	34	36	43	36	46	66
	2	|E*| (MPa)	616	852	1061	1745	2255	3924	4796	6070
		Phase Angle, F (º)	33.1	35.6	33.6	34.3	31.9	28.6	24.6	22.4
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.065	0.097	0.138	0.221	0.391
		Average Peak Strain (με)	23	33	35	37	43	35	46	64
	3	|E*| (MPa)	777	1054	1270	1992	2484	4335	5263	6285
		Phase Angle, F (º)	34.3	34.5	36.1	36.0	34.4	29.9	25.8	23.5
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.138	0.220	0.388
		Average Peak Strain (με)	18	27	29	32	39	32	42	62
	Avg.	|E*| Average	654	923	1135	1838	2342	4040	4945	6101
		F Average	33.3	34.4	33.9	34.3	32.2	28.5	24.9	22.6
		|E*| Coeff. of Variation	0.166	0.122	0.103	0.073	0.053	0.064	0.056	0.028
		F Coeff. of Variation	0.03	0.04	0.06	0.05	0.07	0.05	0.03	0.04
		|E*| Std. Dev.	108.9	113.0	117.4	133.9	124.3	256.8	275.3	171.6
		F Std. Dev.	1.000	1.247	2.034	1.780	2.097	1.441	0.868	0.891
54.4	1	|E*| (MPa)	250	250	262	387	484	885	1201	1799
		Phase Angle, F (º)	20.4	19.2	21.4	25.4	26.1	26.8	25.8	27.0
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.090	0.121
		Average Peak Strain (με)	22	34	54	73	75	69	75	67
	2	|E*| (MPa)	491	547	504	678	839	1526	1902	2576
		Phase Angle, F (º)	16.7	17.2	25.6	27.9	28.3	30.0	32.1	34.3
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.090	0.123
		Average Peak Strain (με)	11	16	28	42	43	40	47	48
	3	|E*| (MPa)	322	319	324	445	557	1046	1393	1997
		Phase Angle, F (º)	25.3	27.9	26.7	30.3	30.2	30.1	28.6	29.1
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.061	0.090	0.122
		Average Peak Strain (με)	17	27	44	63	65	58	65	61
	Avg.	|E*| Average	354	372	364	503	626	1152	1499	2124
		F Average	20.8	21.4	24.6	27.8	28.2	29.0	28.8	30.2
		|E*| Coeff. of Variation	0.350	0.418	0.346	0.306	0.300	0.289	0.242	0.190
		F Coeff. of Variation	0.21	0.27	0.11	0.09	0.07	0.06	0.11	0.12
		|E*| Std. Dev.	123.9	155.5	125.8	153.9	187.6	333.4	362.4	403.5
		F Std. Dev.	4.313	5.717	2.766	2.426	2.058	1.877	3.164	3.745

Table B-73. I19.0CC–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16802	19690	20536	25223	26535	30216	32261	34042
		Phase Angle, F (º)	13.8	4.6	12.7	10.8	11.0	10.3	9.1	8.5
		Average Peak Stress (MPa)	0.956	0.984	1.012	1.040	1.068	1.065	1.064	1.084
		Average Peak Strain (με)	57	50	49	41	40	35	33	32
	2	|E*| (MPa)	16941	19366	21247	25193	26277	29555	31013	33354
		Phase Angle, F (º)	14.8	7.5	15.8	12.5	12.9	12.0	10.3	10.2
		Average Peak Stress (MPa)	0.844	0.928	0.985	1.012	1.039	1.063	1.063	1.082
		Average Peak Strain (με)	50	48	46	40	40	36	34	32
	3	|E*| (MPa)	16255		19430	23746	25087	27895	29246	30798
		Phase Angle, F (º)	11.2		8.0	8.5	8.0	6.6	6.3	6.2
		Average Peak Stress (MPa)	0.844		0.985	1.012	1.039	1.064	1.063	1.085
		Average Peak Strain (με)	52		51	43	41	38	36	35
	Avg.	|E*| Average	16666	19528	20404	24720	25967	29222	30840	32732
		F Average	13.3	6.1	12.2	10.6	10.6	9.7	8.6	8.3
		|E*| Coeff. of Variation	0.022	0.012	0.045	0.034	0.030	0.041	0.049	0.052
		F Coeff. of Variation	0.14	0.34	0.32	0.19	0.23	0.29	0.24	0.24
		|E*| Std. Dev.	363.0	229.1	915.6	844.3	772.2	1195.8	1515.0	1709.5
		F Std. Dev.	1.827	2.086	3.923	2.018	2.479	2.792	2.042	2.026
10	1	|E*| (MPa)	3441	5191	6400	9264	10484	14156	15818	18030
		Phase Angle, F (º)	32.1	24.5	27.5	22.2	20.8	17.2	16.0	14.8
		Average Peak Stress (MPa)	0.169	0.309	0.365	0.506	0.589	0.729	0.812	0.911
		Average Peak Strain (με)	49	59	57	55	56	51	51	51
	2	|E*| (MPa)	3977	5721	7098	9602	10869	14292	15761	17828
		Phase Angle, F (º)	33.6	25.6	24.9	22.5	20.9	17.9	16.1	14.7
		Average Peak Stress (MPa)	0.169	0.309	0.366	0.506	0.589	0.728	0.810	0.905
		Average Peak Strain (με)	42	54	52	53	54	51	51	51
	3	|E*| (MPa)	3451	5664	6532	9097	10290	13706	15149	17115
		Phase Angle, F (º)	29.7	29.5	25.2	19.6	18.4	14.8	13.3	12.1
		Average Peak Stress (MPa)	0.168	0.309	0.365	0.506	0.589	0.728	0.812	0.913
		Average Peak Strain (με)	49	55	56	56	57	53	54	53
	Avg.	|E*| Average	3623	5525	6677	9321	10548	14051	15576	17657
		F Average	31.8	26.5	25.9	21.4	20.0	16.6	15.1	13.9
		|E*| Coeff. of Variation	0.085	0.053	0.056	0.028	0.028	0.022	0.024	0.027
		F Coeff. of Variation	0.06	0.10	0.05	0.07	0.07	0.10	0.10	0.11
		|E*| Std. Dev.	306.6	291.2	370.6	257.1	294.3	306.4	371.3	480.7
		F Std. Dev.	1.980	2.638	1.414	1.584	1.428	1.646	1.585	1.493
35	1	|E*| (MPa)	280	436	508	876		2160	2818	3881
		Phase Angle, F (º)	28.7	30.8	31.8	33.4		30.1	29.1	27.5
		Average Peak Stress (MPa)	0.017	0.023	0.028	0.056		0.135	0.161	0.241
		Average Peak Strain (με)	60	53	55	63		63	57	62
	2	|E*| (MPa)	430	575	664	1088	1398	2509	3187	4211
		Phase Angle, F (º)	32.6	35.4	33.9	34.5	34.0	30.6	29.8	28.1
		Average Peak Stress (MPa)	0.017	0.022	0.028	0.056	0.069	0.134	0.157	0.227
		Average Peak Strain (με)	39	39	42	51	49	53	49	54
	3	|E*| (MPa)	290	418	521	923	1212	2362	3065	4209
		Phase Angle, F (º)	27.3	28.4	31.2	32.8	33.1	30.1	28.6	26.7
		Average Peak Stress (MPa)	0.017	0.022	0.028	0.056	0.069	0.134	0.160	0.235
		Average Peak Strain (με)	58	53	53	60	57	57	52	56
	Avg.	|E*| Average	333	476	565	963	1305	2344	3023	4100
		F Average	29.5	31.5	32.3	33.6	33.5	30.3	29.2	27.4
		|E*| Coeff. of Variation	0.252	0.180	0.153	0.116	0.101	0.075	0.062	0.046
		F Coeff. of Variation	0.09	0.11	0.04	0.03	0.02	0.01	0.02	0.03
		|E*| Std. Dev.	83.9	85.9	86.6	111.6	131.8	175.0	187.8	190.2
		F Std. Dev.	2.740	3.544	1.406	0.859	0.630	0.262	0.598	0.709
54.4	Est.	|E*| (MPa)	274	457	577	1014	1297	2281	2885	3885

Table B-74. I19.0CF–Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	14571	18376	17432	20489	21469	23755	24680	25799
		Phase Angle, F (º)	7.5	6.0	4.5	4.1	3.8	2.6	2.1	2.0
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.751	1.807	1.975	2.035	2.197
		Average Peak Strain (με)	93	86	94	85	84	83	82	85
	2	|E*| (MPa)	15440	19738	19402	22139	23231			
		Phase Angle, F (º)	9.2	5.8	9.4	5.9	5.5			
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.751	1.807			
		Average Peak Strain (με)	88	80	84	79	78			
	3	|E*| (MPa)	17465	18618	20580	24261	25300	28045	29208	30704
		Phase Angle, F (º)	8.6	9.5	7.3	5.4	5.9	4.6	4.3	4.0
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.751	1.807	1.975	2.035	2.198
		Average Peak Strain (με)	78	85	80	72	71	70	70	72
	Avg.	|E*| Average	15825	18910	19138	22296	23333	25900	26944	28251
		F Average	8.4	7.1	7.1	5.1	5.1	3.6	3.2	3.0
		|E*| Coeff. of Variation	0.094	0.038	0.083	0.085	0.082	0.117	0.119	0.123
		F Coeff. of Variation	0.10	0.29	0.35	0.18	0.22	0.40	0.49	0.47
		|E*| Std. Dev.	1485.0	726.6	1590.3	1891.2	1917.9	3033.4	3202.0	3468.1
		F Std. Dev.	0.853	2.093	2.471	0.940	1.107	1.445	1.566	1.414
10	1	|E*| (MPa)	3778	5630	6485	8483	9568	12204	13444	15074
		Phase Angle, F (º)	22.2	22.0	16.5	14.6	12.9	10.3	9.1	8.4
		Average Peak Stress (MPa)	0.282	0.367	0.424	0.565	0.677	0.930	1.043	1.149
		Average Peak Strain (με)	75	65	65	67	71	76	78	76
	2	|E*| (MPa)	3760	5718	6301	8795	9815	12606	13944	15826
		Phase Angle, F (º)	24.8	24.2	18.5	16.4	15.0	12.1	10.9	10.3
		Average Peak Stress (MPa)	0.282	0.367	0.424	0.565	0.677	0.930	1.043	1.150
		Average Peak Strain (με)	75	64	67	64	69	74	75	73
	3	|E*| (MPa)	5039	7507	8338	10758	11933	14787	16334	18269
		Phase Angle, F (º)	23.4	24.3	17.3	15.9	14.3	11.8	10.7	10.1
		Average Peak Stress (MPa)	0.282	0.367	0.424	0.565	0.677	0.931	1.043	1.150
		Average Peak Strain (με)	56	49	51	53	57	63	64	63
	Avg.	|E*| Average	4192	6285	7041	9345	10439	13199	14574	16390
		F Average	23.5	23.5	17.4	15.6	14.1	11.4	10.2	9.6
		|E*| Coeff. of Variation	0.175	0.169	0.160	0.132	0.125	0.105	0.106	0.102
		F Coeff. of Variation	0.05	0.06	0.06	0.06	0.08	0.08	0.10	0.11
		|E*| Std. Dev.	733.1	1059.2	1126.6	1233.1	1299.8	1390.0	1544.5	1670.3
		F Std. Dev.	1.284	1.307	0.998	0.971	1.089	0.941	0.999	1.031
35	1	|E*| (MPa)	374	602	752	1266	1664	2834	3455	4371
		Phase Angle, F (º)	26.9	28.0	28.6	28.7	26.6	23.1	21.4	20.7
		Average Peak Stress (MPa)	0.021	0.028	0.042	0.070	0.140	0.207	0.275	0.416
		Average Peak Strain (με)	57	47	56	55	84	73	80	95
	2	|E*| (MPa)	388	588	727	1199	1564	2679	3286	4201
		Phase Angle, F (º)	29.3	30.6	29.7	30.4	27.5	24.3	22.8	21.9
		Average Peak Stress (MPa)	0.021	0.028	0.042	0.070	0.140	0.207	0.275	0.415
		Average Peak Strain (με)	54	48	58	58	90	77	84	99
	3	|E*| (MPa)	554	818	1006	1599	2081	3517		
		Phase Angle, F (º)	27.0	29.7	29.6	30.7	27.8	25.5		
		Average Peak Stress (MPa)	0.021	0.028	0.042	0.070	0.140	0.208		
		Average Peak Strain (με)	38	34	42	44	67	59		
	Avg.	|E*| Average	439	669	828	1355	1769	3010	3370	4286
		F Average	27.7	29.4	29.3	29.9	27.3	24.3	22.1	21.3
		|E*| Coeff. of Variation	0.229	0.192	0.186	0.158	0.155	0.148	0.035	0.028
		F Coeff. of Variation	0.05	0.05	0.02	0.04	0.02	0.05	0.05	0.04
		|E*| Std. Dev.	100.3	128.7	154.1	214.2	274.2	445.9	119.4	119.9
		F Std. Dev.	1.369	1.351	0.623	1.102	0.585	1.204	1.004	0.811
54.4	Est.	|E*| (MPa)	123	193	238	391	486	812	1011	1344

Table B-75. I19.0CF – Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	19764	21931	22494	25521	26555	28528	29351	30499
		Phase Angle, F (º)	8.1	1.4	7.5	5.3	5.3	3.8	3.1	3.1
		Average Peak Stress (MPa)	1.218	1.422	1.473	1.575	1.625	1.776	1.829	1.977
		Average Peak Strain (με)	62	65	65	62	61	62	62	65
	2	|E*| (MPa)	18986	19828	22631	24553	25271	27294	27979	28606
		Phase Angle, F (º)	10.8	8.8	10.8	7.9	7.5	6.5	6.0	5.4
		Average Peak Stress (MPa)	1.351	1.577	1.634	1.747	1.803	1.971	2.030	2.195
		Average Peak Strain (με)	71	80	72	71	71	72	73	77
	3	|E*| (MPa)	19595	23353	23292	25179	26068	28035	28608	29631
		Phase Angle, F (º)	12.0	13.5	11.0	8.9	8.3	6.9	6.5	6.1
		Average Peak Stress (MPa)	1.351	1.577	1.634	1.747	1.803	1.970	2.029	2.193
		Average Peak Strain (με)	69	68	70	69	69	70	71	74
	Avg.	|E*| Average	19448	21704	22805	25084	25965	27952	28646	29578
		F Average	10.3	7.9	9.8	7.4	7.0	5.8	5.2	4.9
		|E*| Coeff. of Variation	0.021	0.082	0.019	0.020	0.025	0.022	0.024	0.032
		F Coeff. of Variation	0.19	0.77	0.20	0.25	0.22	0.30	0.36	0.32
		|E*| Std. Dev.	409.3	1773.1	426.6	490.6	648.3	621.4	687.3	947.7
		F Std. Dev.	1.991	6.100	1.972	1.866	1.520	1.709	1.851	1.549
10	1	|E*| (MPa)	6749	8654	10251	13206	14425	17388	18649	20623
		Phase Angle, F (º)	24.1	20.5	19.9	15.6	13.6	10.8	9.4	8.7
		Average Peak Stress (MPa)	0.254	0.355	0.432	0.559	0.661	0.913	1.040	1.138
		Average Peak Strain (με)	38	41	42	42	46	52	56	55
	2	|E*| (MPa)	6780	8765	9975	12857	14071	16689	17927	19428
		Phase Angle, F (º)	28.0	21.0	22.3	18.4	17.7	14.1	12.8	11.9
		Average Peak Stress (MPa)	0.281	0.394	0.479	0.621	0.733	1.013	1.154	1.262
		Average Peak Strain (με)	42	45	48	48	52	61	64	65
	3	|E*| (MPa)	7551	10805	10938	14095	15136	17749	18838	20544
		Phase Angle, F (º)	28.8	26.8	21.5	19.4	18.2	14.8	13.3	12.5
		Average Peak Stress (MPa)	0.282	0.394	0.479	0.620	0.733	1.013	1.154	1.264
		Average Peak Strain (με)	37	36	44	44	48	57	61	62
	Avg.	|E*| Average	7026	9408	10388	13386	14544	17275	18471	20198
		F Average	27.0	22.8	21.2	17.8	16.5	13.2	11.8	11.0
		|E*| Coeff. of Variation	0.065	0.129	0.048	0.048	0.037	0.031	0.026	0.033
		F Coeff. of Variation	0.09	0.15	0.06	0.11	0.15	0.16	0.18	0.18
		|E*| Std. Dev.	454.3	1210.9	495.9	638.5	542.6	538.9	481.2	668.5
		F Std. Dev.	2.549	3.487	1.267	1.956	2.522	2.089	2.095	2.009
35	1	|E*| (MPa)	869	1254	1486	2337	2837	4763	5712	6949
		Phase Angle, F (º)	38.0	36.1	34.6	35.3	32.7	28.5	24.5	21.5
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.058	0.088	0.123	0.198	0.348
		Average Peak Strain (με)	16	22	25	25	31	26	35	50
	2	|E*| (MPa)	843	1184	1429	2323	2840	4949	5923	6961
		Phase Angle, F (º)	43.4	40.3	39.0	37.7	35.8	29.4	27.2	24.6
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.166	0.220	0.387
		Average Peak Strain (με)	17	24	26	28	34	34	37	56
	3	|E*| (MPa)	711	1078	1327	2124	2694	4568	5556	6907
		Phase Angle, F (º)	34.8	36.1	33.6	33.5	31.9	26.1	23.5	23.5
		Average Peak Stress (MPa)	0.028	0.042	0.074	0.112	0.168	0.279	0.390	0.448
		Average Peak Strain (με)	39	39	55	53	62	61	70	65
	Avg.	|E*| Average	808	1172	1414	2261	2790	4760	5730	6939
		F Average	38.7	37.5	35.7	35.5	33.5	28.0	25.1	23.2
		|E*| Coeff. of Variation	0.105	0.076	0.057	0.053	0.030	0.040	0.032	0.004
		F Coeff. of Variation	0.11	0.06	0.08	0.06	0.06	0.06	0.08	0.07
		|E*| Std. Dev.	84.6	88.5	80.4	119.4	83.5	190.6	184.0	28.2
		F Std. Dev.	4.330	2.399	2.854	2.084	2.094	1.672	1.933	1.569
54.4	1	|E*| (MPa)	311	345	368	548	721	1187	1550	2182
		Phase Angle, F (º)	24.2	23.0	21.7	25.2	24.3	26.2	25.6	26.2
		Average Peak Stress (MPa)	0.009	0.011	0.023	0.042	0.069	0.079	0.104	0.152
		Average Peak Strain (με)	27	32	61	77	96	67	67	70
	2	|E*| (MPa)	198	248	282	461	639	1136	1506	2144
		Phase Angle, F (º)	28.6	32.8	27.9	30.2	28.2	29.3	28.0	28.4
		Average Peak Stress (MPa)	0.008	0.011	0.023	0.042	0.069	0.079	0.103	0.151
		Average Peak Strain (με)	43	45	80	92	108	69	68	70
	3	|E*| (MPa)	294	354	388	574	774	1277	1658	2299
		Phase Angle, F (º)	23.3	26.7	24.1	26.6	25.8	27.4	26.5	27.3
		Average Peak Stress (MPa)	0.008	0.011	0.023	0.042	0.069	0.079	0.104	0.153
		Average Peak Strain (με)	29	32	58	74	89	62	63	67
	Avg.	|E*| Average	268	316	346	528	711	1200	1572	2208
		F Average	25.3	27.5	24.6	27.3	26.1	27.6	26.7	27.3
		|E*| Coeff. of Variation	0.227	0.186	0.162	0.113	0.095	0.059	0.050	0.037
		F Coeff. of Variation	0.11	0.18	0.13	0.09	0.08	0.06	0.05	0.04
		|E*| Std. Dev.	60.7	58.6	56.2	59.4	67.8	71.2	78.2	81.1
		F Std. Dev.	2.841	4.928	3.152	2.560	1.970	1.595	1.235	1.087

Table B-76. I19.0DC – Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	21059		25227	29058	30236	32848	33889	35390
		Phase Angle, F (º)	8.5		4.3	5.7	4.3	2.8	2.4	2.3
		Average Peak Stress (MPa)	1.356		1.639	1.753	1.808	1.976	2.035	2.137
		Average Peak Strain (με)	64		65	60	60	60	60	60
	2	|E*| (MPa)	20280	22479	24606	27996	29274	31892	32994	34433
		Phase Angle, F (º)	7.6	13.1	9.0	5.0	4.6	3.3	2.6	2.6
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.753	1.809	1.976	2.033	2.195
		Average Peak Strain (με)	67	70	67	63	62	62	62	64
	3	|E*| (MPa)	18926	22364	24436	26171	27566	30365	31453	33018
		Phase Angle, F (º)	8.1	13.4	6.8	4.9	4.8	3.2	3.1	3.1
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.753	1.808	1.974	2.030	2.194
		Average Peak Strain (με)	72	71	67	67	66	65	65	66
	Avg.	|E*| Average	20088	22422	24756	27741	29025	31702	32779	34280
		F Average	8.1	13.2	6.7	5.2	4.6	3.1	2.7	2.7
		|E*| Coeff. of Variation	0.054	0.004	0.017	0.053	0.047	0.039	0.038	0.035
		F Coeff. of Variation	0.05	0.02	0.35	0.08	0.06	0.08	0.12	0.14
		|E*| Std. Dev.	1079.2	81.0	416.3	1460.3	1352.6	1252.2	1232.0	1193.2
		F Std. Dev.	0.437	0.225	2.373	0.427	0.272	0.234	0.337	0.385
10	1	|E*| (MPa)	5336	7609	9442	12463	13975	17696	19414	21459
		Phase Angle, F (º)	24.2	18.4	19.0	15.7	14.6	10.8	9.8	9.3
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.707	0.820	1.100	1.185	1.323
		Average Peak Strain (με)	69	63	60	57	59	62	61	62
	2	|E*| (MPa)	5456	8122	9060	12282	13757	17389	19099	21172
		Phase Angle, F (º)	23.1	15.5	19.2	14.9	13.2	10.3	9.5	8.9
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.708	0.820	1.099	1.209	1.317
		Average Peak Strain (με)	67	59	62	58	60	63	63	62
	3	|E*| (MPa)	4829	7129	8095	11005	12422	16144	17880	20007
		Phase Angle, F (º)	23.4	16.0	19.5	16.0	14.0	11.1	10.0	9.3
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.708	0.820	1.097	1.209	1.317
		Average Peak Strain (με)	76	67	70	64	66	68	68	66
	Avg.	|E*| Average	5207	7620	8866	11917	13385	17076	18798	20879
		F Average	23.6	16.6	19.3	15.6	14.0	10.8	9.8	9.2
		|E*| Coeff. of Variation	0.064	0.065	0.078	0.067	0.063	0.048	0.043	0.037
		F Coeff. of Variation	0.02	0.09	0.01	0.04	0.05	0.04	0.02	0.03
		|E*| Std. Dev.	332.7	496.5	694.0	794.7	841.0	821.8	810.3	769.1
		F Std. Dev.	0.583	1.565	0.250	0.583	0.674	0.401	0.230	0.241
35	1	|E*| (MPa)	651	903	1077	1736	2347	3957	5000	6414
		Phase Angle, F (º)	29.7	30.6	30.8	35.0	29.4	26.6	24.1	23.4
		Average Peak Stress (MPa)	0.034	0.042	0.057	0.085	0.169	0.220	0.303	0.445
		Average Peak Strain (με)	52	47	53	49	72	56	61	69
	2	|E*| (MPa)	543	861	1080	1709	2350	4042	4990	6443
		Phase Angle, F (º)	29.7	30.5	31.1	32.9	28.0	25.6	23.1	22.0
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.079	0.169	0.219	0.301	0.440
		Average Peak Strain (με)	47	39	47	46	72	54	60	68
	3	|E*| (MPa)	441	689	892	1457	2121	3662	4607	5979
		Phase Angle, F (º)	27.7	28.8	29.5	32.9	27.8	25.4	23.4	22.5
		Average Peak Stress (MPa)	0.026	0.033	0.051	0.079	0.169	0.219	0.303	0.443
		Average Peak Strain (με)	58	48	57	54	80	60	66	74
	Avg.	|E*| Average	545	817	1016	1634	2273	3887	4865	6279
		F Average	29.0	30.0	30.5	33.6	28.4	25.9	23.5	22.7
		|E*| Coeff. of Variation	0.193	0.139	0.106	0.094	0.058	0.051	0.046	0.041
		F Coeff. of Variation	0.04	0.03	0.03	0.04	0.03	0.02	0.02	0.03
		|E*| Std. Dev.	105.0	113.4	107.7	153.5	131.2	199.6	224.2	259.8
		F Std. Dev.	1.163	1.022	0.851	1.241	0.872	0.647	0.467	0.721
54.4	Est.	|E*| (MPa)	147	208	246	381	468	776	973	1319

Table B-77. I19.0DF – Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	24186	27130	27813	31805	32404	35446	36371	37796
		Phase Angle, F (º)	6.2		8.0	3.8	3.0	2.2	1.4	1.8
		Average Peak Stress (MPa)	1.354	1.580	1.637	1.751	1.806	1.973	2.031	2.194
		Average Peak Strain (με)	56	58	59	55	56	56	56	58
	2	|E*| (MPa)	21146	26191	26432	27898	29241	31695	32340	33854
		Phase Angle, F (º)	7.2	5.8	4.3	2.9	3.1	2.8	2.2	2.3
		Average Peak Stress (MPa)	1.354	1.580	1.637	1.751	1.806	1.972	2.031	2.193
		Average Peak Strain (με)	64	60	62	63	62	62	63	65
	3	|E*| (MPa)	20867	25153	25850	27393	28623	31094	31971	33241
		Phase Angle, F (º)	8.3	10.4	7.9	5.0	5.3	4.5	4.0	3.9
		Average Peak Stress (MPa)	1.354	1.580	1.637	1.750	1.806	1.970	2.028	2.190
		Average Peak Strain (με)	65	63	63	64	63	63	63	66
	Avg.	|E*| Average	22066	26158	26698	29032	30089	32745	33561	34963
		F Average	7.2	8.1	6.7	3.9	3.8	3.2	2.5	2.7
		|E*| Coeff. of Variation	0.083	0.038	0.038	0.083	0.067	0.072	0.073	0.071
		F Coeff. of Variation	0.14	0.40	0.31	0.28	0.35	0.37	0.52	0.41
		|E*| Std. Dev.	1841.0	988.7	1008.1	2415.2	2028.3	2358.4	2440.9	2472.0
		F Std. Dev.	1.024	3.272	2.090	1.091	1.305	1.176	1.330	1.109
10	1	|E*| (MPa)	7706	11878	12494	15729	17255	20842	22331	24575
		Phase Angle, F (º)	20.7	15.4	13.3	12.3	11.7	8.4	7.8	7.0
		Average Peak Stress (MPa)	0.367	0.480	0.564	0.707	0.819	1.099	1.211	1.325
		Average Peak Strain (με)	48	40	45	45	47	53	54	54
	2	|E*| (MPa)	6909	10456	11250	13883	15325	18606	20082	22074
		Phase Angle, F (º)	21.0	16.2	14.7	12.7	11.8	9.1	8.2	7.6
		Average Peak Stress (MPa)	0.367	0.479	0.565	0.707	0.819	1.099	1.210	1.320
		Average Peak Strain (με)	53	46	50	51	53	59	60	60
	3	|E*| (MPa)	6839	9851	10519	13579	14870	18088	19514	21382
		Phase Angle, F (º)	21.9	21.0	17.1	14.0	13.3	10.4	9.7	9.1
		Average Peak Stress (MPa)	0.367	0.480	0.564	0.707	0.819	1.097	1.207	1.314
		Average Peak Strain (με)	54	49	54	52	55	61	62	61
	Avg.	|E*| Average	7151	10728	11421	14397	15817	19179	20642	22677
		F Average	21.2	17.5	15.0	13.0	12.3	9.3	8.6	7.9
		|E*| Coeff. of Variation	0.067	0.097	0.087	0.081	0.080	0.076	0.072	0.074
		F Coeff. of Variation	0.03	0.17	0.13	0.07	0.07	0.11	0.12	0.13
		|E*| Std. Dev.	481.7	1040.7	998.8	1163.6	1266.3	1463.6	1490.0	1679.8
		F Std. Dev.	0.615	3.005	1.909	0.869	0.874	0.988	1.023	1.061
35	1	|E*| (MPa)	647	1079	1344	2172	2987	5078	6086	7686
		Phase Angle, F (º)	30.2	33.0	31.1	32.7	28.0	24.5	21.1	20.1
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.079	0.168	0.221	0.304	0.447
		Average Peak Strain (με)	39	31	38	36	56	44	50	58
	2	|E*| (MPa)	639	1076	1317	2091	2798	4674	5688	7128
		Phase Angle, F (º)	32.8	34.0	31.6	32.6	28.1	24.3	22.0	20.6
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.079	0.169	0.222	0.304	0.448
		Average Peak Strain (με)	40	31	39	38	60	47	54	63
	3	|E*| (MPa)	689	1107	1375	2152	2898	4806	5807	7115
		Phase Angle, F (º)	31.9	32.1	30.9	32.8	28.2	24.7	23.1	21.7
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.079	0.169	0.222	0.303	0.441
		Average Peak Strain (με)	37	30	37	37	58	46	52	62
	Avg.	|E*| Average	658	1087	1345	2138	2894	4853	5860	7310
		F Average	31.6	33.0	31.2	32.7	28.1	24.5	22.1	20.8
		|E*| Coeff. of Variation	0.041	0.016	0.022	0.020	0.033	0.042	0.035	0.045
		F Coeff. of Variation	0.04	0.03	0.01	0.00	0.00	0.01	0.05	0.04
		|E*| Std. Dev.	26.7	17.0	29.0	42.2	94.8	206.1	204.2	325.8
		F Std. Dev.	1.307	0.912	0.372	0.072	0.083	0.209	1.003	0.768
54.4	Est.	|E*| (MPa)	162	266	334	576	732	1273	1607	2169

Table B-78. B25.0BC – Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	18408		22873	27145	28297	31426	32493	33614
		Phase Angle, F (º)	13.9		8.6	10.1	8.3	7.8	7.0	6.4
		Average Peak Stress (MPa)	1.354		1.638	1.752	1.807	1.977	2.035	2.200
		Average Peak Strain (με)	74		72	65	64	63	63	65
	2	|E*| (MPa)	15914	19459	20983	22540	23644	25863	26724	27728
		Phase Angle, F (º)	7.5	10.9	5.1	3.9	2.0	1.8	1.1	1.3
		Average Peak Stress (MPa)	1.242	1.468	1.553	1.667	1.695	1.861	1.921	2.083
		Average Peak Strain (με)	78	75	74	74	72	72	72	75
	3	|E*| (MPa)	15924	17540	20617	22433	23623	26011	27128	28175
		Phase Angle, F (º)	7.5	2.9	5.4	3.7	1.5	1.6	1.3	0.9
		Average Peak Stress (MPa)	1.354	1.581	1.638	1.751	1.808	1.973	2.035	2.200
		Average Peak Strain (με)	85	90	79	78	77	76	75	78
	Avg.	|E*| Average	16749	18500	21491	24039	25188	27767	28781	29839
		F Average	9.6	6.9	6.4	5.9	4.0	3.7	3.1	2.9
		|E*| Coeff. of Variation	0.086	0.073	0.056	0.112	0.107	0.114	0.112	0.110
		F Coeff. of Variation	0.39	0.82	0.30	0.62	0.96	0.94	1.06	1.07
		|E*| Std. Dev.	1437.0	1356.6	1211.2	2689.7	2692.5	3169.7	3220.5	3276.9
		F Std. Dev.	3.719	5.652	1.904	3.654	3.789	3.508	3.311	3.056
10	1	|E*| (MPa)	3417	5467	6558	9440	10868	14662	16111	18480
		Phase Angle, F (º)	29.1	23.0	26.3	21.1	18.1	14.8	12.9	12.1
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.707	0.820	1.100	1.269	1.382
		Average Peak Strain (με)	107	88	86	75	75	75	79	75
	2	|E*| (MPa)	3119	4912	6138	8667	9957	13138	14517	16291
		Phase Angle, F (º)	25.6	19.1	19.3	16.5	13.8	10.7	9.3	8.4
		Average Peak Stress (MPa)	0.254	0.395	0.508	0.622	0.735	1.014	1.156	1.265
		Average Peak Strain (με)	81	80	83	72	74	77	80	78
	3	|E*| (MPa)	3087	4894	5795	8630	9934	13113	14556	16317
		Phase Angle, F (º)	25.9	24.1	20.3	16.3	13.3	10.4	9.0	7.8
		Average Peak Stress (MPa)	0.367	0.480	0.565	0.707	0.819	1.099	1.268	1.381
		Average Peak Strain (με)	119	98	97	82	82	84	87	85
	Avg.	|E*| Average	3208	5091	6163	8912	10253	13637	15061	17029
		F Average	26.9	22.0	22.0	18.0	15.0	11.9	10.4	9.4
		|E*| Coeff. of Variation	0.057	0.064	0.062	0.051	0.052	0.065	0.060	0.074
		F Coeff. of Variation	0.07	0.12	0.17	0.15	0.18	0.20	0.21	0.25
		|E*| Std. Dev.	182.0	325.4	382.5	457.2	533.0	887.0	908.9	1256.6
		F Std. Dev.	1.963	2.619	3.762	2.694	2.648	2.443	2.166	2.321
35	1	|E*| (MPa)	263	416	517	962	1326	2523	3257	4527
		Phase Angle, F (º)	23.1	28.1	29.3	32.2	29.2	29.5	27.6	25.7
		Average Peak Stress (MPa)	0.020	0.034	0.042	0.079	0.140	0.220	0.303	0.444
		Average Peak Strain (με)	76	81	82	82	105	87	93	98
	2	|E*| (MPa)	240	377	474	881	1256	2458	3144	4414
		Phase Angle, F (º)	24.0	28.6	29.2	31.8	29.1	28.0	25.6	24.3
		Average Peak Stress (MPa)	0.014	0.023	0.028	0.051	0.098	0.165	0.218	0.359
		Average Peak Strain (με)	59	60	59	58	78	67	69	81
	3	|E*| (MPa)	220	352	455	857	1215	2380	3112	4346
		Phase Angle, F (º)	21.9	27.1	28.7	31.8	28.9	27.7	26.1	24.9
		Average Peak Stress (MPa)	0.014	0.023	0.028	0.051	0.098	0.164	0.218	0.359
		Average Peak Strain (με)	64	64	62	59	81	69	70	83
	Avg.	|E*| Average	241	382	482	900	1266	2454	3171	4429
		F Average	23.0	27.9	29.1	32.0	29.1	28.4	26.4	25.0
		|E*| Coeff. of Variation	0.090	0.084	0.066	0.061	0.044	0.029	0.024	0.021
		F Coeff. of Variation	0.05	0.03	0.01	0.01	0.01	0.03	0.04	0.03
		|E*| Std. Dev.	21.7	32.2	31.8	55.1	56.2	71.4	76.1	91.2
		F Std. Dev.	1.053	0.779	0.322	0.251	0.167	0.943	1.013	0.695
54.4	Est.	|E*| (MPa)	56	80	96	156	196	350	456	652

Table B-79. B25.0BC – Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	24483	27088	27680	31248	32093	34154	35104	36086
		Phase Angle, F (º)	11.7	15.4	9.4	8.2	7.9	6.2	5.6	5.2
		Average Peak Stress (MPa)	1.219	1.422	1.474	1.576	1.626	1.778	1.831	1.975
		Average Peak Strain (με)	50	53	53	50	51	52	52	55
	2	|E*| (MPa)	21239	24997	24022	26898	27853	29381	30087	31106
		Phase Angle, F (º)	6.8	0.4	2.8	3.8	3.0	1.9	2.1	1.6
		Average Peak Stress (MPa)	1.219	1.422	1.474	1.577	1.627	1.777	1.831	1.985
		Average Peak Strain (με)	57	57	61	59	58	60	61	64
	3	|E*| (MPa)	22971	28571	25660	29372	30091	31784	32574	33646
		Phase Angle, F (º)	7.5	5.9	5.2	4.4	4.1	2.7	2.3	2.3
		Average Peak Stress (MPa)	1.219	1.422	1.474	1.576	1.627	1.778	1.831	1.978
		Average Peak Strain (με)	53	50	57	54	54	56	56	59
	Avg.	|E*| Average	22898	26885	25787	29173	30012	31773	32588	33613
		F Average	8.7	7.2	5.8	5.5	5.0	3.6	3.3	3.0
		|E*| Coeff. of Variation	0.071	0.067	0.071	0.075	0.071	0.075	0.077	0.074
		F Coeff. of Variation	0.31	1.05	0.58	0.44	0.52	0.63	0.60	0.63
		|E*| Std. Dev.	1623.3	1795.4	1832.1	2181.6	2121.2	2386.5	2508.4	2490.0
		F Std. Dev.	2.674	7.594	3.358	2.405	2.583	2.267	1.990	1.913
10	1	|E*| (MPa)	7796	12528	13030	16219	17661	21036	22610	24998
		Phase Angle, F (º)	32.7	28.7	25.8	20.1	18.1	13.6	12.6	11.8
		Average Peak Stress (MPa)	0.254	0.356	0.432	0.560	0.661	0.914	1.041	1.137
		Average Peak Strain (με)	33	28	33	35	37	43	46	45
	2	|E*| (MPa)	6704	8835	11145	13951	15211	18239	19582	21406
		Phase Angle, F (º)	24.6	20.5	17.1	14.1	12.4	9.2	7.7	7.1
		Average Peak Stress (MPa)	0.254	0.356	0.432	0.560	0.661	0.914	1.041	1.141
		Average Peak Strain (με)	38	40	39	40	43	50	53	53
	3	|E*| (MPa)	7709	10089	11912	15621	17123	20239	21646	23522
		Phase Angle, F (º)	26.2	16.8	20.5	15.0	13.4	10.2	9.4	8.5
		Average Peak Stress (MPa)	0.254	0.356	0.432	0.560	0.661	0.914	1.041	1.142
		Average Peak Strain (με)	33	35	36	36	39	45	48	49
	Avg.	|E*| Average	7403	10484	12029	15264	16665	19838	21280	23309
		F Average	27.8	22.0	21.1	16.4	14.6	11.0	9.9	9.1
		|E*| Coeff. of Variation	0.082	0.179	0.079	0.077	0.077	0.073	0.073	0.077
		F Coeff. of Variation	0.15	0.28	0.21	0.20	0.21	0.21	0.25	0.27
		|E*| Std. Dev.	607.0	1877.5	948.0	1175.3	1287.8	1440.9	1546.9	1805.2
		F Std. Dev.	4.286	6.093	4.356	3.219	3.006	2.341	2.501	2.428
35	1	|E*| (MPa)	862	1141	1424	2372	3028	5716	6880	8523
		Phase Angle, F (º)	36.1	37.3	40.1	41.7	37.9	33.9	29.9	25.8
		Average Peak Stress (MPa)	0.013	0.025	0.033	0.058	0.088	0.123	0.197	0.353
		Average Peak Strain (με)	15	22	23	24	29	22	29	41
	2	|E*| (MPa)	614	974	1247	2150	2813	4949	6060	7723
		Phase Angle, F (º)	27.9	29.1	31.0	31.6	30.1	25.9	22.5	20.3
		Average Peak Stress (MPa)	0.013	0.025	0.033	0.058	0.088	0.123	0.197	0.350
		Average Peak Strain (με)	21	26	26	27	31	25	33	45
	3	|E*| (MPa)	661	1010	1258	2223	2919	5217	6383	7990
		Phase Angle, F (º)	33.4	33.1	33.8	34.6	31.9	27.6	23.5	20.9
		Average Peak Stress (MPa)	0.013	0.025	0.033	0.058	0.088	0.124	0.199	0.352
		Average Peak Strain (με)	19	25	26	26	30	24	31	44
	Avg.	|E*| Average	712	1042	1310	2248	2920	5294	6441	8079
		F Average	32.5	33.2	35.0	36.0	33.3	29.1	25.3	22.3
		|E*| Coeff. of Variation	0.185	0.084	0.076	0.050	0.037	0.074	0.064	0.050
		F Coeff. of Variation	0.13	0.12	0.13	0.14	0.12	0.14	0.16	0.13
		|E*| Std. Dev.	131.8	87.6	98.9	113.3	108.0	389.3	413.1	407.0
		F Std. Dev.	4.151	4.086	4.636	5.175	4.118	4.189	4.048	3.006
54.4	1	|E*| (MPa)	629	546	441	543	649	1167	1566	2359
		Phase Angle, F (º)	25.3	31.6	26.3	31.0	31.8	32.9	32.4	32.5
		Average Peak Stress (MPa)	0.005	0.008	0.013	0.025	0.033	0.054	0.080	0.111
		Average Peak Strain (με)	8	14	29	47	50	47	51	47
	2	|E*| (MPa)	252	302	289	446	566	1056	1447	2176
		Phase Angle, F (º)	19.8	21.1	21.0	25.0	26.1	26.7	26.3	26.9
		Average Peak Stress (MPa)	0.005	0.008	0.013	0.026	0.033	0.055	0.081	0.109
		Average Peak Strain (με)	20	25	45	57	58	52	56	50
	3	|E*| (MPa)	219	251	283	446	572	1094	1501	2279
		Phase Angle, F (º)	18.3	19.4	22.4	26.4	27.8	28.2	27.9	27.5
		Average Peak Stress (MPa)	0.005	0.008	0.013	0.025	0.033	0.055	0.081	0.111
		Average Peak Strain (με)	23	31	45	57	57	50	54	49
	Avg.	|E*| Average	367	366	337	479	596	1106	1505	2272
		F Average	21.1	24.1	23.2	27.5	28.6	29.3	28.8	29.0
		|E*| Coeff. of Variation	0.622	0.430	0.266	0.117	0.077	0.051	0.040	0.040
		F Coeff. of Variation	0.17	0.27	0.12	0.11	0.10	0.11	0.11	0.11
		|E*| Std. Dev.	227.9	157.6	89.7	56.0	46.1	56.3	59.7	91.7
		F Std. Dev.	3.654	6.599	2.761	3.145	2.912	3.269	3.187	3.052

Table B-80. B25.0BF – Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	22800	24140	27215	32658	33727	36471	37766	39099
		Phase Angle, F (º)	12.7	7.4	9.9	9.4	8.3	6.6	6.4	5.7
		Average Peak Stress (MPa)	1.353	1.579	1.636	1.752	1.811	1.980	2.041	2.208
		Average Peak Strain (με)	59	65	60	54	54	54	54	56
	2	|E*| (MPa)	23059	26454	27067	31951	33312	35665	36807	
		Phase Angle, F (º)	9.6		6.5	6.5	6.0	4.9	4.0	
		Average Peak Stress (MPa)	1.353	1.579	1.636	1.752	1.810	1.980	2.041	
		Average Peak Strain (με)	59	60	60	55	54	56	55	
	3	|E*| (MPa)	19365	25535	24360	26956	28056	30406	31214	32463
		Phase Angle, F (º)	8.9	6.3	4.0	5.8	5.2	3.6	3.1	2.8
		Average Peak Stress (MPa)	1.354	1.580	1.637	1.751	1.807	1.975	2.034	2.196
		Average Peak Strain (με)	70	62	67	65	64	65	65	68
	Avg.	|E*| Average	21741	25376	26214	30522	31698	34181	35262	35781
		F Average	10.4	6.8	6.8	7.2	6.5	5.1	4.5	4.2
		|E*| Coeff. of Variation	0.095	0.046	0.061	0.102	0.100	0.096	0.100	0.131
		F Coeff. of Variation	0.20	0.11	0.44	0.26	0.25	0.30	0.38	0.50
		|E*| Std. Dev.	2062.2	1165.2	1607.3	3107.9	3161.5	3293.8	3538.5	4692.2
		F Std. Dev.	2.030	0.735	2.968	1.876	1.609	1.506	1.711	2.109
10	1	|E*| (MPa)	5265	9347	10081	13580	15450	19479	21307	24084
		Phase Angle, F (º)	31.8	24.2	27.9	20.5	18.7	14.9	13.4	12.3
		Average Peak Stress (MPa)	0.282	0.367	0.423	0.566	0.679	0.934	1.048	1.159
		Average Peak Strain (με)	54	39	42	42	44	48	49	48
	2	|E*| (MPa)	5123	8841	9872	13293	14727	18501	20201	
		Phase Angle, F (º)	29.5	25.5	21.4	18.7	16.4	12.2	11.3	
		Average Peak Stress (MPa)	0.367	0.479	0.564	0.707	0.821	1.103	1.217	
		Average Peak Strain (με)	72	54	57	53	56	60	60	
	3	|E*| (MPa)	4013	6756	7821	10556	12191	15890	17455	19499
		Phase Angle, F (º)	28.1	24.8	21.6	17.7	15.8	11.9	10.3	9.3
		Average Peak Stress (MPa)	0.367	0.480	0.564	0.707	0.819	1.100	1.211	1.323
		Average Peak Strain (με)	91	71	72	67	67	69	69	68
	Avg.	|E*| Average	4800	8315	9258	12476	14123	17957	19654	21792
		F Average	29.8	24.8	23.6	19.0	16.9	13.0	11.7	10.8
		|E*| Coeff. of Variation	0.143	0.165	0.135	0.134	0.121	0.103	0.101	0.149
		F Coeff. of Variation	0.06	0.02	0.16	0.08	0.09	0.13	0.14	0.20
		|E*| Std. Dev.	685.2	1373.2	1248.7	1669.7	1711.1	1855.7	1983.5	3242.3
		F Std. Dev.	1.855	0.616	3.711	1.435	1.567	1.647	1.602	2.153
35	1	|E*| (MPa)	368	588	752	1380	1925	3666	4683	6304
		Phase Angle, F (º)	32.6	36.2	36.4	38.9	34.7	31.4	29.0	26.7
		Average Peak Stress (MPa)	0.021	0.028	0.042	0.071	0.142	0.209	0.278	0.421
		Average Peak Strain (με)	57	48	56	51	74	57	59	67
	2	|E*| (MPa)	341	539		1355	1991	3757	5377	6557
		Phase Angle, F (º)	26.2	31.8		35.4	31.8	29.1	22.9	24.7
		Average Peak Stress (MPa)	0.025	0.034		0.079	0.170	0.222	0.074	0.448
		Average Peak Strain (με)	74	63		59	85	59	14	68
	3	|E*| (MPa)	251	371	487	877	1399	2718	3622	5144
		Phase Angle, F (º)	24.4	26.4	28.7	35.4	30.2	29.2	27.3	25.4
		Average Peak Stress (MPa)	0.025	0.034	0.051	0.079	0.169	0.219	0.301	0.437
		Average Peak Strain (με)	101	91	104	90	121	81	83	85
	Avg.	|E*| Average	320	499	620	1204	1772	3380	4561	6002
		F Average	27.7	31.5	32.5	36.6	32.2	29.9	26.4	25.6
		|E*| Coeff. of Variation	0.191	0.227	0.302	0.235	0.183	0.170	0.194	0.126
		F Coeff. of Variation	0.16	0.16	0.17	0.05	0.07	0.04	0.12	0.04
		|E*| Std. Dev.	61.0	113.6	187.1	283.5	324.4	575.5	884.0	753.5
		F Std. Dev.	4.346	4.905	5.422	2.007	2.247	1.320	3.144	0.988
54.4	Est.	|E*| (MPa)	72	113	140	244	316	591	778	1119

Table B-81. B25.0BF – Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	18875	20572	23908	25466	26198	28475	29339	30320
		Phase Angle, F (º)	9.7	12.0	6.3	6.8	6.7	5.2	4.5	4.2
		Average Peak Stress (MPa)	1.151	1.343	1.391	1.488	1.535	1.677	1.727	1.864
		Average Peak Strain (με)	61	65	58	58	59	59	59	61
	2	|E*| (MPa)	18826	20566	22965	25675	26411	28497	29367	30704
		Phase Angle, F (º)	9.5	5.2	9.5	7.7	6.1	5.5	4.9	4.6
		Average Peak Stress (MPa)	1.151	1.343	1.391	1.488	1.535	1.678	1.729	1.866
		Average Peak Strain (με)	61	65	61	58	58	59	59	61
	3	|E*| (MPa)	22625	26835	26816	30391	31636	33643	36808	
		Phase Angle, F (º)	8.5	1.0	8.6	5.8	4.6	4.0	5.3	
		Average Peak Stress (MPa)	1.016	1.184	1.227	1.312	1.354	1.479	1.524	
		Average Peak Strain (με)	45	44	46	43	43	44	41	
	Avg.	|E*| Average	20108	22658	24563	27177	28082	30205	31838	30512
		F Average	9.2	6.1	8.1	6.8	5.8	4.9	4.9	4.4
		|E*| Coeff. of Variation	0.108	0.160	0.082	0.102	0.110	0.099	0.135	0.009
		F Coeff. of Variation	0.07	0.92	0.21	0.14	0.18	0.16	0.08	0.07
		|E*| Std. Dev.	2179.3	3617.5	2007.1	2784.9	3080.0	2977.5	4303.9	271.3
		F Std. Dev.	0.620	5.559	1.676	0.963	1.070	0.794	0.380	0.291
10	1	|E*| (MPa)	5618	8586	9143	11798	13109	16038	17341	19154
		Phase Angle, F (º)	27.8	23.1	22.6	17.6	16.2	12.7	11.4	10.2
		Average Peak Stress (MPa)	0.240	0.336	0.408	0.528	0.624	0.862	0.978	1.070
		Average Peak Strain (με)	43	39	45	45	48	54	56	56
	2	|E*| (MPa)	5461	7464	8838	11843	13072	15949	17265	19071
		Phase Angle, F (º)	28.2	24.4	22.0	18.6	16.5	12.8	11.5	10.7
		Average Peak Stress (MPa)	0.210	0.296	0.359	0.466	0.550	0.760	0.869	0.953
		Average Peak Strain (με)	38	40	41	39	42	48	50	50
	3	|E*| (MPa)	7037	10346	10709	14475	15855	19169	20558	22694
		Phase Angle, F (º)	26.8	18.0	19.0	16.2	14.8	11.2	10.1	9.2
		Average Peak Stress (MPa)	0.212	0.296	0.360	0.466	0.550	0.759	0.865	0.939
		Average Peak Strain (με)	30	29	34	32	35	40	42	41
	Avg.	|E*| Average	6039	8799	9563	12705	14012	17052	18388	20306
		F Average	27.6	21.9	21.2	17.4	15.8	12.2	11.0	10.0
		|E*| Coeff. of Variation	0.144	0.165	0.105	0.121	0.114	0.108	0.102	0.102
		F Coeff. of Variation	0.03	0.15	0.09	0.07	0.06	0.08	0.07	0.07
		|E*| Std. Dev.	868.3	1452.9	1003.8	1532.8	1596.2	1834.0	1879.6	2068.4
		F Std. Dev.	0.726	3.351	1.936	1.199	0.919	0.921	0.773	0.730
35	1	|E*| (MPa)	678	912	1073	1756	2243	3997	4923	6136
		Phase Angle, F (º)	34.6	36.8	36.5	37.2	34.7	30.8	26.2	23.5
		Average Peak Stress (MPa)	0.012	0.024	0.031	0.055	0.082	0.116	0.185	0.327
		Average Peak Strain (με)	18	26	29	31	37	29	38	53
	2	|E*| (MPa)	686	870	1042	1683	2149	3736	4873	5844
		Phase Angle, F (º)	34.7	31.6	32.8	32.8	31.3	27.4	22.3	22.5
		Average Peak Stress (MPa)	0.011	0.021	0.028	0.049	0.072	0.102	0.163	0.286
		Average Peak Strain (με)	16	24	26	29	34	27	33	49
	3	|E*| (MPa)	793	1174	1432	2294	2919	4913	5867	7275
		Phase Angle, F (º)	31.8	31.4	33.2	34.0	32.3	26.8	24.4	22.0
		Average Peak Stress (MPa)	0.014	0.028	0.027	0.048	0.072	0.101	0.162	0.283
		Average Peak Strain (με)	18	24	19	21	25	21	28	39
	Avg.	|E*| Average	719	986	1182	1911	2437	4215	5221	6419
		F Average	33.7	33.2	34.2	34.7	32.8	28.3	24.3	22.7
		|E*| Coeff. of Variation	0.089	0.167	0.183	0.175	0.172	0.147	0.107	0.118
		F Coeff. of Variation	0.05	0.09	0.06	0.07	0.05	0.08	0.08	0.04
		|E*| Std. Dev.	63.9	164.7	216.8	333.8	420.2	618.2	559.7	755.9
		F Std. Dev.	1.624	3.084	2.063	2.287	1.765	2.156	1.906	0.795
54.4	1	|E*| (MPa)	352	366	322	422	519	951	1274	1849
		Phase Angle, F (º)	18.0	27.5	25.1	28.7	29.2	29.4	28.4	28.7
		Average Peak Stress (MPa)	0.005	0.007	0.012	0.024	0.031	0.051	0.074	0.099
		Average Peak Strain (με)	13	20	38	57	59	54	58	54
	2	|E*| (MPa)	368	447	344	405	487	864	1146	1667
		Phase Angle, F (º)	24.6	23.5	25.9	26.6	27.3	27.6	26.8	27.5
		Average Peak Stress (MPa)	0.004	0.006	0.011	0.021	0.027	0.045	0.066	0.087
		Average Peak Strain (με)	11	14	31	52	56	53	58	52
	3	|E*| (MPa)		328	355	491	602	1074	1420	2072
		Phase Angle, F (º)		17.1	19.6	23.9	25.3	26.1	25.6	27.1
		Average Peak Stress (MPa)		0.009	0.014	0.028	0.036	0.060	0.088	0.117
		Average Peak Strain (με)		26	40	57	60	56	62	56
	Avg.	|E*| Average	360	380	340	439	536	963	1280	1863
		F Average	21.3	22.7	23.5	26.4	27.2	27.7	26.9	27.8
		|E*| Coeff. of Variation	0.033	0.160	0.050	0.103	0.110	0.110	0.107	0.109
		F Coeff. of Variation	0.22	0.23	0.14	0.09	0.07	0.06	0.05	0.03
		|E*| Std. Dev.	11.8	60.8	16.9	45.4	59.1	105.6	137.2	202.9
		F Std. Dev.	4.659	5.237	3.405	2.408	1.954	1.662	1.411	0.853

Table B-82. B25.0CC – Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	24759	32712	32133	36206	37831	41047	42879	44709
		Phase Angle, F (º)	12.7	3.4	6.5	7.8	7.9	6.6	5.9	6.0
		Average Peak Stress (MPa)	1.241	1.466	1.551	1.664	1.691	1.859	1.918	2.079
		Average Peak Strain (με)	50	45	48	46	45	45	45	46
	2	|E*| (MPa)	20435	24681	24493	28671	30043	33227	34011	35288
		Phase Angle, F (º)	9.9	14.7	6.3	5.7	4.5	3.3	2.5	2.1
		Average Peak Stress (MPa)	1.269	1.495	1.579	1.694	1.746	1.916	1.975	2.197
		Average Peak Strain (με)	62	61	64	59	58	58	58	62
	3	|E*| (MPa)	21173	27689	26787	32148	33333	37056	38202	39337
		Phase Angle, F (º)	14.1	16.4	11.9	8.2	7.9	5.8	5.6	5.1
		Average Peak Stress (MPa)	1.269	1.495	1.579	1.694	1.746	1.916	1.976	2.199
		Average Peak Strain (με)	60	54	59	53	52	52	52	56
	Avg.	|E*| Average	22122	28361	27805	32342	33736	37110	38364	39778
		F Average	12.2	11.5	8.3	7.2	6.8	5.3	4.7	4.4
		|E*| Coeff. of Variation	0.105	0.143	0.141	0.117	0.116	0.105	0.116	0.119
		F Coeff. of Variation	0.17	0.61	0.38	0.19	0.29	0.33	0.40	0.46
		|E*| Std. Dev.	2312.9	4057.4	3920.0	3771.1	3909.9	3910.0	4436.3	4726.2
		F Std. Dev.	2.128	7.077	3.180	1.371	1.949	1.714	1.879	2.044
10	1	|E*| (MPa)	4428	7019	8888	13517	15596	20519	22889	25961
		Phase Angle, F (º)	32.9	28.1	27.6	22.1	20.5	15.7	13.9	12.9
		Average Peak Stress (MPa)	0.282	0.451	0.564	0.705	0.817	1.125	1.267	1.381
		Average Peak Strain (με)	64	64	63	52	52	55	55	53
	2	|E*| (MPa)	3657	6109	7568	11014	12817	17107	18927	21386
		Phase Angle, F (º)	29.6	22.8	25.4	19.3	17.0	12.7	11.1	10.0
		Average Peak Stress (MPa)	0.282	0.451	0.564	0.705	0.817	1.125	1.266	1.381
		Average Peak Strain (με)	77	74	75	64	64	66	67	65
	3	|E*| (MPa)	3605	6852	7927	11732	13553	18531	20499	23421
		Phase Angle, F (º)	34.5	29.3	27.1	23.9	21.8	16.7	14.7	13.2
		Average Peak Stress (MPa)	0.282	0.451	0.564	0.705	0.817	1.125	1.267	1.382
		Average Peak Strain (με)	78	66	71	60	60	61	62	59
	Avg.	|E*| Average	3897	6660	8128	12088	13989	18719	20772	23589
		F Average	32.3	26.7	26.7	21.8	19.8	15.0	13.3	12.0
		|E*| Coeff. of Variation	0.118	0.073	0.084	0.107	0.103	0.092	0.096	0.097
		F Coeff. of Variation	0.08	0.13	0.04	0.11	0.13	0.14	0.14	0.15
		|E*| Std. Dev.	461.0	484.0	682.5	1288.9	1439.8	1713.9	1994.7	2291.9
		F Std. Dev.	2.526	3.469	1.194	2.303	2.521	2.100	1.912	1.787
35	1	|E*| (MPa)	358	495	600	1084	1531	3093	4143	5979
		Phase Angle, F (º)	25.1	30.1	30.7	35.7	33.6	33.3	31.8	29.6
		Average Peak Stress (MPa)	0.017	0.025	0.034	0.056	0.111	0.178	0.246	0.413
		Average Peak Strain (με)	47	51	56	52	73	57	59	69
	2	|E*| (MPa)	329	442	522	925	1326	2670	3603	5248
		Phase Angle, F (º)	22.1	26.5	27.3	32.7	31.4	31.6	30.2	27.8
		Average Peak Stress (MPa)	0.017	0.025	0.034	0.056	0.111	0.177	0.245	0.412
		Average Peak Strain (με)	51	58	65	61	84	66	68	79
	3	|E*| (MPa)	289	410	511	905	1274	2586	3456	5104
		Phase Angle, F (º)	25.1	29.1	30.3	35.4	33.8	34.1	32.9	31.2
		Average Peak Stress (MPa)	0.017	0.025	0.034	0.056	0.111	0.178	0.245	0.412
		Average Peak Strain (με)	58	62	66	62	87	69	71	81
	Avg.	|E*| Average	325	449	544	972	1377	2783	3734	5444
		F Average	24.1	28.5	29.4	34.6	32.9	33.0	31.6	29.5
		|E*| Coeff. of Variation	0.107	0.096	0.089	0.101	0.099	0.098	0.097	0.086
		F Coeff. of Variation	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.06
		|E*| Std. Dev.	34.9	43.1	48.4	97.9	136.0	271.8	361.8	469.1
		F Std. Dev.	1.714	1.858	1.828	1.656	1.309	1.247	1.360	1.714
54.4	Est.	|E*| (MPa)	117	146	163	228	271	435	548	762

Table B-83. B25.0CF – Granite (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	16536	18902	21164	22946	23998	26301	27143	28419
		Phase Angle, F (º)	8.3	11.9	5.1	4.9	4.3	3.2	2.6	2.5
		Average Peak Stress (MPa)	1.356	1.582	1.639	1.751	1.806	1.974	2.034	2.197
		Average Peak Strain (με)	82	84	77	76	75	75	75	77
	2	|E*| (MPa)	17232	20922	22033	23798	25242	27824	28896	30075
		Phase Angle, F (º)	9.5	13.2	6.4	8.5	7.4	6.7	6.4	6.1
		Average Peak Stress (MPa)	1.356	1.582	1.639	1.751	1.807	1.973	2.033	2.196
		Average Peak Strain (με)	79	76	74	74	72	71	70	73
	3	|E*| (MPa)	16487	19811	21177	23012	23848	26459		
		Phase Angle, F (º)	10.8	13.8	8.5	7.1	7.3	6.7		
		Average Peak Stress (MPa)	1.355	1.582	1.639	1.751	1.806	1.974		
		Average Peak Strain (με)	82	80	77	76	76	75		
	Avg.	|E*| Average	16751	19878	21458	23252	24363	26861	28019	29247
		F Average	9.5	13.0	6.7	6.8	6.3	5.5	4.5	4.3
		|E*| Coeff. of Variation	0.025	0.051	0.023	0.020	0.031	0.031	0.044	0.040
		F Coeff. of Variation	0.13	0.08	0.26	0.26	0.28	0.37	0.59	0.61
		|E*| Std. Dev.	416.5	1011.5	498.0	474.1	765.5	837.3	1239.6	1171.3
		F Std. Dev.	1.239	1.001	1.749	1.794	1.756	2.048	2.676	2.611
10	1	|E*| (MPa)	4555	6770	7642	9752	10714	13507	14808	16547
		Phase Angle, F (º)	23.0	23.0	18.0	15.5	14.3	11.0	9.6	9.0
		Average Peak Stress (MPa)	0.282	0.367	0.424	0.565	0.677	0.930	1.043	1.150
		Average Peak Strain (με)	62	54	55	58	63	69	70	69
	2	|E*| (MPa)	4779	6811	8045	10263	11451	14375	15773	17584
		Phase Angle, F (º)	24.7	17.3	20.6	17.7	16.3	13.4	12.5	11.8
		Average Peak Stress (MPa)	0.282	0.367	0.424	0.565	0.677	0.930	1.042	1.147
		Average Peak Strain (με)	59	54	53	55	59	65	66	65
	3	|E*| (MPa)	4531	6918	7347	9866	10946	13887	15249	17117
		Phase Angle, F (º)	26.6	21.3	22.9	18.3	17.2	14.1	12.9	12.5
		Average Peak Stress (MPa)	0.282	0.367	0.424	0.565	0.677	0.930	1.043	1.149
		Average Peak Strain (με)	62	53	58	57	62	67	68	67
	Avg.	|E*| Average	4622	6833	7678	9960	11037	13923	15277	17083
		F Average	24.7	20.5	20.5	17.2	15.9	12.8	11.7	11.1
		|E*| Coeff. of Variation	0.030	0.011	0.046	0.027	0.034	0.031	0.032	0.030
		F Coeff. of Variation	0.07	0.14	0.12	0.09	0.10	0.13	0.15	0.17
		|E*| Std. Dev.	136.5	76.1	350.0	268.2	376.6	434.9	483.1	519.1
		F Std. Dev.	1.794	2.918	2.448	1.503	1.530	1.658	1.801	1.837
35	1	|E*| (MPa)	463	710	892	1496	1994	3366	4145	5297
		Phase Angle, F (º)	27.3	28.2	28.1	28.8	26.3	23.5	21.8	20.3
		Average Peak Stress (MPa)	0.022	0.028	0.042	0.070	0.140	0.208	0.277	0.420
		Average Peak Strain (με)	47	40	48	47	70	62	67	79
	2	|E*| (MPa)	511	769	912	1512	1951	3341	4080	5180
		Phase Angle, F (º)	28.2	32.5	30.2	30.8	28.3	24.9	23.5	22.1
		Average Peak Stress (MPa)	0.021	0.028	0.042	0.070	0.140	0.207	0.276	0.416
		Average Peak Strain (με)	41	37	46	46	72	62	68	80
	3	|E*| (MPa)	554	818	1006	1599	2081	3517	4293	5331
		Phase Angle, F (º)	27.0	29.7	29.6	30.7	27.8	25.5	24.0	22.7
		Average Peak Stress (MPa)	0.021	0.028	0.042	0.070	0.140	0.208	0.277	0.419
		Average Peak Strain (με)	38	34	42	44	67	59	64	79
	Avg.	|E*| Average	510	766	936	1536	2009	3408	4173	5269
		F Average	27.5	30.1	29.3	30.1	27.5	24.6	23.1	21.7
		|E*| Coeff. of Variation	0.089	0.071	0.065	0.036	0.033	0.028	0.026	0.015
		F Coeff. of Variation	0.02	0.07	0.04	0.04	0.04	0.04	0.05	0.06
		|E*| Std. Dev.	45.5	54.0	60.9	55.6	66.1	95.3	109.6	79.3
		F Std. Dev.	0.660	2.149	1.040	1.140	1.037	0.990	1.145	1.235
54.4	Est.	|E*| (MPa)	127	197	241	396	495	833	1043	1397

Table B-84. B25.0CF – Limestone (SI Unit)

Temp (°C)	Rep.	Parameters	Frequency (Hz)							
			0.01	0.05	0.1	0.5	1	5	10	25
-10	1	|E*| (MPa)	17099	18323	19701	22218	23139	25076	25869	26804
		Phase Angle, F (°)	5.7	2.2	3.3	2.9	3.0	1.7	1.4	1.5
		Average Peak Stress (MPa)	1.353	1.579	1.636	1.750	1.806	1.975	2.034	2.197
		Average Peak Strain (με)	79	86	83	79	78	79	79	82
	2	|E*| (MPa)	18512	21170	22473	24461	25212	27050	27946	28874
		Phase Angle, F (°)	11.5	12.5	8.3	7.9	7.6	6.1	5.2	4.5
		Average Peak Stress (MPa)	1.353	1.579	1.636	1.749	1.805	1.974	2.033	2.195
		Average Peak Strain (με)	73	75	73	72	72	73	73	76
	3	|E*| (MPa)	16784	18608	20044	22556	23539	25469	26396	27282
		Phase Angle, F (°)	11.0	9.7	9.3	8.2	7.9	6.3	6.1	5.7
		Average Peak Stress (MPa)	1.353	1.579	1.636	1.750	1.805	1.973	2.031	2.197
		Average Peak Strain (με)	81	85	82	78	77	77	77	81
	Avg.	|E*| Average	17465	19367	20740	23078	23964	25865	26737	27653
		F Average	9.4	8.1	6.9	6.4	6.2	4.7	4.2	3.9
		|E*| Coeff. of Variation	0.053	0.081	0.073	0.052	0.046	0.040	0.040	0.039
		F Coeff. of Variation	0.34	0.65	0.46	0.47	0.45	0.56	0.59	0.55
		|E*| Std. Dev.	920.3	1568.2	1511.3	1209.1	1099.6	1044.8	1079.7	1084.1
		F Std. Dev.	3.209	5.316	3.213	2.990	2.779	2.622	2.496	2.168
10	1	|E*| (MPa)	4927	6845	7956	10531	11603	14245	15451	17138
		Phase Angle, F (°)	22.6	15.8	16.9	13.5	12.4	9.0	7.7	7.4
		Average Peak Stress (MPa)	0.282	0.395	0.479	0.622	0.734	1.015	1.158	1.263
		Average Peak Strain (με)	57	58	60	59	63	71	75	74
	2	|E*| (MPa)	5561	8232	8840	11586	12829	15462	16746	18454
		Phase Angle, F (°)	28.7	22.6	22.1	18.0	16.7	12.7	11.4	10.2
		Average Peak Stress (MPa)	0.282	0.395	0.480	0.621	0.734	1.014	1.156	1.263
		Average Peak Strain (με)	51	48	54	54	57	66	69	68
	3	|E*| (MPa)	4991	7139	7881	10479	11634	14567	15986	17454
		Phase Angle, F (°)	27.0	19.3	20.9	17.5	15.7	12.1	11.4	10.4
		Average Peak Stress (MPa)	0.282	0.395	0.479	0.621	0.734	1.014	1.156	1.264
		Average Peak Strain (με)	56	55	61	59	63	70	72	72
	Avg.	|E*| Average	5160	7405	8226	10865	12022	14758	16061	17682
		F Average	26.1	19.3	20.0	16.3	14.9	11.3	10.2	9.3
		|E*| Coeff. of Variation	0.068	0.099	0.065	0.058	0.058	0.043	0.041	0.039
		F Coeff. of Variation	0.12	0.18	0.14	0.15	0.15	0.17	0.21	0.18
		|E*| Std. Dev.	349.0	730.6	533.3	624.8	699.1	630.6	650.5	687.1
		F Std. Dev.	3.132	3.410	2.714	2.476	2.255	1.967	2.099	1.698
35	1	|E*| (MPa)	475	749	903	1533	1984	3481	4376	5599
		Phase Angle, F (°)	28.6	29.6	30.1	31.4	29.5	25.0	21.0	21.1
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.220	0.389
		Average Peak Strain (με)	30	38	41	42	49	39	50	69
	2	|E*| (MPa)	590	853	1022	1671	2150	3841	4674	5752
		Phase Angle, F (°)	31.6	36.8	36.0	37.4	34.6	30.6	26.8	23.6
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.220	0.387
		Average Peak Strain (με)	24	33	36	39	45	36	47	67
	3	|E*| (MPa)	602	856	1060	1766	2295	4024	4989	6242
		Phase Angle, F (°)	33.7	33.9	33.6	35.1	32.7	28.7	25.4	22.9
		Average Peak Stress (MPa)	0.014	0.028	0.037	0.064	0.097	0.137	0.219	0.387
		Average Peak Strain (με)	24	33	35	36	42	34	44	62
	Avg.	|E*| Average	556	819	995	1656	2143	3782	4680	5864
		F Average	31.3	33.4	33.2	34.6	32.3	28.1	24.4	22.6
		|E*| Coeff. of Variation	0.126	0.075	0.082	0.071	0.073	0.073	0.065	0.057
		F Coeff. of Variation	0.08	0.11	0.09	0.09	0.08	0.10	0.12	0.06
		|E*| Std. Dev.	70.1	61.0	81.8	117.2	155.5	276.4	306.3	335.9
		F Std. Dev.	2.547	3.625	2.962	3.034	2.561	2.846	2.994	1.308
54.4	1	|E*| (MPa)	157	197	218	345	441	842	1146	1694
		Phase Angle, F (°)	16.9	20.6	21.0	24.7	26.0	26.6	25.6	26.3
		Average Peak Stress (MPa)	0.006	0.008	0.014	0.028	0.036	0.061	0.090	0.121
		Average Peak Strain (με)	35	43	66	82	83	72	78	72
	2	|E*| (MPa)	485	414	373	445	536	960	1255	1785
		Phase Angle, F (°)	27.4	33.0	30.8	32.9	32.5	32.6	30.1	30.0
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.060	0.089	0.120
		Average Peak Strain (με)	12	21	38	63	68	63	71	68
	3	|E*| (MPa)	418	338	319	434	528	962	1281	1887
		Phase Angle, F (°)	20.9	22.4	22.6	25.7	26.9	28.9	28.1	28.6
		Average Peak Stress (MPa)	0.006	0.009	0.014	0.028	0.036	0.060	0.088	0.118
		Average Peak Strain (με)	13	25	44	65	69	62	68	63
	Avg.	|E*| Average	353	316	303	408	501	921	1227	1789
		F Average	21.7	25.3	24.8	27.8	28.5	29.3	27.9	28.3
		|E*| Coeff. of Variation	0.490	0.349	0.260	0.134	0.105	0.074	0.059	0.054
		F Coeff. of Variation	0.24	0.27	0.21	0.16	0.12	0.10	0.08	0.07
		|E*| Std. Dev.	173.1	110.3	79.0	54.8	52.4	68.6	71.9	96.2
		F Std. Dev.	5.294	6.724	5.275	4.483	3.523	3.003	2.221	1.905

APPENDIX C: IDT DYNAMIC MODULUS DATA

C.1 Sigmoidal and Shift Factor Function Coefficients

Table C.1 summarizes the sigmoidal coefficients and the shift factor function coefficients obtained from the IDT test results.

Table C-1. Dynamic Modulus Calculation Coefficients in IDT

Mixture	Sigmoidal Function Coefficients				Shift Factor Coefficients		
	a	b	d	e	α_1	α_2	α_3
I[a]19.0[b]B[c] C[d]	2.11225	2.44575	1.53176	0.49729	0.00065	-0.15589	1.48397
S9.5B F	1.58015	2.89004	1.66129	0.44887	0.00065	-0.16032	1.54830
S9.5A C	1.84531	2.65263	1.72908	0.50478	0.00062	-0.15833	1.52598
B25.0B C	1.96698	2.59049	1.67001	0.56604	0.00073	-0.15589	1.48316
B25.0C C	2.24369	2.33629	1.61582	0.61168	0.00072	-0.15337	1.46430
I19.0C C	1.62411	2.89073	1.70272	0.53172	0.00071	-0.15394	1.47117
S12.5B C	1.63064	2.89780	1.70500	0.52335	0.00070	-0.15675	1.50193
S9.5B C	1.58317	2.92155	1.54672	0.50761	0.00076	-0.15484	1.47942
B25.0B F	1.83174	2.71626	1.80393	0.56046	0.00065	-0.15433	1.50680
I19.0B F	1.72611	2.76621	1.52908	0.53587	0.00079	-0.15714	1.48523
S12.5B F	1.50551	3.00251	1.85828	0.50401	0.00076	-0.15759	1.51368
S9.5A F	1.69710	2.80058	1.42370	0.48621	0.00088	-0.16021	1.51443
I19B 1	1.58686	3.02563	1.73393	0.48027	0.00077	-0.15881	1.52518
S9.5B 1	1.55577	2.94578	1.53680	0.47158	0.00087	-0.15899	1.51279
B25.0C F	2.05644	2.48934	1.66764	0.49169	0.00078	-0.15835	1.51934
I19.0C F	1.92492	2.59199	1.70443	0.45683	0.00064	-0.15867	1.52730
I19.0D F	1.52817	3.00408	2.06655	0.45215	0.00063	-0.16155	1.58982
I19.0D C	1.76768	2.82264	1.85563	0.48768	0.00058	-0.15454	1.49454
S12.5D C	1.83576	2.70519	1.80787	0.48416	0.00060	-0.15570	1.50211
S9.5C C	1.58688	2.94035	1.93390	0.44341	0.00054	-0.15543	1.50970
S12.5C F	1.45544	3.09336	1.93971	0.43362	0.00063	-0.15759	1.51324
S9.5C F	1.50592	3.03385	1.99774	0.43985	0.00056	-0.15630	1.52179
S12.5D F	1.51680	3.00767	2.07468	0.42684	0.00039	-0.15494	1.51241
S12.5C C	1.95165	2.58640	1.50594	0.40418	0.00099	-0.16899	1.59627

C.2 Data Base

A database is developed for the 24 mixtures tested in the IDT mode and presented in this section. The database includes dynamic moduli, Poisson's ratio, and phase angles for each of the three replicates for all the 24 mixtures. The data are presented in Tables C.2 to C.25.

Table C-2. S 9.5 C Fine Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	31685	0.08	3.3	14.5	32202	0.20	2.0	6.0	31231	0.24	2.6	5.4	S 9.5C F
	10	30421	0.08	3.3	13.8	30856	0.20	2.0	7.0	30038	0.25	2.6	6.9	
	5	29894	0.09	3.5	14.7	30059	0.21	2.1	6.5	29271	0.25	3.4	7.1	
	1	27710	0.11	4.7	15.7	27999	0.22	3.3	8.0	26953	0.26	4.3	7.6	
	0.5	27048	0.13	4.9	15.4	26962	0.22	3.5	7.6	26162	0.27	4.7	8.1	
	0.1	24214	0.13	7.0	14.5	24697	0.24	5.2	8.1	23755	0.28	5.6	10.4	
	0.05	22306	0.10	6.7	18.1	23259	0.23	4.8	10.7	22150	0.27	7.5	9.1	
	0.01	20514	0.17	8.2	18.7	20791	0.26	6.8	10.7	20009	0.31	7.9	12.4	
10	25	21458	0.11	9.6	17.1	21113	0.23	8.2	13.4	20646	0.30	8.3	12.7	
	10	19419	0.13	10.0	19.6	19141	0.24	8.3	13.3	18837	0.33	8.8	13.3	
	5	17961	0.15	10.6	20.9	17804	0.26	9.0	13.2	17443	0.34	10.0	14.5	
	1	14814	0.22	13.0	22.8	14542	0.28	11.4	14.9	14476	0.39	11.8	16.1	
	0.5	13434	0.23	14.2	24.0	13130	0.28	12.7	15.7	13045	0.38	13.1	17.3	
	0.1	10360	0.27	17.0	26.9	10173	0.30	16.1	18.2	10181	0.41	15.6	20.2	
	0.05	9160	0.29	19.4	26.3	8745	0.28	17.6	19.1	9070	0.41	16.9	21.8	
	0.01	6737	0.30	22.3	30.0	6488	0.31	20.5	23.2	6713	0.42	20.9	24.3	
35	25	7186	0.34	21.3	26.9	6877	0.30	20.4	22.4	6928	0.47	21.3	23.9	
	10	5678	0.37	23.6	30.9	5622	0.36	21.8	22.7	5355	0.47	21.8	23.9	
	5	4555	0.40	24.1	29.9	4570	0.36	23.3	24.8	4411	0.50	23.3	26.1	
	1	2715	0.46	28.2	31.8	2629	0.37	28.0	29.2	2577	0.53	28.4	30.7	
	0.5	2144	0.48	28.9	31.9	2037	0.37	29.2	30.5	2048	0.53	29.3	31.6	
	0.1	1279	0.52	28.6	30.9	1177	0.37	29.0	29.8	1231	0.55	29.4	31.4	
	0.05	933	0.42	31.3	36.3	948.5	0.39	28.2	29.5	1031	0.56	29.3	30.9	
	0.01	646	0.41	28.9	33.2	593.2	0.41	25.8	27.6	697.7	0.56	26.8	29.3	

Table C-3.S 12.5 D Fine Data

Temp (^{o}C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	32615	0.28	1.7	0.9	30619	0.19	1.7	8.0	30210	0.10	0.6	12.4	S 12.5D F
	10	30944	0.25	1.5	1.6	28862	0.16	2.0	8.3	28788	0.09	0.9	13.4	
	5	30317	0.27	1.9	2.5	27980	0.17	2.1	8.2	28016	0.10	1.1	13.6	
	1	28128	0.26	3.0	3.4	26090	0.18	2.9	8.1	26108	0.10	1.9	14.4	
	0.5	27132	0.27	2.8	3.7	25208	0.18	3.2	8.9	25153	0.09	2.2	14.7	
	0.1	24552	0.26	4.1	4.0	23060	0.19	4.0	9.8	22777	0.09	3.8	14.8	
	0.05	23734	0.26	3.3	7.9	21280	0.14	5.5	9.7	21389	0.06	4.0	16.5	
	0.01	21425	0.29	5.7	6.9	19459	0.17	5.8	12.0	19688	0.09	4.8	19.5	
10	25	22355	0.30	6.5	6.9	20075	0.16	7.4	12.9	20252	0.12	5.7	17.4	
	10	20174	0.29	7.1	8.8	18274	0.18	7.4	14.1	18432	0.13	6.5	18.0	
	5	18978	0.31	7.6	8.9	16997	0.18	8.5	15.5	17060	0.13	6.6	20.4	
	1	15998	0.32	10.0	12.0	14151	0.20	10.8	17.4	14408	0.15	9.0	22.1	
	0.5	14748	0.33	10.7	12.3	13110	0.21	10.6	17.4	13204	0.15	10.1	23.6	
	0.1	11812	0.35	13.9	14.4	10454	0.22	13.2	20.7	10519	0.15	13.2	25.3	
	0.05	10334	0.32	14.7	17.9	9466	0.23	14.5	22.5	9413	0.12	15.0	26.0	
	0.01	8158	0.34	18.0	19.2	7101	0.19	18.0	25.0	7172	0.09	17.0	30.8	
35	25	7897	0.40	19.0	21.9	6952	0.31	19.6	24.9	7122	0.26	18.8	27.0	
	10	6265	0.38	20.3	21.8	5534	0.32	20.8	28.3	5778	0.30	19.6	28.6	
	5	5217	0.40	22.2	24.7	4502	0.31	22.3	27.9	4748	0.29	21.6	31.1	
	1	2904	0.43	30.1	31.4	2460	0.30	30.1	35.3	2673	0.27	28.9	39.6	
	0.5	2402	0.43	29.9	32.3	2086	0.29	29.7	35.1	2252	0.28	28.8	39.0	
	0.1	1468	0.44	30.2	32.0	1307	0.27	30.2	34.3	1397	0.26	28.9	38.7	
	0.05	1158	0.47	31.3	33.2	1050	0.22	30.9	35.1	1136	0.27	29.5	40.1	
	0.01	733	0.49	26.7	36.1	723.5	0.19	25.8	38.7	757.4	0.19	27.7	39.3	

Table C-4. S 12.5 D Coarse Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	33763	0.21	1.7	3.2	30586	0.13	1.1	7.4	32922	0.19	1.3	5.3	S 12.5D C
	10	32494	0.23	1.5	3.8	29520	0.14	1.3	7.4	31330	0.18	1.5	7.1	
	5	31622	0.22	1.9	4.1	28566	0.14	1.7	8.3	30448	0.19	1.9	7.2	
	1	29428	0.24	3.3	5.2	26314	0.15	2.5	9.3	28054	0.19	3.0	7.7	
	0.5	28517	0.25	3.6	5.5	25299	0.15	3.3	9.6	27146	0.21	3.4	7.8	
	0.1	26159	0.27	5.0	7.0	22277	0.14	4.0	10.9	24409	0.21	4.3	9.7	
	0.05	24535	0.27	7.9	5.3	20808	0.13	4.2	12.2	23859	0.25	7.1	8.4	
	0.01	21538	0.28	7.5	8.8	18553	0.17	7.1	13.0	20366	0.24	7.1	11.5	
10	25	21967	0.26	7.8	12.3	19775	0.17	7.8	14.0	21274	0.27	8.4	13.0	
	10	19986	0.30	8.7	12.6	17678	0.19	8.2	13.9	19126	0.27	9.1	14.3	
	5	18440	0.30	10.1	13.1	15940	0.18	9.6	15.5	17886	0.30	9.8	15.0	
	1	14949	0.33	13.0	15.7	12545	0.21	13.2	18.1	14194	0.31	12.7	17.2	
	0.5	13538	0.35	14.3	17.5	11293	0.21	14.1	19.0	12594	0.33	14.3	18.7	
	0.1	10178	0.37	17.9	20.5	8391	0.23	17.9	22.4	9514	0.36	18.4	20.8	
	0.05	8890	0.41	20.5	21.7	7359	0.26	19.6	24.2	8625	0.40	19.4	22.6	
	0.01	6151	0.42	24.0	25.9	4967	0.25	23.6	27.9	5702	0.39	23.8	26.3	
35	25	6855	0.43	21.8	25.4	5800	0.31	22.3	25.2	6338	0.34	22.3	25.9	
	10	5255	0.46	23.7	26.0	4316	0.31	23.6	28.8	4798	0.32	23.1	27.8	
	5	4246	0.48	24.8	28.7	3444	0.32	24.6	28.2	3914	0.36	25.1	28.4	
	1	2396	0.50	28.4	31.7	1893	0.33	28.1	32.1	2240	0.40	28.4	31.3	
	0.5	1853	0.52	29.0	32.8	1475	0.34	28.2	33.1	1731	0.40	29.0	32.8	
	0.1	1111	0.56	27.4	31.4	874.8	0.35	26.2	31.2	1034	0.41	26.9	30.8	
	0.05	898	0.55	25.9	31.5	719.6	0.35	25.3	31.5	845.6	0.40	25.3	29.7	
	0.01	621	0.61	23.4	29.6	493.6	0.36	22.4	29.7	582.6	0.41	21.8	26.5	

Table C-5. S 12.5 C Fine Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	30793	0.03	2.4	11.5	30704	0.16	-0.6	9.7	33977	0.20	0.5	7.8	S 12.5C F
	10	29771	0.04	1.9	12.6	29255	0.16	1.6	9.6	32719	0.20	0.4	9.9	
	5	29191	0.05	2.2	13.5	28064	0.16	1.1	10.6	31648	0.19	0.9	11.0	
	1	26837	0.05	3.1	14.7	26038	0.17	2.5	10.9	29547	0.20	1.9	12.0	
	0.5	25878	0.06	3.6	13.8	25087	0.18	2.6	11.1	28396	0.20	2.0	12.1	
	0.1	23543	0.06	5.7	15.3	22962	0.19	4.3	12.3	26160	0.22	3.9	13.0	
	0.05	21945	0.06	7.3	14.2	21109	0.16	2.9	15.6	24345	0.21	5.9	12.2	
	0.01	19617	0.07	6.9	19.0	18662	0.19	5.8	15.8	21741	0.21	5.9	16.5	
10	25	20390	0.06	7.1	17.7	19889	0.20	6.9	16.8	21947	0.20	6.3	16.4	
	10	18359	0.05	7.8	19.6	17918	0.21	6.9	18.0	19886	0.21	7.1	16.7	
	5	17019	0.06	9.3	21.4	16367	0.22	7.2	18.7	18368	0.22	8.1	18.3	
	1	13905	0.10	11.7	24.0	13427	0.26	11.3	20.6	15154	0.26	10.8	20.4	
	0.5	12619	0.10	13.0	24.8	12061	0.26	12.4	21.8	13687	0.27	12.3	22.0	
	0.1	9622	0.08	17.2	28.1	9223	0.28	15.9	25.8	10277	0.26	15.2	24.9	
	0.05	8389	0.08	18.6	28.3	8052	0.28	17.4	27.5	8992	0.27	16.8	26.8	
	0.01	5936	0.09	21.9	33.0	5736	0.30	21.7	31.2	6465	0.31	21.9	29.8	
35	25	6145	0.08	20.7	31.2	6474	0.39	20.0	25.3	6980	0.36	20.7	28.2	
	10	5093	0.09	22.2	33.9	5065	0.40	21.3	27.2	5426	0.35	21.6	28.1	
	5	4119	0.09	23.7	34.7	4127	0.40	23.7	28.9	4514	0.40	23.2	29.8	
	1	2380	0.15	28.8	40.5	2437	0.49	27.4	32.4	2643	0.44	27.5	34.0	
	0.5	1830	0.14	30.6	42.9	1854	0.47	28.1	34.5	2045	0.42	29.2	35.7	
	0.1	1087	0.08	30.4	39.9	1111	0.48	28.3	33.8	1244	0.41	28.0	35.6	
	0.05	885	0.05	30.0	37.9	898.1	0.46	27.4	33.8	999.8	0.39	27.4	34.7	
	0.01	556	0.02	28.4	37.0	566.5	0.41	24.8	32.6	632.1	0.36	25.7	34.6	

Table C-6. S 12.5 C Coarse Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	28534	0.06	2.8	10.3	36666	0.29	6.4	4.8	31209	0.20	4.4	11.0	S 12.5C C
	10	26712	0.06	3.1	12.1	35163	0.30	7.1	4.6	29549	0.19	4.6	11.6	
	5	25762	0.05	3.3	10.8	33579	0.29	7.2	5.5	28593	0.20	5.0	11.9	
	1	23629	0.07	4.7	13.1	30540	0.31	7.9	6.4	26154	0.22	5.9	12.1	
	0.5	22661	0.08	4.9	14.1	29163	0.30	8.4	7.2	25195	0.22	6.2	12.3	
	0.1	20318	0.09	5.9	15.5	27204	0.36	9.5	8.0	22894	0.25	7.2	13.9	
	0.05	19092	0.07	5.1	17.5	25096	0.34	12.1	7.0	21852	0.26	8.8	13.1	
	0.01	16702	0.08	8.1	16.2	22105	0.33	11.4	10.5	18687	0.23	9.6	15.6	
10	25	16332	0.11	9.9	19.7	21747	0.35	12.4	12.1	18943	0.25	10.5	16.0	
	10	14231	0.15	10.7	22.0	19233	0.36	13.2	12.9	16834	0.26	11.3	17.9	
	5	12973	0.18	12.0	23.2	17981	0.39	14.1	13.6	15472	0.27	12.4	19.1	
	1	10205	0.23	15.5	26.6	14212	0.41	16.9	16.6	12442	0.31	15.0	20.2	
	0.5	9271	0.23	16.0	27.7	12918	0.43	18.1	17.6	11280	0.33	15.9	21.7	
	0.1	7250	0.26	18.5	29.6	9930	0.46	21.5	19.6	8482	0.33	18.8	24.3	
	0.05	6235	0.24	20.2	32.6	8695	0.47	23.5	21.8	7429	0.34	21.1	26.2	
	0.01	4545	0.27	22.7	34.3	6721	0.53	26.4	24.7	5604	0.36	24.0	29.8	
35	25	5671	0.27	20.3	33.4	7382	0.53	22.2	21.1	6225	0.36	21.7	26.8	
	10	4563	0.32	20.6	32.1	6001	0.59	23.1	22.1	4992	0.38	21.9	28.1	
	5	3835	0.35	22.1	34.3	5062	0.60	24.4	22.8	4210	0.41	23.1	29.4	
	1	2248	0.41	27.8	39.5	3150	0.72	30.7	28.7	2498	0.46	29.4	33.7	
	0.5	1932	0.39	27.1	38.7	2741	0.75	30.2	28.1	2006	0.35	38.2	45.2	
	0.1	1260	0.34	27.9	37.2	1960	0.92	31.1	28.3	1447	0.47	30.2	35.9	
	0.05	1058	0.33	28.7	39.1	1770	1.03	30.5	27.5	1242	0.47	30.9	36.5	
	0.01	765	0.28	28.5	36.6	1508	1.35	29.5	25.9	904.3	0.45	29.9	35.6	

Table C-7. S 12.5 B Fine Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	27970	0.17	1.0	7.6	30072	0.18	1.3	7.8	32500	0.16	1.9	12.2	S 12.5B F
	10	26487	0.16	1.2	8.6	29647	0.20	1.4	8.5	31243	0.17	2.7	12.0	
	5	25844	0.16	1.7	8.2	28722	0.19	1.9	9.0	30516	0.18	2.5	12.6	
	1	23497	0.16	3.0	10.5	26449	0.21	3.4	9.2	28454	0.20	3.8	13.7	
	0.5	22680	0.17	3.5	10.9	25539	0.22	3.8	10.3	27252	0.19	4.6	13.5	
	0.1	19804	0.15	5.9	11.5	22824	0.21	5.3	12.0	24579	0.20	6.0	16.7	
	0.05	18196	0.13	5.9	13.7	21700	0.28	6.2	12.0	23140	0.19	5.3	19.1	
	0.01	16152	0.17	7.7	15.4	18911	0.25	8.0	14.1	20251	0.21	9.2	17.9	
10	25	17413	0.20	8.4	15.2	19389	0.24	8.1	10.5	20269	0.23	9.2	17.7	
	10	15374	0.20	9.8	18.0	17490	0.29	9.3	17.4	18247	0.25	10.5	20.3	
	5	13891	0.21	10.7	19.1	15982	0.29	10.5	17.5	16582	0.26	11.1	22.0	
	1	10783	0.25	14.9	22.2	12490	0.33	14.3	20.3	12996	0.30	15.4	25.8	
	0.5	9522	0.26	16.4	24.0	11150	0.36	16.1	21.6	11655	0.33	16.9	26.1	
	0.1	6854	0.28	20.3	28.7	8118	0.38	19.7	26.3	8552	0.35	20.8	30.3	
	0.05	5654	0.28	23.3	29.6	6864	0.39	21.7	28.1	7171	0.35	24.2	31.9	
	0.01	3786	0.30	26.1	34.0	4694	0.44	25.7	31.0	4785	0.37	26.3	36.3	
35	25	5098	0.37	24.4	28.1	6020	0.52	23.2	26.4	6182	0.44	24.8	31.5	
	10	3626	0.37	26.2	30.6	4278	0.53	24.6	27.8	4471	0.46	25.9	31.6	
	5	2789	0.40	27.8	29.6	3359	0.60	26.2	27.4	3494	0.51	27.7	31.1	
	1	1321	0.33	33.8	37.9	1678	0.57	31.5	33.3	1739	0.49	34.2	37.1	
	0.5	1067	0.47	32.7	38.2	1336	0.65	29.9	34.0	1401	0.59	32.4	37.1	
	0.1	578	0.49	29.6	33.8	767.1	0.74	26.9	31.2	784	0.66	29.6	33.6	
	0.05	444	0.48	29.8	36.1	601.5	0.72	26.7	33.8	608.8	0.62	29.5	35.3	
	0.01	259	0.59	27.7	30.4	391.3	0.98	24.1	26.7	382.1	0.69	26.9	30.6	

Table C-8. S 12.5 B Coarse Data

Temp (^{o}C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	32300	0.11	2.8	12.7	38265	0.28	8.7	0.6	31639	0.08	2.1	14.3	S 12.5B C
	10	30870	0.11	2.9	12.7	37403	0.30	10.1	1.4	29999	0.07	2.6	15.6	
	5	29748	0.11	3.5	13.0	35954	0.30	10.6	2.4	28904	0.08	3.1	14.8	
	1	27115	0.12	4.9	14.5	32506	0.29	12.2	3.0	26401	0.09	4.4	16.1	
	0.5	26023	0.14	5.3	15.4	31457	0.31	12.5	3.5	25533	0.10	4.9	17.0	
	0.1	23435	0.15	6.3	17.1	28039	0.30	14.9	3.4	22443	0.10	7.6	18.1	
	0.05	21824	0.14	6.8	18.6	25910	0.27	15.8	4.1	20903	0.09	9.3	17.4	
	0.01	18767	0.16	10.0	18.7	22706	0.33	17.2	8.8	17692	0.11	10.1	20.9	
10	25	19596	0.18	10.6	18.7	22233	0.32	16.0	10.3	19014	0.16	10.2	19.5	
	10	16893	0.20	11.8	19.9	19745	0.34	17.6	11.5	16691	0.16	11.6	21.4	
	5	15252	0.22	13.6	21.4	17874	0.35	19.4	13.0	14959	0.18	12.9	21.8	
	1	11437	0.27	17.9	26.4	13261	0.36	23.7	17.8	11371	0.21	17.1	24.4	
	0.5	10202	0.27	19.4	27.2	11542	0.37	24.5	18.5	9988	0.22	18.7	26.4	
	0.1	7291	0.31	23.2	31.0	7969	0.37	29.3	22.8	6956	0.22	23.0	30.5	
	0.05	6027	0.29	26.5	31.5	6742	0.44	31.3	26.0	5747	0.23	25.9	31.9	
	0.01	3841	0.31	29.6	35.0	4242	0.44	35.1	28.9	3725	0.23	28.7	37.0	
35	25	4693	0.28	28.4	35.5	5031	0.36	28.7	27.1	4856	0.29	26.4	31.1	
	10	3362	0.44	29.0	35.2	3534	0.40	29.7	29.2	3442	0.35	27.4	33.3	
	5	2496	0.42	30.4	32.6	2659	0.38	31.1	27.9	2588	0.33	28.8	33.5	
	1	1146	0.42	34.9	37.7	1318	0.45	35.6	32.8	1280	0.38	33.2	37.4	
	0.5	923	0.44	33.1	37.4	1024	0.42	33.3	32.6	1005	0.36	31.4	37.3	
	0.1	506	0.40	29.7	32.3	571.5	0.43	30.2	26.4	572.8	0.40	28.0	30.8	
	0.05	402	0.39	29.4	36.8	455	0.44	29.6	30.2	459.6	0.43	27.6	35.2	
	0.01	269	0.37	27.8	31.8	316.3	0.58	27.8	25.3	313.9	0.55	24.8	29.4	

Table C-9. S 9.5 C Coarse Data

Temp (^oC)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	30035	0.22	1.4	7.5	30777	0.06	2.4	10.9	31701	0.12	0.7	7.4	S 9.5C C
	10	28989	0.22	1.3	9.9	29354	0.04	2.3	13.4	30580	0.12	0.8	9.7	
	5	28110	0.22	1.6	9.2	28590	0.06	2.4	13.3	29807	0.13	1.3	8.9	
	1	25869	0.23	2.9	9.9	26320	0.06	3.8	13.8	27811	0.14	2.3	9.1	
	0.5	24623	0.23	3.3	10.9	25357	0.06	4.1	13.4	26801	0.13	2.8	9.1	
	0.1	22689	0.26	5.0	11.4	22980	0.06	5.5	16.3	24248	0.13	3.0	11.4	
	0.05	21445	0.25	4.1	14.2	20969	0.03	5.8	16.7	22462	0.11	5.6	9.5	
	0.01	18701	0.26	7.0	14.5	19092	0.05	7.6	18.3	20808	0.15	6.0	12.9	
10	25	19776	0.27	7.0	14.7	19668	0.06	8.1	18.9	20884	0.16	5.9	13.4	
	10	17876	0.27	8.0	13.8	17892	0.07	8.5	20.7	18006	0.14	7.8	14.6	
	5	16832	0.34	8.9	15.6	16728	0.08	9.3	20.9	17590	0.16	8.1	14.6	
	1	13353	0.31	11.7	19.4	13783	0.09	11.9	24.3	14674	0.20	10.6	17.6	
	0.5	12070	0.32	12.6	20.8	12425	0.07	12.8	25.3	13283	0.20	11.5	19.3	
	0.1	8997	0.30	16.5	23.6	9642	0.07	16.3	27.6	10537	0.21	15.0	21.2	
	0.05	7739	0.25	17.9	25.9	8467	0.07	17.7	28.7	9652	0.24	17.3	22.1	
	0.01	5565	0.25	20.4	29.6	5926	0.04	20.3	32.4	6870	0.22	19.4	26.6	
35	25	6217	0.37	21.0	25.3	6490	0.22	20.7	29.2	7277	0.31	19.6	25.9	
	10	4795	0.37	23.1	28.2	5067	0.19	21.8	31.8	5729	0.31	20.5	27.5	
	5	3816	0.37	26.5	33.6	4152	0.20	23.2	31.9	4734	0.31	22.6	28.7	
	1	2162	0.39	29.6	35.1	2403	0.23	28.5	37.5	2849	0.35	27.3	33.4	
	0.5	1677	0.35	30.0	34.8	1888	0.22	29.6	38.7	2228	0.34	28.0	34.9	
	0.1	988	0.33	28.5	33.8	1179	0.23	28.8	37.7	1327	0.34	27.5	33.5	
	0.05	758	0.29	28.3	34.2	960.6	0.24	28.8	37.3	1072	0.37	27.8	33.9	
	0.01	526	0.23	24.9	33.0	644.6	0.27	26.5	35.6	707.7	0.38	24.6	31.4	

Table C-10. S 9.5 B Fine Data

Temp (^{o}C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	26505	0.17	2.1	8.3	25856	0.25	3.3	4.4	26962	0.21	2.2	7.2	S 9.5B F
	10	25250	0.17	2.4	9.6	24501	0.23	3.5	5.8	25679	0.22	3.1	7.6	
	5	24594	0.19	2.4	9.2	23707	0.25	4.1	6.9	24877	0.23	3.2	7.7	
	1	22424	0.18	3.7	10.6	21709	0.27	5.2	8.0	22563	0.23	4.3	9.1	
	0.5	21333	0.18	3.9	10.8	20551	0.25	5.8	8.5	21397	0.22	4.7	10.2	
	0.1	18469	0.16	5.0	11.6	18238	0.27	7.7	8.6	19109	0.23	6.7	10.0	
	0.05	18818	0.24	8.0	10.3	17506	0.29	8.9	9.5	18373	0.25	7.9	10.9	
	0.01	15458	0.20	7.9	15.0	14578	0.27	10.0	12.6	15515	0.24	8.8	14.0	
10	25	15748	0.22	8.9	15.3	15234	0.28	10.9	12.7	15945	0.25	9.3	13.8	
	10	13971	0.23	9.7	15.2	13344	0.29	11.7	14.6	13963	0.26	10.7	15.3	
	5	12766	0.25	10.7	16.1	12040	0.29	12.7	16.1	12763	0.26	11.7	15.8	
	1	10010	0.26	13.9	20.0	9384	0.33	16.3	18.6	10032	0.28	14.7	19.1	
	0.5	8924	0.25	14.7	21.5	8345	0.32	17.5	20.0	9034	0.29	16.3	19.8	
	0.1	6629	0.27	17.9	24.3	6049	0.33	21.1	23.4	6546	0.27	20.0	24.0	
	0.05	5886	0.29	21.7	25.2	5339	0.35	23.0	26.1	5583	0.26	21.3	27.3	
	0.01	3928	0.28	24.9	29.8	3589	0.35	27.8	28.7	3946	0.29	25.8	30.4	
35	25	4295	0.34	23.5	25.0	4059	0.40	25.4	28.4	4299	0.30	24.6	29.1	
	10	3303	0.36	24.5	25.5	3026	0.45	26.5	27.5	3261	0.34	23.4	27.5	
	5	2628	0.38	25.8	25.8	2381	0.50	28.6	31.0	2623	0.38	27.1	31.2	
	1	1456	0.40	31.7	33.4	1207	0.47	34.1	42.0	1357	0.32	32.9	37.9	
	0.5	1172	0.43	31.1	35.0	977.6	0.53	33.0	37.2	1115	0.35	32.0	38.5	
	0.1	699	0.44	30.2	33.3	611.1	0.54	32.5	34.8	659.4	0.35	31.2	37.1	
	0.05	549	0.43	29.5	37.9	531.4	0.52	32.6	40.5	529.8	0.36	31.5	44.8	
	0.01	355	0.48	28.1	23.3	402.7	0.62	30.8	28.9	373.1	0.40	29.4	29.0	

Table C-11. S 9.5 B Coarse Data

Temp (^{o}C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	28214	-	3.4	15.9	29326	-	4.9	18.0	30331	0.11	3.7	13.1	S 9.5B C
	10	26660	-	3.9	18.5	27896	-	5.7	20.7	28683	0.09	4.3	15.3	
	5	25361	-	4.5	18.6	26789	-	6.4	22.2	27769	0.10	4.9	16.0	
	1	23107	-	6.0	20.7	24213	0.02	7.9	22.6	24930	0.11	6.5	17.0	
	0.5	21937	-	6.6	22.3	23083	0.03	8.5	23.0	23844	0.12	6.9	17.4	
	0.1	18845	-	8.0	23.9	19799	0.02	9.9	25.6	20774	0.14	9.4	17.9	
	0.05	17240	-	9.8	23.7	18176	0.01	11.3	24.8	19837	0.15	8.5	21.1	
	0.01	14913	-	11.3	26.5	15679	0.05	13.4	28.0	16242	0.15	12.3	22.4	
10	25	15457	-	11.2	28.4	16505	0.04	13.1	29.1	16802	0.17	12.4	23.1	
	10	13527	-	13.0	30.3	14363	0.06	14.5	30.3	14699	0.20	13.7	23.6	
	5	12180	-	14.4	32.1	12925	0.08	16.1	30.9	13149	0.21	15.1	25.1	
	1	9089	0.08	18.7	36.6	9587	0.13	20.5	35.0	9736	0.27	19.5	28.6	
	0.5	7812	0.08	20.5	38.5	8235	0.13	22.3	36.4	8476	0.28	21.2	29.9	
	0.1	5311	0.11	25.1	40.7	5647	0.16	26.2	38.3	5787	0.32	25.3	33.7	
	0.05	4366	0.14	28.2	41.9	4536	0.14	29.0	40.8	4583	0.29	27.5	35.5	
	0.01	2792	0.15	30.3	44.2	2912	0.14	32.2	42.8	2948	0.34	30.6	38.9	
35	25	3625	0.16	27.7	39.8	4113	0.26	29.6	36.2	4191	0.44	27.3	30.9	
	10	2606	0.18	28.2	40.2	2896	0.31	30.6	34.6	2951	0.47	28.7	32.4	
	5	1987	0.18	28.9	41.2	2197	0.33	31.4	35.5	2227	0.45	31.3	35.3	
	1	987	0.22	33.1	45.3	1110	0.33	34.9	41.6	1120	0.53	34.2	39.3	
	0.5	751	0.21	32.2	44.5	848.5	0.34	34.1	39.6	845.5	0.54	33.7	37.6	
	0.1	419	0.14	28.4	39.1	496	0.39	31.0	34.5	475.7	0.54	30.4	32.3	
	0.05	324	0.08	28.5	42.9	399	0.38	30.9	36.6	380.1	0.55	30.3	35.5	
	0.01	224		24.6	35.8	299.2	0.50	28.9	32.8	265.6	0.56	27.3	29.5	

Table C-12. S 9.5 B 1 Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	26064	0.16	4.0	9.5	28358	0.21	2.4	7.6	30053	0.14	2.9	12.6	S 9.5B 1
	10	24652	0.15	4.7	10.4	26921	0.21	2.4	8.6	28422	0.12	3.4	13.8	
	5	23780	0.16	5.2	11.9	25967	0.22	3.0	8.6	27622	0.12	3.5	15.6	
	1	21218	0.17	6.9	12.9	23235	0.21	4.4	10.3	24939	0.13	5.6	17.1	
	0.5	20160	0.17	7.6	13.8	22312	0.22	4.7	11.3	23711	0.12	6.2	16.5	
	0.1	17468	0.18	8.5	16.5	19698	0.24	6.0	14.1	21261	0.14	7.5	18.6	
	0.05	16714	0.21	10.5	17.0	18384	0.25	9.0	12.1	19178	0.11	10.0	17.4	
	0.01	13383	0.18	12.7	19.1	15334	0.25	9.7	16.3	16310	0.11	10.4	21.4	
10	25	13831	0.22	12.6	18.8	15873	0.28	10.7	16.1	16988	0.20	11.9	20.5	
	10	12519	0.25	14.5	19.8	13934	0.28	11.9	17.9	14842	0.21	12.8	23.0	
	5	11202	0.27	15.6	20.8	12596	0.31	12.9	19.7	13271	0.21	14.6	23.5	
	1	7978	0.28	20.6	25.1	9340	0.33	17.3	23.2	9878	0.23	18.0	27.5	
	0.5	7004	0.29	21.6	26.0	8193	0.34	18.8	25.0	8597	0.23	19.7	29.4	
	0.1	5017	0.32	25.1	29.4	5852	0.36	22.3	28.2	6109	0.25	23.9	31.8	
	0.05	4216	0.33	26.3	32.1	4849	0.36	25.1	29.8	4991	0.22	26.4	34.2	
	0.01	2753	0.35	29.7	34.9	3178	0.38	28.1	32.8	3308	0.24	29.1	37.4	
35	25	3786	0.41	24.7	32.6	4173	0.43	23.8	29.9	4485	0.37	25.0	29.2	
	10	2727	0.41	24.7	31.6	3107	0.44	24.8	30.9	3281	0.39	25.8	29.4	
	5	2094	0.41	26.2	32.2	2595	0.38	26.6	28.8	2516	0.37	27.0	33.0	
	1	1074	0.42	30.5	41.2	1192	0.51	33.9	39.5	1222	0.35	32.2	40.1	
	0.5	867	0.46	28.4	33.3	982.4	0.50	29.2	32.6	964	0.33	30.6	32.9	
	0.1	530	0.49	25.9	34.3	659.4	0.37	31.2	40.7	548.4	0.31	28.6	34.2	
	0.05	419	0.36	25.4	36.5	492.2	0.62	26.5	36.8	428.3	0.25	28.0	37.6	
	0.01	311	0.37	23.8	27.2	338.5	0.50	24.8	23.9	281.8	0.16	26.4	22.6	

Table C-13. S 9.5 A Fine Data

Temp (^oC)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	28880	0.25	2.8	6.0	28451	0.15	2.5	9.6	26729	0.17	2.6	9.1	S 9.5A F
	10	27204	0.25	3.3	7.8	27091	0.17	3.0	11.1	25439	0.18	3.0	10.0	
	5	26095	0.25	3.9	7.4	26111	0.17	3.4	11.4	24366	0.19	3.6	9.9	
	1	23468	0.26	5.4	9.4	23557	0.18	5.1	13.1	21916	0.20	5.1	11.2	
	0.5	22466	0.27	5.9	10.4	22378	0.18	5.9	13.4	20822	0.21	5.6	11.8	
	0.1	19433	0.27	8.2	10.9	19092	0.17	6.6	14.8	18278	0.24	7.8	12.5	
	0.05	18731	0.31	8.7	11.9	17761	0.16	6.3	17.2	16536	0.21	7.8	13.7	
	0.01	15180	0.31	11.0	13.9	15266	0.20	10.1	18.4	14139	0.26	10.6	15.3	
10	25	15663	0.33	11.8	16.9	15270	0.21	11.1	17.8	14690	0.25	12.0	17.7	
	10	13474	0.34	12.8	17.5	13225	0.22	12.2	19.4	12705	0.27	13.3	18.8	
	5	12046	0.34	14.2	18.7	11905	0.24	13.8	20.6	11367	0.28	14.4	19.7	
	1	8855	0.38	18.1	22.2	8824	0.29	17.8	24.6	8371	0.31	18.4	23.0	
	0.5	7694	0.40	19.7	23.5	7657	0.30	19.7	26.3	7261	0.33	20.1	24.4	
	0.1	5240	0.39	23.6	26.1	5243	0.30	23.7	28.6	5007	0.35	23.9	28.0	
	0.05	4579	0.44	25.4	27.5	4277	0.29	25.0	30.2	4258	0.37	25.1	29.5	
	0.01	2846	0.44	28.4	30.7	2566	0.31	29.3	33.6	2653	0.37	29.6	32.2	
35	25	3581	0.44	27.4	28.7	3710	0.43	25.2	26.0	3493	0.41	25.1	26.5	
	10	2648	0.46	28.0	30.1	2733	0.44	26.0	24.6	2507	0.41	26.7	26.8	
	5	2081	0.49	29.5	30.5	2135	0.47	26.3	27.8	1942	0.44	27.1	26.9	
	1	1105	0.51	30.5	33.3	1112	0.44	28.7	31.3	1008	0.43	29.7	31.4	
	0.5	861	0.50	29.7	31.5	864.7	0.49	28.5	29.9	770.1	0.47	29.3	31.0	
	0.1	544	0.56	26.8	28.6	513.8	0.50	25.4	27.3	440	0.46	26.5	27.9	
	0.05	456	0.51	25.6	31.2	423.9	0.56	23.3	21.7	359.5	0.52	24.9	23.7	
	0.01	361	0.66	25.9	33.8	299.7	0.53	20.1	32.8	240	0.49	21.5	32.1	

Table C-14. S 9.5 A Coarse Data

Temp (^oC)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	29990	-	3.7	8.2	29519	-	1.3	14.3	30713	0.20	2.0	10.0	S 9.5A C
	10	-	-	-	-	28457	-	1.8	15.7	29590	0.21	2.2	11.7	
	5	-	-	-	-	27442	-	1.7	13.6	28684	0.21	2.5	12.6	
	1	25097	-	5.6	17.4	25002	-	3.1	17.8	26235	0.22	3.5	12.9	
	0.5	24012	-	5.9	18.7	23994	-	3.3	17.2	25642	0.25	4.1	12.9	
	0.1	21219	-	8.4	18.4	21923	-	4.1	19.8	22187	0.23	6.2	14.4	
	0.05	-	-	-	-	20874	-	2.6	20.8	20192	0.19	6.8	14.4	
	0.01	17427	-	10.4	21.8	17644	-	6.9	21.7	18670	0.26	7.9	16.6	
10	25	18379	-	10.7	23.1	18064	0.01	8.4	22.9	19135	0.26	9.1	16.4	
	10	16349	-	11.9	27.6	16199	0.03	9.3	25.2	17294	0.30	9.8	19.0	
	5	14858	-	12.8	29.2	14973	0.04	9.9	24.6	15882	0.32	10.9	19.7	
	1	11816	0.02	16.2	35.0	12037	0.08	13.1	29.2	12622	0.37	14.2	22.3	
	0.5	10391	0.00	17.7	33.0	10781	0.06	14.6	30.8	11299	0.38	15.4	23.4	
	0.1	7650	0.02	21.1	38.2	7740	0.07	18.6	32.8	8247	0.40	19.2	27.5	
	0.05	6460	0.01	23.7	41.9	6692	0.11	21.7	35.9	6949	0.39	21.6	29.5	
	0.01	4405	0.00	27.7	44.8	4469	0.10	25.1	39.4	4884	0.43	26.6	32.8	
35	25	5427	0.15	26.2	31.8	5307	0.28	22.4	34.9	5697	0.55	24.4	24.1	
	10	-	-	-	-	3941	0.25	25.0	40.1	4064	0.55	26.2	29.7	
	5	-	-	-	-	3181	0.36	26.7	39.3	3217	0.61	27.9	27.0	
	1	1581	0.48	35.9	44.5	1678	0.29	31.5	44.5	1651	0.58	33.5	33.8	
	0.5	1200	0.48	35.0	41.5	1351	0.35	30.7	45.3	1321	0.64	32.5	35.3	
	0.1	699	0.52	34.3	38.6	795.6	0.33	28.2	43.2	747.3	0.64	30.5	32.9	
	0.05	569	0.52	34.8	37.6	653.6	0.31	27.8	47.8	613.7	0.72	30.6	35.4	
	0.01	412	0.60	25.9	29.4	457	0.25	24.2	37.0	445.6	0.83	27.9	29.9	

Table C-15. I 19.0D Fine Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	30593	0.15	1.1	8.0	-	-	1.4	3.5	33571	0.20	0.9	4.1	I 19.0D F
	10	28994	0.14	1.0	9.5	-	-	1.4	4.1	32279	0.21	0.9	5.3	
	5	28453	0.15	1.9	9.6	-	-	2.2	4.3	31779	0.22	1.1	5.1	
	1	26833	0.18	2.7	9.5	-	-	3.2	4.9	29731	0.21	2.1	5.5	
	0.5	25947	0.17	3.2	9.9	-	-	3.9	5.1	28823	0.23	2.3	6.0	
	0.1	23612	0.18	5.4	10.2	-	-	3.9	7.9	26343	0.22	4.0	6.3	
	0.05	21960	0.15	6.4	10.7	-	-	4.6	8.5	26417	0.27	4.4	8.6	
	0.01	19972	0.18	6.8	12.9	-	-	6.7	9.3	22866	0.24	5.0	9.3	
10	25	20224	0.20	6.8	13.3	22175	0.23	6.7	12.9	22852	0.23	5.5	10.1	
	10	18116	0.20	8.1	15.2	20042	0.24	7.2	14.0	20823	0.24	6.9	12.1	
	5	16816	0.22	9.0	15.6	19036	0.27	8.2	15.2	19721	0.26	7.2	12.1	
	1	13781	0.26	11.7	17.5	15751	0.30	10.7	17.1	16594	0.29	9.7	14.1	
	0.5	12429	0.25	13.2	18.1	14365	0.30	11.9	18.4	15316	0.30	10.6	14.2	
	0.1	9427	0.23	16.6	21.5	11238	0.31	15.7	19.2	12169	0.31	13.7	18.9	
	0.05	8228	0.22	17.4	24.1	10009	0.34	17.8	20.6	10900	0.32	14.1	19.9	
	0.01	5976	0.23	22.2	27.5	7346	0.37	20.0	25.4	7924	0.31	19.3	22.7	
35	25	6471	0.28	21.7	26.0	7814	0.44	19.7	22.5	8174	0.36	19.3	22.3	
	10	5040	0.29	22.8	29.7	6111	0.45	21.3	23.4	6618	0.40	21.3	23.8	
	5	4103	0.29	25.0	30.6	4940	0.45	23.2	25.0	5379	0.36	23.3	27.0	
	1	2342	0.33	29.7	35.2	2854	0.47	28.5	29.6	3140	0.43	29.4	32.5	
	0.5	1823	0.31	31.0	37.8	2224	0.47	30.2	31.3	2450	-	32.2	34.3	
	0.1	1064	0.32	30.4	37.2	1340	0.45	30.1	30.5	1450	0.37	33.2	34.5	
	0.05	869	0.31	30.4	36.5	1144	0.48	30.3	30.8	1190	0.33	33.0	35.4	
	0.01	580	0.31	26.7	35.5	749.4	0.46	28.1	30.0	716	0.34	31.4	34.1	

Table C-16. I 19.0D Coarse Data

Temp (^{o}C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	36579	0.22	2.1	5.6	36792	0.13	2.0	10.2	-	-	-	-	I 19.0D C
	10	34797	0.22	2.6	6.8	34932	0.13	2.0	9.9	-	-	-	-	
	5	33585	0.22	2.8	6.3	33906	0.13	2.4	10.8	-	-	-	-	
	1	31517	0.23	4.0	7.7	31380	0.14	3.5	12.1	-	-	-	-	
	0.5	30210	0.23	4.7	7.8	30596	0.16	4.0	12.1	-	-	-	-	
	0.1	27064	0.22	6.6	7.8	26897	0.13	5.1	12.6	-	-	-	-	
	0.05	25384	0.23	5.5	11.4	25611	0.13	4.6	15.8	-	-	-	-	
	0.01	22196	0.24	8.2	12.7	22872	0.16	6.7	17.3	-	-	-	-	
10	25	23175	0.26	8.0	13.0	23880	0.19	6.8	15.4	-	-	-	-	
	10	20957	0.28	9.1	14.0	21413	0.19	8.8	17.4	-	-	-	-	
	5	19214	0.29	10.3	14.4	19489	0.19	9.5	19.1	-	-	-	-	
	1	15253	0.31	13.6	17.3	15733	0.23	12.5	21.3	-	-	-	-	
	0.5	13773	0.33	15.0	19.3	14155	0.24	13.8	23.1	-	-	-	-	
	0.1	10141	0.35	18.4	22.5	10684	0.26	18.5	25.4	-	-	-	-	
	0.05	8767	0.37	21.1	23.0	9465	0.28	18.6	26.9	-	-	-	-	
	0.01	5967	0.40	24.4	27.8	6376	0.31	23.1	30.1	-	-	-	-	
35	25	6875	0.41	21.9	24.4	7156	0.33	21.9	27.2	-	-	-	-	
	10	5205	0.43	24.3	28.9	5463	0.35	26.0	28.8	-	-	-	-	
	5	4167	0.47	26.3	28.5	4285	0.36	24.7	30.1	-	-	-	-	
	1	2222	0.49	29.7	32.6	2375	0.41	28.6	34.6	-	-	-	-	
	0.5	1656	0.50	30.6	34.3	1802	0.42	30.0	36.8	-	-	-	-	
	0.1	955	0.54	28.7	31.8	1103	0.48	28.2	35.3	-	-	-	-	
	0.05	787	0.56	27.5	31.0	914.3	0.47	27.7	34.5	-	-	-	-	
	0.01	516	0.63	25.3	28.8	587.9	0.53	25.8	34.7	-	-	-	-	

Table C-17. I 19.0C Fine Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	28960	0.09	1.9	12.3	31585	0.21	2.7	1.9	29627	0.14	2.0	4.4	I 19.0C F
	10	27376	0.07	2.2	14.4	29991	0.20	3.0	3.0	28569	0.15	2.2	5.5	
	5	26612	0.08	2.7	15.5	29304	0.22	3.6	1.6	27642	0.15	2.7	6.1	
	1	24320	0.08	3.7	16.2	26854	0.23	4.4	3.4	25425	0.17	3.5	6.5	
	0.5	23563	0.08	4.2	16.1	25837	0.23	4.9	3.8	24359	0.17	3.9	7.1	
	0.1	21570	0.10	5.2	19.1	23507	0.26	7.3	4.3	22340	0.20	5.6	7.7	
	0.05	19264	0.04	5.0	19.6	22060	0.25	8.6	3.2	21850	0.23	5.6	10.1	
	0.01	17476	0.07	7.7	20.9	19401	0.24	8.2	7.5	18307	0.21	7.7	11.6	
10	25	18345	0.11	8.1	19.8	20275	0.29	9.7	8.2	19069	0.27	8.1	11.8	
	10	16384	0.11	9.0	22.8	17757	0.25	10.9	9.4	17223	0.28	8.9	15.2	
	5	15048	0.12	10.0	23.1	16286	0.27	11.7	11.1	15856	0.27	9.6	16.5	
	1	12058	0.12	13.0	27.3	13021	0.28	14.5	13.9	12993	0.31	12.6	18.2	
	0.5	10870	0.12	14.2	27.8	11627	0.27	15.7	14.3	11671	0.31	14.0	19.7	
	0.1	8122	0.11	17.8	30.1	9046	0.31	18.8	17.3	8982	0.33	16.2	22.9	
	0.05	7211	0.12	18.5	33.7	7531	0.26	19.9	19.8	7942	0.34	17.8	25.3	
	0.01	5072	0.07	22.5	36.2	5688	0.32	24.6	22.4	5651	0.32	21.3	27.1	
35	25	6073	0.27	21.1	28.5	6043	0.33	22.7	22.3	5995	0.37	21.4	25.8	
	10	4675	0.27	22.2	28.5	4734	0.35	23.6	22.4	4679	0.39	22.2	26.2	
	5	3805	0.27	23.4	30.3	3830	0.35	23.9	24.0	3805	0.41	23.5	28.3	
	1	2200	0.26	28.4	34.2	2075	0.34	30.5	28.9	2115	0.44	29.8	33.8	
	0.5	1858	0.25	27.2	33.7	1759	0.34	29.9	29.3	1767	0.43	28.6	34.2	
	0.1	1171	0.23	26.8	32.7	1099	0.35	29.2	27.7	1124	0.48	28.1	32.0	
	0.05	977	0.21	26.7	30.9	895.3	0.37	29.7	28.0	915.3	0.49	28.0	32.2	
	0.01	717	0.15	25.4	33.7	641.8	0.35	29.5	30.8	634	0.46	26.7	31.1	

Table C-18. I 19.0C Coarse Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	30162	0.21	1.4	7.0	30259	0.07	2.1	13.1	32393	0.21	1.3	9.1	I 19.0C C
	10	28719	0.21	1.9	6.8	28866	0.07	2.5	14.5	30775	0.22	1.8	7.8	
	5	27990	0.22	2.3	8.3	27832	0.09	3.0	15.1	29660	0.21	2.2	10.7	
	1	25761	0.24	3.8	9.0	25455	0.10	4.5	15.2	27582	0.23	3.6	11.5	
	0.5	24519	0.24	4.5	9.6	24191	0.10	5.1	16.3	26301	0.23	3.9	12.6	
	0.1	22008	0.27	5.6	12.2	21628	0.12	6.9	17.8	22910	0.22	5.0	14.8	
	0.05	20623	0.27	6.3	13.5	20572	0.14	6.8	19.8	-	0.29	8.1	13.9	
	0.01	17193	0.28	9.8	15.0	16861	0.12	10.0	21.8	18651	0.25	9.4	17.2	
10	25	18357	0.28	9.8	16.0	17678	0.12	10.7	19.9	19352	0.24	9.6	18.9	
	10	16573	0.31	10.8	17.0	15550	0.16	12.0	22.3	17179	0.27	10.3	20.6	
	5	14659	0.33	12.8	18.2	14269	0.20	13.0	23.5	15694	0.29	11.7	20.0	
	1	10888	0.37	17.4	22.2	10789	0.23	17.0	25.9	11876	0.33	16.4	23.4	
	0.5	9458	0.38	19.5	23.8	9379	0.24	19.0	28.0	10288	0.29	22.7	33.4	
	0.1	6627	0.43	23.8	27.4	6386	0.26	23.1	31.2	7332	0.39	23.2	29.5	
	0.05	5566	0.45	25.8	29.9	5491	0.29	26.1	31.6	6423	0.42	24.3	31.7	
	0.01	3291	0.49	31.2	33.4	3354	0.29	29.0	35.6	3825	0.42	29.2	36.1	
35	25	4613	0.71	27.3	31.7	4448	0.34	26.8	33.5	5316	0.46	25.5	29.4	
	10	2938	0.70	28.7	30.7	3017	0.36	28.5	36.9	3830	0.55	27.9	34.0	
	5	2284	0.87	29.5	33.7	2295	0.42	29.1	35.0	2931	0.57	29.7	33.9	
	1	1161	0.88	30.3	39.0	1181	0.45	30.4	38.3	1523	0.63	31.4	37.5	
	0.5	832	0.87	30.8	37.5	873.8	0.47	30.5	36.0	1091	0.58	31.6	35.9	
	0.1	457	0.93	27.1	33.5	501.2	0.54	26.8	32.3	598.3	0.64	28.3	31.9	
	0.05	377	1.02	25.9	34.4	407.7	0.52	25.9	32.7	468.6	0.64	27.9	33.7	
	0.01	248	1.26	24.2	34.4	285.6	0.54	22.9	31.4	312.2	0.72	25.0	32.2	

Table C-19. I 19.0B Fine Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	32414	0.25	3.7	5.6	27685	0.32	2.3	6.9	26747	0.17	2.1	3.5	I 19.0B F
	10	30904	0.25	3.9	5.9	26063	0.32	2.5	7.3	25457	0.18	2.7	4.1	
	5	29951	0.26	3.9	5.7	25414	0.34	3.0	8.6	24606	0.18	3.1	4.4	
	1	27538	0.28	5.8	7.6	22802	0.36	4.6	9.7	22292	0.19	4.4	6.3	
	0.5	26131	0.27	6.2	8.3	21895	0.37	5.6	10.6	21323	0.20	5.1	6.3	
	0.1	22895	0.28	7.0	10.7	19422	0.41	7.8	12.5	18517	0.20	5.9	10.2	
	0.05	21954	0.31	11.0	9.1	18335	0.43	6.6	15.2	16453	0.15	9.2	6.8	
	0.01	18316	0.31	11.9	14.1	14922	0.42	10.6	16.3	14262	0.19	10.5	12.4	
10	25	18962	0.27	11.5	11.6	15790	0.37	11.3	16.9	15000	0.20	11.4	14.0	
	10	16655	0.27	12.8	14.8	13969	0.41	12.6	18.5	12914	0.20	12.7	13.9	
	5	15152	0.30	14.6	16.5	12666	0.43	13.2	19.1	11552	0.21	13.9	15.6	
	1	11287	0.32	18.8	19.9	9398	0.50	18.1	23.5	8400	0.22	18.3	19.8	
	0.5	9619	0.33	21.5	20.9	7973	0.51	20.0	25.1	7223	0.21	20.5	21.6	
	0.1	6547	0.34	26.0	26.0	5436	0.55	24.8	27.8	4741	0.19	25.7	24.9	
	0.05	5340	0.35	28.3	29.2	4553	0.57	26.2	30.2	3939	0.19	27.5	25.9	
	0.01	3181	0.33	31.4	31.8	2818	0.65	30.8	33.7	2411	0.20	30.8	30.2	
35	25	4211	0.34	28.9	29.8	3672	0.76	27.2	29.0	3330	0.24	26.7	28.8	
	10	2878	0.34	30.1	31.8	2862	0.82	28.4	32.4	2337	0.25	28.5	31.7	
	5	2161	0.34	29.3	31.8	2162	0.87	29.7	28.9	1741	0.27	30.8	34.3	
	1	1077	0.39	32.7	37.0	1123	0.96	32.2	37.4	891.1	0.25	31.0	35.5	
	0.5	810	0.39	32.1	37.1	842.4	0.99	32.0	37.0	672.4	0.26	30.3	36.0	
	0.1	477	0.44	27.9	30.8	477.9	1.01	28.3	30.3	382.8	0.21	26.2	29.7	
	0.05	386	0.38	28.1	32.5	385.5	1.00	27.1	28.7	321.4	0.24	24.1	28.1	
	0.01	286	0.47	22.5	23.9	277.1	1.43	25.0	31.2	227.8	0.27	20.8	32.3	

Table C-20. I 19.0B Coarse Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	34818	0.20	7.2	7.0	33470	0.19	2.9	5.6	32405	0.10	3.5	13.8	I 19.0B C
	10	32991	0.21	7.6	8.7	31681	0.19	2.8	5.2	30871	0.09	3.8	16.5	
	5	31877	0.21	8.7	8.3	30696	0.20	3.2	6.3	29760	0.10	4.2	15.7	
	1	28866	0.22	9.6	10.8	27767	0.21	4.4	8.0	27019	0.12	5.3	16.2	
	0.5	28152	0.23	10.8	9.4	26545	0.22	5.2	7.2	25591	0.11	6.0	18.0	
	0.1	24544	0.23	10.9	13.5	23886	0.24	5.2	9.6	23479	0.15	7.0	16.8	
	0.05	22447	0.20	12.8	10.9	21699	0.21	5.5	10.8	21876	0.13	6.6	19.2	
	0.01	20375	0.26	14.1	14.9	19405	0.27	8.6	11.5	18719	0.15	9.3	20.2	
10	25	21017	0.26	13.7	15.8	20430	0.24	9.1	12.0	19627	0.16	10.1	20.5	
	10	18566	0.28	15.0	18.0	18071	0.26	10.3	14.2	17620	0.17	10.7	22.2	
	5	16947	0.31	15.7	18.1	16464	0.27	11.6	15.1	15863	0.17	12.4	23.7	
	1	12866	0.33	19.8	21.2	12850	0.33	15.1	18.8	12496	0.22	15.1	25.2	
	0.5	11457	0.34	21.2	22.9	11341	0.34	16.6	20.5	11113	0.23	16.7	27.2	
	0.1	8178	0.36	24.7	25.8	8204	0.36	20.2	22.9	8153	0.23	18.9	30.1	
	0.05	7380	0.43	27.1	28.2	7194	0.40	22.0	26.6	7094	0.26	22.7	30.5	
	0.01	4942	0.42	30.3	30.3	4747	0.39	25.2	27.7	4912	0.25	23.9	35.2	
35	25	5976	0.44	28.2	28.3	5741	0.44	23.6	26.5	5673	0.21	25.1	30.5	
	10	4380	0.45	29.7	29.2	4233	0.44	25.2	26.3	4304	0.32	25.3	32.0	
	5	3521	0.50	31.4	31.8	3356	0.46	26.7	27.9	3463	0.33	27.0	34.2	
	1	1889	0.51	35.0	34.0	1852	0.49	29.2	30.1	1987	0.41	30.6	36.2	
	0.5	1494	0.52	35.0	34.5	1464	0.48	28.2	29.7	1593	0.43	29.9	36.1	
	0.1	930	0.59	32.3	32.1	917.4	0.54	24.9	26.5	999.9	0.46	28.3	33.7	
	0.05	859	0.80	32.9	30.8	750.9	0.54	23.4	25.6	859.2	0.47	28.3	35.3	
	0.01	628	0.83	26.7	29.6	560.7	0.55	20.2	24.1	694	0.53	25.1	33.2	

Table C-21 I 19.0B 1 Data

Temp (^{o}C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	37482	0.12	3.6	8.1	36424	0.08	1.4	15.7	37556	0.12	5.1	12.3	I 19.0B 1
	10	35776	0.11	4.2	10.3	34985	0.07	2.1	16.8	36728	0.12	5.5	13.0	
	5	34605	0.12	4.3	10.2	34186	0.09	2.6	16.4	35445	0.12	6.0	15.0	
	1	32057	0.14	6.0	13.6	31449	0.10	3.9	16.5	32272	0.11	7.0	15.2	
	0.5	30527	0.14	6.5	11.7	30170	0.10	4.5	17.5	30594	0.10	7.4	16.4	
	0.1	26923	0.14	9.0	13.0	26381	0.09	6.6	19.4	28019	0.13	9.8	17.3	
	0.05	24286	0.10	8.9	14.9	23800	0.16	7.7	19.5	25216	0.09	11.6	15.0	
	0.01	21565	0.13	11.2	16.5	-	-	11.2	20.5	22144	0.12	12.3	19.2	
10	25	21896	0.12	11.5	17.2	22452	0.10	9.9	22.8	23052	0.16	13.3	19.5	
	10	19066	0.14	12.4	19.9	19845	0.13	10.9	27.0	20697	0.19	14.6	23.2	
	5	17094	0.16	14.0	21.5	17920	0.17	12.1	26.3	18698	0.20	16.0	24.0	
	1	12893	0.23	18.6	25.4	13880	0.24	16.4	29.6	14226	0.23	19.5	28.0	
	0.5	11258	0.22	20.1	26.7	12285	0.25	17.5	30.6	12457	0.24	21.0	28.6	
	0.1	7951	0.22	23.9	29.7	8900	0.26	21.7	33.6	9009	0.25	24.4	32.4	
	0.05	6693	0.22	25.8	32.5	7321	0.26	24.2	37.1	7628	0.26	28.2	33.6	
	0.01	-	-	28.7	35.6	5050	0.32	27.3	40.3	5075	0.28	30.9	39.0	
35	25	6002	0.36	25.5	30.4	6479	0.29	22.8	37.7	6563	0.32	26.1	31.7	
	10	4154	0.39	26.8	30.6	4677	0.35	24.4	37.8	4817	0.37	27.3	33.7	
	5	3195	0.42	27.8	35.1	3598	0.37	25.6	41.2	3780	0.40	28.8	35.8	
	1	1573	0.42	32.9	43.9	1873	0.46	31.0	45.3	1871	0.38	35.7	41.2	
	0.5	1211	0.45	30.9	34.9	1469	0.53	29.4	39.2	1442	0.40	34.5	41.1	
	0.1	697	0.50	27.3	35.3	859.1	0.58	26.4	40.1	828.7	0.43	32.2	39.2	
	0.05	549	0.49	27.3	36.9	676.6	0.59	26.3	41.4	644.5	0.43	32.6	40.4	
	0.01	383	0.52	24.2	33.1	434.3	0.54	24.0	35.8	446	0.43	30.5	38.8	

Table C-22. B 25.0C Fine Data

Temp (^oC)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	31482	0.19	2.4	7.1	34154	0.14	2.2	7.4	33013	0.14	4.0	8.8	B 25.0C F
	10	30045	0.21	2.5	7.7	32832	0.13	2.1	11.3	31298	0.13	4.2	10.5	
	5	29019	0.21	2.9	8.4	31782	0.14	2.5	11.3	30532	0.15	4.6	9.9	
	1	26629	0.22	4.3	9.2	29515	0.16	3.7	12.1	27940	0.16	5.9	11.9	
	0.5	25745	0.24	4.6	9.7	28491	0.17	3.8	13.4	26813	0.16	6.0	11.0	
	0.1	23218	0.25	5.5	10.9	25719	0.18	5.6	13.7	24672	0.19	7.2	12.9	
	0.05	21370	0.21	5.2	12.5	24509	0.19	7.6	12.9	22408	0.14	7.3	13.4	
	0.01	19125	0.26	8.2	14.1	21697	0.21	7.1	16.5	20207	0.18	9.4	16.3	
10	25	20083	0.29	8.8	12.7	21804	0.23	8.1	16.7	20888	0.19	9.9	14.2	
	10	17811	0.30	9.8	14.1	19627	0.26	9.4	18.6	18566	0.20	11.0	16.9	
	5	16358	0.32	10.7	14.9	18047	0.27	10.0	20.3	17073	0.22	12.2	18.7	
	1	12994	0.35	14.1	18.9	14643	0.35	13.7	24.3	13580	0.28	16.2	22.3	
	0.5	11525	0.35	15.4	20.5	13051	0.34	15.1	25.1	12122	0.28	17.4	23.5	
	0.1	8745	0.41	19.4	23.3	9791	0.37	19.3	28.2	8877	0.28	21.1	26.5	
	0.05	7395	0.39	21.0	26.1	8356	0.36	21.7	29.9	7475	0.27	23.1	28.9	
	0.01	5261	0.44	24.6	28.4	5938	0.38	24.2	34.2	5443	0.29	26.8	31.3	
35	25	6309	0.38	22.8	26.6	7361	0.44	21.3	29.5	6780	0.35	23.8	27.7	
	10	4777	0.41	23.9	27.4	5572	0.49	23.0	28.7	5236	0.39	24.8	27.9	
	5	3837	0.42	25.4	29.1	4496	0.52	24.2	29.9	4216	0.40	26.7	29.0	
	1	2047	0.46	31.2	34.8	2590	0.58	28.7	34.7	2382	0.47	32.8	35.4	
	0.5	1654	0.47	30.6	33.6	2045	0.54	28.4	33.5	1948	0.48	31.9	34.5	
	0.1	987	0.48	28.9	31.8	1353	0.63	26.3	31.8	1204	0.53	30.2	33.4	
	0.05	805	0.50	29.4	32.0	1153	0.68	26.4	31.9	1003	0.56	30.4	33.4	
	0.01	444	0.53	25.5	30.9	915.7	0.74	23.4	31.7	744.1	0.69	29.7	31.3	

Table C-23. B 25.0C Coarse Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	39923	0.14	2.1	12.4	40624	0.13	1.7	6.5	31212	0.13	2.3	5.6	B 25.0C C
	10	38116	0.13	2.7	13.3	38876	0.11	2.1	8.9	30961	0.16	2.1	7.3	
	5	37248	0.15	2.9	13.8	37824	0.12	2.5	10.0	29856	0.15	2.5	7.8	
	1	34451	0.18	4.5	15.0	35398	0.12	3.6	11.6	27577	0.16	3.9	9.7	
	0.5	33156	0.18	5.2	14.7	33957	0.11	4.4	12.2	26439	0.17	4.5	9.9	
	0.1	28889	0.18	7.1	16.6	31528	0.13	4.8	16.0	23835	0.20	7.0	11.0	
	0.05	28741	0.24	8.5	16.5	29201	0.12	8.5	11.9	21846	0.17	8.7	11.1	
	0.01	23892	0.23	10.7	19.7	25448	0.12	8.7	18.1	19159	0.22	9.9	16.0	
10	25	25372	0.26	10.3	18.8	27020	0.17	9.0	15.8	20075	0.21	10.0	14.7	
	10	22501	0.29	11.8	18.2	24813	0.21	10.3	17.6	17683	0.24	11.2	17.0	
	5	20245	0.32	13.0	19.7	22624	0.20	11.7	20.8	15893	0.27	12.5	19.6	
	1	15330	0.38	18.7	24.9	17442	0.26	16.4	25.4	11909	0.34	18.3	24.6	
	0.5	13501	0.40	20.4	26.4	15568	0.27	17.6	27.1	10339	0.37	20.2	26.1	
	0.1	9076	0.45	25.1	30.0	11005	0.30	22.6	30.8	7017	0.42	24.5	30.5	
	0.05	7371	0.45	27.1	33.3	8982	0.29	25.6	34.4	5654	0.45	27.6	33.0	
	0.01	4569	0.52	30.9	36.2	6010	0.37	27.7	38.0	3582	0.56	30.2	35.5	
35	25	6201	0.39	27.2	34.5	7973	0.37	26.4	32.3	5095	0.53	27.8	32.5	
	10	4389	0.54	29.1	33.9	5779	0.48	26.9	36.8	3423	0.61	28.6	34.7	
	5	3318	0.58	29.9	35.2	4300	0.44	29.5	34.5	2571	0.61	29.2	31.8	
	1	1621	0.58	33.3	42.7	2226	0.49	33.0	42.0	1306	0.69	30.5	36.7	
	0.5	1304	0.74	31.1	41.4	1806	0.66	30.6	39.4	1058	0.85	27.9	33.7	
	0.1	764	0.90	27.6	36.6	1088	0.83	26.6	34.3	658.7	0.92	22.3	28.6	
	0.05	602	0.93	28.6	39.8	901.3	0.86	27.1	36.6	591.7	1.06	21.2	30.3	
	0.01	435	1.17	26.4	34.3	658.8	1.20	26.4	31.6	496.8	1.64	19.6	23.1	

Table C-24. B 25.0B Fine Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	35988	0.19	4.2	7.3	34058	0.20	1.0	3.7	33443	0.21	1.5	4.5	B 25.0B F
	10	35026	0.20	4.8	7.4	32527	0.20	0.6	3.1	31674	0.21	1.5	5.4	
	5	33807	0.20	5.0	7.8	32055	0.22	1.1	4.3	30698	0.21	2.0	5.7	
	1	31213	0.21	6.1	8.7	29871	0.23	2.0	4.5	28558	0.23	3.2	6.8	
	0.5	29834	0.21	6.6	9.2	28746	0.24	2.7	6.0	27434	0.23	3.6	6.8	
	0.1	26976	0.23	8.6	10.5	26402	0.26	4.6	6.4	25038	0.26	5.0	9.2	
	0.05	25964	0.25	10.0	8.9	24085	0.23	5.7	6.2	22665	0.22	5.1	10.9	
	0.01	21703	0.25	11.0	13.3	21787	0.28	7.0	10.0	20117	0.28	8.0	12.2	
10	25	23380	0.26	11.1	14.5	21876	0.27	8.0	11.5	20969	0.29	8.7	12.6	
	10	20265	0.26	12.7	15.5	19656	0.29	9.0	12.7	18313	0.30	9.7	14.1	
	5	18709	0.28	13.4	16.0	18094	0.31	10.3	13.1	16945	0.33	11.2	15.5	
	1	14314	0.30	17.2	19.0	14292	0.35	14.0	17.2	13228	0.38	15.4	18.7	
	0.5	12537	0.31	18.7	20.6	12710	0.37	16.0	19.2	11655	0.40	16.8	21.3	
	0.1	8795	0.33	23.4	24.1	9046	0.39	21.0	23.0	8239	0.45	22.1	24.6	
	0.05	7310	0.33	25.6	26.5	7781	0.43	22.8	25.4	6890	0.46	24.3	26.4	
	0.01	4688	0.37	30.3	30.1	5029	0.44	27.0	29.9	4399	0.51	28.5	30.7	
35	25	5977	0.39	27.4	28.6	6201	0.53	24.7	28.0	5756	0.63	26.8	31.0	
	10	4201	0.44	28.8	27.9	4381	0.54	27.0	31.8	3775	0.57	29.2	34.0	
	5	3165	0.50	30.3	31.6	3417	0.65	27.8	30.9	2920	0.67	30.1	33.2	
	1	1570	0.45	33.3	36.0	1857	0.89	30.1	36.8	1428	0.62	32.7	35.7	
	0.5	1197	0.54	32.9	31.0	1358	0.88	30.7	30.6	1033	0.72	34.6	33.5	
	0.1	663	0.61	30.3	32.5	763.5	0.87	26.8	32.3	564.3	0.73	31.0	34.8	
	0.05	531	0.62	29.9	34.1	631.2	0.98	25.8	33.9	441.9	0.68	30.6	36.8	
	0.01	378	0.80	29.0	33.0	459	1.35	23.6	32.6	281.5	0.84	27.7	34.0	

Table C-25. B 25.0B Coarse Data

Temp (°C)	Freq.	Replicate 1				Replicate 2				Replicate 3				Mixture
		E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	E*	v	A.V. ϕ	A.H. ϕ	
-10	25	39395	0.33	0.7	4.1	33162	0.24	3.5	8.4	32573	0.11	3.3	11.0	B 25.0B C
	10	37336	0.33	0.8	3.4	31692	0.24	3.4	9.1	31843	0.14	3.3	11.5	
	5	36397	0.33	1.4	5.4	30717	0.25	4.1	9.1	30868	0.15	4.0	11.4	
	1	33680	0.35	2.6	5.6	28552	0.27	5.3	10.6	28296	0.15	5.6	12.8	
	0.5	32407	0.36	3.1	6.5	27482	0.28	5.7	11.1	27186	0.17	6.0	14.7	
	0.1	28305	0.34	5.3	6.9	24576	0.30	8.5	12.6	23836	0.17	8.5	14.0	
	0.05	26292	0.33	5.1	8.7	22789	0.28	9.7	12.6	22559	0.18	10.2	15.0	
	0.01	23378	0.39	7.7	10.8	20116	0.34	10.8	16.1	19785	0.22	11.0	18.9	
10	25	23430	0.36	8.2	12.3	20724	0.30	10.4	15.2	20722	0.22	10.8	17.6	
	10	20743	0.39	9.8	13.3	18592	0.36	11.5	17.8	18275	0.22	11.4	20.4	
	5	18866	0.41	11.5	14.9	16837	0.36	13.0	19.1	16725	0.23	12.5	21.7	
	1	14247	0.44	16.3	19.2	12956	0.42	17.8	23.2	13075	0.31	17.0	24.9	
	0.5	12358	0.46	18.6	21.1	11418	0.44	19.7	25.8	11531	0.32	18.6	27.1	
	0.1	8539	0.49	23.5	24.2	7874	0.44	24.2	28.7	8328	0.35	23.6	30.8	
	0.05	7134	0.53	26.3	27.6	6488	0.45	27.2	31.5	7029	0.36	24.5	33.7	
	0.01	4323	0.51	28.7	29.8	4138	0.50	30.5	34.3	4464	0.39	29.0	36.0	
35	25	5989	0.58	26.4	28.3	5811	0.53	28.1	30.0	5679	0.40	26.2	31.3	
	10	3979	0.65	28.1	28.5	4119	0.57	30.6	33.5	3950	0.37	27.9	32.7	
	5	2952	0.68	28.0	28.6	3072	0.57	33.7	36.4	2976	0.45	31.5	37.0	
	1	1484	0.62	31.5	37.1	1554	0.60	34.5	38.3	1593	0.61	34.2	40.5	
	0.5	1090	0.65	30.6	39.4	1181	0.65	33.5	38.1	1243	0.64	33.8	41.2	
	0.1	655	0.82	26.7	33.3	682	0.70	30.1	31.8	700.9	0.62	30.9	35.7	
	0.05	525	0.87	25.3	36.0	549.9	0.70	26.1	30.6	646.7	0.62	26.4	34.4	
	0.01	392	1.31	22.9	30.8	381.2	0.70	24.5	25.9	441.7	0.66	27.4	34.8	

APPENDIX D: COMPARISON OF AXIAL COMPRESSION AND IDT DYNAMIC MODULI VALUES

D.1 Dynamic Modulus

In this section, dynamic moduli determined from the 24 mixtures using the IDT test method are compared with those from the axial compression test. The graphs in this section represent the mastercurve of each mixture in semi-log scale with the error bars representing the range of data from the three replicates. In all the graphs, the hollow symbols represent IDT data while filled symbols represent axial compression data.

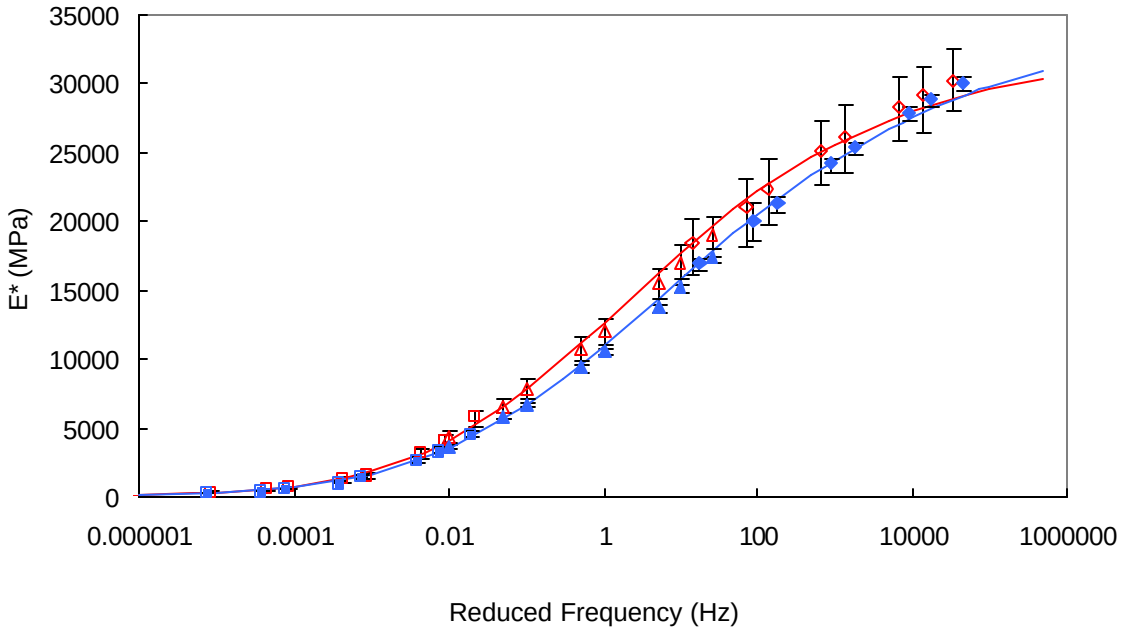

Figure D 1. S 12.5B-Fine Mixture

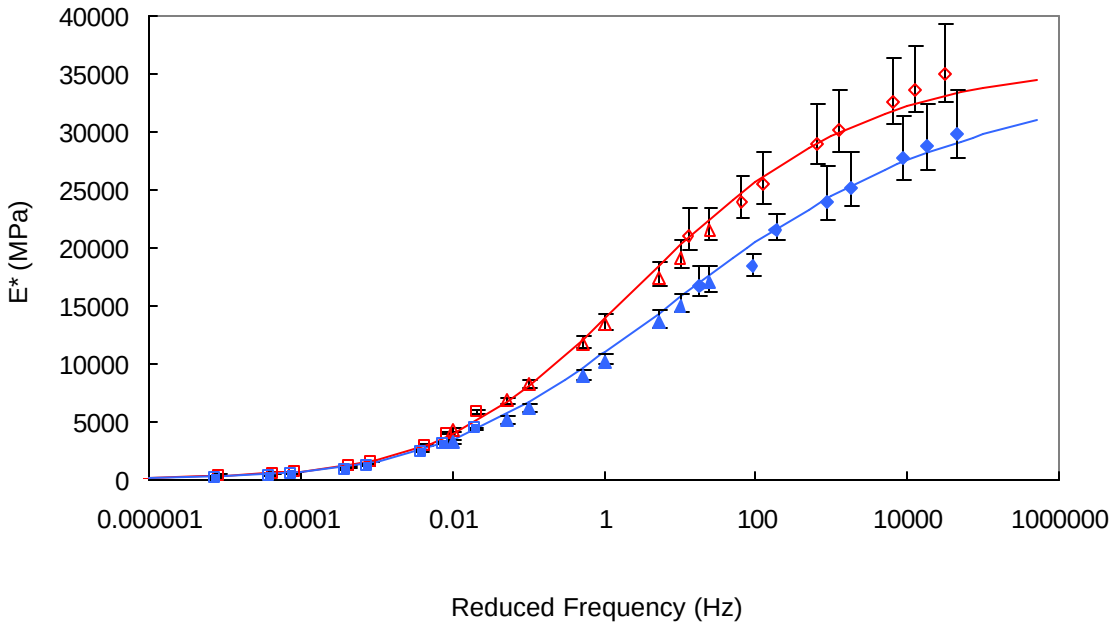

Figure D 2. B25.0B-Coarse Mixture

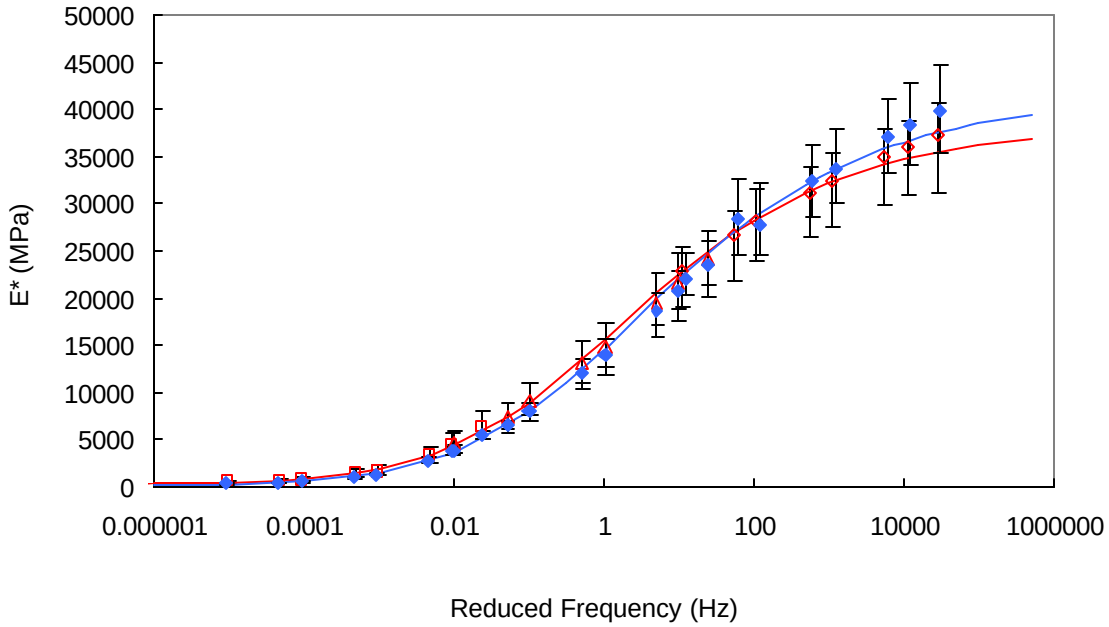

Figure D 3. B25.0C-Coarse Mixture

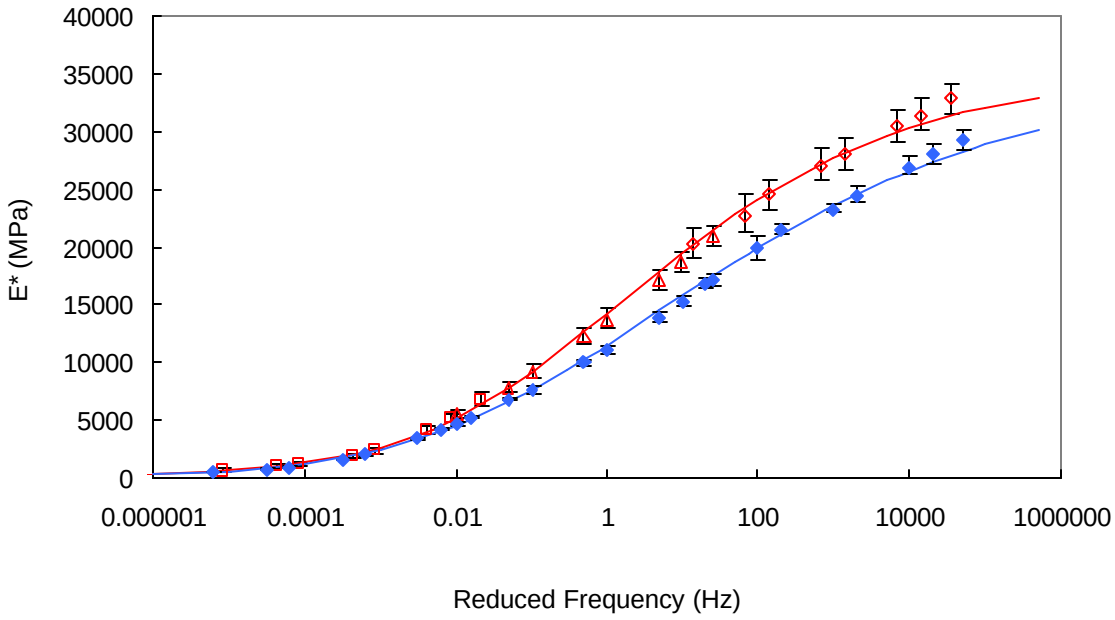

Figure D 4. B25.0C-Fine Mixture

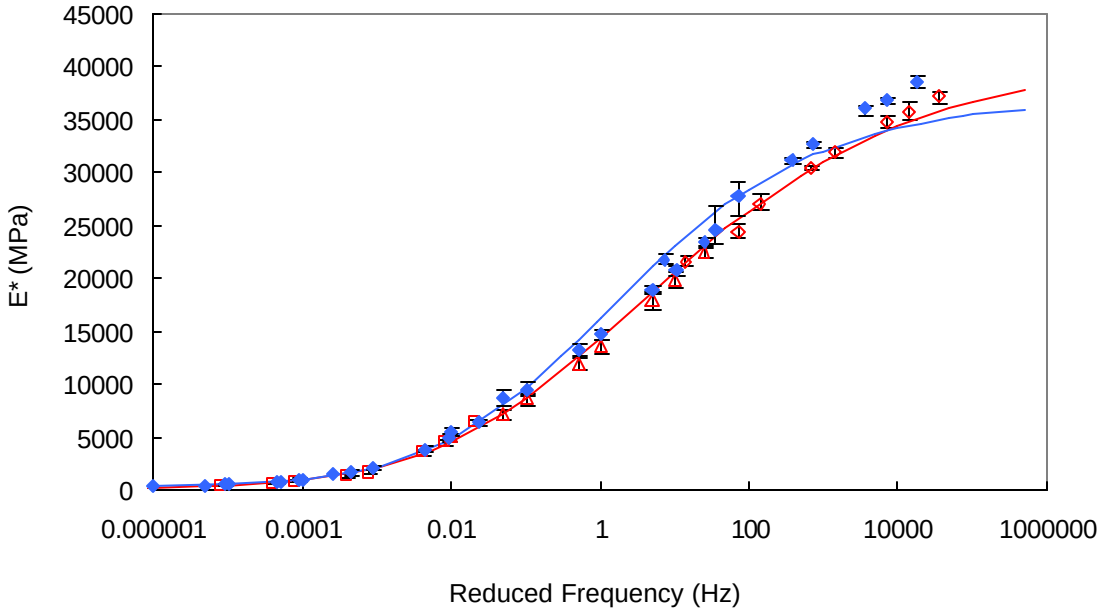

Figure D 5. I19.0B-1 Mixture

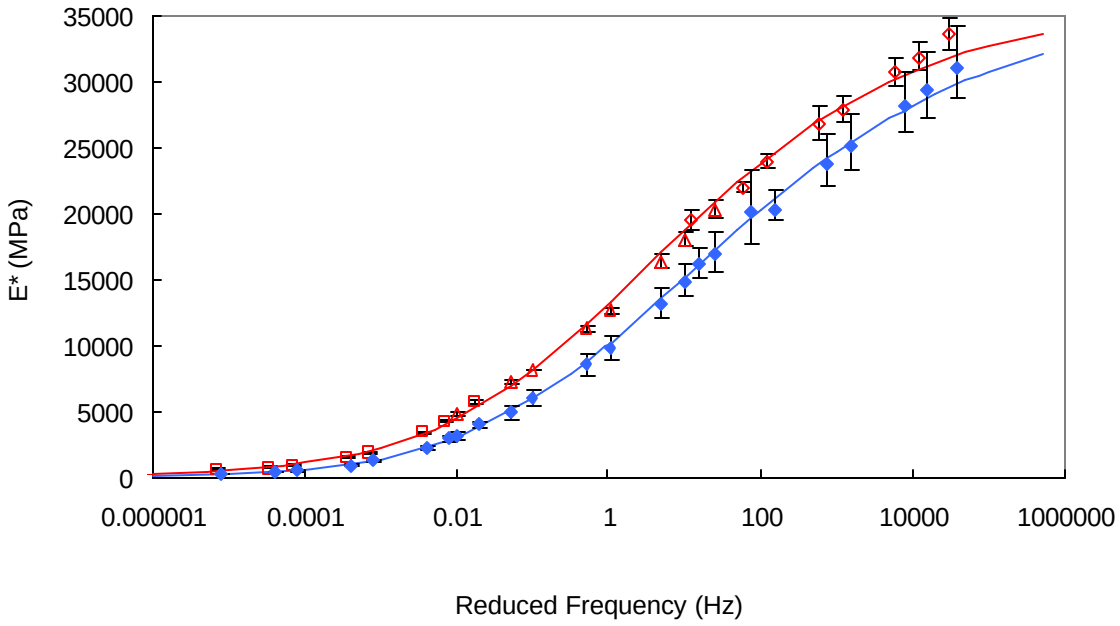

Figure D 6. I19.0B-Coarse Mixture

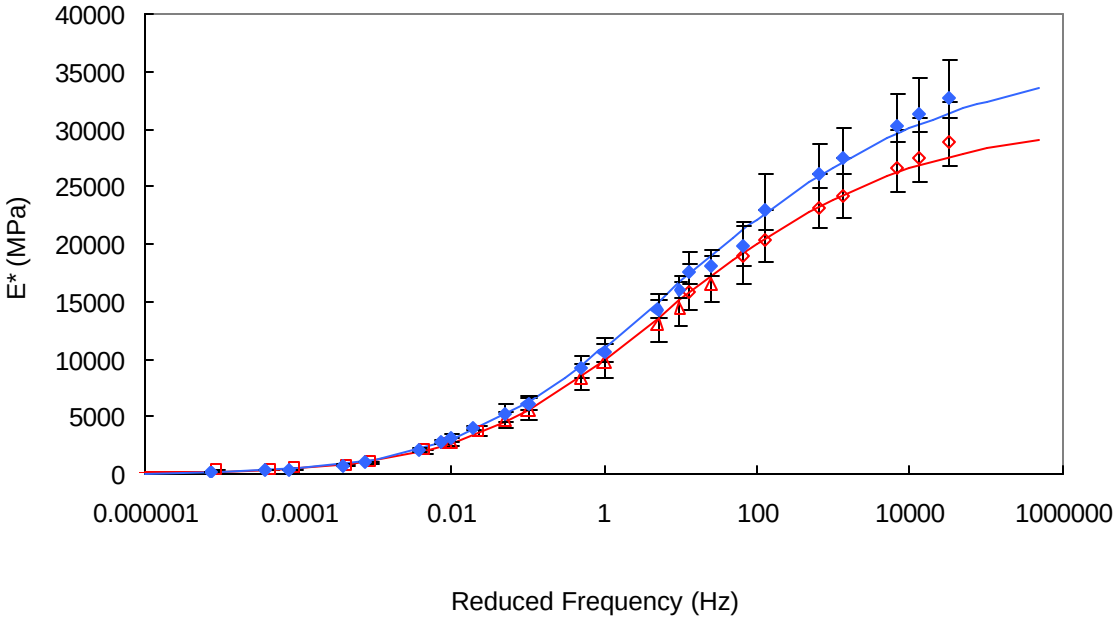

Figure D 7. I19.0B-Fine Mixture

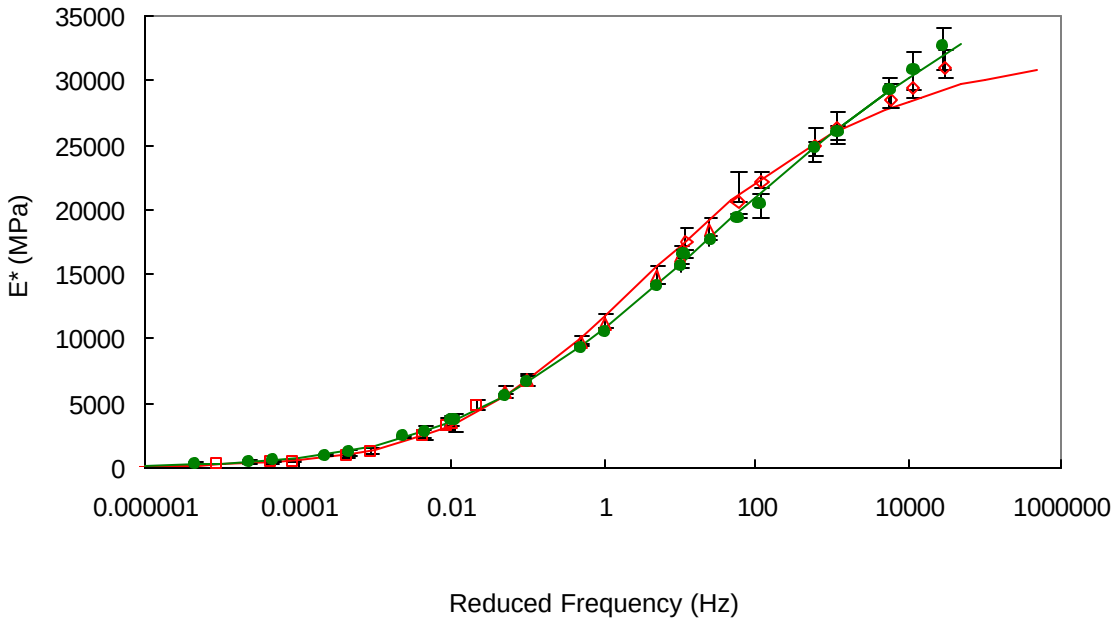

Figure D 8. I19.0C-Coarse Mixture

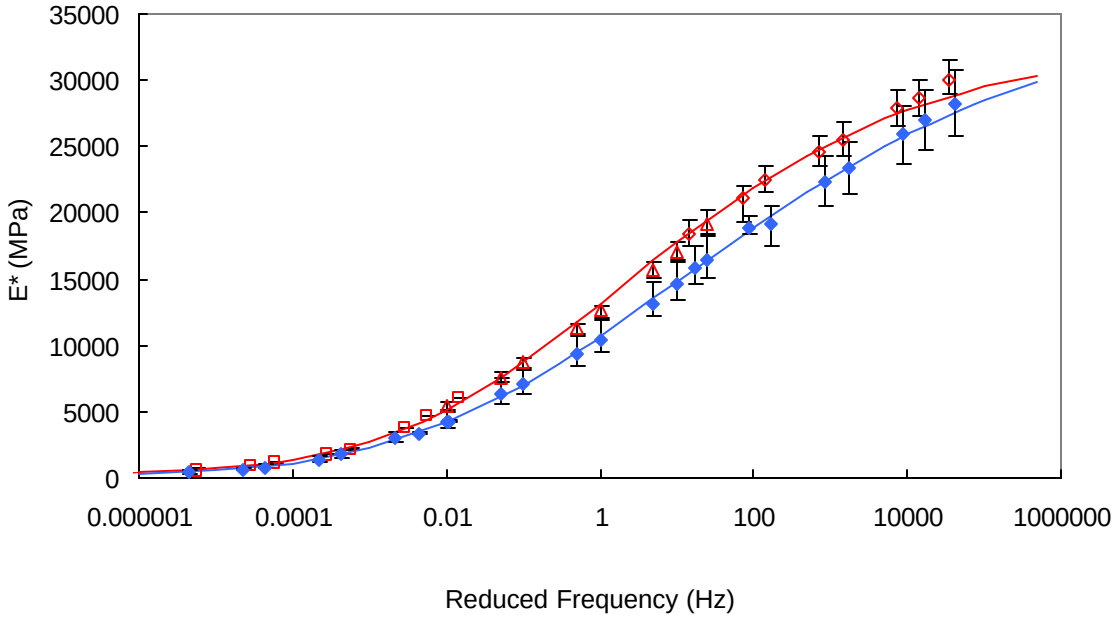

Figure D 9. I19.0C-Fine Mixture

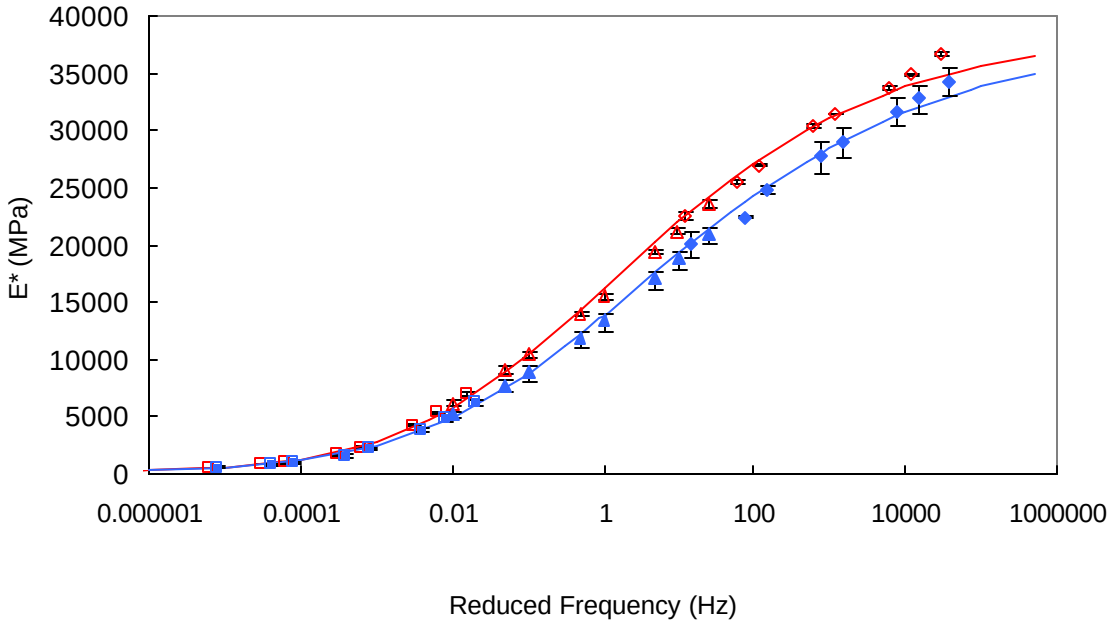

Figure D 10. I19.0D-Coarse Mixture

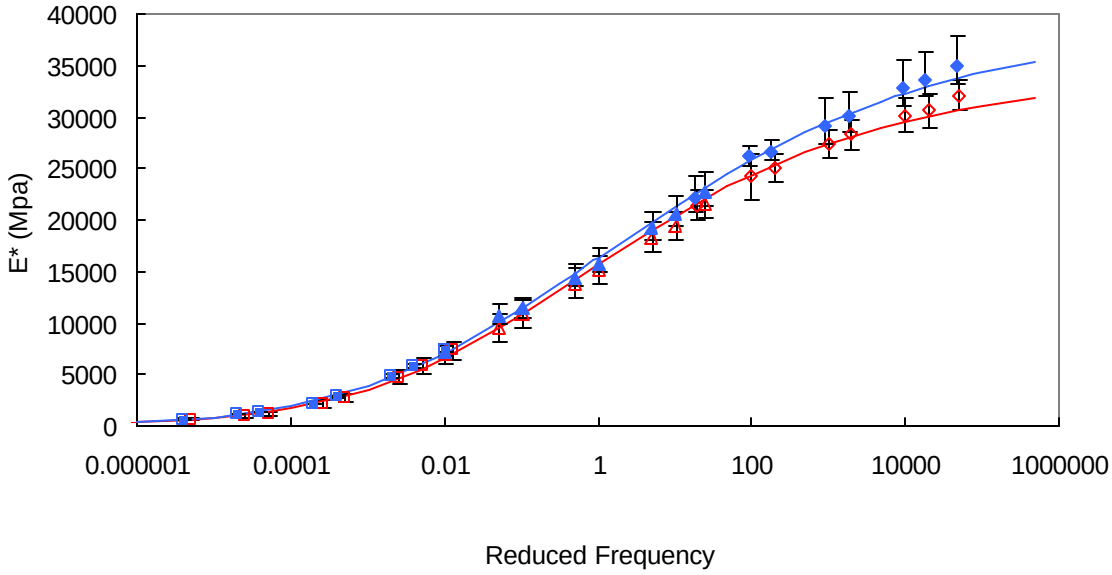

Figure D 11. I19.0D-Fine Mixture

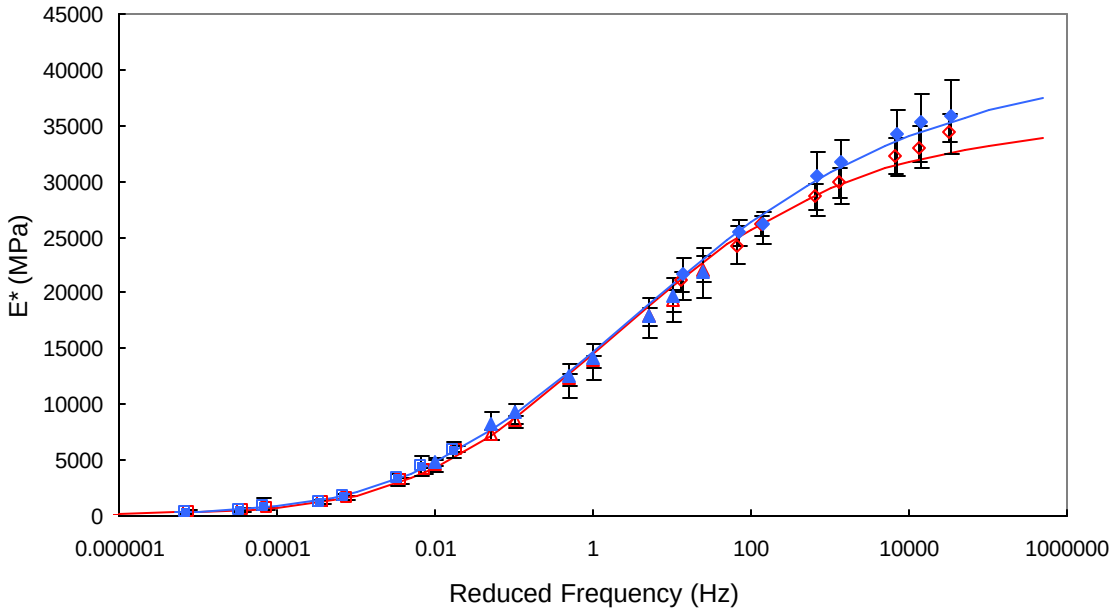

Figure D 12. B25.0B-Fine Mixture

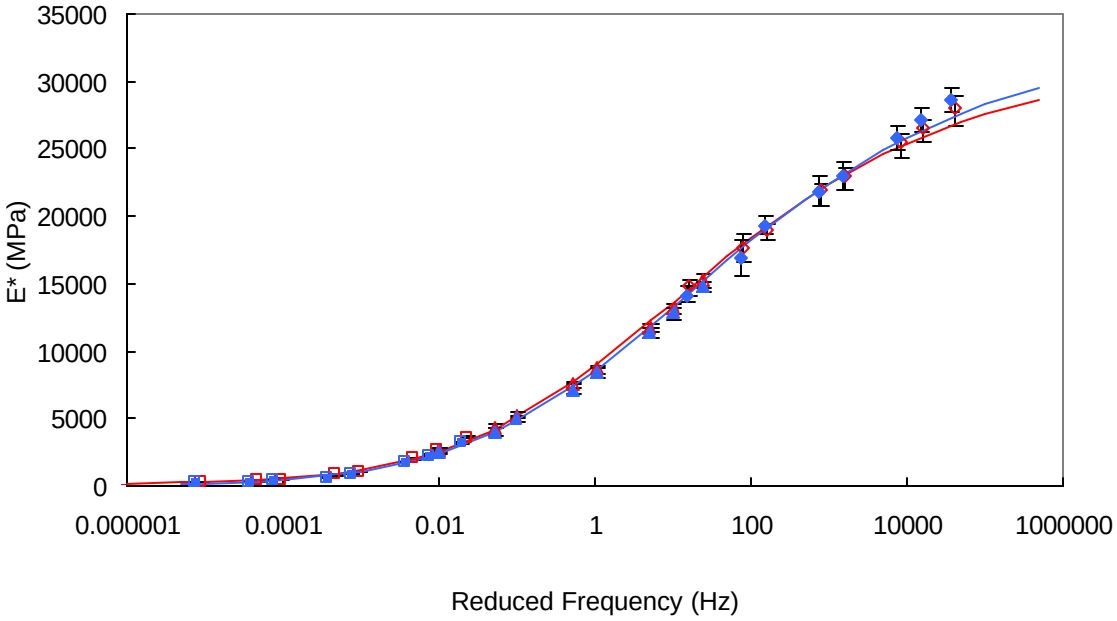

Figure D 13. S9.5A-Fine Mixture

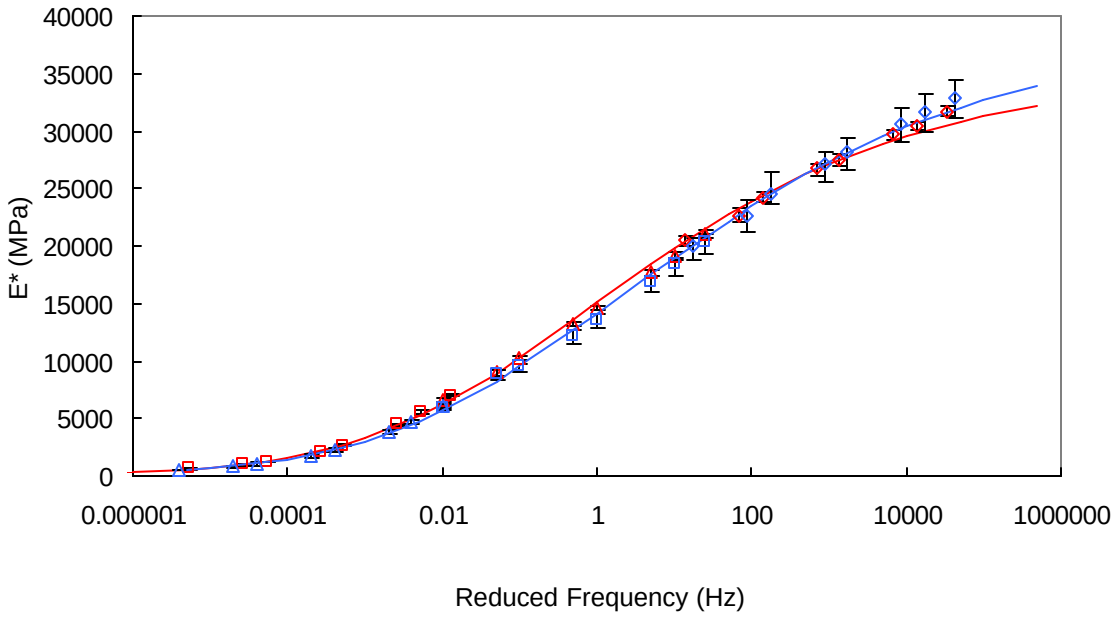

Figure D 14. S9.5C-Fine Mixture

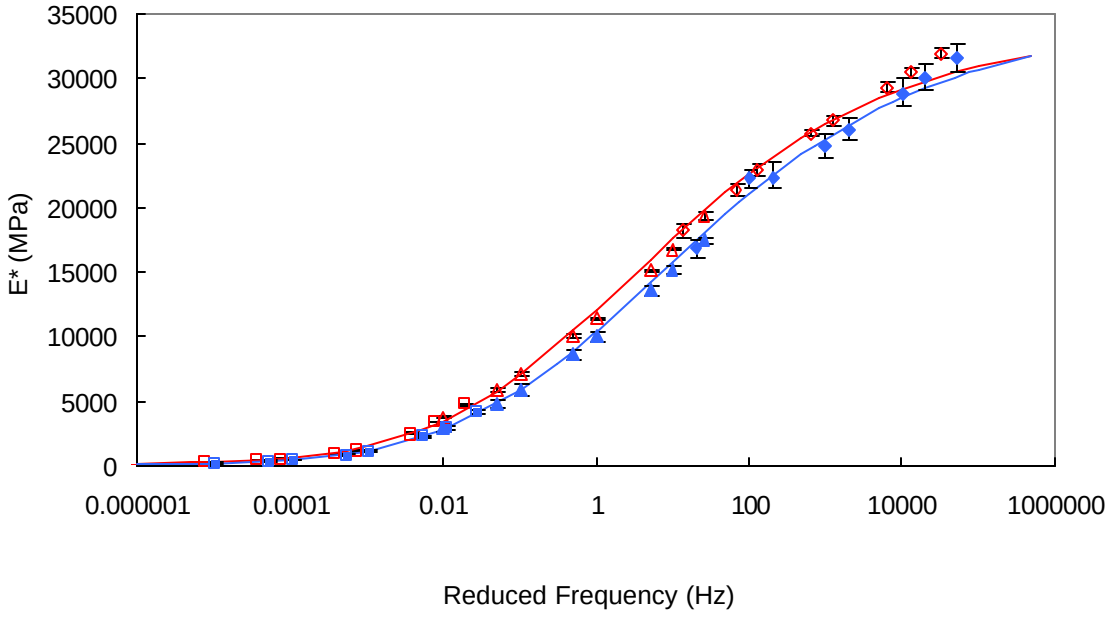

Figure D 15. S12.5B-Coarse Mixture

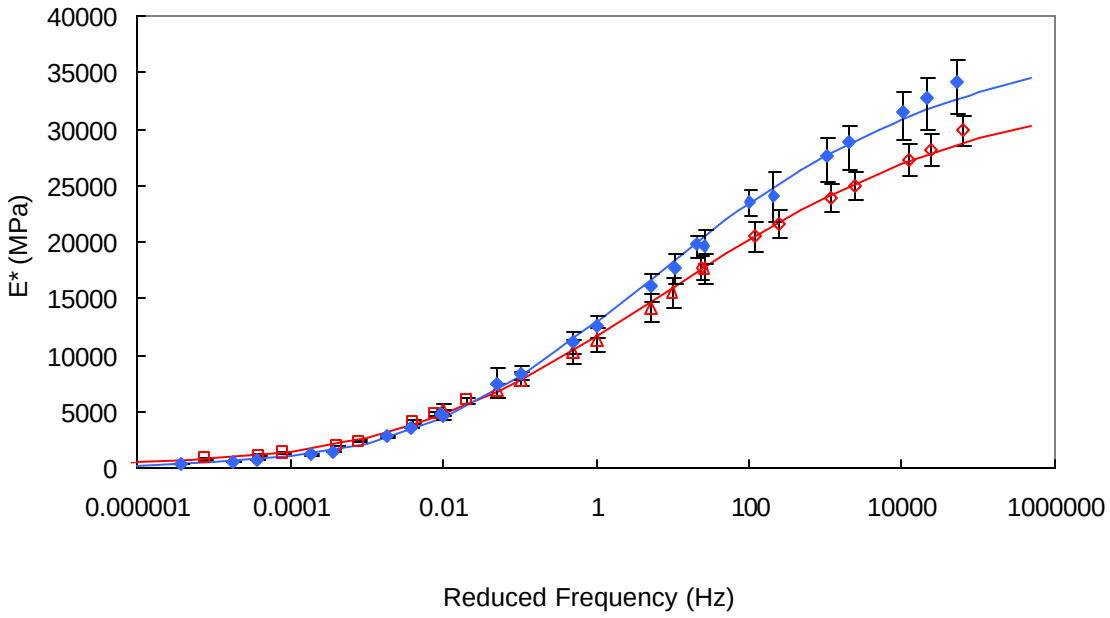

Figure D 16. S12.5C-Coarse Mixture

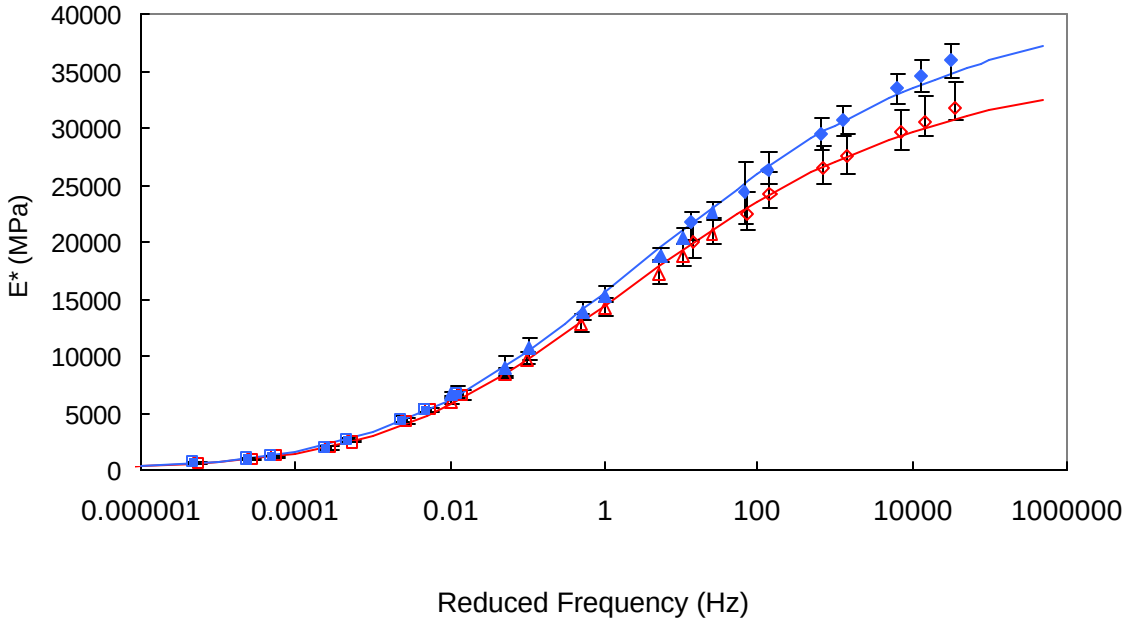

Figure D 17. S12.5C-Fine Mixture

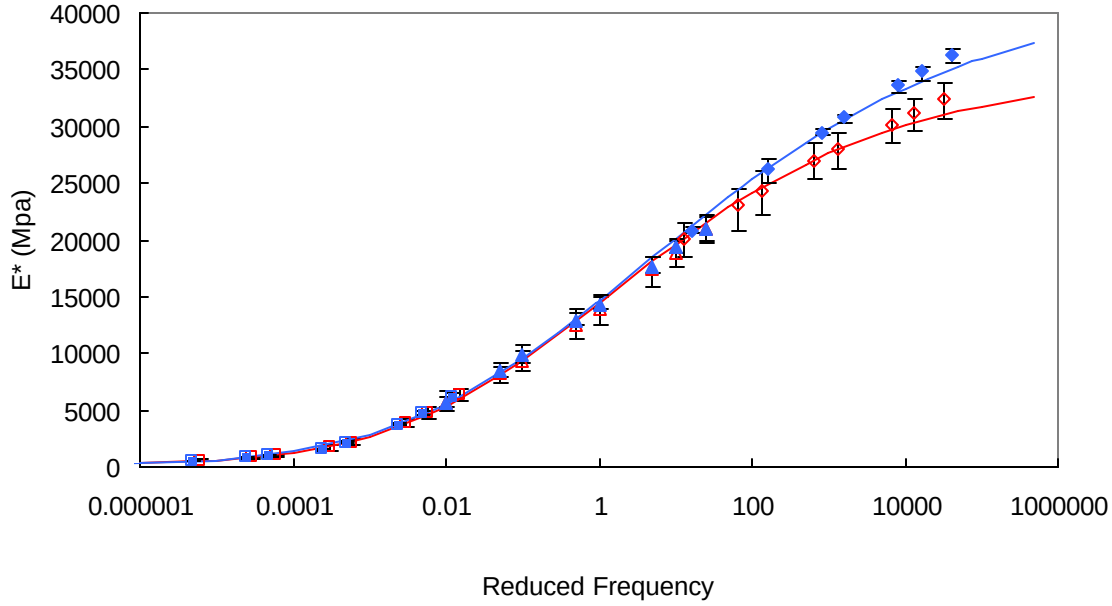

Figure D 18. S12.5D-Coarse Mixture

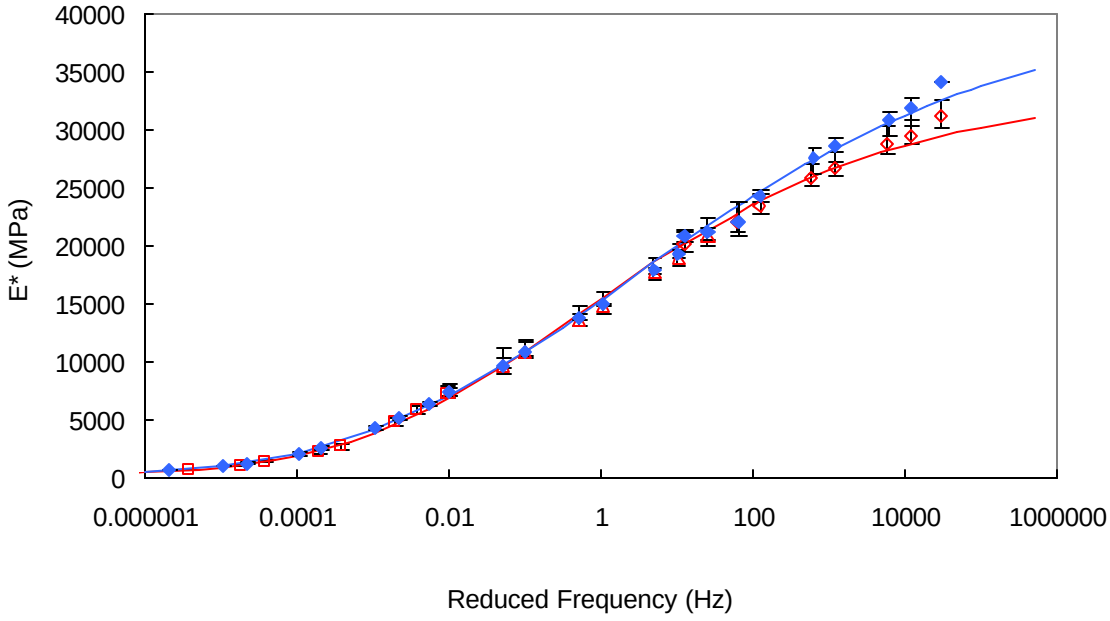

Figure D 19. S12.5D-Fine Mixture

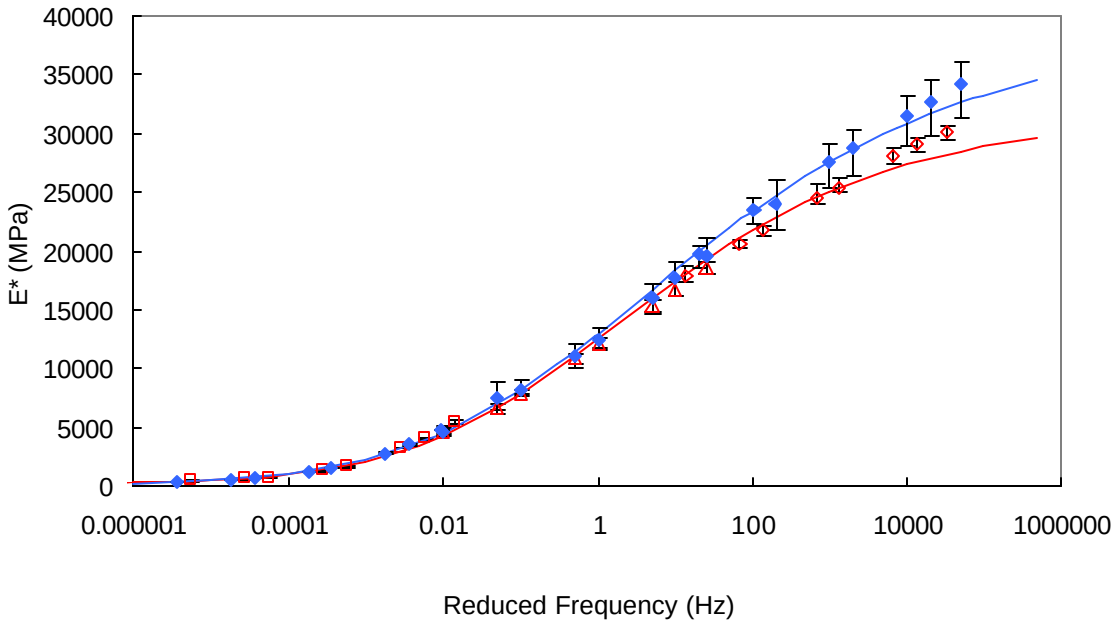

Figure D 20. S9.5A-Coarse Mixture

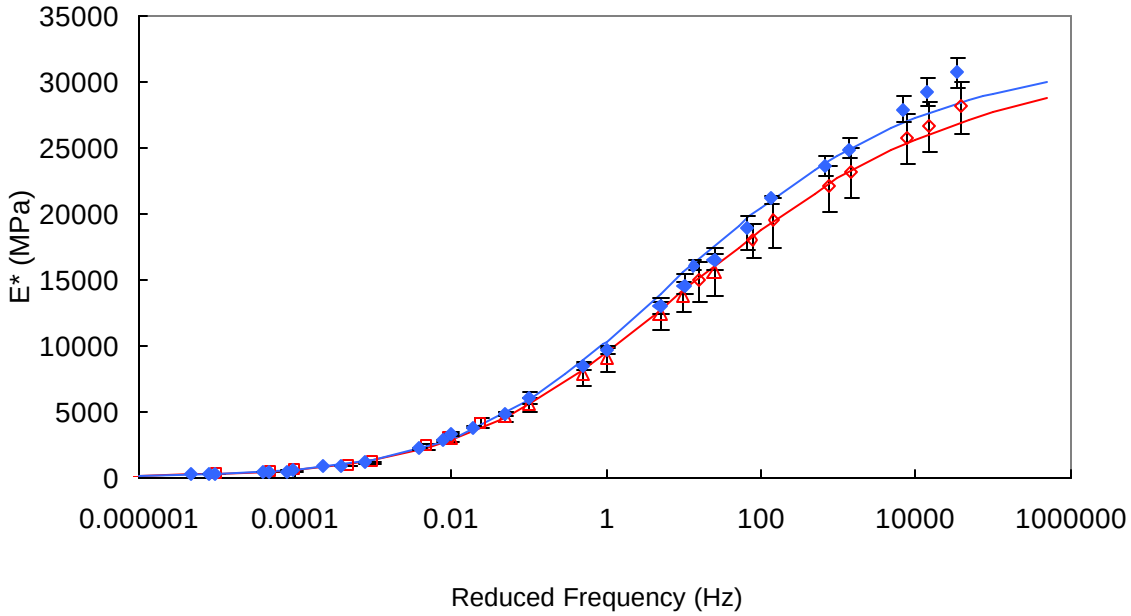

Figure D 21. S9.5B-1 Mixture

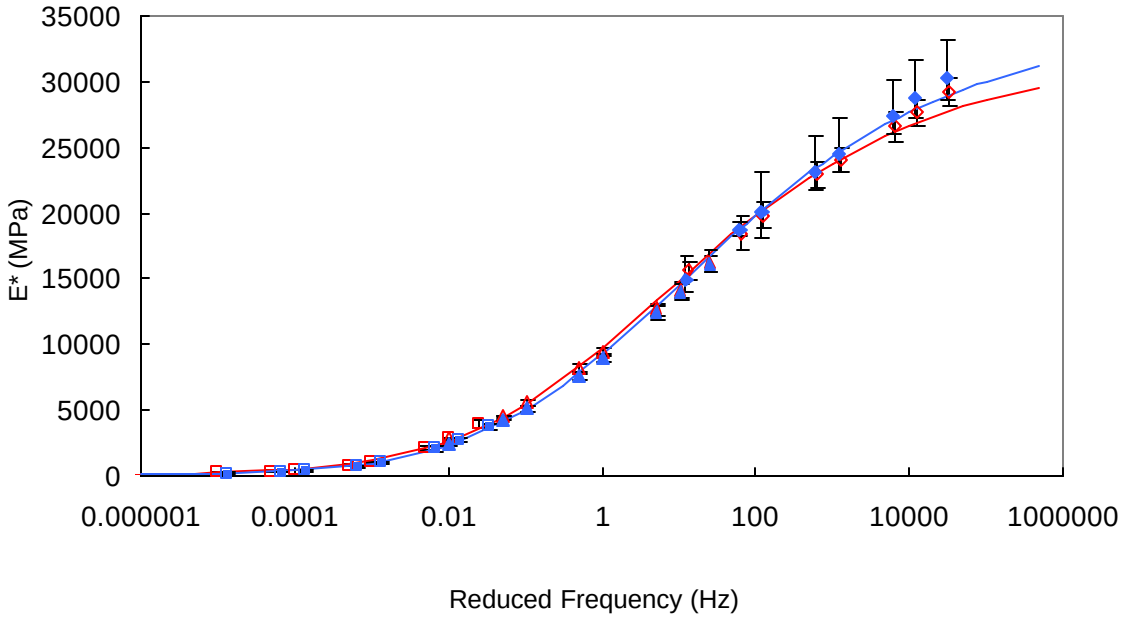

Figure D 22. S9.5B-Coarse Mixture

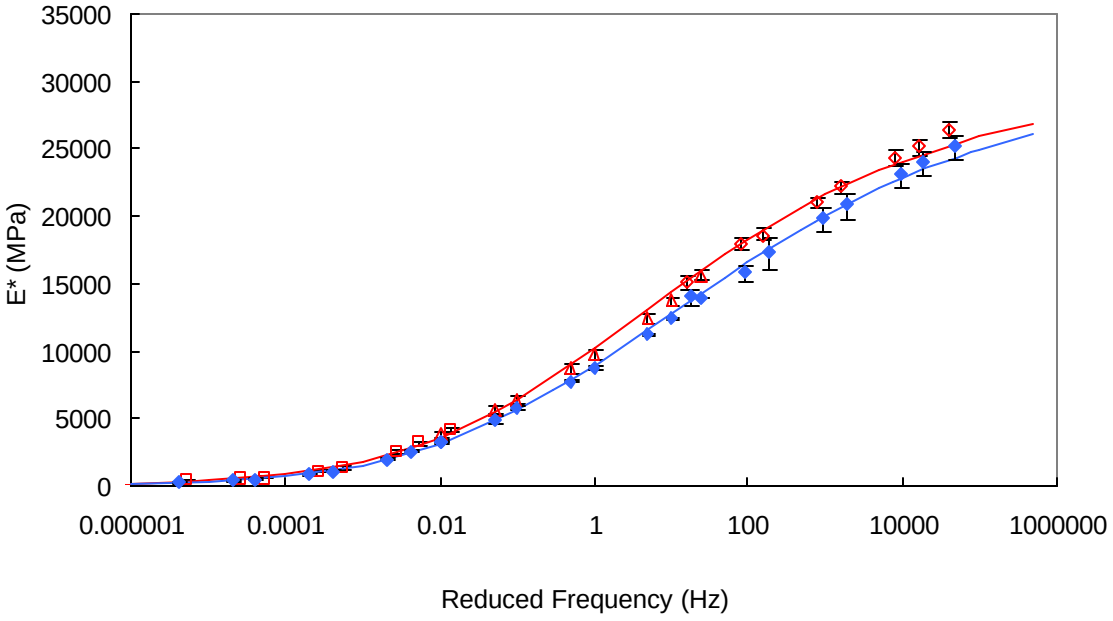

Figure D 23. S9.5B-Fine Mixture

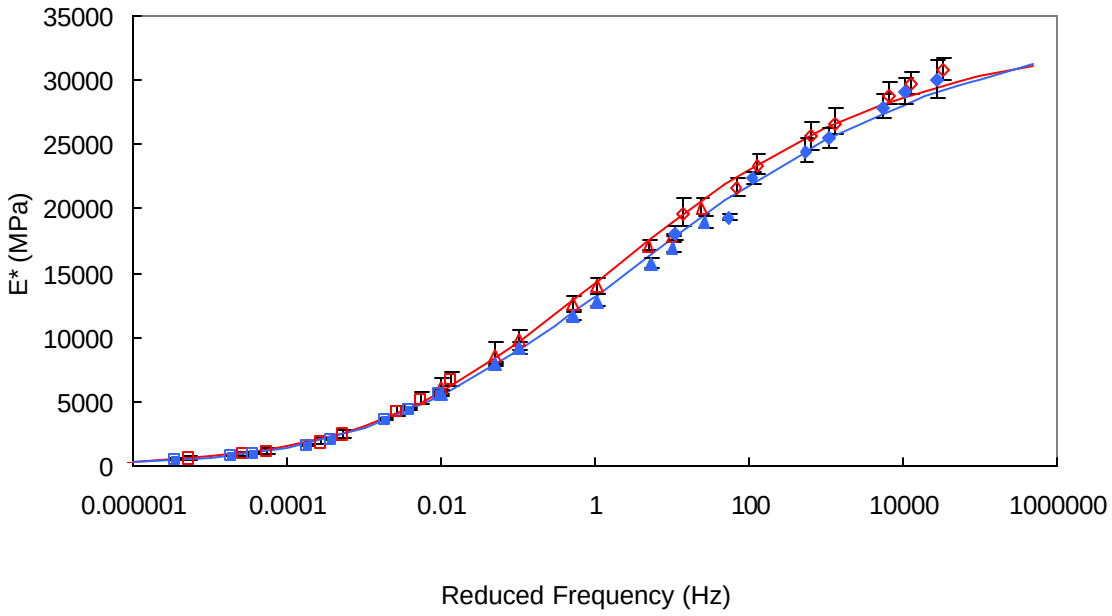

Figure D 24. S9.5C-Coarse Mixture

D.2 Phase Angle

In this section, the phase angle comparison is made between the IDT results and the axial compression results for the selected ten mixtures. The plots represent the phase angle mastercurve of each mixture in semi-log scale. The symbols without a legend represent the axial compression data.

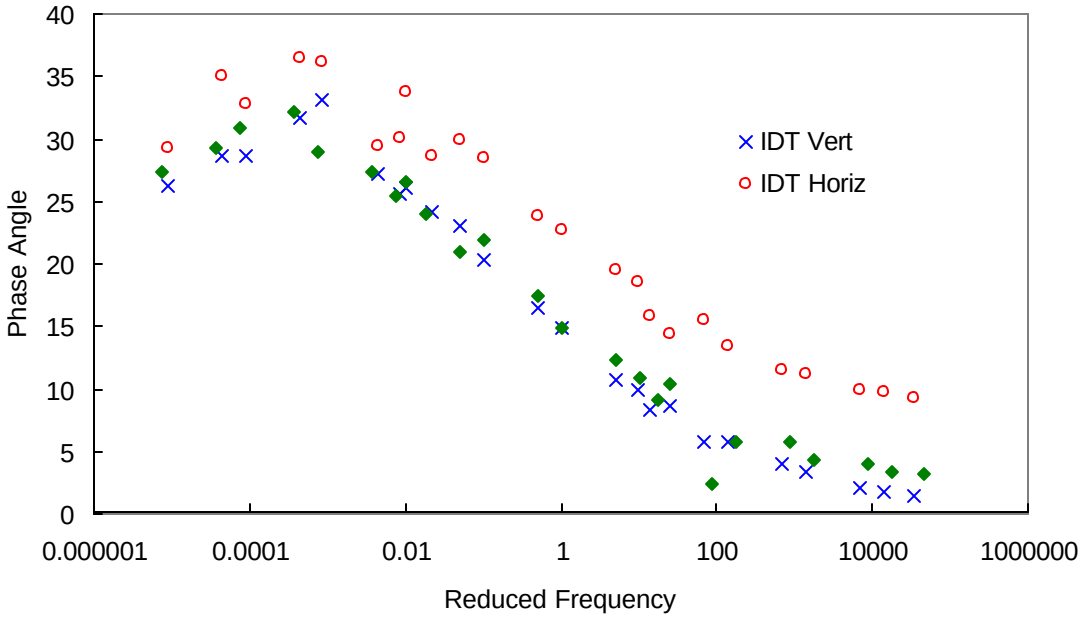

Figure D 25. S12.5B-Fine Mixture

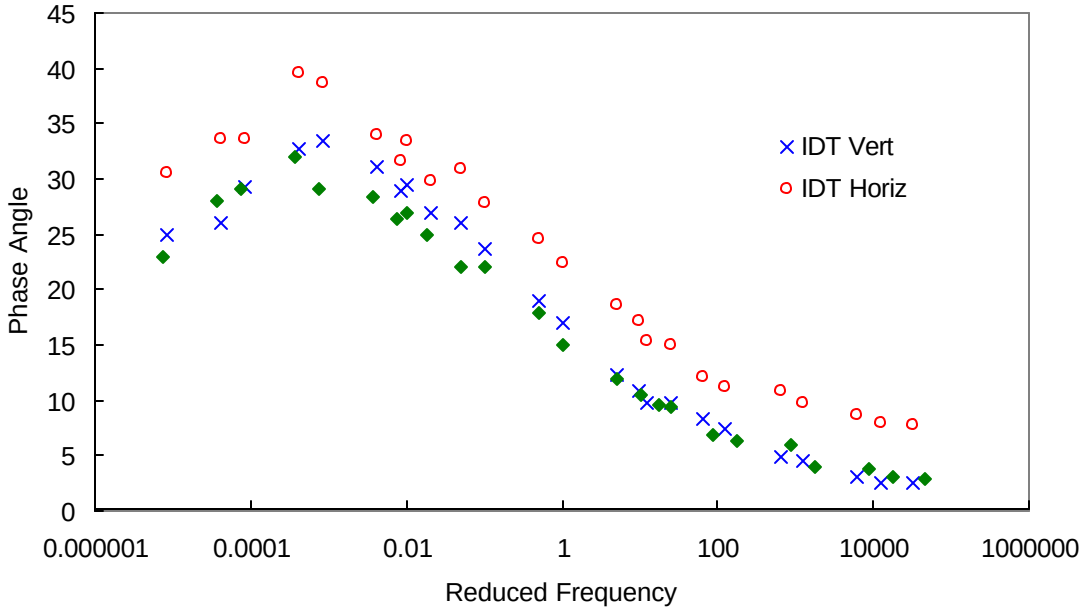

Figure D 26. B25.0B-Coarse Mixture

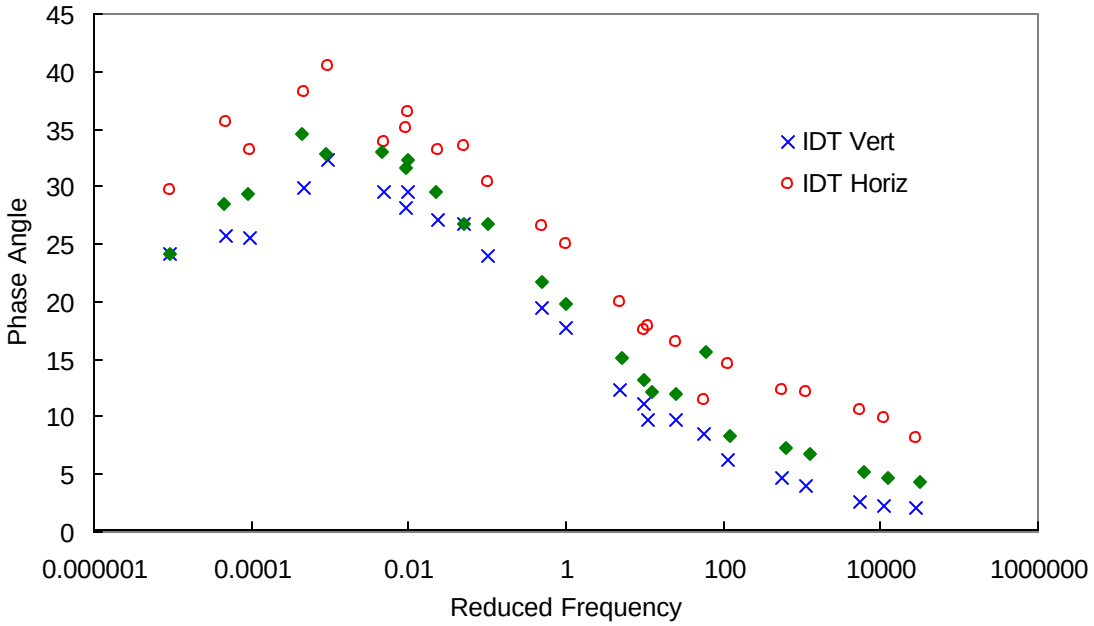

Figure D 27. B25.0C-Coarse Mixture

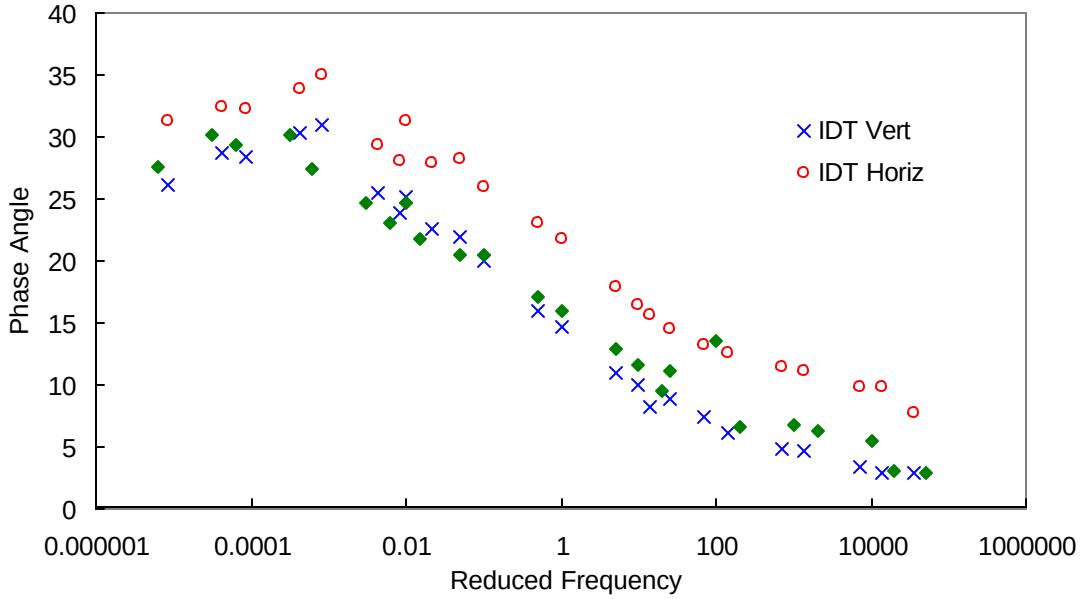

Figure D 28. B25.0C-Fine Mixture

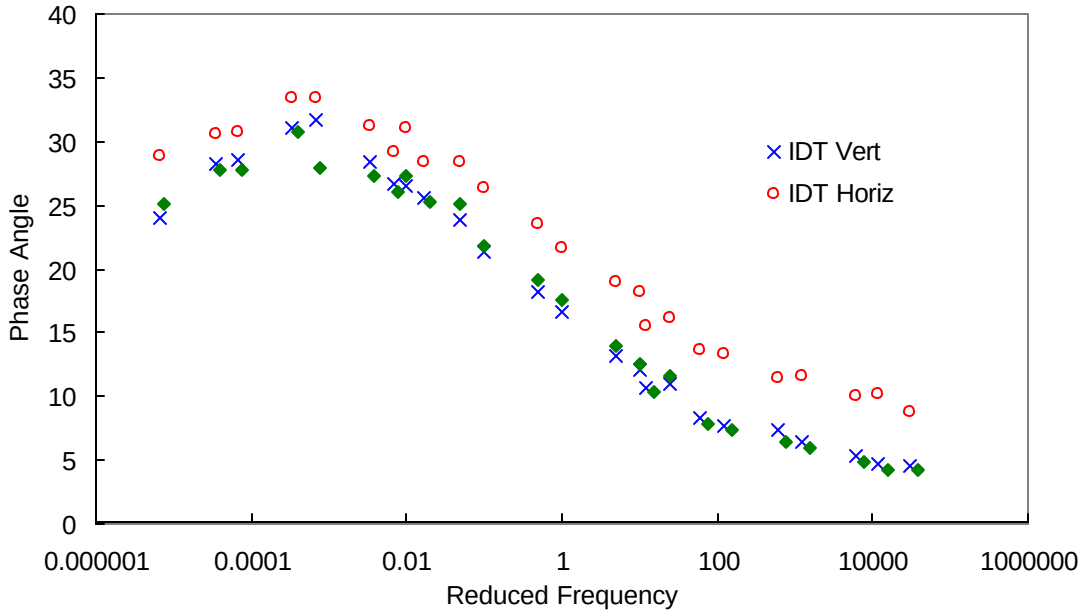

Figure D 29. I19.0B-Coarse Mixture

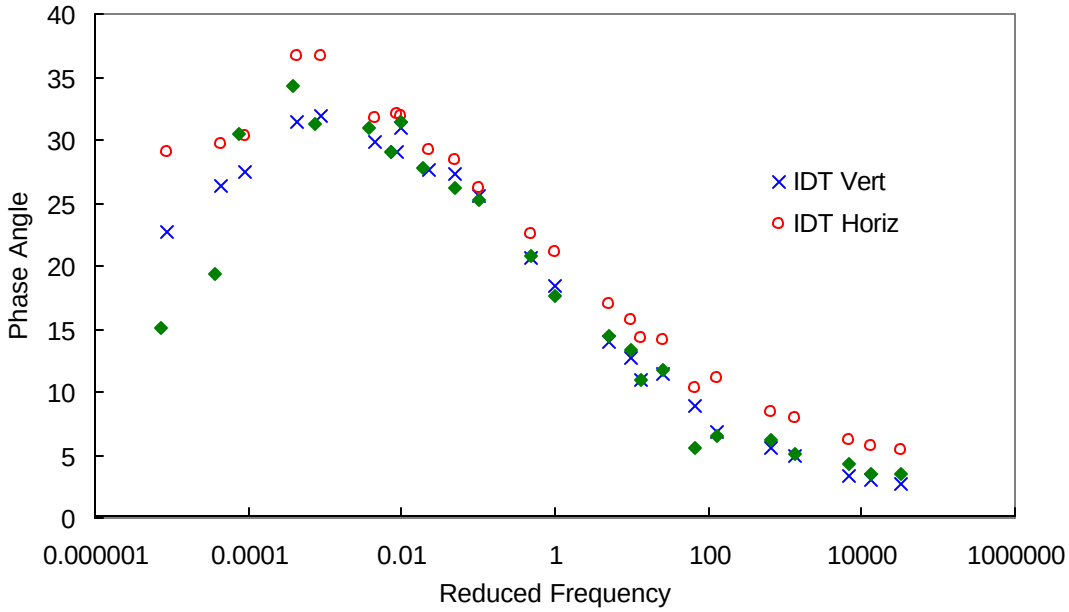

Figure D 30. I19.0B-Fine Mixture

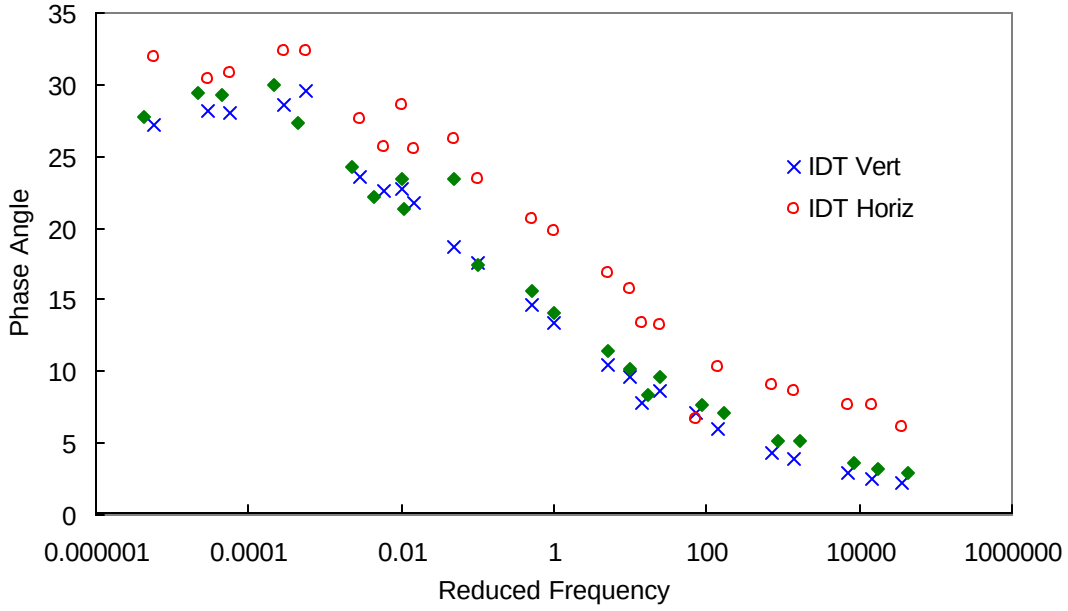

Figure D 31. I19.0C-Fine Mixture

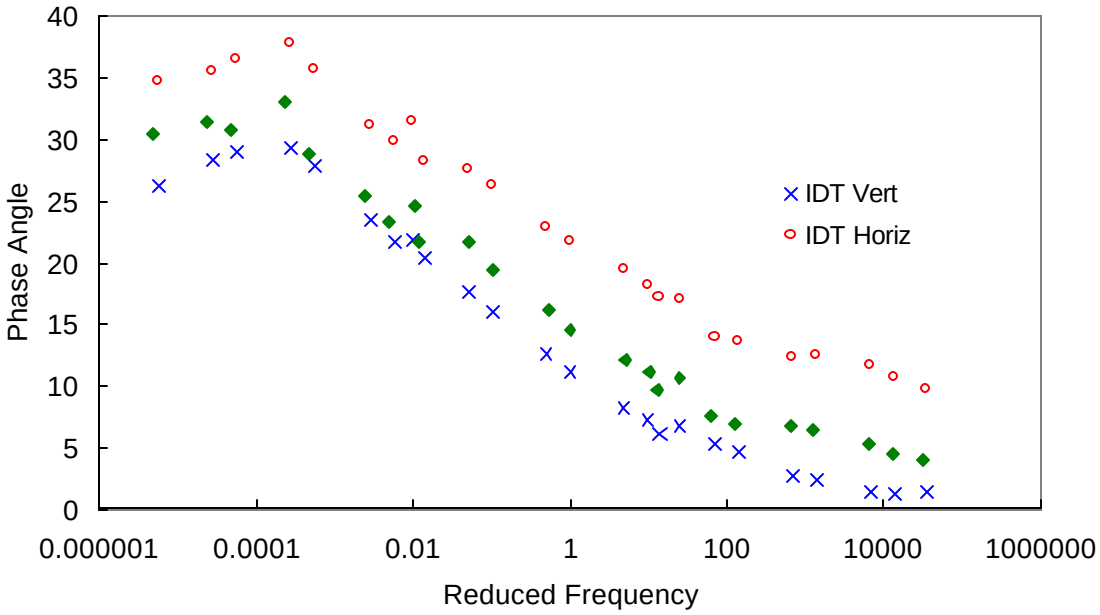

Figure D 32. S12.5C-Fine Mixture

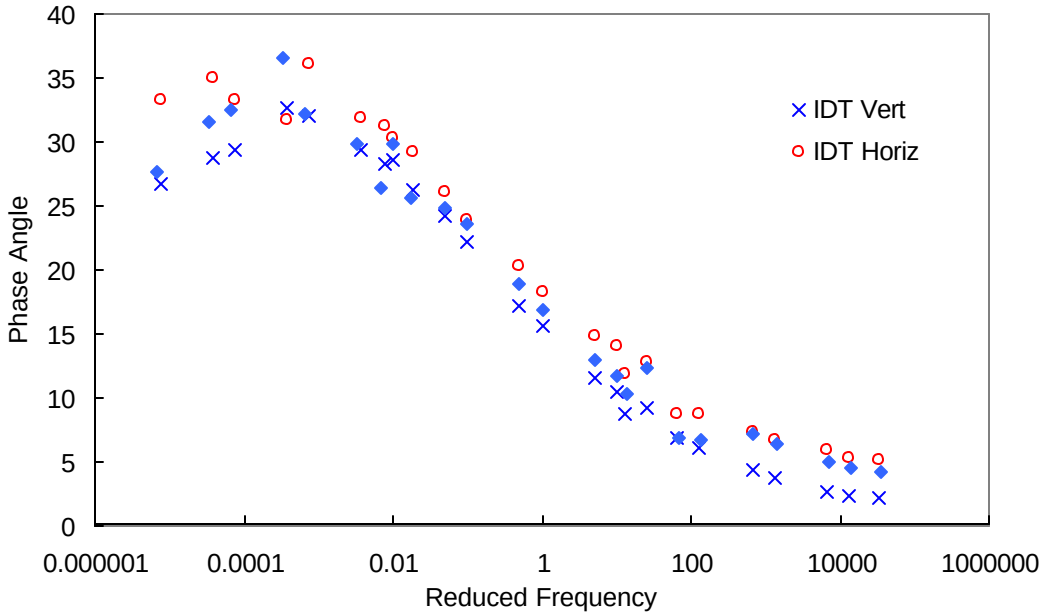

Figure D 33. B25.0B-Fine Mixture

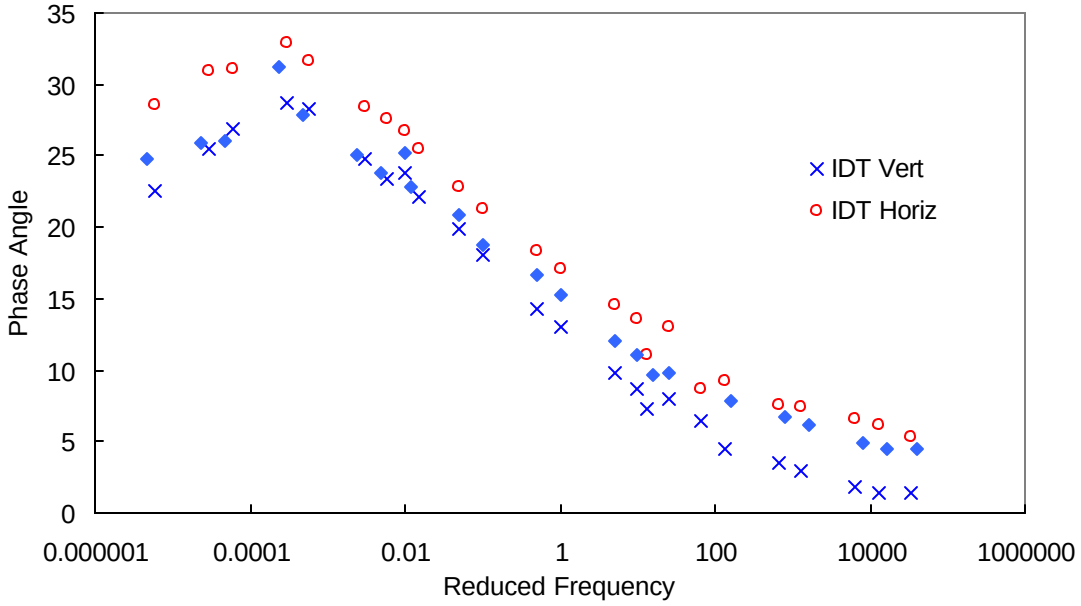

Figure D 34. S12.5D-Coarse Mixture