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UNDER CYCLIC LOAD USING FLEXURAL TESTS

presented by

KISE LEE

has been accepted towards fulfillment
of the requirements for

Ph. D degree in CIVIL ENGINEERING

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Major professor

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# CHARACTERISTICS OF ASPHALT PAVING MIXTURES UNDER CYCLIC LOAD USING FLEXURAL TESTS

Volume 1

BY

KISE LEE

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# ABSTRACT

## CHARACTERISTICS OF ASPHALT PAVING MIXTURES UNDER CYCLIC LOAD USING FLEXURAL TESTS

BY

KISE LEE

Increasing heavy wheel loads and truck traffic on flexible highway and airport pavements has necessitated more rational design approaches. Recently, significant progress has been made to develop new pavement structural design models (e.g. elastic and viscoelastic, and finite element models). This gave rise to the problem of material characterization under simulated field loading conditions. Moreover, attempts to directly relate mix design variables to the structural properties of the materials are limited or non-existence. Consequently, the need for quantifying relationships between the structural properties of compacted asphalt mixes and mix design parameters was realized.

In this study, it was hypothesized that relationships between the structural properties of the asphalt mixes and the asphalt mix design parameters can be found using statistical analyses. To verify the hypothesis, laboratory flexural cyclic load tests were designed and conducted to evaluate the structural properties of the mix, and the

standard Marshall mix design procedures were employed to obtain the mix design parameters. Based upon physical interpretation of the test results, statistical relationships between the structural properties of asphalt mixes and their mix design parameters were examined. These relationships are presented and discussed in this dissertation.

TO MY PARENTS

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## LIST OF SYMBOLS

A and B = parameters of the plastic basin.

A1 and B1 = regression coefficients.

AC = the actual percent asphalt content.

ANG = aggregate angularity.

APP = apparent.

AS = marshall stability adjusted to the sample height.

AV = percent air voids.

AVG = average

BK = bulk.

$CD_i$ = permanent deformation of $LVDT_i$.

CD(X) = cumulative plastic deformation of a point on the surface of the beam located at distance x from the edge of the loaded area.

CFP = compactor foot pressure (psi).

CL = cyclic loads (pounds).

$dCD_i/dN$ = the rate of change of the cumulative plastic deformation with respect to N.

$C_o$, $C_1$, $C_2$, and $C_3$ = coefficients.

E = total modulus (psi).

$e_T$ = total strain.

$e_E$ = elastic strain.

$e_{VE}$ = viscoelastic strain.

$e_p$ = plastic strain.

EXP = exponential function.

F = flow (1/100").

GB = the bulk specific gravity of the beam specimen.

GMM = the maximum theoretical specific gravity of the mix.

GRAD = gradation of aggregate.

Gs = specific gravity.

$I_i$ = intercepts of equation 5.1.

KV = kinematic viscosity of the asphalt binders (centistokes).

ln = natural logarithm.

Log = logarithm to base 10.

LVDT = linear variable differential transducer.

MR = resilient modulus (psi).

N = number of load applications.

$N_{FL}$ = number of load applications to fatigue failure.

NT = number of tamping.

$R^2$ = coefficient of determination.

S = marshall stability (pounds).

SE = standard error of the estimate.

$S_i$ = coefficients of equation 5.1.

SSD = saturated surface dry.

STAB = marshall stability.

TAV = the target percent air voids.

TAC = the target percent asphalt content.

VMA = percent voids in mineral aggregates.

WM = weight of asphalt mixes (grams).

X = lateral distance from the edge of the loaded area.

X1 = percent passing #200 sieve;

X2 = percent air voids in mix;

X3 = asphalt viscosity at 70 $^{o}$F ($10^{6}$ poises);

X4 = percent asphalt by total weight of mix;

X5 = test temperature ($^{o}$F);

X6 = the logarithmic value of the viscosity (in poises) of the asphalt at the test temperature;

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

Over the years, Americans alone have invested more than one trillion dollars in their highway systems and are just beginning to realize that the conditions of the highway infrastructures are a major problem that requires the infusion of funds for maintaining, rehabilitating, and rebuilding the systems. Public and legislative attentions have been focused on the scope of public programs to rebuild and upgrade existing facilities and on the financing aspects of these programs. Financing alone cannot solve the problem because the needs far exceed the available resources. Innovation in structural and material mix design is the key to bridging the gap and to accelerate the search for a better solution.

In general, the highway systems were built using two types of surfacing materials: rigid (Portland cement concrete) and flexible (asphalt mixes). The latter pavement type (flexible) is the subject of this research study.

As stated by Yoder and Witczak, the classical definition of flexible pavements includes those pavements that have an asphalt concrete surface (185). An asphalt pavement may consist of thin wearing surface course built over a base course, subbase course, and compacted subgrade. Thus, the

term pavement herein implies all the layers (courses) in the pavement structure. The load carrying-capacity of a flexible pavement is brought about by the load distribution characteristics of the layered system. The highest quality layer is placed at or near the surface. Hence, the strength of the pavement is the result of building up thick layers and, thereby, distributing the load over the relatively weak subgrade (185).

A typical asphalt paving mix consists of four major components: asphalt, coarse and fine aggregates, mineral fillers, and air. Also, certain types of additives or modifiers could be added to the mix to alter some of its properties. The so called "properties" of an asphalt concrete mix are dependent upon the properties of the material in the mix, the proportioning of the different component in the mix (the asphalt mix design), the test type and procedure, and temperature and environmental conditions.

The structural design of flexible pavements has evolved from rule-of-thumb procedures to methods based primarily on the experience and judgement of highway engineers augmented by empirical relationships developed through research and field observations. Recently, significant progress has been made to develop new pavement structural design models (e.g. elastic and viscoelastic, and finite element models). The accuracy of these models, however, depends upon the accuracy of the input data such as the structural and material

properties, and others. Several laboratory test procedures were developed for the evaluation of these properties. However, numerous practical difficulties are often encountered in each test to exactly load the test specimen as dictated by theoretical considerations and/or to duplicate field conditions. Moreover, attempts to directly relate mix design variables (e.g. asphalt type and content) to the structural properties of the materials are either very few or non-existence. Consequently, there have been few links between the newly developed laboratory tests (e.g., flexural tests and indirect tensile tests) and the traditional mix design methods (e.g., Hveem stabilometer, and Mashall stability and flow method) that have been in existence for many decades.

The objectives of this study are to:

a) Determine the asphalt mix design parameters using the standard Marshall tests.
b) Determine the structural properties of the asphalt mixes using cyclic load flexural tests.
c) Quantify relationships between the structural properties of the asphalt mix and the types of the material in the mix.
d) Identify a laboratory test procedure whereby the asphalt mix design can be tailored to optimize its structural properties.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 GENERAL

The field of flexible pavement design has evolved from empirical rule-of-thumb procedures based on past experience to rational methods based on soil classification systems and later on road test data. Beginning in the 1950s, however, heavy wheel loads and truck traffic resulted in severe breakup of some highways which necessitated more rational approaches. Consequently, analytical (mechanistic) pavement design methods were introduced which provided a better understanding of pavement response under traffic loading. This, however, gave rise to the problem of material characterization under simulated field loading conditions. To solve the problem, new laboratory tests such as the resilient modulus and permanent deformation-creep were developed, which enabled pavement engineers to obtain material properties necessary for mechanistic pavement design models (50).

In order to understand the material properties and to be able to extract the design parameters, the stress-strain responses of the material under simulated traffic loading must be obtained. Statistical and actual variations of the responses and the design parameters relative to other factors (e.g., temperature) should also be determined.

Existing information concerning these variations of asphalt mixes are presented in the following sections.

## 2.2 Material Evaluation

The mechanical response of most asphalt mixes subjected to static and quasi-static loading is complex and differs considerably from that of the constituent materials in the mixes (109). The response depends on several variables which can be divided into three common groups (26, 32, 35, 44, 47, 71, 100):

1) Asphalt mix variables including types of asphalt, the percent asphalt content, types of aggregate and their proportion and gradation, types and proportion of the mineral filler, and types and concentration of modifier (if any).
2) Specimen variables including compaction variables, density or the percent air voids, specimen size, and the amount of induced moisture.
3) Test variables including temperature, load intensity and frequency, and loading and relaxation periods.

Figure 1 depicts a typical mechanical response (stress-strain) of asphalt mixes subjected to cyclic loading (81). The pertinent features of the strain response include:

1) Time-independent elastic strain (also called resilient strain) which is immediately recoverable upon unloading. This is shown as ab in figure 2.1.

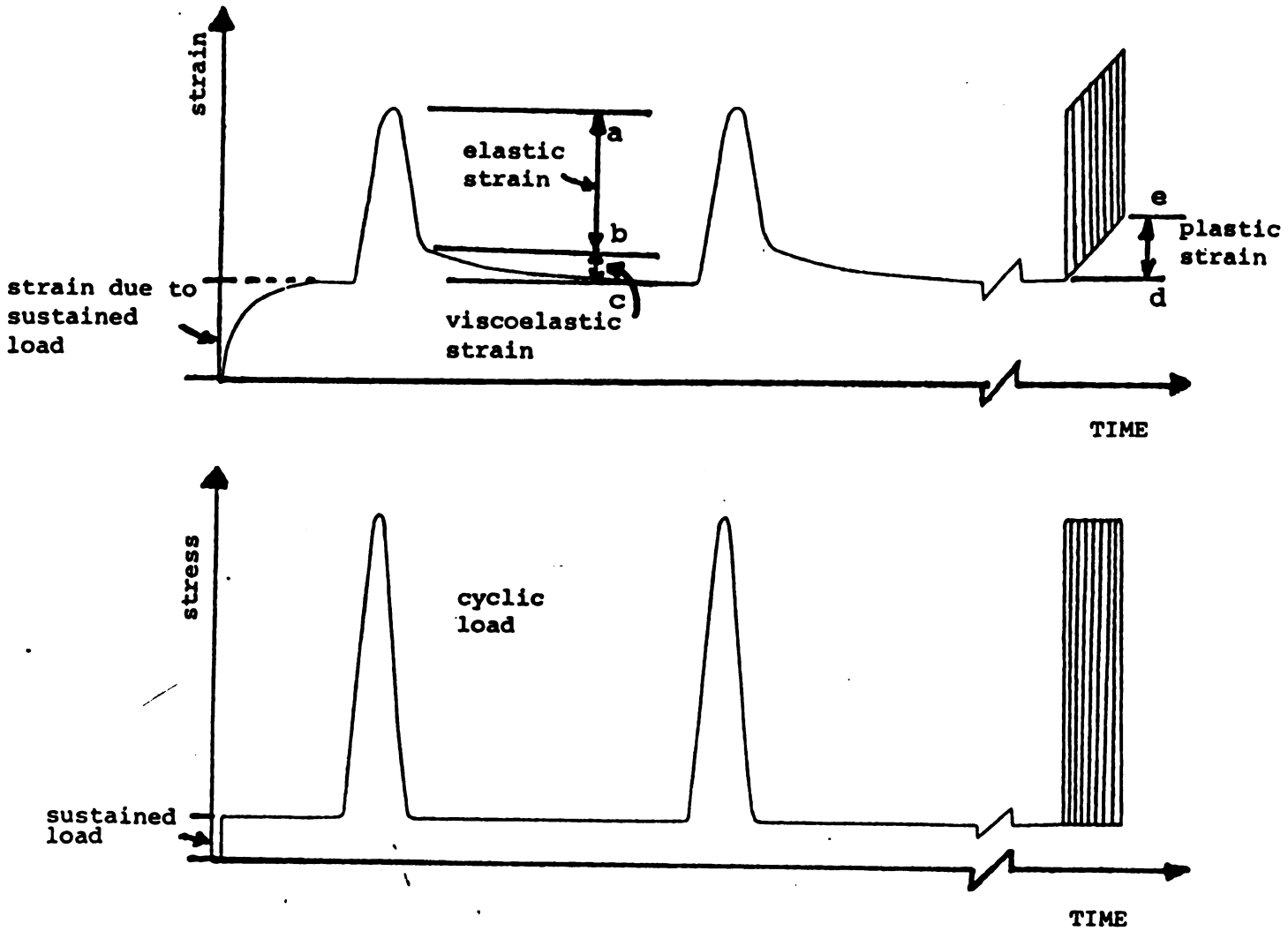



Figure 2.1 Features of the cyclic stress-strain curve of asphalt mixes.

2) Time-dependent viscoelastic strain which is recoverable during and after removal of the load (bc in figure 2.1).

3) Plastic (permanent) strain which is irrecoverable (ed in the figure).

In order to obtain an analytical assessment of the mechanical response, a constitutive model should be used that can account for the pertinent features of the stress-strain properties of the asphalt mixes. Laboratory observations suggest that several different models can be constructed that include:

1) Linear or nonlinear elastic.

2) Elasto-plastic.

3) Elastic-viscoelastic-plastic.

4) Elastic-viscoelastic.

5) Viscoelastic-plastic.

The model to be selected for the analysis depends upon the desired type or types of strain to be modeled, the degree of accuracy, the desired mathematical simplicity, and the anticipated load intensity. For example: mathematically, the linear elastic model is the simplest. However, the model does not account for the viscoelastic and plastic deformations of the mix. In general, the elastic-viscoelastic-plastic model is appropriate because of its ability to accurately manage the actual pavement response when subjected to traffic loading (17, 18). The basic

premise of this model is the assumption that, at each loading increment, the material is capable of undergoing a small plastic (permanent) strain, a small viscoelastic strain, and a small elastic strain. Mathematically, for each loading cycle, the total strain is the sum of the plastic, viscoelastic, and elastic components, i.e.

$$e_T = e_E + e_{VE} + e_P \tag{2.1}$$

where : $e_T$ = total strain;
$e_E$ = elastic strain;
$e_{VE}$ = viscoelastic strain; and
$e_p$ = plastic strain.

Since the elastic strain is time independent, the total strain rate is the sum of the components of the viscoelastic and plastic strain rates. That is:

$$\frac{de_T}{d_t} = \frac{de_{VE}}{d_t} + \frac{de_p}{d_t} \tag{2.2}$$

where: the strain rate is the first derivative of strain with respect to time.

It should be noted that equation 2.2 indicates that the stress is applied and removed instantly. That is, the stress

intensity is either zero or a prespecified value. If the stress increases gradually with time (as the case of moving wheel load in the field and most laboratory tests) then strain rates in equation 2.2 should be expressed in terms of partial derivatives. All strain rates (including the elastic one) would be stress-dependent. Equation 2.2 represents the strain rates during the period of constant stress.

Nevertheless, using figure 2.1 and the above scenario, one can define the three types of strain as follows:

a) Resilient strain - The resilient strain for each load cycle is defined as the difference between the instantaneous values of the strain at peak and zero loads. This is shown as line ab in figure 2.1.

b) Viscoelastic strain - For each load cycle, the viscoelastic strain can be measured by the differences between the values of strain at zero load and that when the second load cycle commences. In figure 2.1, line bc is a measure of the viscoelastic strain.

c) Plastic strain - The value of the plastic strain per load cycle is very small and difficult to measure. Therefore, the cumulative plastic strain due to a certain number of load repetitions is generally measured. This is shown as line de in figure 2.1.

It should be noted that the accuracy of the actual measurement of strains depends on the rate of unloading.

A higher rate permits more accurate measurement of the resilient and viscoelastic strains. In reference to figure 2.1, the values of the resilient strain represented by ab increases and the viscoelastic (bc) decreases with decreasing unloading rate. Because, during the unloading period, the test specimen will recover all the resilient and part of the viscoelastic strains. Hence, the actual values of the resilient and viscoelastic strains cannot be accurately determined

In general, the applied cyclic stress, and the resilient, viscoelastic, and plastic strains are used to obtain the structural properties of asphalt mixes. The following definitions of the structural properties are relevant and can be found throughout the literature.

1) Resilient modulus is the ratio of the applied cyclic deviatoric stress to the resilient part of the axial strain (ab).
2) Resilient Poisson's ratio is the ratio of the radial (not shown in figure 2.1) to the axial resilient strains.
3) Viscoelastic modulus is the ratio of the applied cyclic deviatoric stress to the viscoelastic part of the axial strain (bc).
4) Total modulus is the ratio of the applied cyclic deviatoric stress to the total axial strain (ac).
5) Stiffness is a general term describing any one of the

above moduli.

6) Fatigue life is the number of load repetitions a material can withstand prior to the initiation of microcracks.
7) Permanent deformation is the sum (cumulative) of the plastic axial deformation (de) developed during the total number of load repetitions.

Whereas the above terms are generally accepted, one can find (in the literature) several terms describing the modulus of a material (e.g., stiffness modulus, mix modulus, complex modulus, dynamic modulus, elastic modulus, elastic stiffness, flexural stiffness) (81, 104). Unfortunately, most of the existing literature do not properly define these terms nor do they offer any explanations concerning the method of calculation. Hence, one can find the same term being used by several authors even though the methods of calculation are different (e.g., one author uses resilient strain, while another uses total strain, to calculate the same modulus).

## 2.3 RESILIENT CHARACTERISTICS OF ASPHALT MIXES

The resilient characteristics of asphalt mixes are the resilient modulus and resilient Poisson's ratio. Existing information concerning the effects of the test, mix, and specimen variables on the resilient characteristics of asphalt mixes are presented below.

### 2.3.1 Effects of Test Variables

The effects of test variables on the resilient modulus of asphalt mixes were investigated by several researchers (27, 28, 51, 52, 54, 106, 109). These variables include applied stress, test temperature, load frequency, relaxation period, and number of load repetitions.

The effects of the number of load applications (N) on the resilient modulus (MR) of asphalt mixes are dependent on the test type and boundary conditions. For example; for a continuously supported beam specimen, increasing N results in increasing MR. While for simply supported beam specimen, increasing N yields a decrease in the values of MR (48, 71).

Brown and Cooper (27) stated that, for a stiff asphalt binder and relatively moderate stress levels, the resilient modulus is independent of stress level (51, 52, 54). Similarly, Yeager and Wood (106) found that a constant value of the resilient modulus can be obtained for a stress level up to 70 psi and test temperatures between 40 and 100$^{o}$F.

The effects of load duration and frequency upon the resilient response of asphalt mixes were also evaluated by several investigators. Generally, it has been found that longer load durations and lower frequencies result in lower values of the resilient modulus (27, 28, 106, 109). Also, since the response of viscoelastic materials, such as asphalt mixes, to load is temperature dependent, higher test

temperatures result in higher deflections and lower values of the modulus (24, 27, 87, 99, 107, 108,).

The resilient Poisson's ratio for isotropic linear elastic material under uniaxial stress is defined, as noted above, by the ratio of recoverable radial strain to the recoverable axial strain. This definition applies only for zero or constant confining pressure. For variable confining pressure, the definition is more complex. The theoretical range of the values of Poisson's ratio is between -1.0 and 0.5, although values higher than 0.5 were reported (51, 52). This can be attributed to several factors:

1) Asphalt mixes are not perfectly linear elastic material.
2) Laboratory test conditions do not exactly duplicate those dictated by the theory of elasticity.
3) The test specimen experiences volume change during shear which is not permissible in the theory of elasticity.

Because of the problems associated with laboratory measurements of Poisson's ratio and since pavement response is relatively insensitive to variations in this parameter, estimated values of Poisson's ratio are generally used by pavement engineers (108). A typical range of Poisson's ratio for asphalt concrete mixes is between 0.2 and 0.4 (109). Nevertheless, researchers have evaluated the effects of the test variables on the value of Poisson's ratio. It was found

that:

a) Higher test temperature yields higher values of Poisson's ratio (104).
b) Increasing number of load applications yields higher values of Poisson's ratio (15).

### 2.3.2 Effects of Mix and Sample Variables

The resilient modulus of asphalt mixes is also a function of the mix and specimen variables including aggregate type, asphalt type and content, gradation of aggregate, and percent air voids. Bonnaure et al. studied the effects of several factors upon the resilient modulus of asphalt mixes utilizing a two-point bending apparatus for testing trapezoidal specimens (24). Some of their test specimens were fabricated in the laboratory while others were obtained from the field. They concluded that:

- Asphalt content, percent air voids, grade of binder, and volume concentration of the aggregate significantly affect the test results.
- Accurate estimates of the stiffness modulus and phase angle of the mix can be obtained using the above noted variables with the aid of nomographs (Van Der Poel).

Saraf and Majidzadeh performed dynamic tests on simply supported beams (12 in. long, 2 in. wide, and 2 in. high) to examine the effects of the type of asphalt binder on the

dynamic modulus (85). They used six different types of asphalt aged for 2, 4, and 6 hours in an oven heated to a constant temperature of 425°F. The tests were conducted using 0.2 second loading time followed by 0.8 second relaxation period. They concluded that:

- The dynamic modulus of the compacted mix increases with an increase in the binder viscosity.
- For any given grade of asphalt, there is an optimum asphalt content at which the value of the dynamic modulus is maximum.
- Aging of asphalt causes an increase in its viscosity and dynamic modulus.
- The dynamic modulus increases with an increase in the compacted density of the mix.

The effects of aggregate gradation on the resilient characteristics of aggregates and asphalt mixes were also investigated by several researchers.. In general, it was found that these effects are insignificant (64, 90, 91, 105, 108, 109).

Because of the complexity of the laboratory tests to obtain the structural properties of asphalt mixes, and because these tests are expensive and time consuming, several researchers correlated the structural properties of the mixes to some of the mix parameters which are easy to obtain. Some of these correlations are presented in the following section.

### 2.3.3 CORRELATIONS

Efforts have been made to correlate the dynamic modulus of asphalt mixes to the test, mix, and sample variables. Shook and Kallas (93) used data from several different tests to develop correlation equations (known as the Asphalt Institute (A.I.) equations) between the dynamic modulus of asphalt mixes and several mix, test, and specimen variables. The tests included:

- Marshall stability and flow at 40, 70, 100, and 140$^{o}$F.
- Hveem tests at the same temperatures.
- Direct and indirect tensile tests.
- Dynamic modulus tests on 4-in diameter and 8-in high cylindrical specimens.

Their statistically correlated equations are:

$$\text{Log } E = 1.54536 + 0.020108(X1) - 0.0318606(X2) + 0.068142(X3) - 0.00127003(X4)^{0.4}(X5)^{1.4} \quad (2.3)$$

$$R^2 = 0.968, \text{ and } S.E. = 0.0888904$$

$$\text{Log } E = 3.12197 + 0.0248722(X1) - 0.0345875(X2) - 9.02594(X4)^{0.19}/(X6)^{0.9} \quad (2.4)$$

$$R^2 = 0.971, \text{ and } S.E. = 0.0849186$$

Where: Log = logarithm to base 10;

E = dynamic modulus, $10^5$ psi (4 Hz loading frequency);

X1 = percent passing #200 sieve;

X2 = percent air voids in mix;

X3 = asphalt viscosity at 70 $^{o}$F ($10^6$ poises);

X4 = percent asphalt by total weight of mix;

X5 = test temperature ($^{o}$F);

X6 = the logarithmic value of the viscosity (in poises) of the asphalt at the test temperature;

S.E. = standard error of the estimate; and

$R^2$ = coefficient of determination.

Shook and Kallas noted that:

- For a constant asphalt content, the resilient modulus decreases as the percent air voids increases.
- The resilient modulus of the mix increases as the asphalt viscosity increases, or as penetration decreases.

Later, Witczak utilized an expanded data base to modify the AI equations and to include the test frequency as one of the variables (104).

Miller et al. compared nearly 1200 laboratory measured dynamic modulus values with those predicted using the AI equations (66). They observed that for all mixes made using crushed aggregate, the measured and predicted moduli showed

a good agreement. However, very poor agreement was noted for mixes made using slag and sand. Thus, they modified the AI equations to obtain a better correlation for all mixes. The findings by Miller support that the modulus of the asphalt mix depends upon the constituent material in the mix. The original AI equations were obtained using crushed and natural gravel. Consequently, when similar aggregates were used, calculated and measured moduli showed a relatively good agreement compared to that of using different aggregates (slag).

Nevertheless, when the AI equations failed to predict the modulus to within reasonable limits, researchers developed alternative equations. For example, Terrel et al. correlated the resilient modulus to the asphalt content, test temperature, and percent air voids in the mix (96). Yeager and Wood correlated the dynamic modulus to the slope of the lines representing the logarithmic values of the kinematic viscosity against the inverse values of the temperature, loading rate, and test temperature (106). Their correlations, however, were limited to a specific aggregate type, gradation, asphalt type, and asphalt content.

To summarize, several correlations relating the resilient and/or total characteristics of asphalt mixes to the mix, test, and specimen variables were developed. These, however, were found to be limited to specific types of aggregate and asphalt, and to the specific tests and

boundary conditions.

## 2.4 PLASTIC CHARACTERISTICS

In general, the plastic characteristics of any material can be divided into two categories: permanent deformation and creep. The basic difference between the two categories is that the former is the cumulative plastic deformation under cyclic load (e.g., a moving wheel load) while the latter is, typically, measured as the total deformation under a constant static load (e.g., a parked vehicle).

Theoretically, permanent deformation of a compacted asphalt mix is a manifestation of two different mechanisms: material densification that results in a volume change; and repetitive shear deformation that results in a plastic flow with no volume change (58). The portion of the deformation due to densification can be minimized by proper compaction specifications (17, 18, 19, 58). To control or minimize plastic flow in a pavement section, the applied shear stress should be minimized by a proper design. In practice, the separation of the two components of permanent deformation is not possible. Therefore, the term permanent deformation herein refers to the sum of both deformations.

Permanent deformation represents a basic concern in the structural design of pavement system. It causes two different distress modes in the pavement: ruts and fatigue cracking (85). Ruts in flexible pavements are simply a

surface distortion that can be found in the wheel paths. This surface distortion can be caused by any one layer or a combination of layers in the pavement system. Water tends to accumulate in the rutted area of the pavement causing a safety problem (hydroplaning). Fatigue cracking (also known as alligator cracking) is the result of the accumulation of cyclic plastic strain induced by repeated traffic loads. These cracks cause slow disintegration of the asphalt course which shortens pavement life.

Concentrated efforts to control both ruts and fatigue cracking resulted in the development of two pavement design methodologies that are based upon limiting permanent deformations (109):

- Empirical methods based on correlations of excessive deformations to preselected failure conditions of the pavement.
- Quasi-elastic or viscoelastic methods that are used to predict the cumulative permanent deformations in pavement systems.

The latter methodology is preferred because it can be used in more theoretical and rational pavement design methods. It should be noted, however, that neither method is perfected to the point where permanent deformations can be accurately predicted.

In the following sections, plastic deformation prediction models and the effects of several variables upon

the plastic characteristics of asphalt mixes are summarized.

### 2.4.1 Plastic Deformation Prediction Models

Monismith et al. found that, for asphalt mixes, the functional relationship between the permanent strain and the number of load cycles can be described as follows (67, 68, 69, 70, 72).

$$\log (e_p) = C_o + C_1 \log(N) + C_2 (\log(N))^2 + C_3 (\log(N))^3 \quad (2.5)$$

where: log = logarithm to base 10;
$e_p$ = plastic strain;
$C_o$, $C_1$, $C_2$, and $C_3$ = coefficients; and
N = number of load application.

The basic concept of the model is based upon the assumption that for a given stress and material properties the plastic deformation of asphalt mixes is a function of the number of load applications. This implies that the prediction of permanent deformation can be determined by repeated load laboratory tests. Allen and Deen confirmed the above finding and expanded the relationship to include the effects of test temperature and applied deviatoric stress (16). Comparisons of predicted permanent deformation with actual rut depths measured from full-depth asphalt pavements showed a

reasonable agreement.

Haas and Morris et al. introduced a polynomial function between the ratio of the logarithmic value of the permanent deformation to the logarithmic value of the number of load repetitions and the applied stress, the test temperature, and the percent air voids in the mix (40, 74, 75).

A different approach was proposed by Brown and Cooper (27). They stated that the permanent deformation of asphalt mixes can be better expressed by using the percent air voids or the voids in the mineral aggregate (VMA) as the independent variable rather than the number of load cycles. This implies that the permanent deformation is independent of the number of load applications. This is true if the permanent deformation term includes only creep. For this case, time becomes important. In general, permanent deformation of asphalt mixes is a function of several variables including time of loading, percent air voids, temperature, material properties, applied stresses, service life, and environmental conditions (26, 32, 35, 40, 42, 44, 45, 47, 50, 53, 55, 71, 73, 76, 78, 79, 83, 86, 173). . For example, the performance and service life of two similar pavement sections are drastically different if one section is subjected to a high number of trucks (high axle loads), while the other is subjected only to automobile traffic. Further, even if the traffic characteristics are the same, pavements located in different geographical areas (e.g.

presence/absence of freeze-thaw cycles) will perform differently. These imply that to properly model permanent deformations of asphalt mixes, all factors involved should be included in the model. Thus, the differences in opinion found in the literature concerning plastic deformation are mainly due to the fact that each study did not include the effects of all possible independent variables and/or their ranges. These are presented in the following section.

### 2.4.2 Effects of Test Variables

The effects of cyclic stress level and test temperature on permanent deformation of asphalt mixes were investigated by several researchers. They reported that higher stress levels and/or test temperatures result in higher permanent deformations (40, 42, 45, 47, 50, 53, 55, 73, 76, 78, 79, 83, 86).

Allen and Deen found that the permanent deformation at the first load application (initial response) is a function of the stress level and test temperature (16). The increment of permanent deformation between any subsequent cycles, however, is independent of stress level and test temperature. Haas and Meyer, on the other hand, reported that the accumulated permanent deformation (in percent) per the logarithmic value of the number of load application increases with increasing axial stress and test temperature (40). The difference between the two findings could be

attributed to the total number of independent variables included in the study or to the type of test used. Different tests may yield different stress distributions and, consequently, the results may not be directly compared.

Monismith and Vallerga examined the effects of the relaxation period during load-unload cycles on permanent deformation (73). They found that, relative to other variables, the effect of the relaxation period is statistically insignificant. Allen and Deen studied the effects of the load duration on permanent deformation (16). They showed that regardless of the load frequency, equivalent loading times (number of load cycles multiplied by load duration) yield similar permanent deformation. In practice, the above findings imply that spacing between equally loaded truck axles (relaxation period) does not affect the permanent deformation. Traffic speed (loading period), on the other hand, inversely affects permanent deformation. That is, the higher the speed the lower the permanent deformation.

The finding by Allen and Deen however, was disputed by Brown and Cooper (16, 27). They examined the behavior of asphalt mixes under static and cyclic load (stationary and moving vehicle) using a square wave. In both tests, the peak cyclic load was equal to the static load in the creep test. Thus, the equivalent loading time for the creep test is much higher than that of the cyclic test. They found that the

permanent deformation obtained from the cyclic test is significantly higher than that measured from the creep test. Brown and Cooper attributed this to the shape of the loading wave. Consequently, they recommended the use of sinusoidal wave forms.

Again, the differences in the findings are actually related to the variables involved. Allen and Deen used a sinusoidal wave form while Brown and Cooper used a square wave form.

To summarize, the effects of test variables on permanent deformation of asphalt mixes vary. Results appear to depend upon the number of independent variables under consideration. Ideally, the effects of the independent variables can be separated by holding all variables but one to be constant. Then the test results from two different investigations can be compared if and only if the constant values in both investigations are equal. The most significant findings are those reported by Allen and Deen (16). That is, regardless of the applied stress level and other mix variables, the permanent deformation at the first load cycle is dependent on the stress level and mix variables and that the increment of permanent deformation between any subsequent cycles is load independent. These findings imply that, in the field, the permanent deformation of a pavement system under the first application of axle load plays a major role in the extent of future ruts of that

pavement. Thus, measurements of the permanent deformation of a newly constructed pavement is crucial to the prediction of its future performance.

### 2.4.3 Effects of Sample and Mix Variables

The effects of sample and mix variables upon the permanent deformation of asphalt mixes have been studied extensively. Since the findings are similar and consistent, a summary with illustrative citations is presented below:

- For a constant asphalt content, lower percent air voids results in lower permanent deformation (27, 40).
- The effects of the percent fine content depend upon the type of the aggregate in the mix (21, 46, 47).
- The percent of coarse aggregate and top size aggregate in the mix cause no significant effects on permanent deformation (46).
- Softer asphalt binder causes higher permanent deformation (40).
- Higher asphalt contents cause higher permanent deformations (46).

These findings have a direct impact on this study in the selection of the specimen and test variables and their ranges. In this study the test matrix was designed to include the following: three values of percent air voids; three viscosity graded asphalts; three types of aggregate

with one top size and a constant percent fine content; two proportions of fine and coarse aggregates (two gradations); three levels of cyclic load; and two test temperatures. These variables and their ranges are detailed in chapter 3.

## 2.5 FATIGUE PROPERTIES

The subject of fatigue is complex and can be studied in many ways (2, 39, 52, 59, 63, 65, 84, 88, 92, 94, 101, 103). Regardless of the complexity of the subject and the way it is studied, it should be clear that cyclic plastic strain is ultimately responsible for fatigue damage (84). Yoder and Witczak stated that fatigue is the phenomenon of repetitive load-induced cracking due to a repeated stress or strain below the ultimate strength of the material (108).

Fatigue failure is one of the most commonly used failure criterion in structural engineering and has been adopted as a pavement failure criterion. In general, tensile cracks in flexible pavements initiate at the bottom of the asphalt mix layer and are located under or in the vicinity of the wheel loads where the tensile strain is high. Hence, the maximum tensile stress and/or strain that can be permitted at the bottom fiber of the asphalt layer can be specified such that fatigue cracks are minimized.

Fatigue tests (although not standardized) have been conducted utilizing several test methods and various specimen sizes (14, 15, 31, 37, 48, 49, 65, 74, 80, 85, 97).

It is generally agreed that because of the effects of the stiffness of the asphalt binder upon fatigue properties and because binder stiffness is temperature-dependent, a temperature-controlled chamber should be used around the test specimens.

Fatigue test methods vary from the repeated load flexural test using beam specimens to repeated load indirect tensile tests on Marshall-type specimens (14, 15, 31, 41). Recently, a test method based upon the principles of fracture mechanics has also been used (43, 63). In addition, fatigue tests may be conducted either in stress or strain-controlled modes (26, 35). In the stress-controlled mode, a constant peak cyclic stress is continuously applied and removed which results in a decrease in stiffness and, consequently, an increase in the actual flexural strain with an increasing number of load applications. In the strain-controlled approach, the peak cyclic load is continuously varied to yield a constant flexural strain. This results in a peak cyclic stress that continuously decreases with increasing load applications. It should be noted that it is difficult (especially in the strain-controlled tests) to establish the number of load repetitions to failure. Consequently, arbitrary definitions of fatigue life of a test specimen has been adopted (fatigue life is defined as the number of load cycles for which the specimen stiffness is reduced to half of its initial value) (26). This

definition should not be interpreted as the higher the stiffness modulus the higher the fatigue life. Indeed, it is well known that softer asphalt has longer fatigue life (85). Nevertheless, In practice, strain-controlled tests are considered to be applicable to thin asphalt layer pavements (less than 2-in), while stress-controlled tests are considered applicable to thick (more than 6-in) asphalt pavement layers (35, 109). Other thicknesses are considered to be in the intermediate range.

The cyclic load applied to the beam specimen (in the flexural tests) is normally a sinusoidal wave with 0.1 second loading time and 0.4 second relaxation time (48). Other wave forms and several loading and relaxation periods have also been used (32, 34, 71). Irrespective of the test procedure, specimen size, and loading characteristics, nine test specimens (triplicate for each stress level, three stress levels) are generally used to establish the necessary fatigue relationship for any given asphalt mix and test conditions (44, 48, 109).

In this study, nine specimens were used (triplicate for each of the following cyclic load levels: 100, 200 and 500 pounds). The test results (fatigue life) were then statistically correlated to the applied cyclic load levels to obtain the fatigue life curve of each type of asphalt mix. Also, in this study, several definitions of fatigue life were employed which are detailed in chapter 5.

In the following section, two types of fatigue models are introduced.

### 2.5.1 Fatigue Models

Several fatigue models have been suggested in the literature. These can be separated into two types (95, 96): phenomenological models (32, 44, 97) and mechanistic models (43, 48, 85, 98). The phenomenological models are essentially based on Miner's law (82) (fatigue damage of asphalt mixes is directly proportional to the number of load application); and they have the advantages of simplicity and availability of data for different materials. Their principal disadvantages are that they do not account satisfactorily for the influence of geometry and material heterogeneities, and they do not provide a quantitative measure for the extent of cracking in pavements. The mechanistic models, although impractical to use due to their complexity, are more amenable than the phenomenological models in providing a quantitative description of the degree of cracking in pavements.

Soussou and Moavenzadeh presented a closed form probabilistic solution based on Miner's law to characterize the accumulation of fatigue damage in flexible pavements (95). Their solution relates the expected values and variances of the measure of damage to the statistical characteristics of load factors and material properties.

They emphasized the need for obtaining more complete material characterization procedures which include measurements of spatial variabilities to determine the average size of cracked areas.

Fatigue life and fatigue properties of asphalt mixes have been evaluated using several different mechanistic models. Irwin used the fracture energy criterion which is directly related to the mechanism that causes materials to fail due to cracking (43, 44). He showed that:

- Unlike stress and strain, the minimum energy required to cause fracture is independent of specimen stiffness.
- Fracture energy is an invariant scalar, relatively simple to calculate, and independent of direction.

Using strain-controlled dynamic bending tests, Van Dijk and Visser found that fatigue behavior of asphalt mixes can be satisfactorily modeled using a mechanistic model (energy concept) (97, 98). Permissible strain and fatigue behavior were shown to depend not only on stiffness, but also on the type of mix. Further, evidence from the data was the positive effect of intermittent loading as opposed to continuous loading on the fatigue life of mixes (i.e., the former results in a longer fatigue life). Secor and Monsmith, on the other hand, showed that a linear viscoelastic model (phenomenological model) predicted the structural response of pavement within 30 percent of the

measured values (89). In general, this model is the most preferred due to the capability of obtaining cumulative deformations of any pavement system (109).

Other researchers introduced guidelines, methodologies, and nomographs for use in the structural design of pavement against fatigue failure (25, 38, 80). Witczak developed a theoretical design procedure for a full depth asphalt concrete airfield pavement based on fatigue failure (102). The procedure limits the development of compressive strain in the subgrade layer and the tensile strains at the bottom fiber of the asphalt layer.

Finally, Kasianchuck et al. suggested a series of required researches and development tasks to improve the design technology. They developed and introduced relationships between fatigue, permanent deformation, and shrinkage cracking for use in the overall design of asphalt pavements (49).

Regardless of the method employed , nomograph, or guide lines, fatigue life of pavement cannot be predicted with reasonable accuracy. Most methods tend to underpredict pavement life (109). Further, there are obvious differences between fatigue failure criteria. These differences exist between methods as well as stiffness levels. At low stiffness, the criterion by Secor and Monismith (71) is more conservative than the others. However, at high stiffness, the Kingham and Kallas criterion (53) is much more

conservative than the others. These differences lead to significant variance when interpretation of the fatigue curve is made on the basis of cumulative damage to determine the critical fatigue period. Regardless of these differences, however, there is no significant difference in the design thickness of the asphalt concrete course necessary for fatigue distress (109). There also appears to be ample evidence that the use of laboratory-developed fatigue results lead to a conservative estimate of fatigue life (95, 98, 109).

Nevertheless, laboratory tests were used by several investigators to evaluate the effects of the different test, mix, and sample variables on fatigue life. The test results were used to:

- Understand the effects of the variables on fatigue life.
- Correlate fatigue life to the different mix compositions.
- Predict the fatigue life of in-service pavements.

These are presented in the following sections.

### 2.5.2 Effects of Test, Sample, and Mix Variables

Throughout this presentation, it should be noted that the tests were conducted using different specimen dimensions, different loading modes, different types of test, and different materials. Consequently, there is no

common basis to compare the findings of the different studies. The objectives of the presentation are to illustrate what has been done and to define what should be done to standardize the tests so that the results can be compared. It should also be noted that a large volume of literature can be found in this area. Thus, the cited references are not exhaustive, rather they are illustrative and are presented to show the need for standardization.

Bonnaure et al. examined the effects of the relaxation (rest) period upon the fatigue characteristics of asphalt concrete mixes (26). They tested 9- by 1.2- by 0.8-in rectangular beam specimens in the stress and strain-controlled modes utilizing two types of penetration graded asphalt (40-60 and 80-100); a three point bending apparatus with a frequency of 50 Hz; rest periods of 0, 3, 5, 10, and 25 times the length of the loading period; and test temperatures of 41, 68, and 77$^{o}$F. They defined the failure condition (fatigue life) as the number of cycles required for a reduction of 50 percent of the initial stiffness modulus of the mix. They concluded that:

1) Longer rest periods yield higher number of load cycles to failure (longer fatigue life).
2) The most beneficial rest period is equal to 25 times the load period.
3) Higher test temperatures result in lower mix stiffness and higher service life.

4) The test results were independent of the test mode (stress or strain-controlled).

Monismith et al. studied the effects of load frequency and stress reversal (from tension to compression) on the fatigue properties of asphalt mixture (71). They tested 12- by 2- by 3-in beam specimens supported on springs. The beams were made using dense graded crushed granite aggregate with (3/4-in top size) and two types of 85-100 penetration graded asphalt cements (a conventional paving asphalt and an air blown material). The tests were conducted under a range of frequencies from 3 to 30 cycles per minute. They concluded that:

1) For a given load, higher frequencies result in lower strain.
2) The test frequency has no effect upon the mix behavior in repeated flexure due to two reasons:
   a) The deflections were measured near the load which may reflect densification within the beam itself.
   b) The spring base did not allow cumulative deformation to build up.
3) For the same value of maximum strain, there is no difference in results obtained from beams flexed in two directions compared to those from beams flexed in one direction.
4) Higher asphalt contents yield longer fatigue life.

Irwin and Gallaway examined the influence of laboratory

test method upon the fatigue life of asphalt mixes (44). Their test methods included uniaxial stress fields (beam specimens), biaxial stress fields (plate specimens), full stress reversal, and no stress reversal. In addition, they compared test results obtained from laboratory-compacted test specimens to those obtained from field-cored specimens (field-compacted asphalt concrete). They concluded that:

1) The degree of stress reversal affects fatigue properties of the mixtures.
2) Fatigue characteristics obtained from laboratory and field prepared beam specimens are not statistically the same.
3) The beam test method allows a better definition of the number of cycles to failure than the biaxial test method using plate specimens.

The results presented above and those found in other references (15, 22, 23, 34, 35, 37, 48, 60, 61, 62) illustrate the fact that different tests and/or specimen sizes lead to different conclusions. A similar point was also made by Epps and Monismith (35). They summarized available information (from 1954 to 1971) concerning the effects of several mixture and test variables upon fatigue properties of asphalt mixes. For convenience, only parts of their summary is presented below.

a) Stress-controlled conditions may not be found in a real pavement subjected to traffic loading. In the

laboratory, however, this mode of testing provides a conservative estimate of fatigue life and it is applicable to relatively thick and stiff asphalt concrete layers.

b) Load frequencies in the range of 3 to 30 cycles per minute have no effect on specimen fatigue life. Frequencies of 30 to 100 cycles per minute, on the other hand, significantly decrease the fatigue life (by approximately 20 percent).

d) For stress-controlled tests, lower test temperatures yield higher specimen stiffness and longer fatigue life.

e) For strain-controlled tests, lower test temperatures result in higher specimen stiffness and shorter fatigue life.

f) Although not conclusively demonstrated, absorption of moisture by asphalt mixtures may lead to a reduction in stiffness and a potential reduction in fatigue life.

g) For the stress-controlled mode of loading, a higher mixture stiffness leads to a longer fatigue life and for the strain-controlled mode of loading, a higher mixture stiffness yields a shorter fatigue life. It should be noted that in real pavements a higher mixture stiffness results in a shorter fatigue life. This is because the stress-controlled mode of loading

is never realized in real pavement conditions (32).

h) For both stress-controlled and strain - controlled modes, a lower percent air voids in the mixture leads to a longer fatigue life.

i) A higher angularity and roughness of the aggregate result in a higher mix stiffness. The effects of stiffness were noted in items g and h above.

Fatigue life of asphalt mixes is also a function of the stress distribution within the material and the magnitude of the applied load. In the field, traffic load is not uniform in intensity and frequency and the actual pavement response is affected by the load variation. Deacon and Monismith studied the effects of load variation on the fatigue life of asphalt mixes (32). They tested 15- by 3.25- by 3.5-in beam specimens made using crushed granite aggregate and penetration graded asphalt cement of 85-100. They employed three types of compound loading ( sequence type, repeated block type, and random type) at a frequency of 0.1 Hz to simulate traffic loads. They concluded that:

1) The mode of loading has a profound influence on the observed fatigue behavior of asphalt-concrete specimens. For the stress-controlled mode, specimens exhibiting the largest initial stiffness moduli tend to perform most satisfactory as long as the mixture is nonbrittle and has a reasonable balance among the proportions of its constituent materials. The reverse

is true for the strain-controlled mode.

2) Fatigue behavior is a stochastic rather than a deterministic phenomenon.
3) The mean fracture lives of specimens subjected to two-level decreasing-sequence tests exceeds that of specimens subjected to two-level increasing-sequence tests if the applied percentage of the larger stress level is small.
4) The mean fracture lives for random and repeated-block (small block size) load histories are identical if the probabilities of application of the various stress levels for the random loading equal the corresponding applied percentages (expressed in decimal form) for the repeated-block loading.
5) The variability of fracture life for random tests exceeds that for comparable repeated-block tests with the relative difference decreasing as the fracture life increases.

Thus, one can conclude that, in the field, traffic pattern and distribution have profound effects on fatigue life. These effects vary from one pavement to another and they cannot be easily simulated in the laboratory. Consequently, the use of laboratory results to predict fatigue life of a pavement is problematic. Laboratory results, however, may be used to analyze the effects of the mix and test variables on fatigue life and, consequently, to improve the asphalt

mix design procedure.

### 2.5.3 Correlations

The characteristics of asphalt mixes such as stiffness modulus, creep, and fatigue life are needed for an adequate design of pavement structures. These characteristics are difficult and time consuming to measure. Thus, the need to estimate these characteristics from the results of simple tests have been recently recognized. Van Der Paul (82) developed a nomograph to estimate the stiffness modulus of asphalt mixes based on the knowledge of the modulus of the bitumen and of the volumetric composition of the mix. As noted in section 2.3.3, Shook and Kallas (93) also developed correlation equations (AI equations) to obtain the stiffness modulus. Later, other researchers (66, 96, 104, 106) modified the equations to include the effects of more variables.

Similarly, methods for predicting the fatigue life of asphalt mixes were investigated and developed by several researchers (24, 25, 38, 43, 80, 97, 98). Two of these methods are presented below.

#### 2.5.3.1 Bonnaure, Gravois, and Udron Method

Bonnaure et al. studied and analyzed 146 fatigue curves (75 stress-controlled and 71 strain-controlled) utilizing a statistical approach (25). The data (fatigue life, asphalt

properties, stiffness modulus of the mix, and mix composition) were obtained from five different European laboratories and universities. The objective of their study was to predict the fatigue characteristics of asphalt mixes based on a small number of parameters that are easy to obtain. They made the following general observations.

1) Test data from stress-controlled tests showed a shorter lifetime than those from strain-controlled tests.
2) For a given level of initial strain, a softer asphalt binder leads to a longer fatigue life.
3) The slope of the fatigue line in the log strain versus log number of load repetition space varies from 0.14 for asphalt binders with a high penetration index to 0.3 for those with a low penetration index.
4) For a given asphalt stiffness modulus and initial strain, higher asphalt contents and/or lower percent air voids result in longer fatigue life.

Based upon these observations, Bonnaure et al. made the following two approximations.

1) Although the slopes of the fatigue lines are dependent on the asphalt type, the test temperature, the asphalt content, and the test type a constant value of 0.2 is assumed to represents all of the 146 fatigue lines.
2) The slope of the line representing the initial strain

as a function of the binder stiffness modulus (in logarithmic space) was assigned two values: 0.36 for the constant strain tests, and 0.28 for the constant stress tests.

Based on these approximations, statistical analyses were conducted and a general mathematical equation was obtained. Solutions of the equation for all possible parameters were then constructed in the form of a nomograph as shown in figure 2.2. They then examined the accuracy of the predicted fatigue life relative to the available data and concluded that:

1) For the 75 fatigue lines obtained in stress-controlled tests, the accuracy of the equation is around plus or minus 40 percent of the original data.
2) For the 71 fatigue lines obtained in strain-controlled tests, the accuracy of the equation is within plus or minus 50 percent of the original data.

Differences between calculated and measured data are mainly due to the two approximations made prior to generating the final equation. Also, the fact that fatigue data were collected from different laboratories where the specimen size and the boundary conditions were not exactly the same contributed to the variance of the data. Nevertheless, the above conclusions indicate that stress-controlled tests are slightly more consistent than strain-controlled tests. It should be remembered that the accuracy

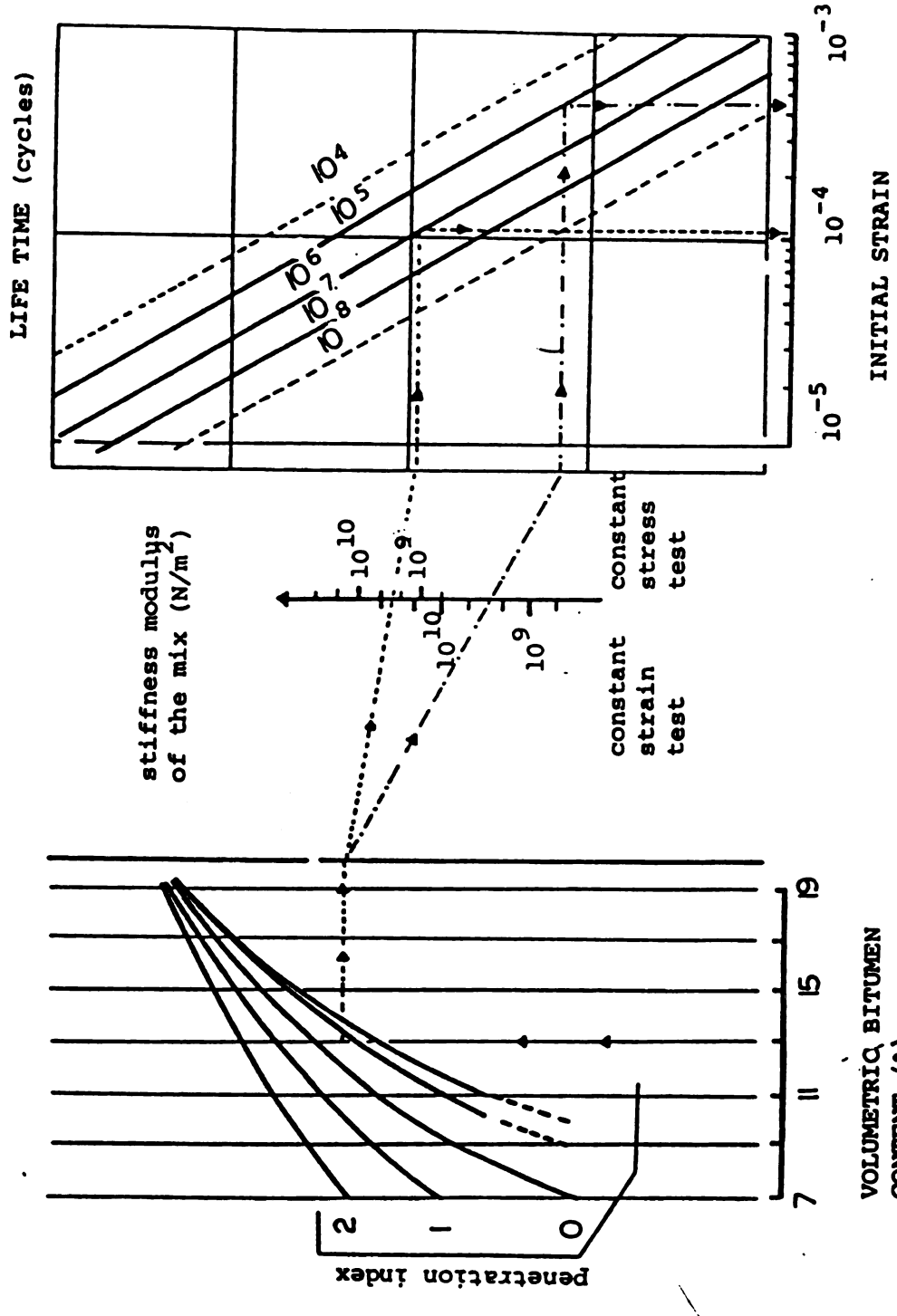



Figure 2.2 Nomograph for predicting the fatigue life of bituminous materials (after bonnaure et al.).

of the calculated data may drop significantly if compared to field measured data. The nomograph, however, represents a significant contribution in the field of fatigue analysis in that it can be used to qualitatively assess the effects of the mix variables on pavement life.

### 2.5.3.2 Pell and Cooper Method

Pell and Cooper examined the effects of test and mix variables on the fatigue life of asphalt mixes (80). They conducted a series of 48 tests on a wide variety of base and wearing course mixes made with gap-graded and continuously-graded aggregates. Stress-controlled flexural tests at $50^{o}F$ were conducted on necked-type specimens (2.5-in diameter at the neck). The specimens were mounted as a vertical cantilever cylinder on a shaft rotating at a constant speed around the specimen axis, while a single constant point load was applied perpendicular to the axis. This produced a sinusoidal bending stress throughout the specimen with a maximum stress amplitude at the neck.

They established two linear logarithmic relationships: the first relates fatigue life (expressed in terms of the number of load repetitions (N) to failure) and the maximum amplitude of the applied dynamic stress; the second relates (N) to the maximum amplitude of the initial dynamic strain. They assumed that all the fatigue lines for the first relationship meet at one focal point as shown in figure 2.3.

They concluded that:

1) Asphalt content is the most important mix variable affecting fatigue life; higher asphalt contents and lower percent air voids result in higher fatigue lives.
2) For good fatigue performance, an aggregate should be rounded to allow effective compaction to take place, have a high crushing strength to prevent fracture during compaction, and have a coarse surface texture for firm binding with the asphalt.
3) In the axial load fatigue tests, fatigue life is independent of the confining stress and temperature.

Again, figure 2.3 can be used to assess the effects of the variables (asphalt type, asphalt content, and strain amplitude) upon the fatigue life of asphalt mixes. Such an assessment leads to a better pavement design relative to fatigue life. The figure should not be used, on the other hand, to predict pavement fatigue life.

### 2.5.4 Fatigue Life of Inservice Pavement

Craus et al. and Kenis assessed the effects of heavier axle loads and higher contact pressures on the fatigue life of pavement structures containing relatively thin layers of asphalt concrete (less than 4-in) (17, 29, 30). Their assessment was made by three computer programs: ELSYM5 and PSAD which are based on layered elastic theory; and VESYS

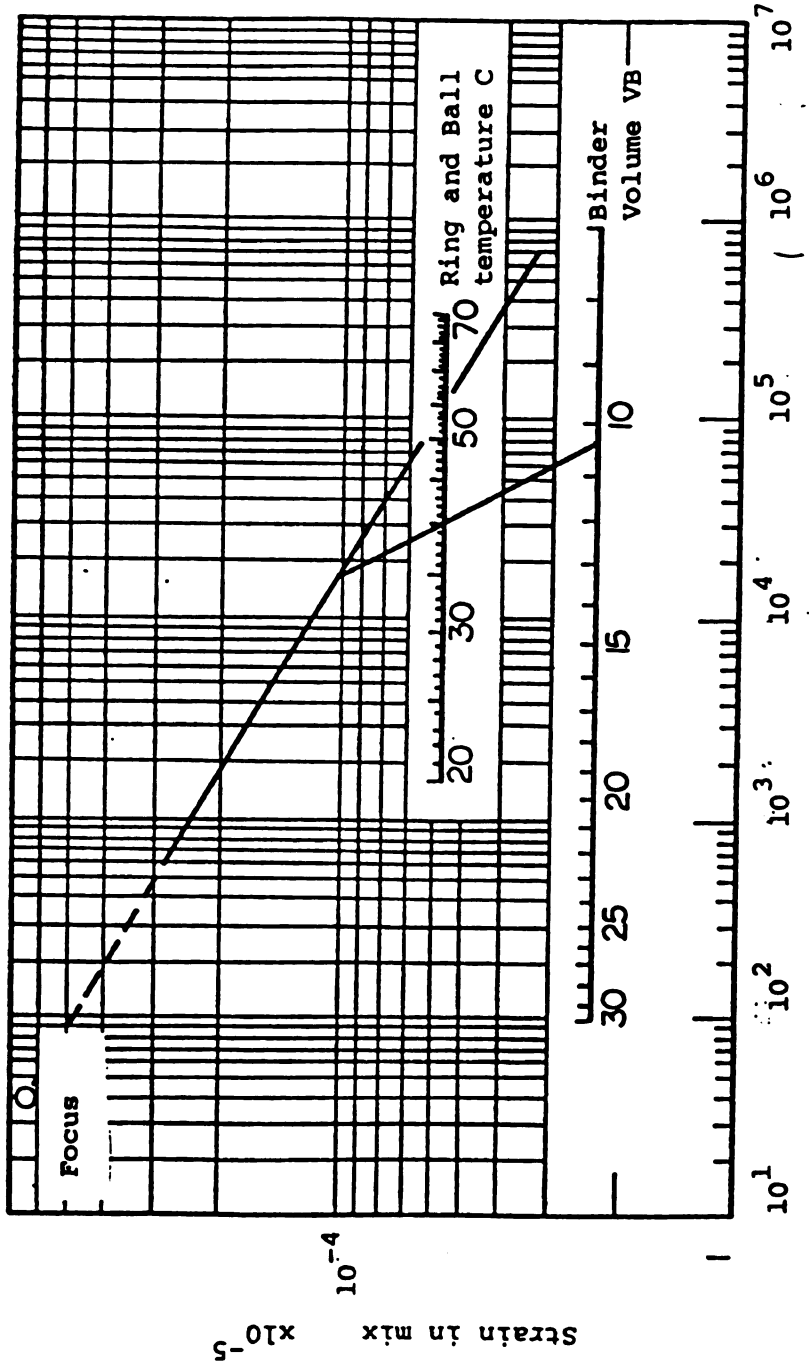



Figure 2.3 Nomograph for prediction on the fatigue life of bituminous materials (after pell and cooper).

which is based on a viscoelastic model. Further, the fatigue response of asphalt pavement with less than 10 percent cracking was defined using the Finn equation (36). It was concluded that:

1) The influence of the asphalt concrete stiffness on fatigue life is dependent upon the layer thickness. For pavements with 4- and 6-in thick asphalt-bound layers, fatigue life increases as the stiffness of the asphalt concrete increases. For a 2-in thick layer, on the other hand, the fatigue life increases as the stiffness of the asphalt concrete decreases.
2) For a constant contact area, an increase in the wheel load and contact pressure causes a proportional decrease in the fatigue life (about 75 percent) for all layer thicknesses.
3) For a constant load, an increase in contact pressure (decrease in the contact area) causes a decrease in the fatigue life.
4) A reduction of 25 to 50 percent in the thicknesses of the base and subbase courses has little influence on the fatigue life of the 2-in thick asphalt concrete structure. However, rutting becomes important. Similar reductions for the 4- and 6-in thick layers cause a decrease of 20 to 25 percent in the fatigue life.
5) The reduction in the values of the resilient modulus

of the base, subbase, and subgrade layers significantly decreases the fatigue life of thin layer asphalt concrete pavement structures.

6) Thin asphalt concrete pavement structures yield longer service lives if the modulus of the asphalt concrete surface course remains low throughout its life.

Based on item (1) above, researchers have agreed to use the stress-controlled tests to study the fatigue life of compacted asphalt mixes in thick (4-in or larger) asphalt layer pavements, and the strain-controlled tests for thin (less than 2-in) asphalt layer pavements. For pavements with asphalt layer thicknesses in between 2- and 4-in however, no test mode has been selected as yet. Item (6), indicates that the fatigue life of asphalt pavement is also a function of the resilient modulus values of the base, subbase, and subgrade materials. This implies that the prediction of pavement fatigue life based solely on the fatigue life data of the asphalt layer is problematic. The properties of all pavement layers should be considered in the prediction of fatigue life.

### 2.5.5 Summary

It is apparent that no standard test procedure to characterize fatigue life, nor a standard definition of fatigue life, has been developed and universally adopted.

Researchers have utilized different size specimens, several testing procedures, and various analysis methods to characterize the fatigue life of asphalt mixes. Several methods to predict fatigue life using asphalt mix variables have also been developed. Problems still exist since the ability of all of these methods in predicting the fatigue life of pavement systems is very poor. It should be noted that:

a) Fatigue life depends upon the stress distribution in the materials and other environmental and material factors.

b) The stress distribution in a pavement system depends upon the characteristics of the different pavement courses.

c) Fatigue life depends on the values of cyclic plastic strain induced by moving wheel loads and has no relationship to the cyclic elastic or viscoelastic strains.

d) There is a significant variation in the definition of fatigue life.

There is still no laboratory test available that will duplicate field conditions. Consequently, prediction of pavement fatigue life is problematic. Despite these facts, the understanding of fatigue life and fatigue failure has improved considerably over the last few decades. A better understanding can be developed only after a long-term

pavement evaluation and monitoring program is established. Such a program has just begun (the Strategy Highway Research Program) and the future seems very promising.

# CHAPTER 3

# LABORATORY INVESTIGATION

## 3.1 GENERAL

The primary objective of this study is to quantify relationships between structural properties and asphalt mix parameters. These properties include:

a) Elastic and resilient characteristics.

b) Permanent deformation.

c) Fatigue life.

To accomplish the objective of the study, flexural cyclic load beam tests (or simply, beam tests) were conducted using several asphalt mixes. The mixes were made using several different materials which are described in the next section.

## 3.2 TEST MATERIALS

Several materials were selected for this study. These include: three types of aggregate, one type of mineral filler (fly ash), and three types of asphalt.

### 3.2.1 AGGREGATE AND MINERAL FILLER

Two primary types of coarse and fine aggregates were used in this study. These are crushed limestone, and rounded river deposited gravel. A third type of aggregate was obtained by mixing (for each sieve size) fifty percent by weight crushed limestone with fifty percent rounded river

deposited gravel. This last type is designated throughout this dissertation as 50/50 mix.

Each type of aggregate (crushed limestone, rounded river deposited gravel, and 50/50 mix) was sieved using AASHTO T 27-84 (ASTM C 136-84a) test procedure and separated into different size fractions. Each size fraction was washed, dried to a constant weight and then recombined in accordance with the two grain size distribution curves ( A and B) shown in figure 3.1, along with the straight line gradation. It should be noted that the abscissa in the figure is scaled to sieve openings raised to the power 0.45. It should also be noted that both grain size distribution curves (gradation curves) had the same top size aggregate of 0.75 inches and percent by weight passing sieve number 200 of 8.29. The percent passing by total weight for each sieve size for gradations A and B are listed in table 3.1.

For each of the coarse and fine portions of each type of aggregate, two values of each of the bulk Gs (BK), saturated surface dry Gs (SSD), and apparent Gs (APP) specific gravity were determined using AASHTO test procedures T-8 (for coarse aggregate) and T-84 (for fine aggregate). The data from each test and the average values are listed in tables 3.2 and 3.3.

It should be noted that neither the limestone dust, nor the material passing sieve number 200 of the natural aggregate was used. Rather, fly ash was used as the mineral

**Table 3.1 Percent passing by weight for gradations A and B.**

| sieve | | | percent passing by weight | |
|---|---|---|---|---|
| number | size(inch) | size (mm) | gradation a | gradation b |
| 3/4" | 0.750 | 19.000 | 100.00[1] | 100.00[1] |
| 3/8" | 0.375 | 9.500 | 70.71 | 78.46 |
| 4.0 | 0.186 | 4.750 | 49.84[2] | 61.42[2] |
| 8.0 | 0.093 | 2.360 | 36.91[2] | 43.93[2] |
| 16.0 | 0.046 | 1.180 | 27.54 | 31.42 |
| 30.0 | 0.024 | 0.600 | 20.40 | 22.65 |
| 50.0 | 0.012 | 0.300 | 15.11 | 16.20 |
| 100.0 | 0.006 | 0.150 | 11.19[3] | 11.59[3] |
| 200.0 | 0.003 | 0.075 | 8.29[3] | 8.29[3] |

[1] Percent coarse aggregate by total weight: 50.16 for gradation A, and 38.58 for B.
[2] Percent fine aggregate (excluding - #200 sieve) by total weight: 41.55 for gradation A and 53.13 for B.
[3] Fly ash.

**Table 3.2 Specific gravity of the coarse aggregate.**

| gradation | | A | | | B | | |
|---|---|---|---|---|---|---|---|
| sample number | | 1 | 2 | AVG | 1 | 2 | AVG |
| limestone | Gs (BK) | 2.665 | 2.676 | 2.671 | 2.757 | 2.699 | 2.728 |
| | Gs (SSD) | 2.688 | 2.699 | 2.694 | 2.768 | 2.716 | 2.742 |
| | Gs (APP) | 2.728 | 2.740 | 2.734 | 2.789 | 2.747 | 2.768 |
| natural gravel | Gs (BK) | 2.683 | 2.704 | 2.694 | 2.623 | 2.703 | 2.663 |
| | Gs (SSD) | 2.712 | 2.732 | 2.722 | 2.653 | 2.732 | 2.693 |
| | Gs (APP) | 2.763 | 2.783 | 2.773 | 2.702 | 2.784 | 2.743 |
| 50/50 mix | Gs (BK) | 2.663 | 2.726 | 2.695 | 2.697 | 2.726 | 2.712 |
| | Gs (SSD) | 2.686 | 2.747 | 2.717 | 2.722 | 2.748 | 2.735 |
| | Gs (APP) | 2.725 | 2.785 | 2.755 | 2.767 | 2.787 | 2.777 |

AVG = average
Gs = specific gravity.
BK = bulk.
SSD = saturated surface dry.
APP = apparent.

**Table 3.3 Specific gravity of the fine aggregate.**

| gradation | | A | | | B | | |
|---|---|---|---|---|---|---|---|
| sample number | | 1 | 2 | AVG. | 1 | 2 | AVG. |
| limestone | Gs (BK) | 2.794 | 2.810 | 2.802 | 2.809 | 2.803 | 2.806 |
| natural gravel | Gs (BK) | 2.720 | 2.746 | 2.733 | 2.722 | 2.750 | 2.736 |
| 50/50 mix | Gs (BK) | 2.765 | 2.776 | 2.771 | 2.783 | 2.770 | 2.777 |

AVG. = average.
Gs = specific gravity.
BK = bulk.
SSD = saturated surface dry.
APP = apparent.

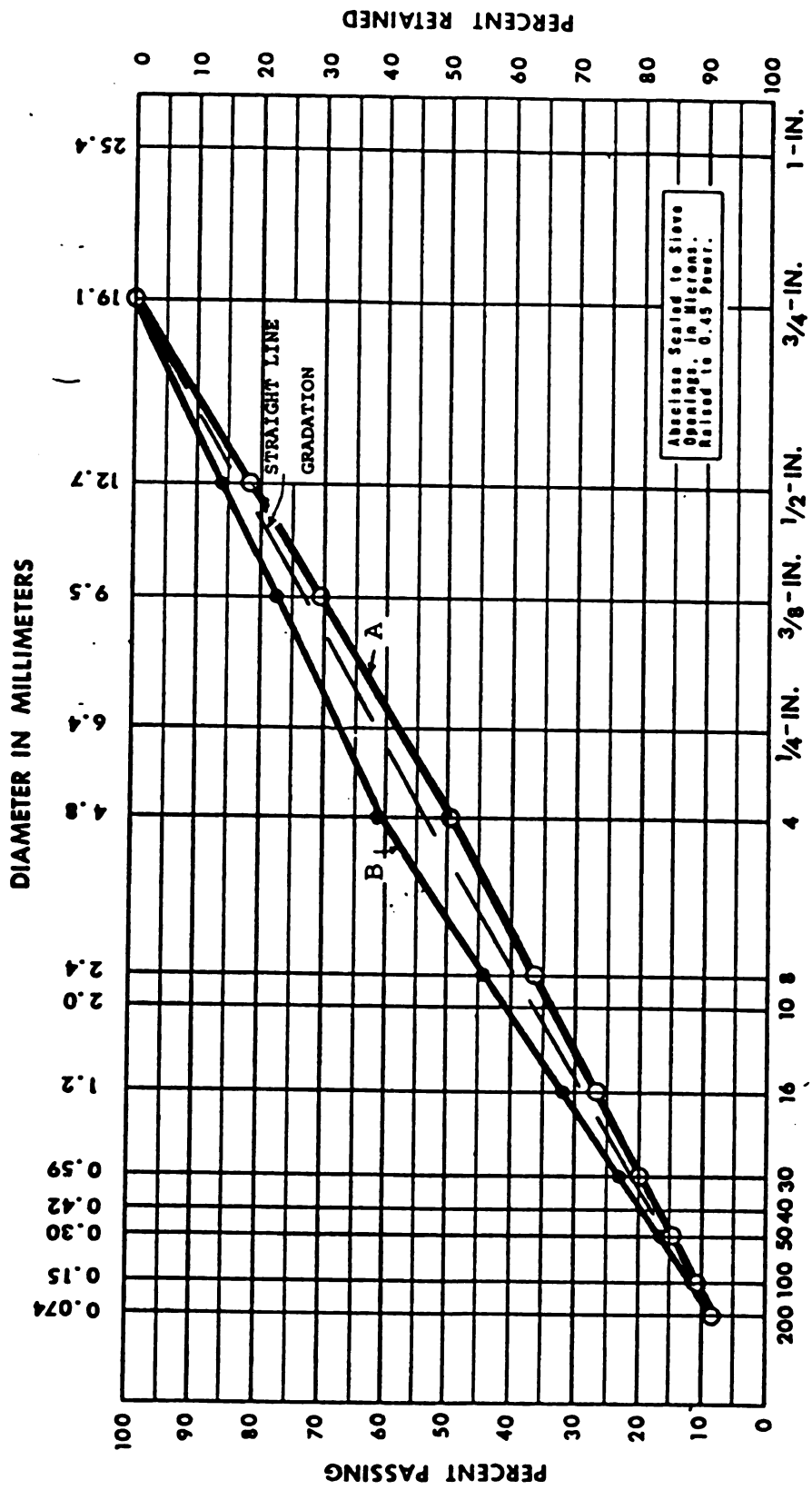



Figure 3.1 Straight line and A and B gradations.

filler.

### 3.2.2 ASPHALT BINDER

Three viscosity graded asphalt cements (AC10, AC5, and AC2.5) were used in this study. Each of these asphalts was tested in accordance with the proper AASHTO test procedures to determine their properties. The test results are listed in table 3.4.

## 3.3 ASPHALT MIX DESIGN

The asphalt mix design was conducted in accordance with the standard Marshall test and test procedures and the full-factorial experiment matrix shown in figure 3.2. It can be seen that there are eighteen cells in the matrix for eighteen possible combinations of the variables (3 asphalts; 3 aggregates, 2 gradations). Each cell, represents a total of 12 specimens; one triplicate for each of the following percent asphalt contents by total weight of mix, 3.5, 4.2, 4.9 and 5.6. Thus, total of 216 specimens were tested. The test results are summarized in tables 3.5 through 3.7. For each asphalt content, the average values for stability, flow, density, percent air voids, and percent voids in mineral aggregates were calculated. These values are also listed in the tables.

For each combination of the variables (asphalt, aggregate, and gradation), the stability, flow, density,

Table 3.4 Asphalt properties.

| Penetration Grade | 75-100 | 120-150 | 200-250 |
|---|---|---|---|
| Viscosity Grade | AC-10 | AC-5 | AC-2.5 |
| Laboratory Number | 86B-296 | 86B-297 | 86B-298 |
| Penetration, 4 C, 200 g., 60 sec. | 35 | 52 | 84 |
| Penetration, 25 C, 100 g., 5 sec. | 96 | 154 | 272 |
| Penetration, 30 C, 100 g., 5 sec. | 157 | 233 | * |
| Specific Gravity 25/25 C. | 1.024 | 1.020 | 1.015 |
| Flash Point (C.O.C.), C. | 288 | 310 | 314 |
| Softening Point (R&B), C. | 42.0 | 37.5 | 35.0 |
| Solubility in Trichloroethylene, % | 99.60 | 99.70 | 99.60 |
| Ductility, 25 C, cm/min, cm. | 150+ | 150+ | 95 |
| Viscosity (cone) 77 F, K poises | 793 | 407 | 162 |
| Viscosity (absolute) 140 F, poises | 1026 | 594 | 271 |
| Viscosity (kinematic) 275 F, cs | 270 | 212 | 159 |
| 1/8" Thin Film, 163 C, 5 hr, 50 g. | | | |
| Change in Weight, percent | 0.47 | 0.43 | 0.34 |
| Penetration, 25 C, 100 g, 5 sec. | 48 | 73 | 123 |
| % of Original Penetration | 50 | 47 | 45 |
| Ductility, 25 C, 5 cm/min, cm | 150+ | 150+ | 106 |
| Viscosity (abs.) 140 F, poises | 3083 | 1614 | 727 |
| Viscosity (kin.) 275 F, cs | 419 | 335 | 237 |
| Viscosity (cone) 77 F, K poises | 4554 | 1742 | 634 |

* Hit Bottom.

# Table 3.5 Marshall mix design results for viscosity graded asphalt AC-10

| aggregate | | limestone | | | | | | natural gravel | | | | | | mix of 50/50 by weight | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| gradation | | A | | | B | | | A | | | B | | | A | | | B | | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| percent asphalt content | S | 2940 | 2590 | 2680 | 2560 | 2975 | 3020 | 2530 | 2430 | 2300 | 2780 | 2770 | 2800 | 2080 | 2480 | 2220 | 3380 | 2930 | 3310 |
| | AS | 3114 | 2722 | 2811 | 2669 | 3116 | 3174 | 2688 | 2589 | 2473 | 2879 | 2893 | 2909 | 2208 | 2621 | 2332 | 3523 | 3064 | 3467 |
| | F | 8 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 6 | 6 | 7 |
| 3.5 | GS | 2.43 | 2.43 | 2.42 | 2.42 | 2.42 | 2.43 | 2.43 | 2.45 | 2.45 | 2.40 | 2.41 | 2.40 | 2.44 | 2.44 | 2.43 | 2.41 | 2.42 | 2.42 |
| | AV | 5.93 | 5.86 | 6.28 | 6.28 | 6.12 | 5.97 | 5.00 | 4.34 | 4.07 | 5.88 | 5.53 | 6.08 | 5.14 | 5.10 | 5.45 | 5.96 | 5.81 | 5.77 |
| | VMA | 14.20 | 14.20 | 14.50 | 14.50 | 14.40 | 14.30 | 13.30 | 12.70 | 12.40 | 14.10 | 13.80 | 14.30 | 13.50 | 13.40 | 13.80 | 14.20 | 14.10 | 14.00 |
| | | averages | | | | | | | | | | | | | | | | | |
| | S | 2734 | | | 2852 | | | 2420 | | | 2783 | | | 2260 | | | 3207 | | |
| | AS | 2882 | | | 2987 | | | 2583 | | | 2894 | | | 2387 | | | 3351 | | |
| | GS | 2.43 | | | 2.42 | | | 2.44 | | | 2.40 | | | 2.43 | | | 2.42 | | |
| | AV | 6.02 | | | 6.13 | | | 4.46 | | | 5.83 | | | 5.23 | | | 5.85 | | |
| | VMA | 14.30 | | | 14.40 | | | 12.80 | | | 14.00 | | | 13.50 | | | 14.10 | | |
| | S | 2510 | 2350 | 2090 | 2650 | 2795 | 2780 | 1820 | 2050 | 2250 | 1660 | 1650 | 1950 | 1800 | 1750 | 1770 | 2560 | 2480 | 2480 |
| | AS | 2726 | 2538 | 2244 | 2824 | 2988 | 2977 | 2108 | 2215 | 2411 | 1766 | 1741 | 2066 | 1948 | 1883 | 1898 | 2736 | 2648 | 2634 |
| | F | 10 | 9 | 9 | 8 | 9 | 8 | 7 | 6 | 6 | 8 | 9 | 9 | 11 | 11 | 11 | 8 | 8 | 8 |
| 4.2 | GS | 2.47 | 2.47 | 2.47 | 2.46 | 2.46 | 2.46 | 2.48 | 2.47 | 2.46 | 2.45 | 2.43 | 2.44 | 2.48 | 2.47 | 2.47 | 2.45 | 2.46 | 2.45 |
| | AV | 3.15 | 3.31 | 3.35 | 3.81 | 3.69 | 3.69 | 1.95 | 2.38 | 2.86 | 2.83 | 3.78 | 3.22 | 2.55 | 2.63 | 2.78 | 3.30 | 3.22 | 3.61 |
| | VMA | 13.30 | 13.40 | 13.50 | 13.90 | 13.80 | 13.80 | 12.10 | 12.50 | 12.90 | 12.90 | 13.70 | 13.20 | 12.70 | 12.80 | 12.90 | 13.40 | 13.30 | 13.60 |
| | | averages | | | | | | | | | | | | | | | | | |
| | S | 2197 | | | 2742 | | | 2073 | | | 1753 | | | 1773 | | | 2507 | | |
| | AS | 2503 | | | 2930 | | | 2245 | | | 1858 | | | 1910 | | | 2673 | | |
| | GS | 2.47 | | | 2.46 | | | 2.47 | | | 2.44 | | | 2.47 | | | 2.45 | | |
| | AV | 3.27 | | | 3.73 | | | 2.40 | | | 3.28 | | | 2.66 | | | 3.38 | | |
| | VMA | 13.40 | | | 13.80 | | | 12.50 | | | 13.30 | | | 12.80 | | | 13.40 | | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |

S = marshall stability (pounds).
AS = marshall stability adjusted to the sample height.
F = flow (1/100").
GS = specific gravity.
AV = air voids in percent.
VMA = voids in mineral aggregates in percent.

## Table 3.5 Continued

| aggregate | | limestone | | | | | | natural gravel | | | | | | mix of 50/50 by weight | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| gradation | | A | | | B | | | A | | | B | | | A | | | B | | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| percent | | | | | | | | | | | | | | | | | | | |
| asphalt | S | 1450 | 1450 | 1530 | 1670 | 2070 | 2040 | 1070 | 1000 | 1050 | 1480 | 1530 | 1850 | 1210 | 1360 | 1200 | 1459 | 1470 | 1650 |
| content | AS | 1577 | 1578 | 1654 | 1801 | 2256 | 2217 | 1153 | 1087 | 1147 | 1590 | 1626 | 2014 | 1302 | 1468 | 1298 | 1550 | 1573 | 1768 |
| | F | 17 | 17 | 17 | 15 | 13 | 14 | 21 | 17 | 16 | 13 | 15 | 12 | 16 | 17 | 17 | 13 | 13 | 12 |
| 4.9 | GS | 2.48 | 2.48 | 2.47 | 2.47 | 2.48 | 2.48 | 2.46 | 2.47 | 2.47 | 2.45 | 2.44 | 2.47 | 2.47 | 2.47 | 2.47 | 2.45 | 2.45 | 2.46 |
| | AV | 1.65 | 1.65 | 1.83 | 2.32 | 2.01 | 2.01 | 1.66 | 1.34 | 1.34 | 1.91 | 2.27 | 0.91 | 1.72 | 1.65 | 1.65 | 2.32 | 2.28 | 2.01 |
| | VMA | 13.50 | 13.50 | 13.80 | 14.10 | 13.80 | 13.80 | 13.40 | 13.20 | 13.20 | 13.60 | 14.00 | 12.70 | 13.50 | 13.50 | 13.50 | 14.10 | 14.00 | 13.80 |
| | | | | | | | | averages | | | | | | | | | | | |
| | S | | 1477 | | | 1927 | | | 1040 | | | 1620 | | | 1257 | | | 1523 | |
| | AS | | 1604 | | | 2091 | | | 1129 | | | 1743 | | | 1356 | | | 1630 | |
| | GS | | 2.48 | | | 2.47 | | | 2.47 | | | 2.45 | | | 2.47 | | | 2.46 | |
| | AV | | 1.76 | | | 2.05 | | | 1.45 | | | 1.70 | | | 1.67 | | | 2.19 | |
| | VMA | | 13.60 | | | 13.90 | | | 13.30 | | | 13.40 | | | 13.50 | | | 13.90 | |
| | S | 1190 | 1350 | 1100 | 1525 | 1650 | 1570 | 880 | 890 | 950 | 1100 | 1200 | 1170 | 1020 | 1050 | 950 | 1080 | 1160 | 1070 |
| | AS | 1287 | 1466 | 1195 | 1640 | 1790 | 1687 | 972 | 964 | 1052 | 1171 | 1277 | 1241 | 1100 | 1144 | 1029 | 1156 | 1242 | 1145 |
| | F | 21 | 23 | 21 | 17 | 20 | 21 | 24 | 27 | 31 | 17 | 18 | 20 | 24 | 29 | 27 | 20 | 19 | 24 |
| 5.6 | GS | 2.47 | 2.47 | 2.46 | 2.46 | 2.47 | 2.46 | 2.46 | 2.44 | 2.46 | 2.43 | 2.44 | 2.42 | 2.46 | 2.48 | 2.46 | 2.44 | 2.45 | 2.44 |
| | AV | 1.12 | 0.92 | 1.56 | 1.40 | 0.96 | 1.44 | 0.52 | 1.37 | 0.85 | 1.46 | 1.42 | 1.86 | 0.97 | 0.36 | 1.17 | 1.69 | 1.37 | 1.57 |
| | VMA | 14.60 | 14.40 | 15.00 | 14.90 | 14.50 | 14.90 | 14.00 | 14.70 | 14.30 | 14.80 | 14.70 | 15.10 | 14.40 | 13.90 | 14.60 | 15.00 | 14.80 | 14.90 |
| | | | | | | | | averages | | | | | | | | | | | |
| | S | | 1213 | | | 1582 | | | 907 | | | 1157 | | | 1007 | | | 1103 | |
| | AS | | 1316 | | | 1708 | | | 996 | | | 1230 | | | 1091 | | | 1181 | |
| | GS | | 2.46 | | | 2.47 | | | 2.46 | | | 2.32 | | | 2.46 | | | 2.44 | |
| | AV | | 1.21 | | | 1.26 | | | 0.91 | | | 1.58 | | | 0.83 | | | 1.55 | |
| | VMA | | 14.70 | | | 14.80 | | | 14.30 | | | 14.90 | | | 14.30 | | | 14.90 | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |

S = marshall stability (pounds).
AS = marshall stability adjusted to the sample height.
F = flow (1/100").
GS = specific gravity.
AV = air voids in percent.
VMA = voids in mineral aggregates in percent.

Table 3.6 Marshall mix design results for viscosity graded asphalt AC-5.

| aggregate | | limestone | | | | | | natural gravel | | | | | | mix of 50/50 by weight | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| gradation | | A | | | B | | | A | | | B | | | A | | | B | | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| percent asphalt content | S | 2540 | 2600 | 2810 | 2290 | 2620 | 2800 | 1920 | 2320 | 2130 | 2520 | 2210 | 2500 | 2740 | 2865 | 2920 | 3360 | 3150 | 3180 |
| | AS | 2681 | 2763 | 2954 | 2413 | 2740 | 2925 | 2045 | 2448 | 2238 | 2623 | 2296 | 2570 | 2914 | 3027 | 3097 | 3492 | 3265 | 3310 |
| | F | 9 | 7 | 8 | 7 | 7 | 7 | 8 | 7 | 6 | 6 | 7 | 6 | 7 | 8 | 8 | 7 | 8 | 7 |
| 3.5 | GS | 2.43 | 2.44 | 2.43 | 2.43 | 2.42 | 2.42 | 2.45 | 2.44 | 2.43 | 2.41 | 2.40 | 2.39 | 2.44 | 2.43 | 2.44 | 2.40 | 2.40 | 2.41 |
| | AV | 5.67 | 5.51 | 5.90 | 5.85 | 6.20 | 6.24 | 4.22 | 4.69 | 4.93 | 5.61 | 5.88 | 6.20 | 5.07 | 5.26 | 4.95 | 6.47 | 6.59 | 6.16 |
| | VMA | 14.00 | 13.90 | 14.20 | 14.20 | 14.50 | 14.50 | 12.60 | 13.10 | 13.30 | 13.90 | 14.10 | 14.40 | 13.40 | 13.60 | 14.30 | 14.70 | 14.80 | 14.40 |
| averages | | | | | | | | | | | | | | | | | | | |
| | S | | 2650 | | | 2570 | | | 2123 | | | 2410 | | | 2842 | | | 3230 | |
| | AS | | 2799 | | | 2692 | | | 2244 | | | 2496 | | | 3013 | | | 3356 | |
| | GS | | 2.43 | | | 2.43 | | | 2.44 | | | 2.40 | | | 2.44 | | | 2.40 | |
| | AV | | 5.69 | | | 6.10 | | | 4.61 | | | 5.91 | | | 5.10 | | | 6.41 | |
| | VMA | | 14.00 | | | 14.40 | | | 12.90 | | | 14.10 | | | 13.40 | | | 14.60 | |
| | S | 2210 | 2380 | 2250 | 2600 | 2530 | 2510 | 1480 | 1450 | 1450 | 1850 | 2040 | 1990 | 2205 | 2030 | 2170 | 3030 | 2880 | 2690 |
| | AS | 2374 | 2562 | 2419 | 2786 | 2702 | 2677 | 1580 | 1561 | 1550 | 2056 | 2165 | 2107 | 2383 | 2182 | 2332 | 3236 | 3059 | 2854 |
| | F | 9 | 10 | 9 | 8 | 8 | 8 | 11 | 8 | 9 | 8 | 6 | 8 | 9 | 10 | 11 | 6 | 9 | 9 |
| 4.2 | GS | 2.47 | 2.47 | 2.47 | 2.45 | 2.45 | 2.46 | 2.48 | 2.47 | 2.46 | 2.43 | 2.45 | 2.44 | 2.48 | 2.47 | 2.47 | 2.45 | 2.45 | 2.44 |
| | AV | 3.11 | 3.11 | 2.99 | 3.85 | 3.97 | 3.74 | 2.65 | 2.33 | 2.85 | 3.49 | 2.93 | 3.37 | 2.39 | 2.67 | 2.78 | 3.26 | 3.53 | 3.69 |
| | VMA | 13.30 | 13.30 | 13.20 | 14.00 | 14.10 | 13.80 | 12.80 | 12.50 | 13.00 | 13.50 | 13.00 | 13.40 | 12.60 | 12.80 | 13.00 | 13.40 | 13.60 | 13.80 |
| averages | | | | | | | | | | | | | | | | | | | |
| | S | | 2280 | | | 2547 | | | 1460 | | | 1993 | | | 2135 | | | 2867 | |
| | AS | | 2452 | | | 2715 | | | 1564 | | | 2110 | | | 2299 | | | 3050 | |
| | GS | | 2.47 | | | 2.45 | | | 2.46 | | | 2.44 | | | 2.47 | | | 2.45 | |
| | AV | | 3.08 | | | 3.85 | | | 2.62 | | | 3.26 | | | 2.62 | | | 3.50 | |
| | VMA | | 13.20 | | | 13.90 | | | 12.70 | | | 13.30 | | | 12.80 | | | 13.50 | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |

S = marshall stability (pounds).
AS = marshall stability adjusted to the sample height.
F = flow (1/100").
GS = specific gravity.
AV = air voids in percent.
VMA = voids in mineral aggregates in percent.

Table 3.6 Continued.

| aggregate | | limestone | | | | | | natural gravel | | | | | | mix of 50/50 by weight | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| gradation | | A | | | B | | | A | | | B | | | A | | | B | | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| percent asphalt content | S | 1530 | 1440 | 1560 | 1820 | 1680 | 1800 | 820 | 1000 | 1020 | 1180 | 1230 | 1300 | 1240 | 1180 | 1260 | 1680 | 1770 | 1830 |
| | AS | 1656 | 1564 | 1681 | 1961 | 1808 | 1950 | 886 | 1077 | 1098 | 1263 | 1314 | 1390 | 1338 | 1266 | 1369 | 1800 | 1904 | 1955 |
| | F | 14 | 16 | 16 | 12 | 14 | 12 | 20 | 15 | 15 | 13 | 13 | 12 | 19 | 15 | 16 | 16 | 12 | 14 |
| 4.9 | GS | 2.48 | 2.48 | 2.47 | 2.48 | 2.47 | 2.48 | 2.45 | 2.47 | 2.47 | 2.44 | 2.45 | 2.45 | 2.46 | 2.46 | 2.48 | 2.46 | 2.47 | 2.46 |
| | AV | 1.45 | 1.73 | 1.89 | 1.89 | 2.32 | 1.81 | 2.28 | 1.40 | 1.48 | 2.04 | 1.76 | 1.96 | 1.96 | 2.20 | 1.37 | 1.89 | 1.61 | 2.13 |
| | VMA | 13.40 | 13.60 | 13.80 | 13.80 | 14.20 | 13.70 | 14.00 | 13.20 | 13.30 | 13.80 | 13.50 | 13.70 | 13.80 | 14.00 | 13.30 | 13.70 | 13.50 | 13.90 |
| averages | | | | | | | | | | | | | | | | | | | |
| | S | 1510 | | | 1767 | | | 980 | | | 1240 | | | 1227 | | | 1760 | | |
| | AS | 1634 | | | 1907 | | | 1054 | | | 1322 | | | 1324 | | | 1886 | | |
| | GS | 2.48 | | | 2.47 | | | 2.46 | | | 2.45 | | | 2.46 | | | 2.46 | | |
| | AV | 1.69 | | | 2.01 | | | 1.72 | | | 1.92 | | | 1.83 | | | 1.86 | | |
| | VMA | 13.60 | | | 13.80 | | | 13.50 | | | 13.60 | | | 13.60 | | | 13.60 | | |
| | S | 980 | 1130 | 1130 | 1220 | 1280 | 1340 | 750 | 700 | 790 | 890 | 890 | 850 | 870 | 895 | 890 | 1230 | 1300 | 1210 |
| | AS | 1053 | 1230 | 1230 | 1312 | 1358 | 1446 | 795 | 754 | 838 | 945 | 951 | 900 | 935 | 967 | 963 | 1322 | 1390 | 1293 |
| | F | 32 | 19 | 21 | 17 | 17 | 18 | 35 | 33 | 37 | 23 | 18 | 17 | 25 | 26 | 25 | 19 | 18 | 23 |
| 5.6 | GS | 2.45 | 2.48 | 2.47 | 2.46 | 2.46 | 2.47 | 2.42 | 2.44 | 2.42 | 2.43 | 2.44 | 2.43 | 2.44 | 2.46 | 2.46 | 2.45 | 2.45 | 2.45 |
| | AV | 1.88 | 0.68 | 0.84 | 1.40 | 1.28 | 1.20 | 2.10 | 1.37 | 2.14 | 1.54 | 1.01 | 1.62 | 1.61 | 1.13 | 1.05 | 1.13 | 1.37 | 1.41 |
| | VMA | 15.30 | 14.30 | 14.40 | 14.90 | 14.80 | 14.80 | 15.40 | 14.80 | 15.40 | 14.90 | 14.40 | 15.00 | 15.00 | 14.60 | 14.50 | 14.60 | 14.80 | 14.80 |
| averages | | | | | | | | | | | | | | | | | | | |
| | S | 1080 | | | 1273 | | | 747 | | | 877 | | | 885 | | | 1247 | | |
| | AS | 1171 | | | 1372 | | | 798 | | | 932 | | | 955 | | | 1335 | | |
| | GS | 2.47 | | | 2.46 | | | 2.43 | | | 2.43 | | | 2.45 | | | 2.45 | | |
| | AV | 1.14 | | | 1.30 | | | 1.87 | | | 1.38 | | | 1.27 | | | 1.29 | | |
| | VMA | 14.60 | | | 14.80 | | | 15.20 | | | 14.70 | | | 14.70 | | | 14.70 | | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |

S = marshall stability (pounds).
AS = marshall stability adjusted to the sample height.
F = flow (1/100").
GS = specific gravity.
AV = air voids in percent.
VMA = voids in mineral aggregates in percent.

Table 3.7 Marshall mix design results for viscosity graded asphalt AC-2.5.

| aggregate | | limestone | | | | | | natural gravel | | | | | | mix of 50/50 by weight | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| gradation | | A | | | B | | | A | | | B | | | A | | | B | | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| percent | | | | | | | | | | | | | | | | | | | |
| asphalt | S | 2610 | 2450 | 2600 | 2920 | 2950 | 3200 | 2070 | 2150 | 1660 | 2560 | 2590 | 2500 | 2200 | 2010 | 2300 | 2190 | 2360 | 2300 |
| content | AS | 2785 | 2631 | 2778 | 3109 | 3107 | 3386 | 2210 | 2254 | 1760 | 2654 | 2668 | 2574 | 2374 | 2157 | 2489 | 2320 | 2457 | 2431 |
| | F | 10 | 8 | 7 | 6 | 5 | 6 | 5 | 6 | 6 | 6 | 7 | 6 | 6 | 5 | 5 | 6 | 6 | 6 |
| 3.5 | GS | 2.45 | 2.45 | 2.45 | 2.44 | 2.44 | 2.44 | 2.45 | 2.42 | 2.43 | 2.39 | 2.38 | 2.39 | 2.47 | 2.45 | 2.47 | 2.43 | 2.41 | 2.43 |
| | AV | 5.01 | 4.83 | 4.85 | 5.27 | 5.54 | 5.31 | 4.23 | 5.16 | 4.93 | 6.08 | 6.44 | 6.32 | 3.70 | 4.37 | 3.59 | 5.07 | 5.93 | 5.19 |
| | VMA | 13.40 | 13.40 | 13.30 | 13.70 | 13.90 | 13.70 | 12.70 | 13.50 | 13.30 | 14.30 | 14.70 | 14.60 | 12.20 | 12.80 | 12.10 | 13.50 | 14.20 | 13.60 |
| | | | | | | | | averages | | | | | | | | | | | |
| | S | | 2553 | | | 3023 | | | 1960 | | | 2550 | | | 2170 | | | 2283 | |
| | AS | | 2731 | | | 3201 | | | 2075 | | | 2632 | | | 2340 | | | 2403 | |
| | GS | | 2.45 | | | 2.44 | | | 2.43 | | | 2.39 | | | 2.46 | | | 2.42 | |
| | AV | | 4.93 | | | 5.39 | | | 4.77 | | | 6.27 | | | 3.90 | | | 5.40 | |
| | VMA | | 13.30 | | | 13.70 | | | 13.10 | | | 14.40 | | | 12.30 | | | 13.70 | |
| | S | 1920 | 1860 | 2000 | 2430 | 2490 | 2680 | 1215 | 1150 | 1480 | 2080 | 2200 | 2270 | 1480 | 1500 | 1780 | 1920 | 1850 | 1780 |
| | AS | 2077 | 2009 | 2169 | 2620 | 2676 | 2873 | 1306 | 1228 | 1584 | 2185 | 2315 | 2389 | 1614 | 1627 | 1930 | 2052 | 1991 | 1913 |
| | F | 10 | 9 | 9 | 8 | 9 | 8 | 8 | 10 | 8 | 9 | 7 | 7 | 8 | 9 | 9 | 7 | 8 | 7 |
| 4.2 | GS | 2.49 | 2.48 | 2.48 | 2.48 | 2.47 | 2.47 | 2.46 | 2.45 | 2.49 | 2.44 | 2.43 | 2.44 | 2.49 | 2.48 | 2.48 | 2.46 | 2.46 | 2.47 |
| | AV | 2.43 | 2.86 | 2.55 | 2.98 | 3.25 | 3.25 | 2.81 | 3.08 | 1.46 | 3.41 | 3.65 | 3.05 | 1.87 | 2.46 | 2.18 | 2.97 | 2.85 | 2.73 |
| | VMA | 12.70 | 13.10 | 12.80 | 13.20 | 13.50 | 13.50 | 13.00 | 13.20 | 11.80 | 13.50 | 13.70 | 13.20 | 12.20 | 12.70 | 12.40 | 13.20 | 13.00 | 12.90 |
| | | | | | | | | averages | | | | | | | | | | | |
| | S | | 1827 | | | 2533 | | | 1275 | | | 2183 | | | 1587 | | | 1850 | |
| | AS | | 2085 | | | 2723 | | | 1376 | | | 2296 | | | 1724 | | | 1985 | |
| | GS | | 2.48 | | | 2.47 | | | 2.47 | | | 2.44 | | | 2.48 | | | 2.46 | |
| | AV | | 2.63 | | | 3.16 | | | 2.45 | | | 3.38 | | | 2.17 | | | 2.85 | |
| | VMA | | 12.80 | | | 13.30 | | | 12.60 | | | 13.40 | | | 12.30 | | | 13.00 | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |

S = marshall stability (pounds).
AS = marshall stability adjusted to the sample height.
F = flow (1/100").
GS = specific gravity.
AV = air voids in percent.
VMA = voids in mineral aggregates in percent.

## Table 3.7 Continued.

| aggregate | | limestone | | | | | | natural gravel | | | | | | mix of 50/50 by weight | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| gradation | | A | | | B | | | A | | | B | | | A | | | B | | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| percent | | | | | | | | | | | | | | | | | | | |
| asphalt | S | 1180 | 1400 | 1390 | 1650 | 1560 | 1660 | 960 | 900 | 1000 | 1050 | 1140 | 1200 | 890 | 860 | 980 | 1300 | 1230 | 1380 |
| content | AS | 1285 | 1527 | 1519 | 1793 | 1697 | 1801 | 1036 | 983 | 1082 | 1117 | 1211 | 1284 | 960 | 927 | 1073 | 1395 | 1329 | 1495 |
| | F | 16 | 13 | 14 | 15 | 13 | 12 | 13 | 12 | 14 | 12 | 12 | 10 | 18 | 16 | 15 | 12 | 10 | 10 |
| 4.9 | GS | 2.48 | 2.48 | 2.49 | 2.49 | 2.49 | 2.48 | 2.46 | 2.48 | 2.46 | 2.44 | 2.44 | 2.47 | 2.46 | 2.46 | 2.48 | 2.46 | 2.47 | 2.47 |
| | AV | 1.51 | 1.55 | 1.23 | 1.47 | 1.43 | 1.59 | 1.72 | 0.72 | 1.52 | 2.09 | 2.00 | 1.08 | 1.82 | 1.90 | 1.14 | 1.98 | 1.58 | 1.42 |
| | VMA | 13.50 | 13.50 | 13.20 | 13.50 | 13.40 | 13.60 | 13.60 | 12.70 | 13.40 | 13.90 | 13.80 | 13.00 | 13.70 | 13.80 | 13.10 | 13.80 | 13.50 | 13.40 |
| | | | | | | | | averages | | | | | | | | | | | |
| | S | | 1323 | | | 1623 | | | 953 | | | 1130 | | | 910 | | | 1303 | |
| | AS | | 1444 | | | 1763 | | | 1034 | | | 1204 | | | 987 | | | 1406 | |
| | GS | | 2.48 | | | 2.48 | | | 2.47 | | | 2.45 | | | 2.47 | | | 2.47 | |
| | AV | | 1.43 | | | 1.50 | | | 1.32 | | | 1.73 | | | 1.62 | | | 1.66 | |
| | VMA | | 13.30 | | | 13.40 | | | 13.10 | | | 13.50 | | | 13.40 | | | 13.50 | |
| | S | 940 | 900 | 970 | 1020 | 1200 | 1190 | 615 | 745 | 850 | 820 | 820 | 910 | 800 | 830 | 720 | 900 | 970 | 930 |
| | AS | 1024 | 981 | 1042 | 1103 | 1300 | 1288 | 660 | 800 | 920 | 980 | 869 | 965 | 864 | 910 | 778 | 962 | 1055 | 994 |
| | F | 25 | 24 | 21 | 18 | 18 | 19 | 29 | 27 | 21 | 21 | 18 | 20 | 30 | 26 | 32 | 20 | 17 | 17 |
| 5.6 | GS | 2.47 | 2.47 | 2.45 | 2.47 | 2.48 | 2.48 | 2.43 | 2.44 | 2.45 | 2.45 | 2.43 | 2.43 | 2.45 | 2.46 | 2.45 | 2.45 | 2.48 | 2.45 |
| | AV | 0.96 | 0.84 | 1.73 | 1.12 | 0.60 | 0.80 | 1.90 | 1.33 | 1.13 | 0.85 | 1.62 | 1.34 | 1.17 | 0.73 | 1.25 | 1.21 | 0.16 | 1.25 |
| | VMA | 14.50 | 14.50 | 15.20 | 14.70 | 14.30 | 14.50 | 15.30 | 14.80 | 14.60 | 14.40 | 15.00 | 14.80 | 14.70 | 14.30 | 14.70 | 14.70 | 13.80 | 14.80 |
| | | | | | | | | averages | | | | | | | | | | | |
| | S | | 937 | | | 1137 | | | 737 | | | 883 | | | 783 | | | 933 | |
| | AS | | 1015 | | | 1230 | | | 793 | | | 938 | | | 851 | | | 1004 | |
| | GS | | 2.46 | | | 2.47 | | | 2.44 | | | 2.44 | | | 2.46 | | | 2.46 | |
| | AV | | 1.18 | | | 0.85 | | | 1.45 | | | 1.28 | | | 1.04 | | | 0.89 | |
| | VMA | | 14.70 | | | 14.40 | | | 14.80 | | | 14.60 | | | 14.50 | | | 14.30 | |
| sample no. | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |

S = marshall stability (pounds).
AS = marshall stability adjusted to the sample height.
F = flow (1/100").
GS = specific gravity.
AV = air voids in percent.
VMA = voids in mineral aggregates in percent.

| AGGREGATE TYPE / GRADATION / ASPHALT TYPE (PENETRATION) | LIMESTONE | | ROUNDED GRAVEL | | 50/50 MIX | |
|---|---|---|---|---|---|---|
| | A | B | A | B | A | B |
| 75-100 | 1 | 2 | 3 | 4 | 5 | 6 |
| 125-150 | 7 | 8 | 9 | 10 | 11 | 12 |
| 200-250 | 13 | 14 | 15 | 16 | 17 | 18 |

Figure 3.2 Full-factorial experiment matrix for marshall tests.

percent air voids, and the percent voids in mineral aggregate were then related to the percent asphalt content. The values of the percent asphalt content corresponding to the three percent air voids were then selected as the design asphalt contents. These values are listed in table 3.8 and were used throughout the rest of the testing program. It should be noted that, for all mixes, the values of the design asphalt content were slightly lower than those determined by the Asphalt Institute criterion and slightly higher than the Corps of Engineers criterion.

Nevertheless, the testing program was designed and conducted to evaluate the effects of the test, mix, and specimen variables on the structural properties of the asphalt mixes. These variables are presented in the following sections.

## 3.4 TEST VARIABLES

The effects of three test variables on the structural properties of asphalt mixes were investigated in this study. These are the magnitude of the applied cyclic load, the test temperature, and the number of load applications.

### 3.4.1 CYCLIC LOAD

The characteristics of the stress-strain diagram of asphalt mixes suggest that the mixes possess a nonlinear behavior. Some researchers, however, found that (for a

**Table 3.8 Asphalt mix design for three percent air voids.**

| asphalt pen | asphalt mix design variables | aggregate type: limestone A | limestone B | rounded A | rounded B | 50% mix A | 50% mix B |
|---|---|---|---|---|---|---|---|
| 75 - 100 | % A.C. | 4.310 | 4.460 | 3.990 | 4.280 | 4.160 | 4.400 |
| | MAX. S. G. | 2.546 | 2.543 | 2.539 | 2.520 | 2.541 | 2.530 |
| | BULK S. G. | 2.470 | 2.467 | 2.463 | 2.445 | 2.465 | 2.454 |
| | STAB.(lbs) | 2242. | 2590. | 2177. | 1984. | 1884. | 2302. |
| | V.M.A | 13.39 | 13.75 | 12.60 | 13.21 | 13.01 | 13.54 |
| | FLOW (0.01") | 11.34 | 10.38 | 7.33 | 9.42 | 10.38 | 8.95 |
| 125 - 150 | % A.C. | 4.250 | 4.480 | 4.030 | 4.320 | 4.140 | 4.380 |
| | MAX. S. G. | 2.547 | 2.541 | 2.537 | 2.517 | 2.541 | 2.530 |
| | BULK S. G. | 2.471 | 2.465 | 2.460 | 2.442 | 2.465 | 2.454 |
| | STAB. (lbs) | 2289. | 2392. | 1701. | 1896. | 2238. | 2655. |
| | V.M.A. | 13.26 | 13.79 | 12.70 | 13.31 | 12.96 | 13.49 |
| | FLOW (0.01") | 9.90 | 9.76 | 7.42 | 8.34 | 9.99 | 9.68 |
| 200 - 250 | % A.C. | 4.070 | 4.240 | 3.990 | 4.330 | 3.860 | 4.200 |
| | MAX. S. G. | 2.553 | 2.549 | 2.537 | 2.516 | 2.551 | 2.535 |
| | BULK S. G. | 2.477 | 2.473 | 2.461 | 2.441 | 2.474 | 2.459 |
| | STAB. (lbs) | 2173. | 2548. | 1584. | 1942. | 1955. | 1935. |
| | V.M.A. | 12.85 | 13.23 | 12.61 | 13.31 | 12.33 | 13.08 |
| | FLOW (0.01") | 8.85 | 8.85 | 6.63 | 7.86 | 6.39 | 7.03 |

AC = percent asphalt content.
GMM = maximum theoretical specific gravity.
STAB = marshall stability.
VMA = percent voids in mineral aggregates.

moderate stress level) the resilient modulus of asphalt mixes are independent of the applied stress level (i.e., they possess a linear behavior). Others stated that increasing stress level yields lower modulus values. To further investigate this point, and to quantify relationships between the structural properties and the magnitude of the applied cyclic load, three cyclic loads were used throughout the testing program of this study. These are 100, 200, and 500 pounds which resulted in applied cyclic stress levels of 50, 100, and 250 psi, respectively. The reason for selecting these stress levels is to simulate field conditions. In general, pavements are subjected to stresses equal to the vehicle tire pressure which varies from about 50 psi for some vehicles to about 100 psi for trucks. The 250 psi value is representative of the tire pressure of a new type of tire (the super tire) that is to be introduced by the tire industry in the near future.

### 3.4.2 TEST TEMPERATURE

Structural properties of asphalt mixes are also functions of the mix temperature. The functional relationships, however, are well known and they are documented throughout the literature (see chapter 2). The purpose of the investigation herein is to verify existing information rather than to develop new models relating the structural properties to test temperature. Consequently,

only two test temperatures were used in this study. These are 40 and 70$^{o}$F.

### 3.4.3 NUMBER OF LOAD APPLICATIONS

The number of load applications plays an insignificant role in determining the resilient characteristics of asphalt mixes. In practice, the resilient characteristics are determined after 500 or 1,000 load applications after which the test is terminated.

Fatigue life, on the other hand, is defined by the number of load application at which microcracks are initiated in the test specimen or the flexural modulus of the asphalt mix is reduced to half of its original value. Thus, it is clear that in the fatigue test, the number of load application to failure will vary and is dependent on several variables. Early in the testing program of this study it was found that the number of load applications to fatigue failure varied from a few thousands for the seven percent air void specimens to a few millions for the three percent air void specimens. This represented a problem because the application of one million load repetitions at a frequency of 2 Hz. requires 6 days of continuous testing. Since about 100 specimens were made at the three percent air voids, it implied that more than five years of continuous testing is required. Consequently, it was decided to subject all specimens to about 100,000 load cycles unless

the specimen fails prior to this number. In addition, to verify the extrapolation of the relationships between plastic strain and the number of load application, a few specimens were subjected to more than 600,000 cycles.

## 3.5 MIX VARIABLES

The effects of three mix variables on the structural properties of asphalt mixes were investigated in this study. These are: aggregate angularity, asphalt type, and gradation of the angularity.

### 3.5.1 AGGREGATE ANGULARITY

Aggregate angularity is a measure of the degree of curvature of the aggregate. In qualitative terms, aggregate angularity can be described as rounded, subrounded, subangular, or angular. Quantitatively, aggregate angularity can be obtained by estimating and/or calculating the proximity of an aggregate to a circumscribing sphere. The calculation, however, has not been standardized. Researchers have suggested several equations (56, 105) and/or scales for calculating or estimating the angularity. In this study, aggregate angularity was "quantified" using a scale from 1.0 to 4.0 (105). A value of 1.0 describes a perfectly spherical and smooth aggregate while a value of 4.0 describes an angular aggregate such as a crushed aggregate. Hence, angularities of the crushed limestone,

natural aggregate and 50/50 mix were assigned the values of four, two, and three, respectively. These numerical values were used to examine the effects of aggregate angularity on the structural properties of the asphalt mixes.

### 3.5.2 ASPHALT TYPE

Traditionally, penetration or viscosity of the asphalt are used to characterize the asphalt type. Since the beam specimens, in this study, are subjected to cyclic loads (a psudodynamic type load) it was thought that the kinematic viscosity of the asphalt is a better descriptor of the asphalt type because kinematic viscosity is the ratio of the asphalt viscosity to its density. Consequently, the kinematic viscosity of the asphalt binder was used to quantify the asphalt type and to examine its effects on the structural properties of the mix. The values of the kinematic viscosity of the three types of asphalt (AC 10, AC5, and AC 2.5) used in this study are 159, 212, and 270 centistokes, respectively. These values are listed in table 3.4.

### 3.5.3 AGGREGATE GRADATION

As noted in the Chapter 2, several investigators have found that aggregate gradation have an insignificant effect on the structural properties of asphalt mixes (64, 90, 91, 105, 108, 109). To substantiate their findings, two

gradations (A and B) are used in this study (see table 3.3 and figure 3.1). It can be noted that gradation A had a higher percent of coarse aggregate than gradation B. For analytical purpose, these gradations can be characterized by the weight ratio of coarse to fine aggregate, by their volume or percent passing ratio, or by the volume concentration of the fine. Since, the same percent fine was used for both gradations (A and B), and since the purpose of the investigation in this study is to determine whether aggregate gradation affects the structural properties or not, it was decided to assign the values of 1 and 2 for gradations A and B, respectively. These two values were then used in the analysis.

### 3.6 SPECIMEN VARIABLES

The effect of only one specimen variable on the structural properties of asphalt mixes was investigated in this study. This was percent air voids. The percent air voids of the beam specimens were varied by varying the compaction efforts. Three values of the percent air voids (three, five, and seven) were targeted. For each combination of material and for each target value of the percent air voids, three specimens (triplicate) were made. Each specimen was then tested to determine its actual (not target) air voids. This last value was then used in the analysis.

## 3.7 TEST MATRICES

As noted above, a total of six independent variables were considered in this study. Each had either two or three levels as follows:

- Three target levels of the percent air voids (AV). These are 3, 5, and 7 percent. The actual values of the percent air voids varied from about three to about seven percent.
- Three values of the kinematic viscosity (KV) of the asphalt binder. The values of KV are 159, 212, and 270 centistokes.
- Three aggregate angularities (ANG). The value of ANG are: two for rounded gravel, three for the 50/50 mix, and four for crushed limestone.
- Three magnitudes of the cyclic load (CL). The values of CL are 100, 200, and 500 pounds.
- Two gradations (GRAD) of the aggregates. The value of GRAD is either one for gradation A or two for gradation B.
- Two test temperatures (TT). The values of TT are 40 and 77$^{o}$F.

Thus, the possible number of combinations of these values is 324 (3 air voids x 3 kinematic viscosities x 3 aggregates x 3 cyclic loads x 2 gradations x 2 test temperatures). This implies that, for the beam tests and for a full

factorial study, 324 specimens (972 specimens in triplicates) were required. This is impractical because of the time involved. Consequently, a partial factorial experiment design matrix was established based on the concept of separation of variables such that the effects of each variable on the structural properties of asphalt mixes could be independently and satisfactorily assessed. This matrix is shown in figure 3.3. There are total of 72 designated cells in the matrix and each cell represents a triplicate for a total of 216 beam tests. The test data can be grouped and subgrouped in certain ways such that the values of all independent variables but one are constants within that group. These groups are:

- Group 1; percent air voids. This group was subdivided to nine subgroups. The only independent variable within each subgroup is the percent air voids. For example: subgroup 1.1 for cells 1, 2, and 3; subgroup 1.2 for cells 13, 14, and 15.
- Group 2; cyclic load. The data in this group were separated into 24 subgroups The independent variables within each subgroup are the cyclic load and the percent air voids although the target values of the percent air voids are the same. For example: subgroup 2.1 for cells 1, 13, and 25; and subgroup 2.2 for cells 70, 71 and 72.
- Group 3; kinematic viscosity. The data in this group

Each cell designates a triplicate.

| TEMPERATURE (°F) | GRADATION | LOAD | AIR VOIDS (%) | ASPHALT PEN | AGGREGATE | LIMESTONE 75-100 3 | 5 | 7 | LIMESTONE 125-150 3 | 5 | 7 | LIMESTONE 200-250 3 | 5 | 7 | ROUNDED GRAVEL 75-100 3 | 5 | 7 | ROUNDED GRAVEL 125-150 3 | 5 | 7 | ROUNDED GRAVEL 200-250 3 | 5 | 7 | 50/50 MIX BY WEIGHT 75-100 3 | 5 | 7 | 50/50 MIX BY WEIGHT 125-150 3 | 5 | 7 | 50/50 MIX BY WEIGHT 200-250 3 | 5 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77° | A | 1 | 1 | 2 | 3 | 4 | | | | | 5 | | | | 6 | 7 | 8 | | 9 | | | | 10 | | 11 | | 12 | | | | | | |
| | | 2 | 13 | 14 | 15 | 16 | | | | | 17 | | | | 18 | 19 | 20 | | 21 | | | | 22 | | 23 | | 24 | | | | | | |
| | | 3 | 25 | 26 | 27 | 28 | | | | | 29 | | | | 30 | 31 | 32 | | 33 | | | | 34 | | 35 | | 36 | | | | | | |
| | B | 1 | 37 | 38 | 39 | | | | 40 | | | | 41 | | | 42 | | | | | | | | | | 43 | | | | | | | |
| | | 2 | 44 | 45 | 46 | | | | 47 | | | | 48 | | | 49 | | | | | | | | | | 50 | | | | | | | |
| | | 3 | 51 | 52 | 53 | | | | 54 | | | | 55 | | | 56 | | | | | | | | | | 57 | | | | | | | |
| 40° | A | 1 | 58 | | | | | | 61 | | | | | | | | | | 64 | | | | | | | | | | | | | | |
| | | 2 | 59 | | | | | | 62 | | | | | | | | | | 65 | | | | | | | | | | | | | | |
| | | 3 | 60 | | | | | | 63 | | | | | | | | | | 66 | | | | | | | | | | | | | | |
| | B | 1 | | | | | | | | | | | | | | 67 | | | | | | | | | | 70 | | | | | | | |
| | | 2 | | | | | | | | | | | | | | 68 | | | | | | | | | | 71 | | | | | | | |
| | | 3 | | | | | | | | | | | | | | 69 | | | | | | | | | | 72 | | | | | | | |

Figure 3.3 Partial factorial experiment matrix for the beam tests.

was separated into 9 subgroups. The independent variables within each subgroup are the kinematic viscosity of the asphalt and the percent air voids although the target values of the latter is constant. For example: subgroup 3.1 for cells 1, 4, and 5, and subgroup 3.7 for cells 39, 40, and 41.

- Group 4; aggregate angularity. This group was also subdivided into 9 subgroups. The independent variables within each subgroup are the aggregate angularity and the percent air voids. For example: subgroup 4.1 for cells 1, 6, and 11 and subgroup 4.4 for cells 15, 20, and 24.
- Group 5; gradation. Twelve subgroups were found herein. For example: subgroup 5.1 for cells 1 and 37 and subgroup 5.10 for cells 7 and 42. The disadvantage herein is that, since only two gradations were used, the effects of this variable cannot be accurately assessed.
- Group 6; temperature. Fifteen subgroups were established. For example: subgroup 6.1 for cells 1 and 58 and subgroup 6.6 for cells 29 and 63. Again, since only two temperatures were used, the effects of the test temperature cannot be accurately assessed.

During the analysis, data subgroups were recalled to analyze the effect of the variable within that subgroup. For example, data from three cells that have all variables,

but one, constant (e.g., cells 1, 4, and 5 in figure 3.3) were analyzed to infer the effects of the independent variable (asphalt type in this case) on test results (e.g., cell 1 corresponds to asphalt type 1; 2 to asphalt type 2; 3 to asphalt type 3; while all other variables are invariant). Similarly, data from cells 1, 2, and 3 can be analyzed to examine the effects of the percent air voids on the structural properties of asphalt mixes.

## 3.8 SPECIMEN DESIGNATION NUMBER

For a proper data storage, retrieval, and management, each test specimen was assigned an unique eight-digit designation number. The designation number was based on the following (the numerical order here is that of the designation, e.g.; number one corresponds to the first significant digit of the designation number):

1. Aggregate type: limestone = 1, gravel = 2, 50/50 mix by weight = 3.
2. Gradation type: gradation A = 1, B = 2.
3. Asphalt viscosity, 1, 2, and 3 for kinematic viscosity of 270, 212, and 159 cs, respectively.
4. Test temperature: $77^{o}F$ = 1, $40^{o}F$ = 2.
5. Test type: Beam = 0.
6. Percent air voids: 3% air voids = 5; 5% air voids = 6; 7% air voids = 7.
7. Sample number (SN) for a triplicate by order of test:

(SN = 1 to 3).

8. Load level: 100 pounds cyclic load = 1, 200 pounds = 2, and 500 pounds = 5).

To illustrate, a designation number of 11110521 implies (from left to right): limestone; gradation A; high viscosity asphalt; 77°F; beam test; 3% air voids; second beam of a triplicate; and 100 pounds cyclic load.

## 3.9 SPECIMEN PREPARATION PROCEDURE

For all beam specimens, each aggregate fraction (size) was washed and oven dried to constant weight at 230°F (100°C) for a 24-hour period. After drying, all aggregate fractions were brought back to room temperature. A portion of each fraction, starting with the top size, was then weighed to the nearest 0.1 gram in accordance with the specific gradation curve (A or B). The proper amount of fly ash was then added. The aggregate mix was then placed in an oven to bring its temperature to the compaction temperature as specified in the AASHTO T 245-82 test procedure. The proper weight of asphalt was then added to the aggregate blend to yield the design asphalt content. The aggregate and asphalt were mixed according to AASHTO T 245-82 procedure. After mixing, the beam specimens were compacted using a California Kneading compactor model CS-1000 and a beam mold 16-in. long, 4-in. wide, and 4-in. high. Each specimen was compacted in four layers. The compaction parameters (weight

of the material, the number of tampings, and the foot pressure per layer) were varied. Three trial beams were made to determine these variables. After compaction, the density of the trial beams were determined as specified in the AASHTO T 166-82. The beams were then sawed to eight equal parts as shown in figure 3.4. The density and the percent air voids of each part was determined. From these trials, the proper weight of asphalt mix, the number of tampings, and the foot pressure per layer were selected to yield uniform beams with near target air voids. The final set of the compaction parameters are listed in tables 3.9 through 3.11.

After compaction, the beam specimen was extracted from the mold, placed on a rubber mat and allowed to cool to room temperature. After cooling, the density and the percent air voids were determined. It should be noted that the maximum variation of the percent air voids of any triplicate was generally less than 0.2 percent. However, the actual air voids in some triplicates varied by as much as one percent from the target air voids, which was mainly related to the hydraulic system of the compactor which did not deliver exactly the specified foot pressure.

The specimen were then air-dried and stored overnight in a temperature-controlled chamber which was set at the test temperature of either 77 or 40$^{o}$F. The next day, the specimen was tested.

**Table 3.9 Typical compaction variables for 3 % air voids using limestone and AC10**

| layer number | WM | CFP | NT |
|---|---|---|---|
| 1 | 3393 | 200 | 78 |
| 2 | 2714 | 250 | 78 |
| 3 | 2262 | 300 | 78 |
| 4 | 1809 | 350 | 78 |

WM = weight of asphalt mixes (grams).
CFP = compactor foot pressure (psi).
NT = number of tamping.

**Table 3.10 Typical compaction variables for 5 % air voids using limestone and AC10**

| layer number | WM | CFP | NT |
|---|---|---|---|
| 1 | 3383 | 200 | 39 |
| 2 | 2706 | 250 | 39 |
| 3 | 2255 | 300 | 39 |
| 4 | 1804 | 350 | 39 |

WM = weight of asphalt mixes (grams).
CFP = compactor foot pressure (psi).
NT = number of tamping.

**Table 3.11 Typical compaction variables for 7 % air voids using limestone and AC10**

| layer number | WM | CFP | NT |
|---|---|---|---|
| 1 | 3267 | 200 | 26 |
| 2 | 2612 | 250 | 26 |
| 3 | 2177 | 300 | 26 |
| 4 | 1741 | 350 | 26 |

WM = weight of asphalt mixes (grams).
CFP = compactor foot pressure (psi).
NT = number of tamping.

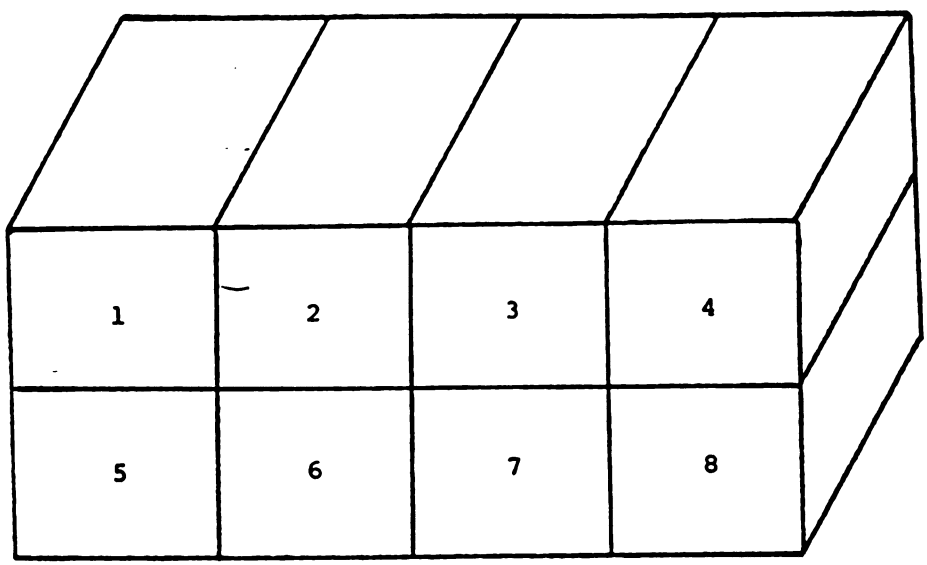



Figure 3.4 Beam specimen sawed to eight equal parts for density analysis.

## 3.10 MEASUREMENT SYSTEM

Early in the testing program, several beams were instrumented using several types of strain gauges (2-, 3-, and 4-in long) mounted at different heights on the side of the beam. The values of the measured strains were found to be random and inconsistent for three reasons:

a) The long (4-in) strain gauges spanned along the neutral axis (the tensile and compressive regions) of the beam. Hence, measured strain values represented the net values of the tensile and compressive strains.

b) Some of the short strain gauges (2-in) spanned only two adjacent aggregates; others spanned only parts of the aggregates; still others were mounted on the asphalt binder on one side and on a part of an aggregate on the other side.

c) Several types of epoxy resins were used to firmly attach the strain gauges to the side of the beam. The magnitude of the cumulative plastic strains at the higher number of load applications caused the epoxy to crack and hence, the strain gauge was separated from the beam.

Consequently, a different measurement system was used that consisted of four linear variable differential transducers (LVDT) mounted on a steel frame along the central line of the surface of the beam specimen at different distances from

the point of load application. The LVDTs were placed at the center of the beam, 2.25-in., 4.25-in., and 6.31-in from the center as shown in figure 3.5. The total surface deflection of the specimen due to the applied cyclic load was recorded at different number of load applications using a strip chart recorder.

### 3.11 TEST PROCEDURES

All beam specimens were prepared using the procedure outlined in section 3.9. The tests were conducted at either 77 or 40$^{o}$F in a temperature-controlled chamber. The sustained and cyclic loads were applied using an MTS hydraulic system. Prior to testing, all equipments used in the flexural beam tests (e.g. MTS hydraulic system, LVDT's, strip chart recorders, and so on) were calibrated in accordance with a proper procedure before commencing the test.

After each specimen was conditioned to the test temperature, the beam specimen was continuously supported by placing it on a rubber pad (1 in. thick) which was then rested on a steel block (8 in. thick) in the test chamber. The rubber plate and the steel block, herein, represent the base or subbase course underlain by a rigid foundation.

After placement, all LVDTs were adjusted to a reference position. A loading strip (0.5 inch-wide and 4 inch-long)

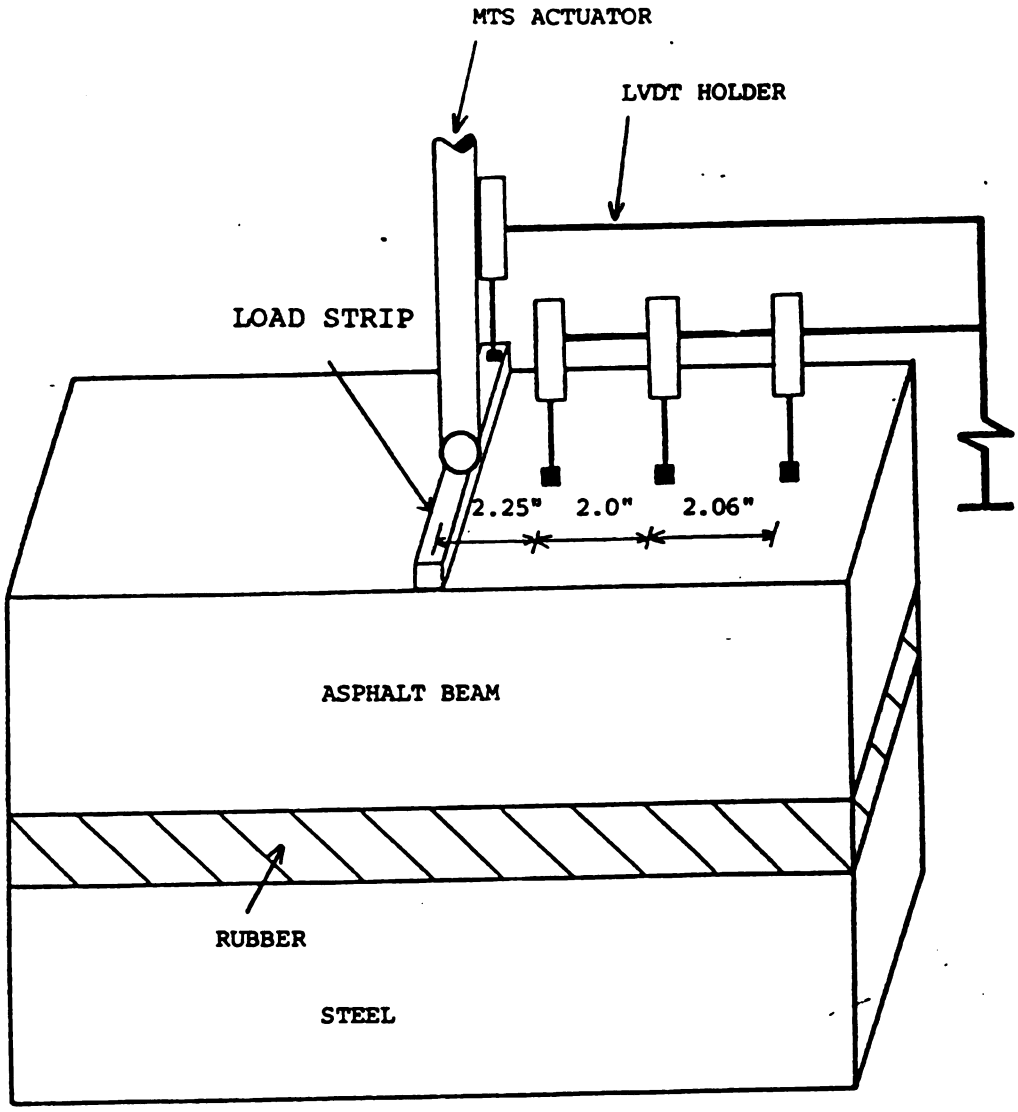



Figure 3.5 Schematic diagram of the beam test set-up.

attached to the actuator of the MTS system was then lowered to make contact with the beam. A sustained load of 50 pounds was then applied and the consequent deformations were recorded. When the rate of deformation dropped to near zero (10 to 20 minutes), the cyclic load with a sinusoidal wave form was applied and the resulting resilient, viscoelastic, plastic deformations, and number of load applications were recorded. The load frequency was set at two cycles per second with 0.1 second loading time and 0.4-second relaxation period. The peak cyclic load, however, was either 100, 200 or 500 pounds. For each load, three beam specimens (triplicate) were tested.

# CHAPTER 4

# TEST RESULTS

## 4.1 GENERAL

In this study, the laboratory tests were performed according to the respective partial factorial experiment matrix shown in chapter 3. The tests were conducted in the laboratory of the Division of Materials and Technology at the Michigan Department of Transportation (MDOT). It should be recalled that all tests were conducted in triplicates. Typical test results are presented in this chapter.

## 4.2 TEST RESULTS

For each of the test materials, the Mashall mix design tests were conducted using four values of the percent asphalt contents by total weight of the mix (3.5, 4.2, 4.9 and 5.6). The test results were analyzed and the design asphalt content was determined as the percent asphalt content by total weight of mix that corresponding to three percent air voids. Typical diagrams relating the stability, specific gravity (density), percent air voids, voids in the mineral aggregates, percent voids filled with asphalt, and flow to the percent asphalt contents are shown in figures 4.1 through 4.6.

Nine specimens (three triplicates) were made at the design asphalt content for each of the test materials. Each

triplicate was compacted to yield specimens with uniform density near the target values of the percent air voids (AV) of either three, five or seven percent. Figures 4.7 and 4.8 show typical diagrams of Mashall stability and flow versus the percent air voids, respectively. For each beam at the 77$^{o}$F, the cyclic load was applied for a period of 24 hours or until failure. Beams at 40$^{o}$F were tested for a period of three to six days (one million load applications). During the test, the resilient, total, and plastic deformations at four points on the surface of the beam were measured and recorded. Figures 4.9, 4.10, and 4.11 show typical curves of resilient, total and plastic deformations of the beam versus the number of load applications, respectively. The maximum specific gravity of the mix (GMM), the bulk specific gravity of the beam specimen (GB), the target air voids (TAV), the actual air voids (AV), the target asphalt content (TAC), and the actual asphalt content (AC) are also shown in the figures. Figure 4.12 depicts typical shapes of the deflection basin at several numbers of load applications. Figure 4.13 shows typical curves of the resilient and total deformations at cycle number 100 versus the percent air voids. Figure 4.14 depicts typical plots of the cumulative plastic deformation versus the percent air voids for cycles number 100, 1,000, 10,000, and 150,000. The test results, for all beams, are presented in Appendix A.

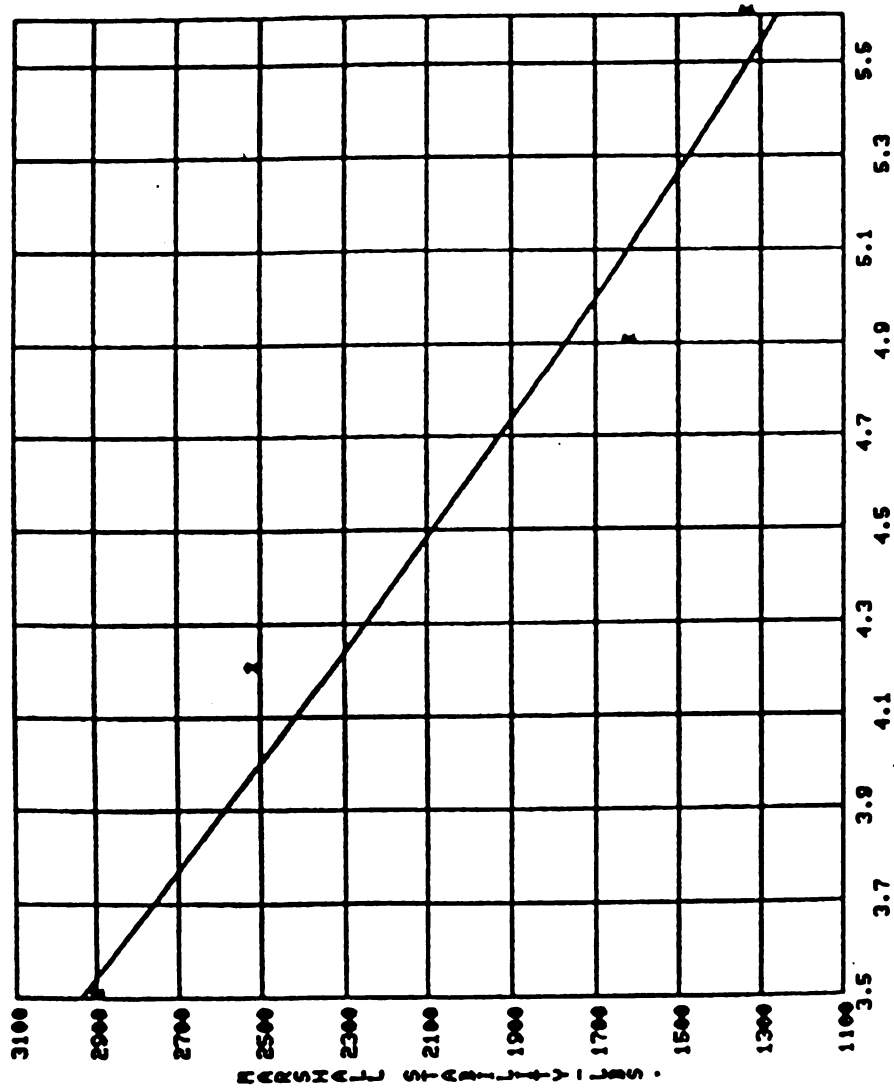



Figure 4.1 Marshall stability versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

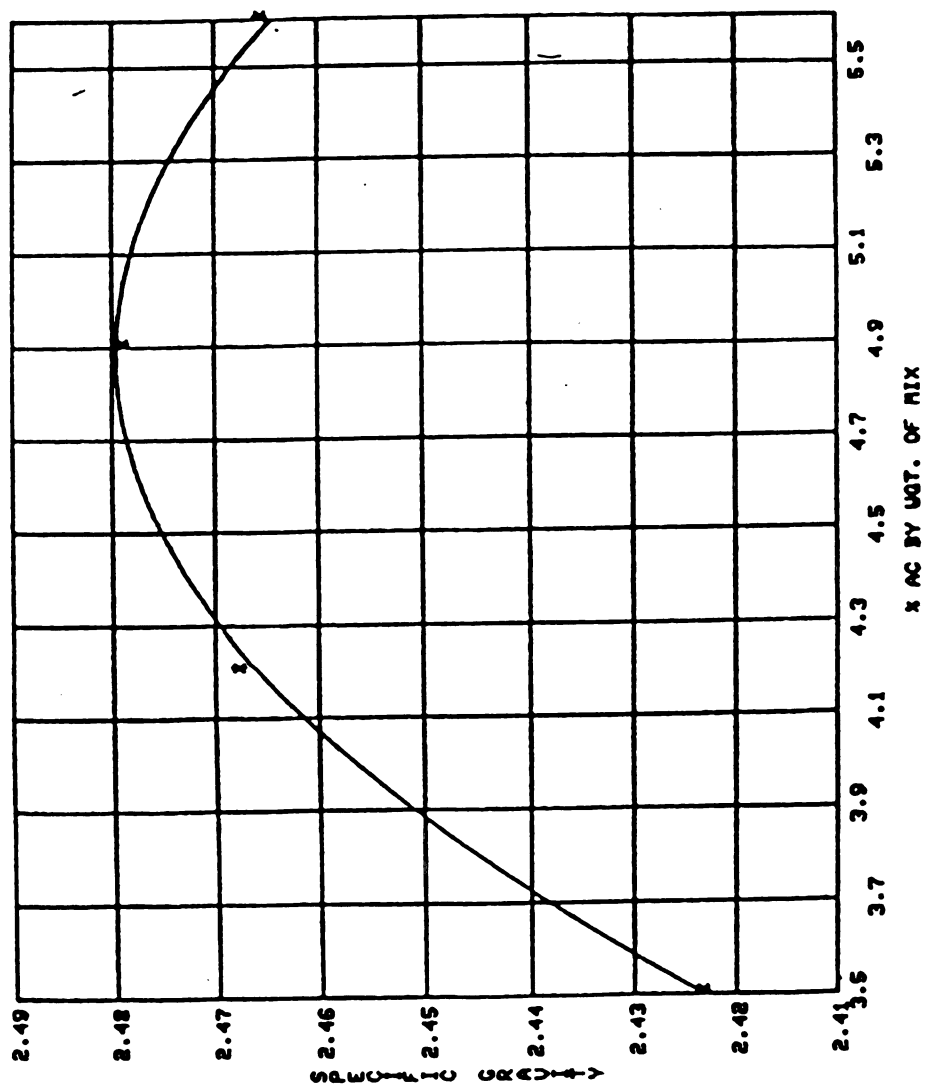



Figure 4.2 bulk specific gravity of the mix versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

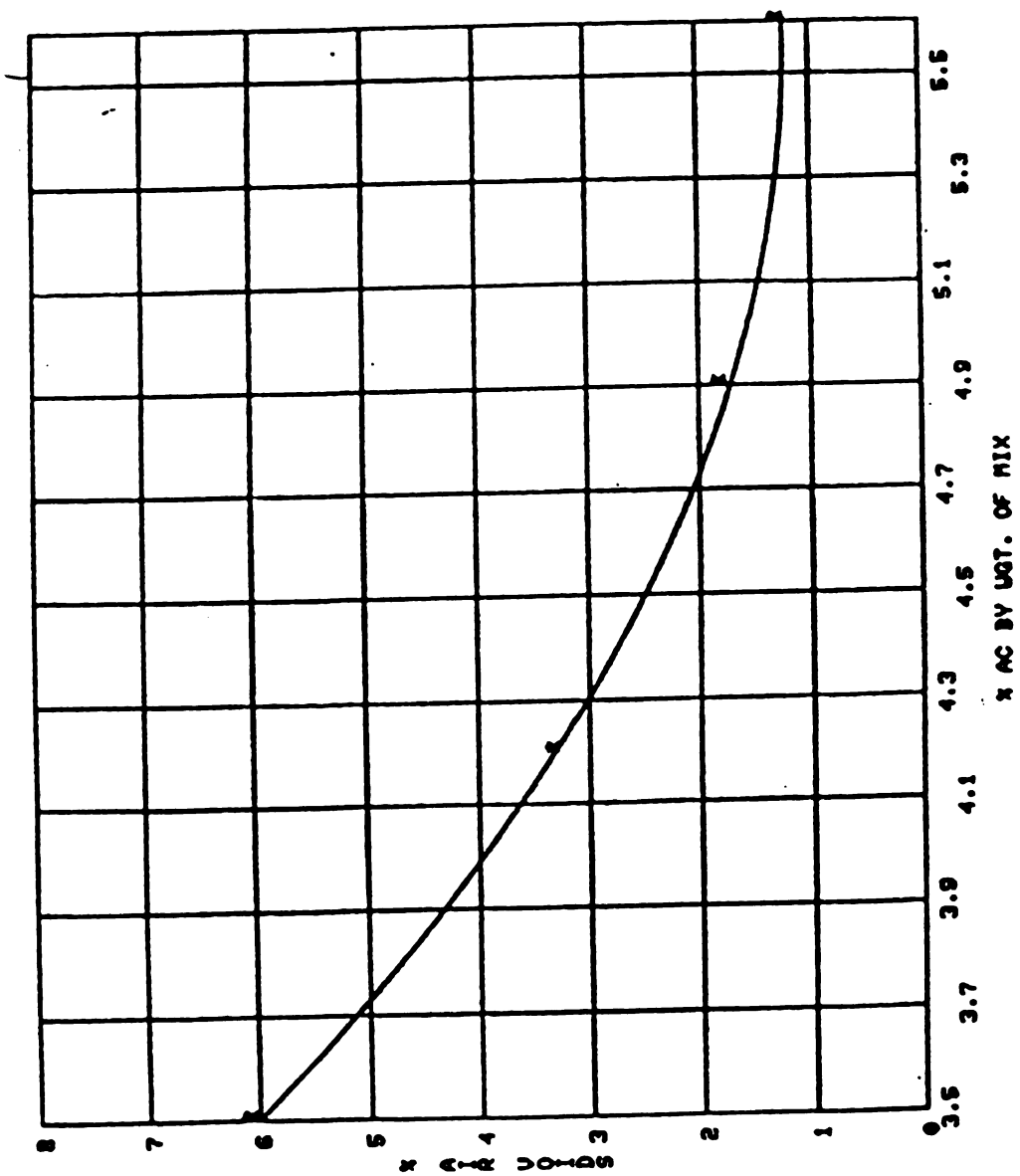



Figure 4.3 Percent air voids versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

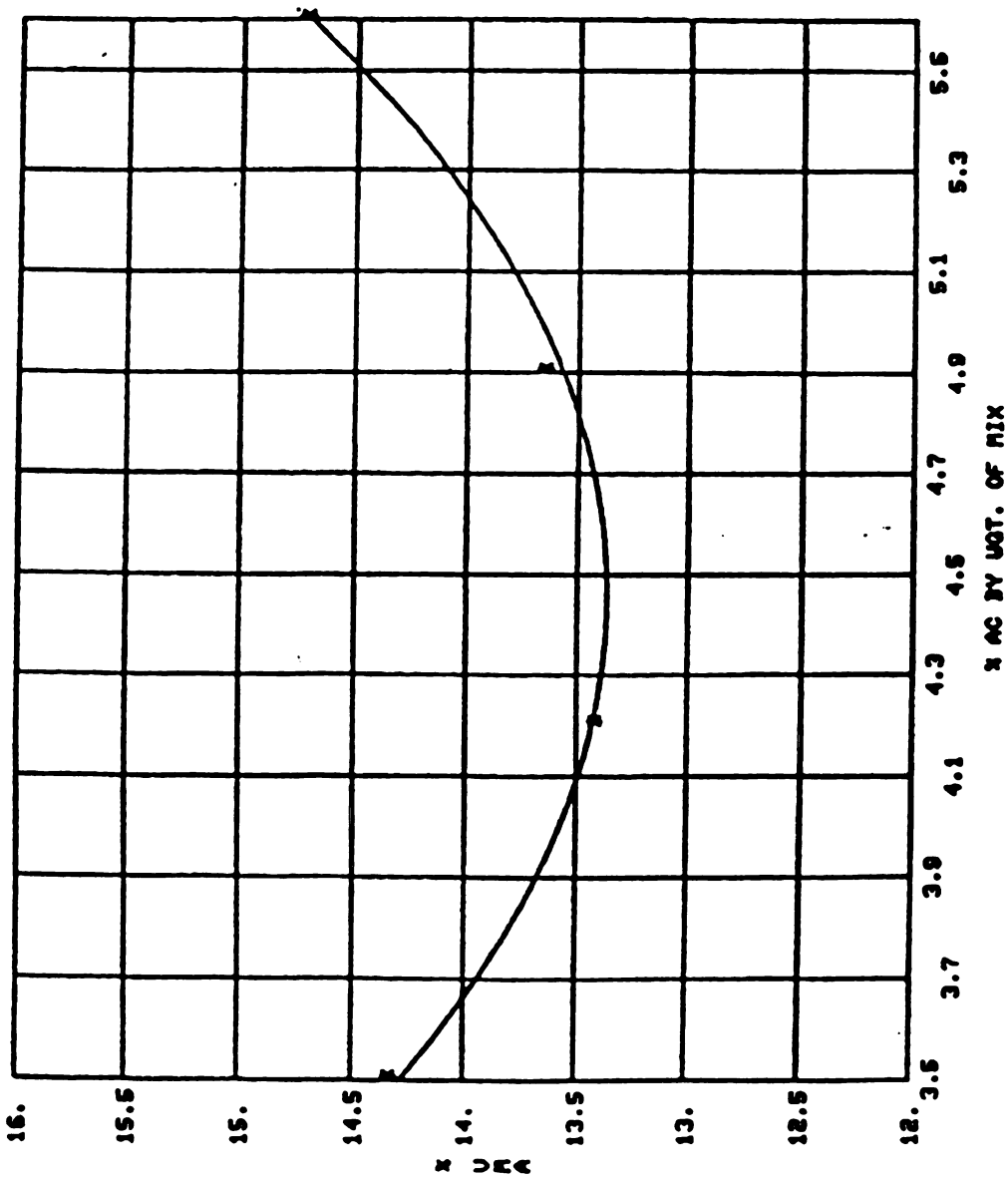



Figure 4.4 Percent voids in mineral aggregate versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

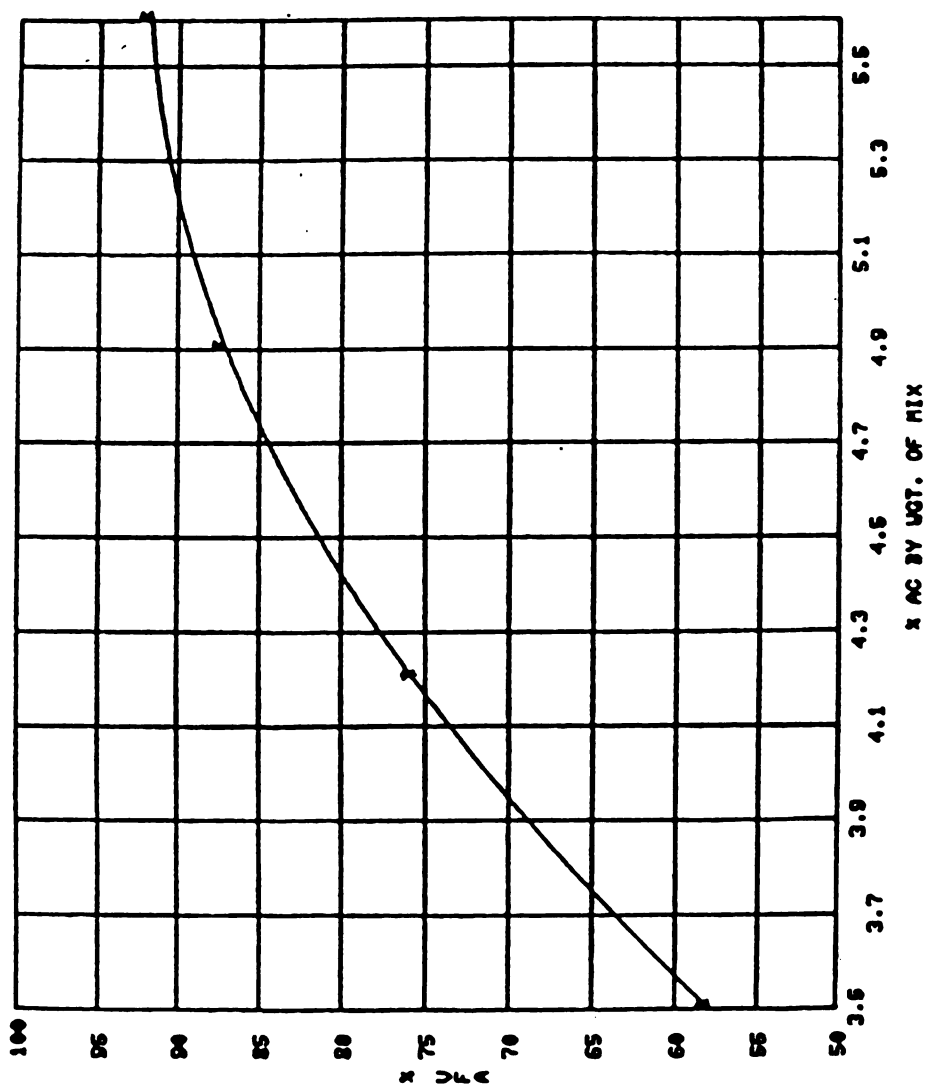



Figure 4.5 Percent voids filled with asphalt versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

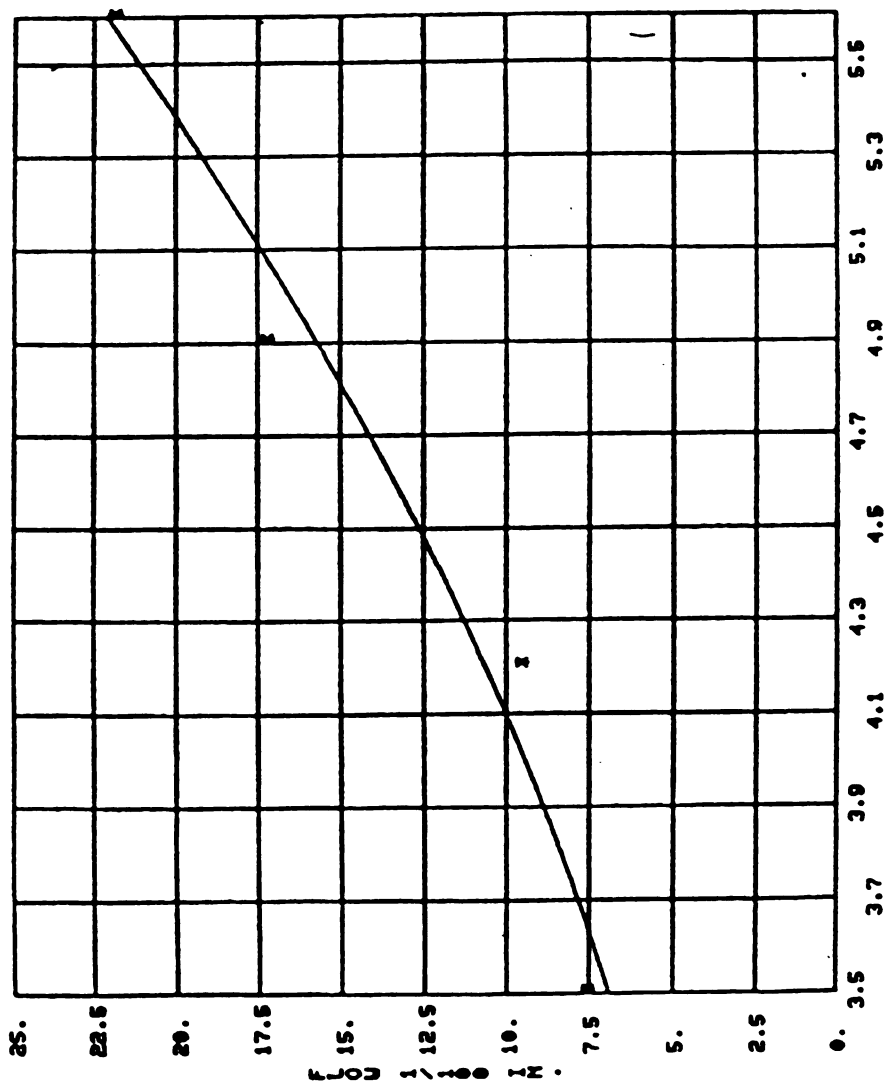



Figure 4.6 Flow versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

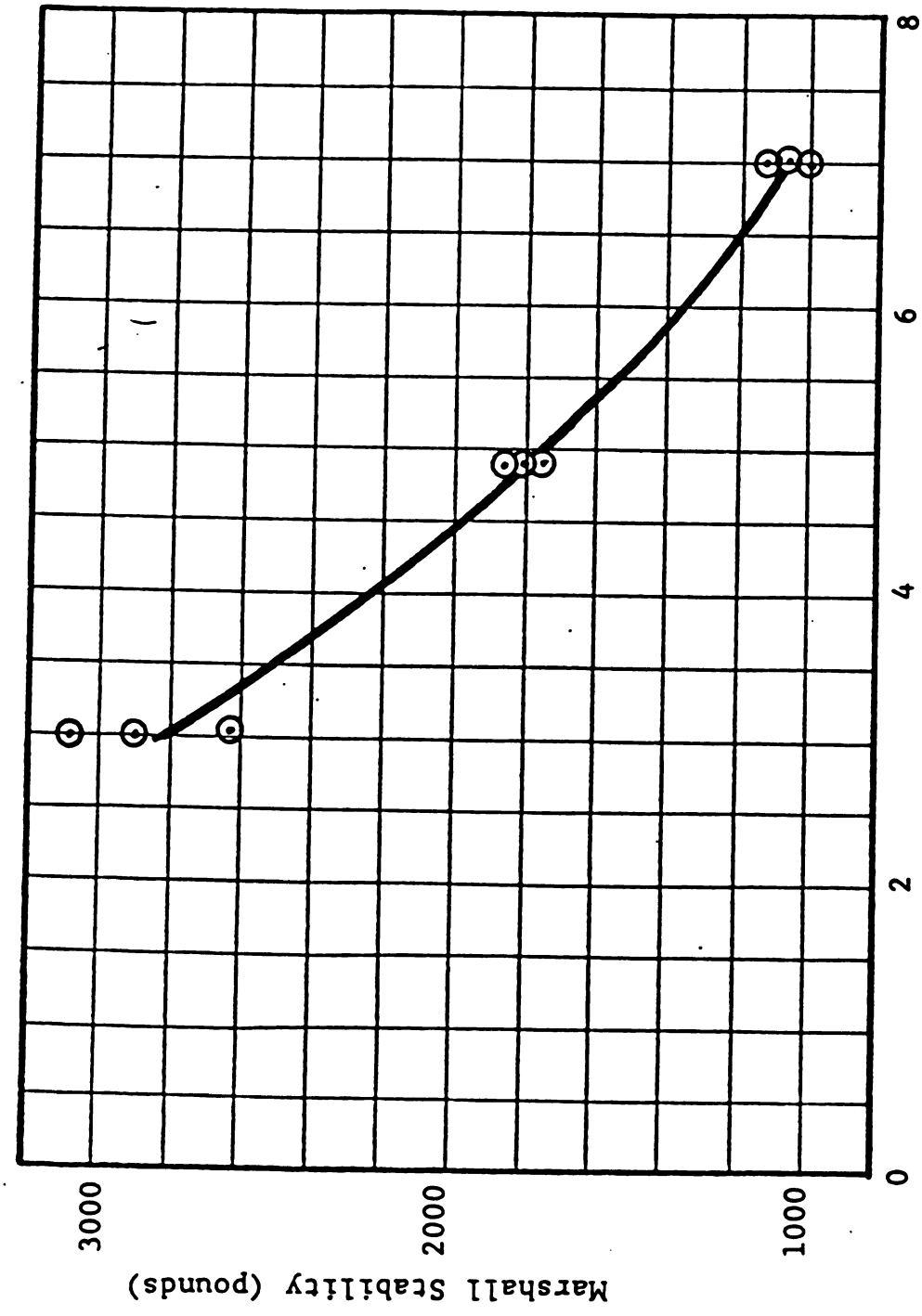



Figure 4.7 Marshall stability versus the percent air voids of the specimen.

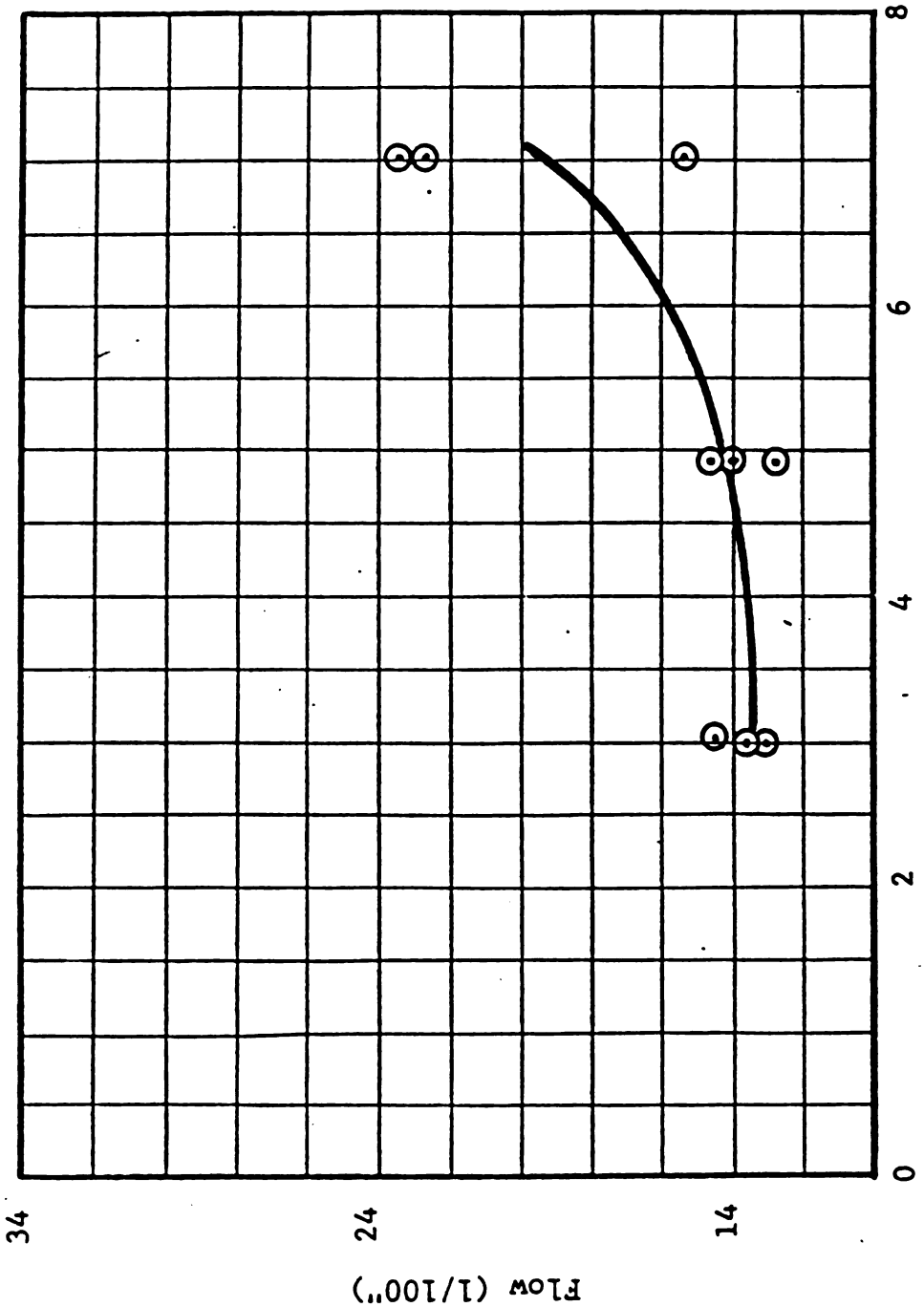



Figure 1.8 Flow values versus the percent air voids of the specimens.

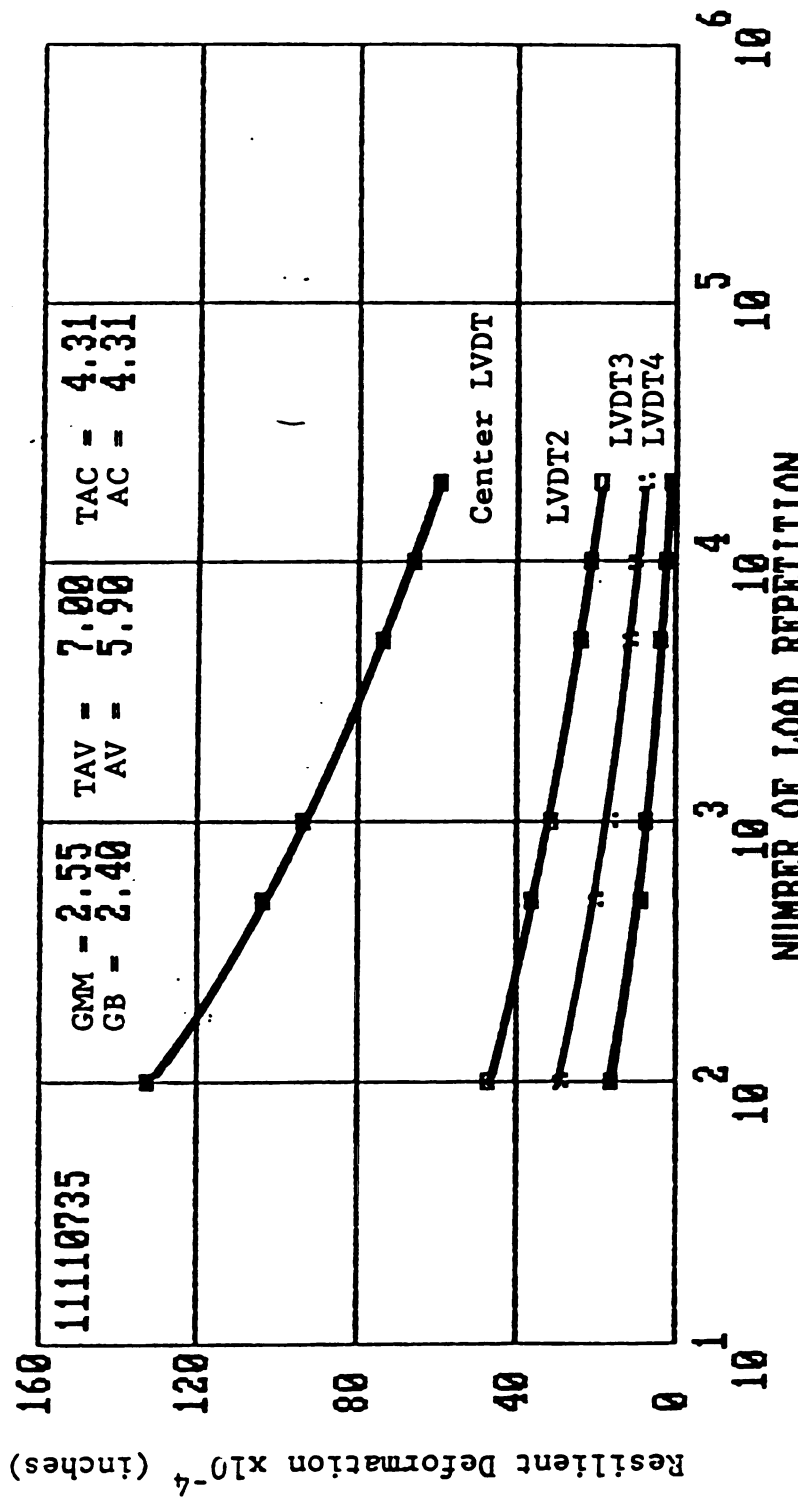



Figure 4.9 Resilient deformations at four points on the surface of the beam specimen versus the number of load applications.

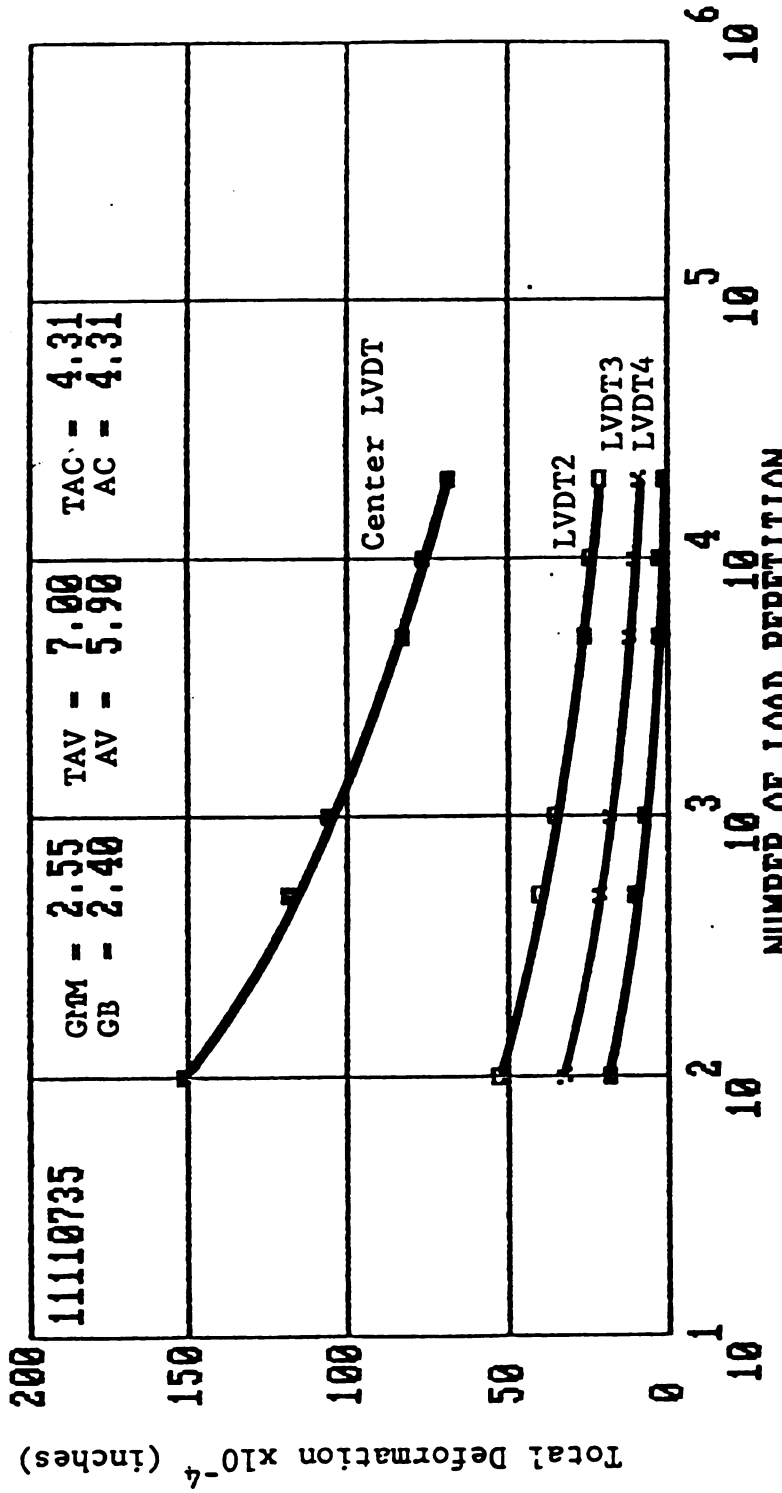



Figure 4.10 Total deformations at four points on the surface of the beam specimen versus the number of load applications.

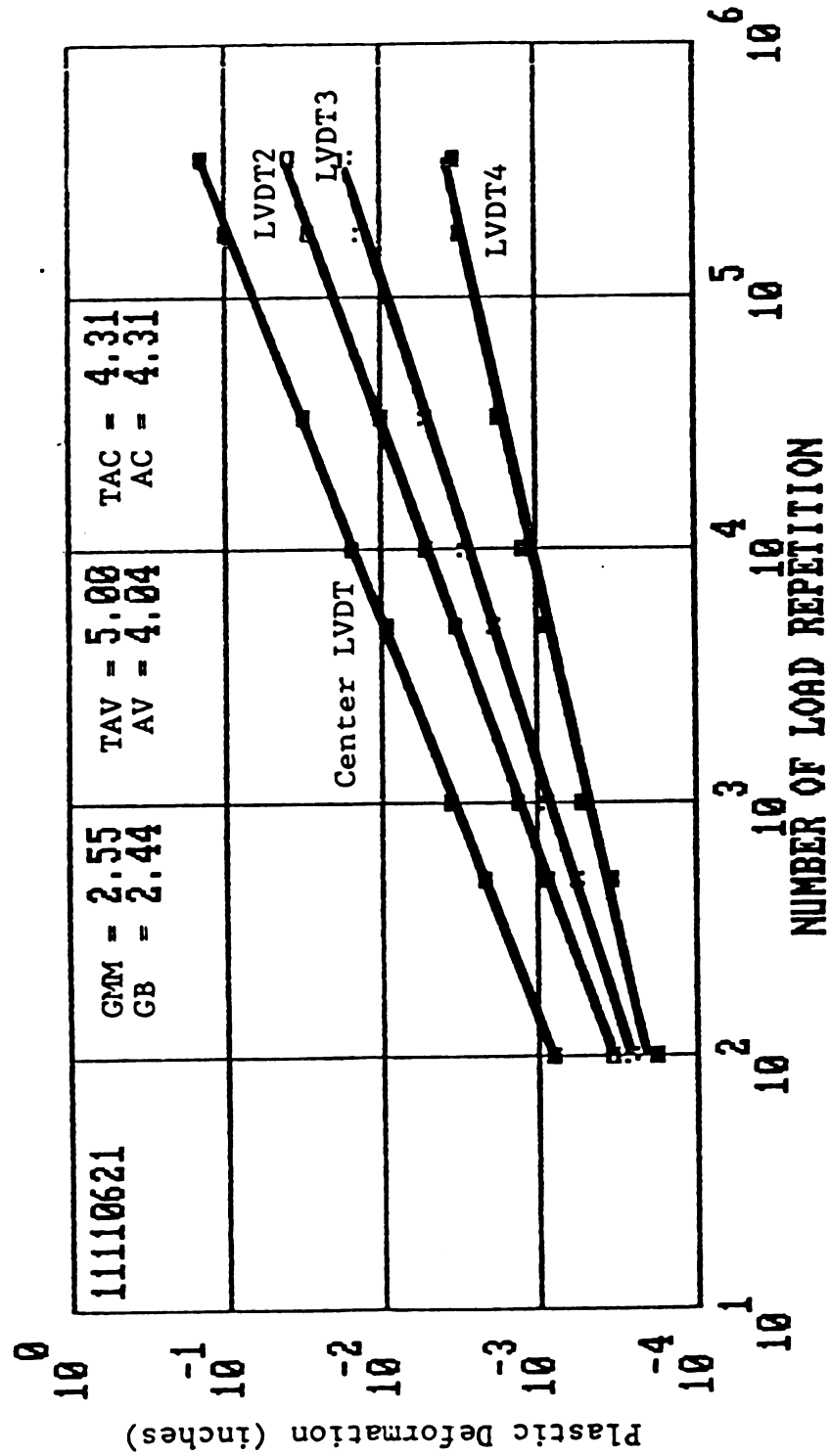



Figure 4.11 Cumulative plastic deformations at four points on the surface of the beam specimen versus the number of load applications.

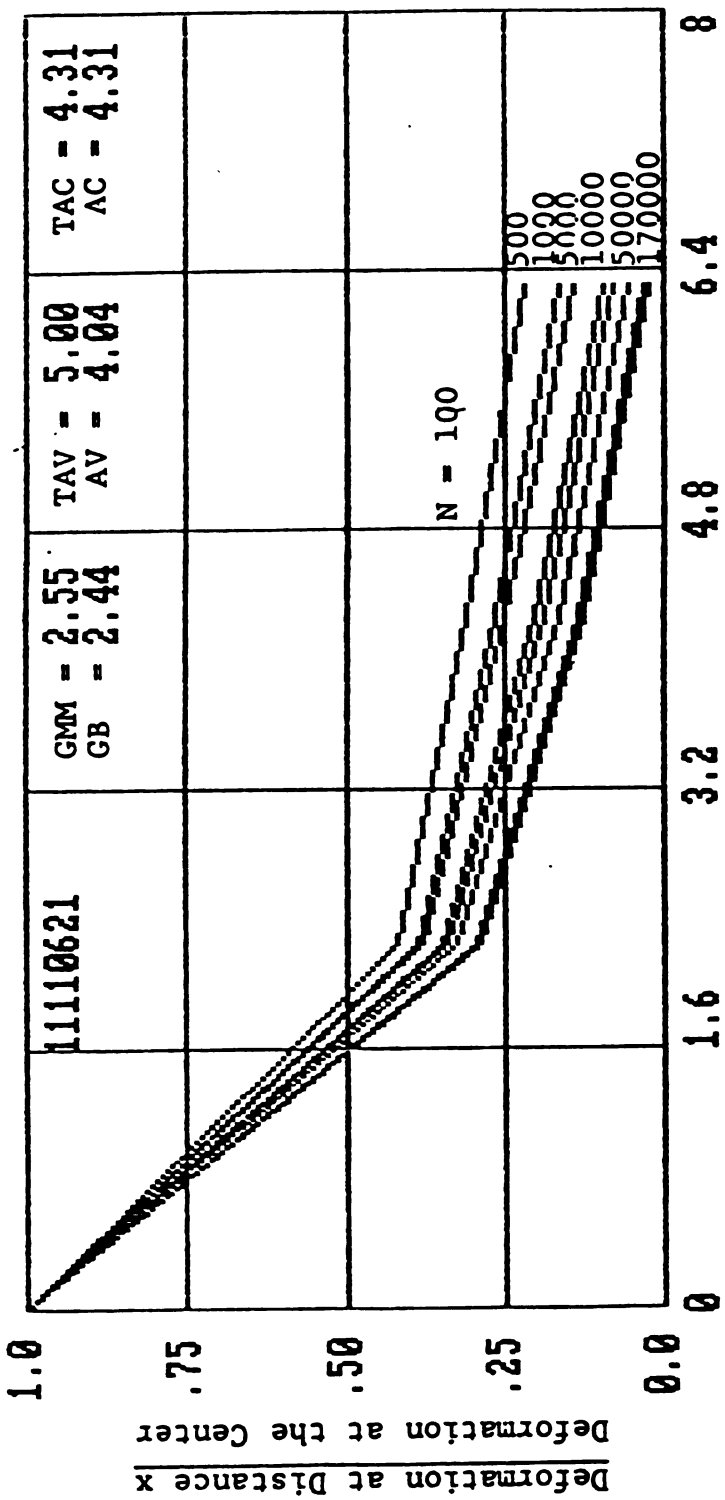



Figure 4.12 Normalized plastic deformation basin of the beam specimen at different number of load applications.

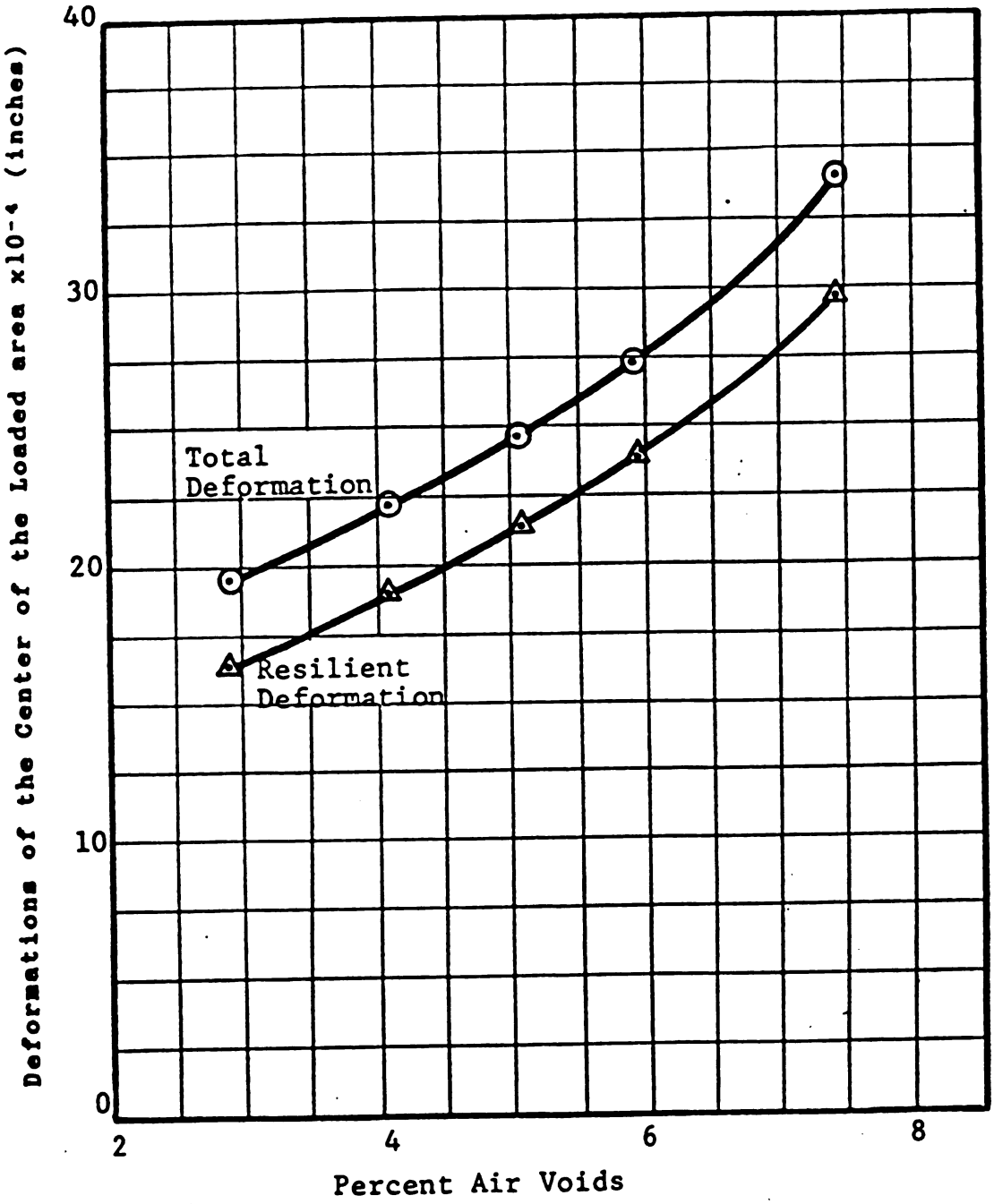



Figure 4.13 Resilient and total deformations at the center of the loaded area at cycle number 100 versus the percent air voids of the beam specimen.

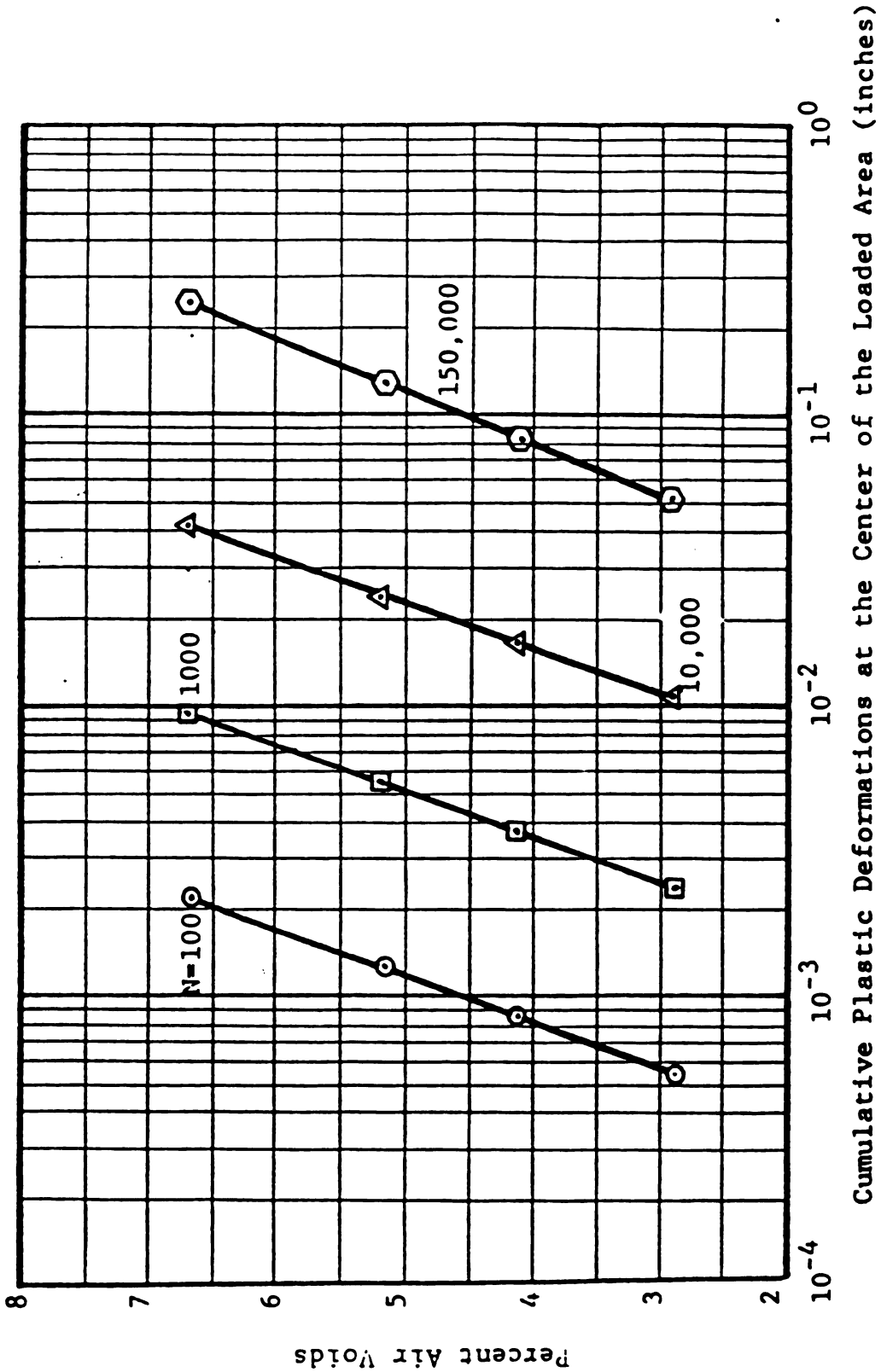



Figure 4.14 Cumulative plastic deformations at the center of the loaded area at different number of load applications versus the percent air voids of the beam specimen.

# CHAPTER 5

# ANALYSIS AND DISCUSSION

## 5.1 GENERAL

Structural properties of asphalt mixes have a direct bearing on the pavement performance under the anticipated traffic loading and environmental conditions (109). The determination of relevant structural properties can be very tedious and involved because said properties change with changing environmental conditions. Unlike the mineral aggregate in the mix or in the pavement base and subbase layers whose properties are relatively constant, physical and chemical asphalt binder properties are dynamic in nature and are influenced by temperature, moisture, and time (35). In addition, the response of asphalt mixes to load (as noted in chapter 2) is the result of three different mechanisms: elastic; viscoelastic; and plastic. Thus, some of the relevant structural properties of asphalt mixes that are needed for the design of asphalt pavement include resilient and/or total characteristics, permanent deformation, creep, and fatigue behavior.

Asphalt mixes are largely composed of coarse and fine aggregates, mineral filler, asphalt binder, and air voids. The proportioning of these components in any given mix (the asphalt mix design) dictates its behavior under traffic loading and affects its structural properties (24, 34, 40,

74, 75, 85). Existing practices, however, divorce the asphalt mix design procedures from those to obtain the structural properties. Hence, a major question facing the pavement engineer is "how to tailor the asphalt mix design procedure to optimize its structural properties which will result in the best pavement performance under traffic loads and environmental conditions?"

## 5.2 STUDY OBJECTIVES

The objectives of this study include:

a) Determining the structural properties of asphalt mixes using cyclic load flexural tests.
b) Determining the asphalt mix design parameters using the standard Marshall tests and test procedures.
c) Quantifying relationships between the standard properties of the asphalt mix and the types of the material in the mix.
d) Identifying a laboratory test procedure whereby the asphalt mix design can be tailored to optimize its structural properties.

To accomplish these objectives, it was hypothesized that relationships between the structural properties and the asphalt mix design parameters can be found using statistical analyses. To verify the hypothesis, laboratory flexural cyclic load tests was designed and conducted to evaluate the structural properties of the mix. The asphalt mix design

parameters (on the other hand) were obtained using standard Marshall tests. The measured structural properties and the asphalt mix design parameters were then analyzed to:

a) Model the structural properties of the compacted mixes as functions of load and temperature.
b) Model the structural properties of the compacted mixes as a function of the types of material in the mix.
c) Correlate items a and b.
d) Evaluate the repeatability of the test results.
e) Examine the feasibility of the beam test.

Items (a), and (b) above are required to verify the hypothesis (item c). Items (d) and (e) are necessary to determine whether the flexural beam test can be used to identify a laboratory test procedure whereby the asphalt mix design can be tailored to optimize the structural properties of the mix.

## 5.3 DATA PREPARATION

For each test, the applied cyclic and the corresponding specimen total deformation were continuously recorded using strip chart recorders at cycles number 100, 500, and a multiple of 10 of these values thereafter. After the test, each data record was examined and the values of the resilient, total, and plastic (permanent) deformations were digitized separately. This can be illustrated with the aid

of figures 5.1 and 5.2. Figure 5.1 depicts a typical load and deformation record versus time during one load-unload cycle. The sustained and cyclic loads, and the loading and relaxation periods are shown on the load record in the figure. The total peak deformation, the time lag between the peak load and peak deformation, and the resilient, viscoelastic, and plastic deformations are designated on the deformation record in figure 5.1. The length of the lines DG, DE, EF, and FG in the figure are proportional to the total resilient, viscoelastic, and plastic deformations, respectively. It can be seen that the length of the line FG is much smaller than those of DE and EF. Indeed, it was noted that the values of the plastic deformation due to any one load-unload cycle is very small and within the accuracy of the measurement system. Consequently, the plastic deformation due to any one load cycle was neglected and the total and resilient deformations (lines DG and DE) were digitized. The viscoelastic deformation is simply the difference between the total and resilient deformations. It should be noted that the value of the viscoelastic deformation depends on several variables such as temperature and loading and relaxation periods. For example, higher temperatures and/or longer loading and relaxation periods produce higher viscoelastic deformation. Since (in this study) the rate of specimen recovery was not recorded and only one loading and relaxation periods were used, the

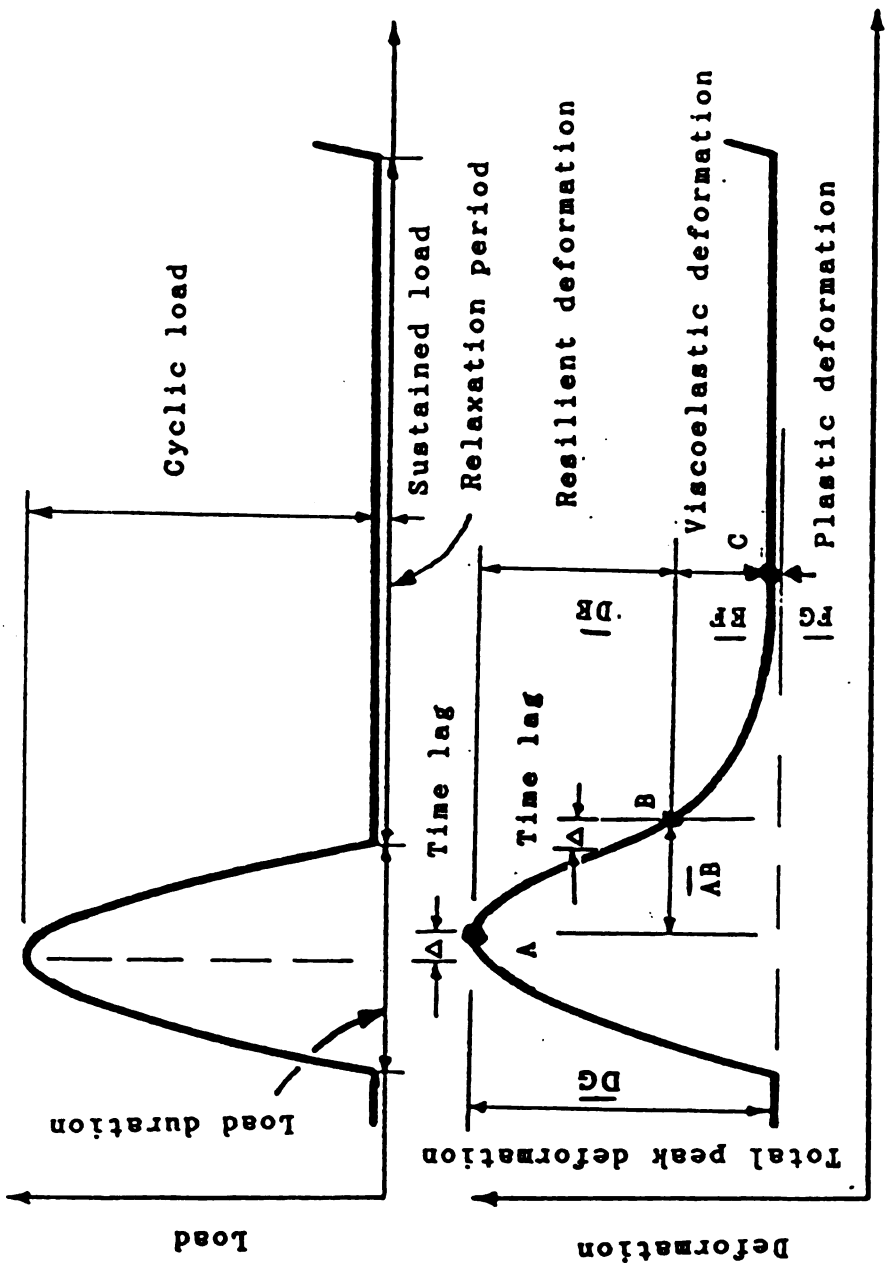



Figure 5.1 Typical load and deformation records versus time.

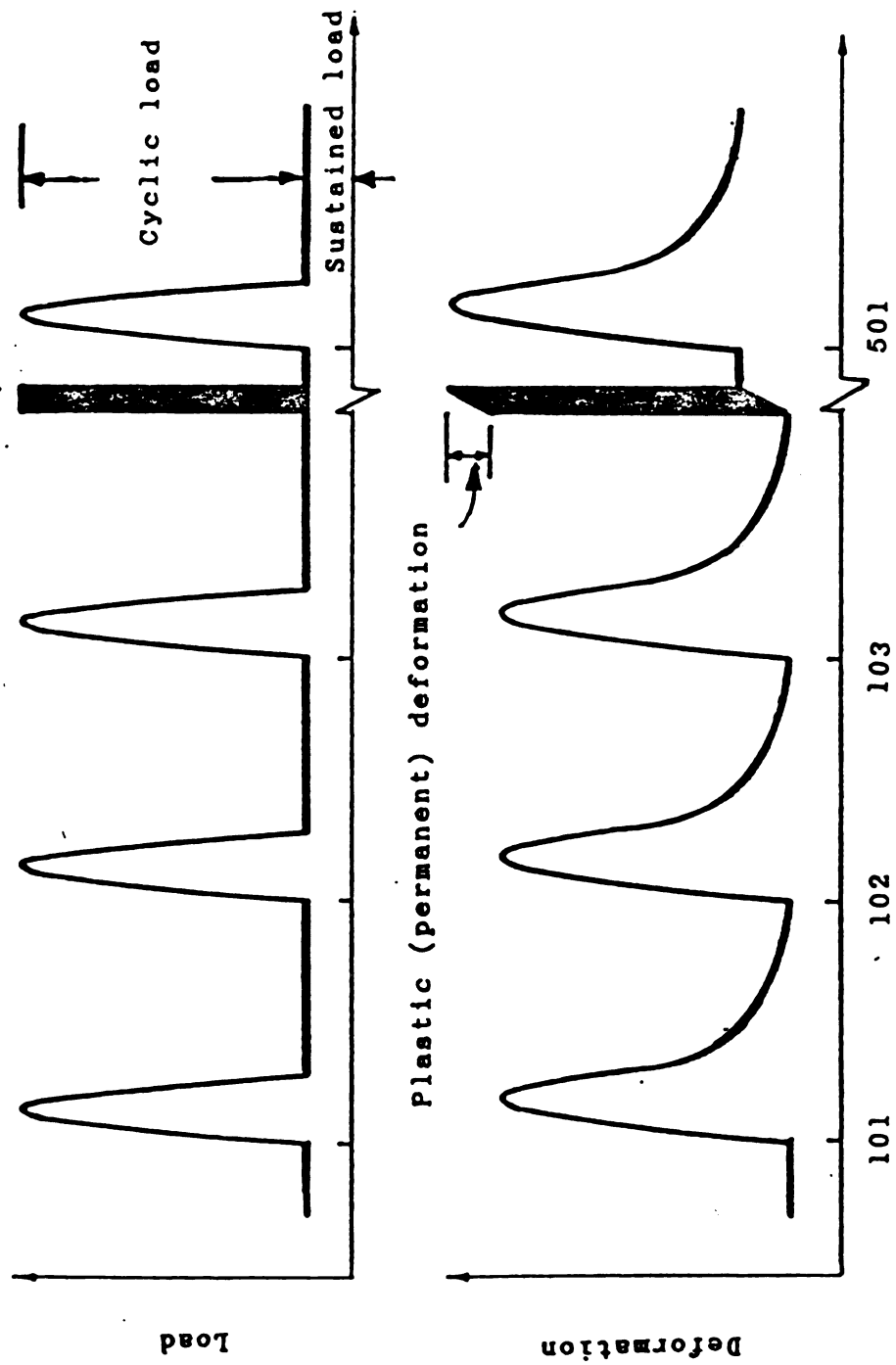



Figure 5.2 Typical load and deformation records versus the number of load application.

calculation of the viscoelastic properties becomes tedious and misleading. Thus, only the resilient, total, and plastic deformations were considered in the analyses.

As noted above, the value of the plastic deformation of the test specimen for any one load cycle is very small and within the accuracy of the measurement system. For this reason, the cumulative plastic deformation due to a number of load applications were determined and analyzed. This can be illustrated using figure 5.2 which shows a typical load and deformation record versus the number of load applications. The records for cycles 101, 102, 103, and 501 were obtained using a higher speed setting on the chart-recorder. The records between cycles number 104 and 500 were obtained using a slow speed setting on the chart-recorder. As it can be seen, the deformation signal drifts away from the horizontal axis as the number of load application increases. The length of the line AB in the figure is proportional to the cumulative plastic deformation between load cycles number 103 and 501. In this study, the value of the cumulative plastic deformation between load cycle number and any other load cycle in question was used in the analysis.

## 5.4 ANALYSIS METHODS

Analytical and statistical methods were used to analyze the data obtained from the flexural tests. The analytical

method was based on the elastic-viscoelastic-plastic model (equation 2.2). In this method, the magnitude of the applied cyclic load and the measured resilient and total deformations of the beam specimens were analyzed using a linear elastic finite element computer program to extract the resilient and total characteristics of the asphalt mixes. The analyses are presented in section 5.7.

For each beam specimen, the values of the resilient and total characteristics obtained using the finite element program, and the values of the measured plastic deformations (permanent deformations) were statistically correlated to the different mix, specimen, and test variables using an available multiple linear regression analysis computer program (SPSS/PC$^+$). In this analysis, three procedures were utilized based on the following concepts:

a) Separation of variables;

b) Determination of the general correlation equations; and

c) Stepwise procedure which is based on the order of significance of the variables.

The three procedures are presented in the following sections.

### 5.4.1 SEPARATION OF VARIABLES

The separation of variables method can be illustrated by considering the partial factorial experiment matrix of the

beam tests repeated, for convenience, in figure 5.3. Each cell in the matrix represents three specimens (triplicate). Data from each triplicate were statistically analyzed to assess the repeatability of the test results and the variability of the percent air voids within each triplicate. For each test within any triplicate in the matrix, the only variable is the number of load repetitions. Hence, the data (e.g. permanent deformation) from each test was first plotted against the number of load applications as shown in figure 5.4. From the figure, the plastic deformations were modeled as a function of the number of load applications using the following equation:

$$CD_i = I_i N^{S_i} \tag{5.1}$$

where: $CD_i$ = permanent deformation of $LVDT_i$;
$I_i$ and $S_i$ = regression constants;
N = number of load applications; and
i = LVDT number (location).

In the logarithmic space, equation 5.1 can be written as

$$\ln(CD)_i = \ln I_i + S_i \ln N \tag{5.2}$$

where: ln = natural logarithm;
all other variables are as before.

Each cell designates a triplicate.

| AGGREGATE / ASPHALT PEN / AIR VOIDS (%) / LOAD / GRADATION / TEMPERATURE (°F) | | | LIMESTONE | | | | | | | | | ROUNDED GRAVEL | | | | | | | | | 50/50 MIX BY WEIGHT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 75–100 | | | 125–150 | | | 200–250 | | | 75–100 | | | 125–150 | | | 200–250 | | | 75–100 | | | 125–150 | | | 200–250 | | |
| | | | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 |
| 77° | A | 1 | 1 | 2 | 3 | 4 | | | 5 | | | 6 | 7 | 8 | | 9 | | | 10 | | 11 | | 12 | | | | | | |
| | | 2 | 13 | 14 | 15 | 16 | | | 17 | | | 18 | 19 | 20 | | 21 | | | 22 | | 23 | | 24 | | | | | | |
| | | 3 | 25 | 26 | 27 | 28 | | | 29 | | | 30 | 31 | 32 | | 33 | | | 34 | | 35 | | 36 | | | | | | |
| | B | 1 | 37 | 38 | 39 | | | 40 | | | 41 | | 42 | | | | | | | | | 43 | | | | | | | |
| | | 2 | 44 | 45 | 46 | | | 47 | | | 48 | | 49 | | | | | | | | | 50 | | | | | | | |
| | | 3 | 51 | 52 | 53 | | | 54 | | | 55 | | 56 | | | | | | | | | 57 | | | | | | | |
| 40° | A | 1 | 58 | | | | | | 61 | | | | | | | 64 | | | | | | | | | | | | | |
| | | 2 | 59 | | | | | | 62 | | | | | | | 65 | | | | | | | | | | | | | |
| | | 3 | 60 | | | | | | 63 | | | | | | | 66 | | | | | | | | | | | | | |
| | B | 1 | | | | | | | | | | | 67 | | | | | | | | | 70 | | | | | | | |
| | | 2 | | | | | | | | | | | 68 | | | | | | | | | 71 | | | | | | | |
| | | 3 | | | | | | | | | | | 69 | | | | | | | | | 72 | | | | | | | |

Figure 5.3 Partial factorial experiment matrix for the beam test.

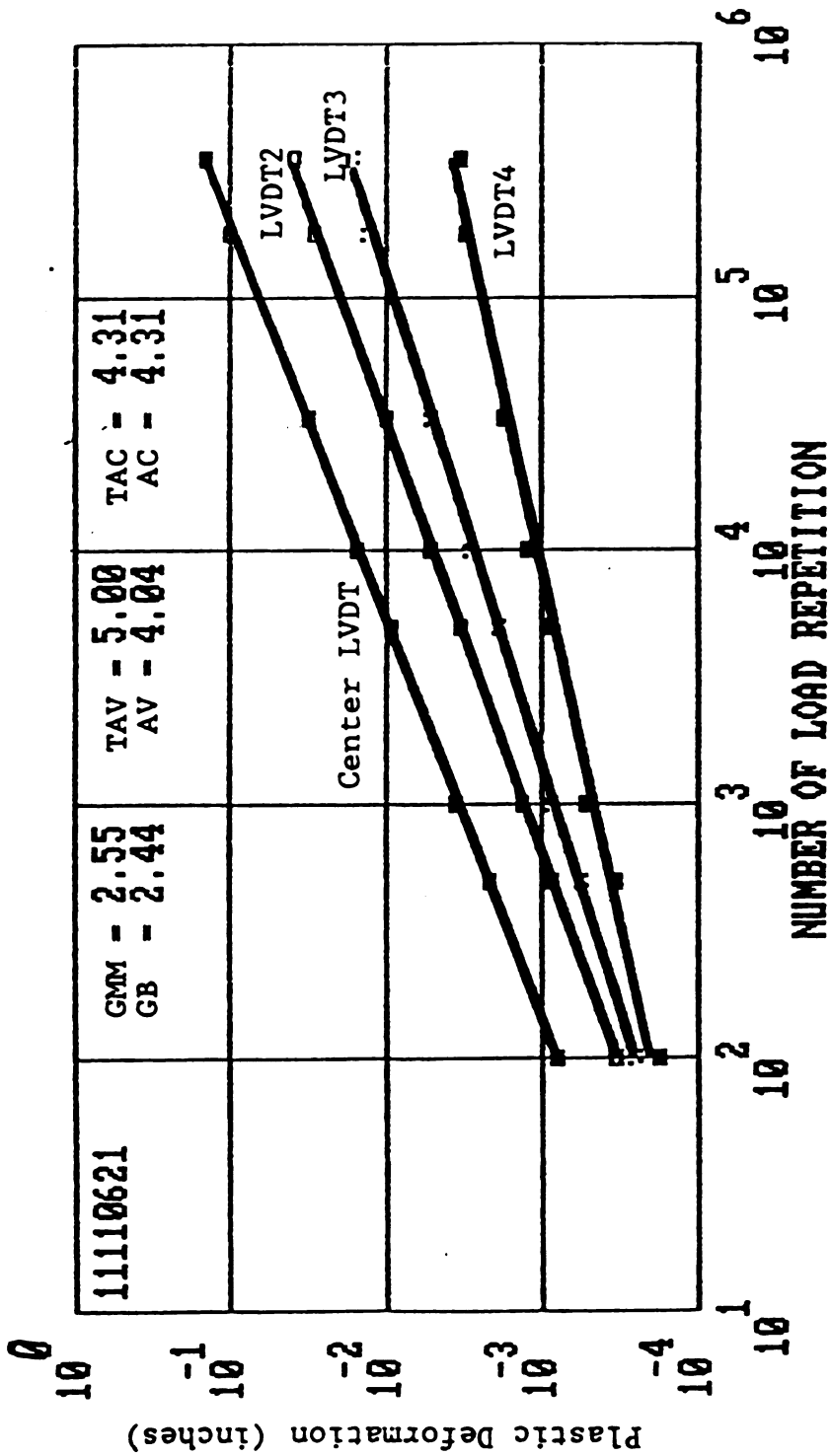



Figure 5.4 Cumulative plastic defromations at four points on the surface of the beam specimen versus the number of load applications.

Equation 5.2 represents a straight line having an intercept of $\ln I_i$ and slope of $S_i$. This equation was employed to model the data (permanent deformation) and to obtain the values of $I_i$ and $S_i$ for each specimen and for all LVDT(s).

It should be noted that the values of the slope ($S_i$) of equation 5.2 should not be interpreted as the rate of change of $CD_i$ with respect to N. This rate can be obtained by taking the first derivative of equation 5.1 with respect to N as follows:

$$(dCD_i/dN) = (I_i)\ (S_i)\ [N^{(S_i-1)}] \qquad (5.3)$$

where: $(dCD_i/dN)$ = the rate of change of the cumulative plastic deformation with respect to N; and
all else are as before.

Thus, the rate of change of $CD_i$ is dependent on the values of $S_i$, $I_i$, and N.

The values of $I_i$ and $S_i$ of equation 5.1 can be regarded as descriptors of the permanent deformation and fatigue life of the compacted asphalt mix in question. For example, higher values of $I_i$ and $S_i$ imply higher permanent deformation and perhaps shorter fatigue life of the mix. Nevertheless, the values of the parameters $I_i$ and $S_i$ along with the coefficient of determination($R^2$) and standard error for all beam specimens are tabulated in Appendix B.

The values of $I_1$ and $S_1$ for the center LVDT were used in the next step of the analysis. In this step, the values of $I_1$ and $S_1$ were first separated into nine groups relative to the independent variables as previously described in section 3.7. After grouping, the values of the slope ($S_1$) and intercept ($I_1$) of the center LVDT of all tests at 77°F were examined. It was found that:

a) The values of $S_1$ are independent of the percent air voids, the magnitude of the cyclic load and the gradation of the aggregate (see figures 5.5 and 5.6).

b) The values of $S_1$ are dependent on the kinematic viscosity of the asphalt (figure 5.7) and the aggregate angularity (figure 5.8). Increasing KV and ANG causes a decrease in the value of $S_1$.

c) The values of $I_1$ are independent of the kinematic viscosity of the asphalt, the aggregate angularity and the gradation of the aggregate (see figures 5.9 and 5.10).

d) The values of $I_1$ are dependent on both the percent air voids and the magnitude of the cyclic load as shown in figure 5.11.

For each of the curves in figure 5.11, equation 5.4 was selected to express the intercept ($I_1$) in term of the percent air voids (AV).

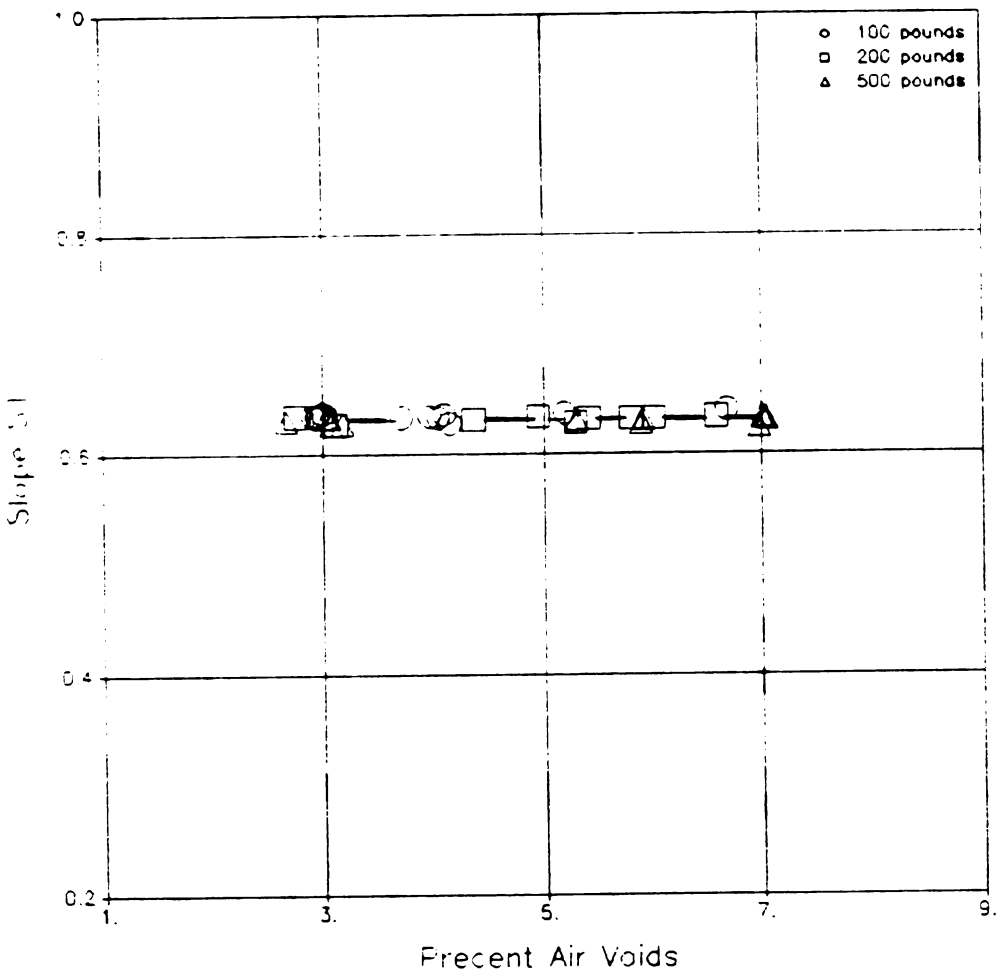



**Figure 5.5 Slope of equation 5.1 versus the percent air voids for three levels of the cyclic load and a kinematic viscosity value of 270 centistoke.**

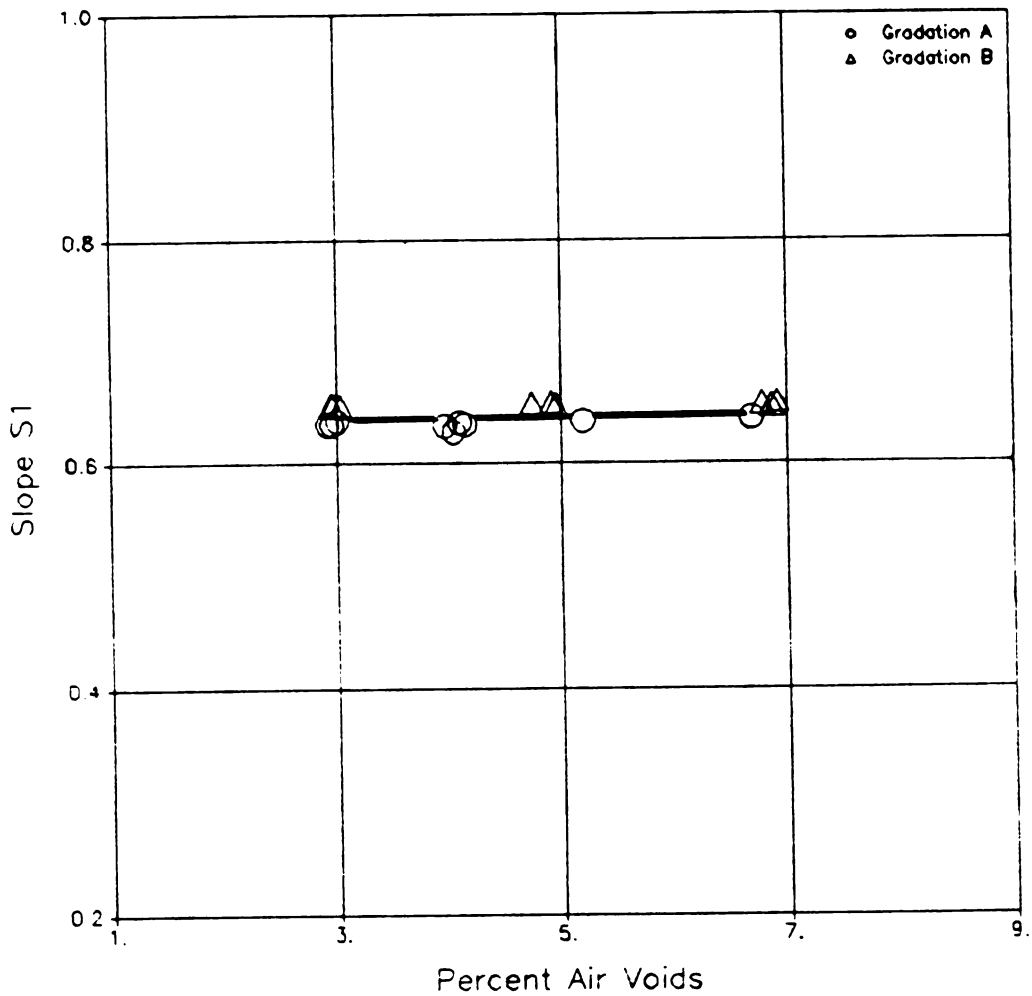



**Figure 5.6 Slope of equation 5.1 versus the percent air voids for aggregate gradations A and B.**

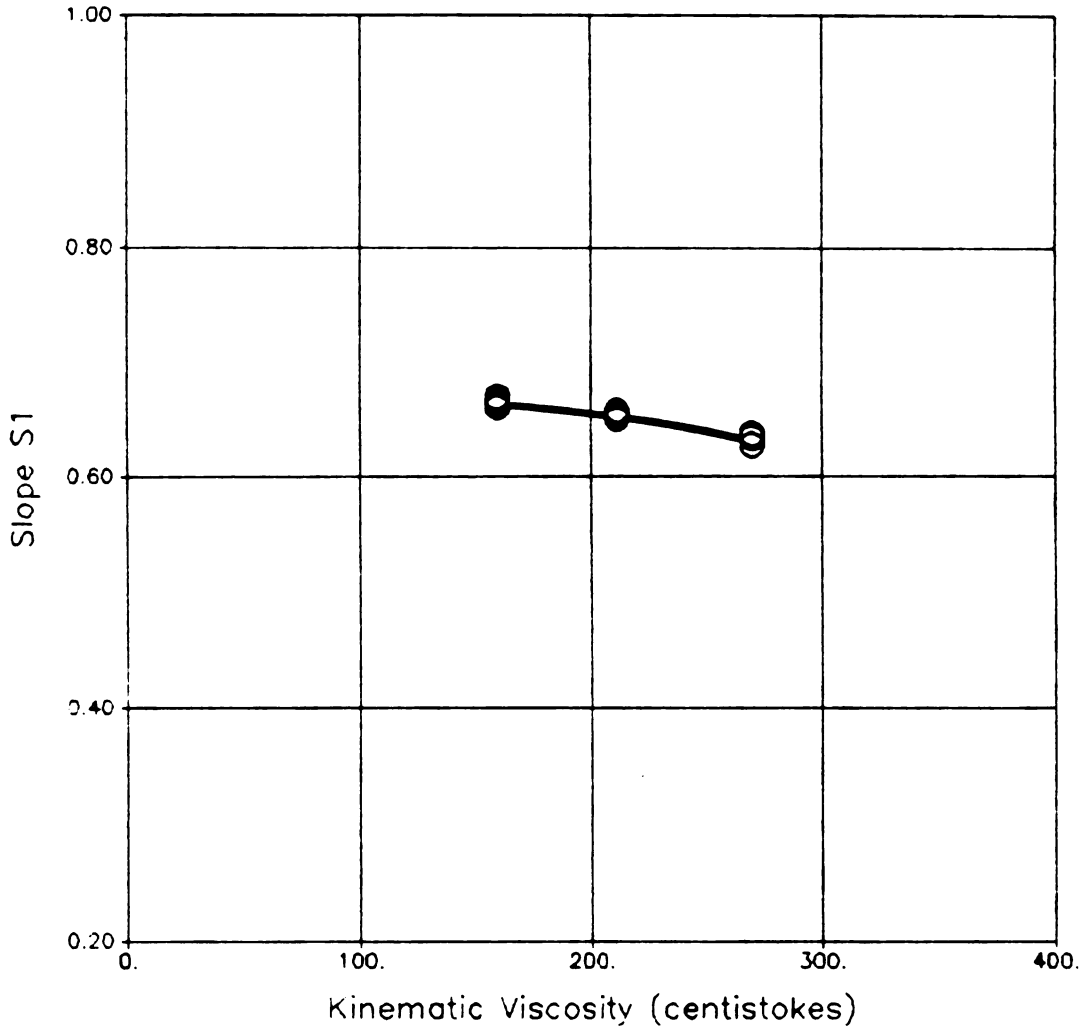



**Figure 5.7 Slope of equation 5.1 versus the kinematic viscosity of the asphalt.**

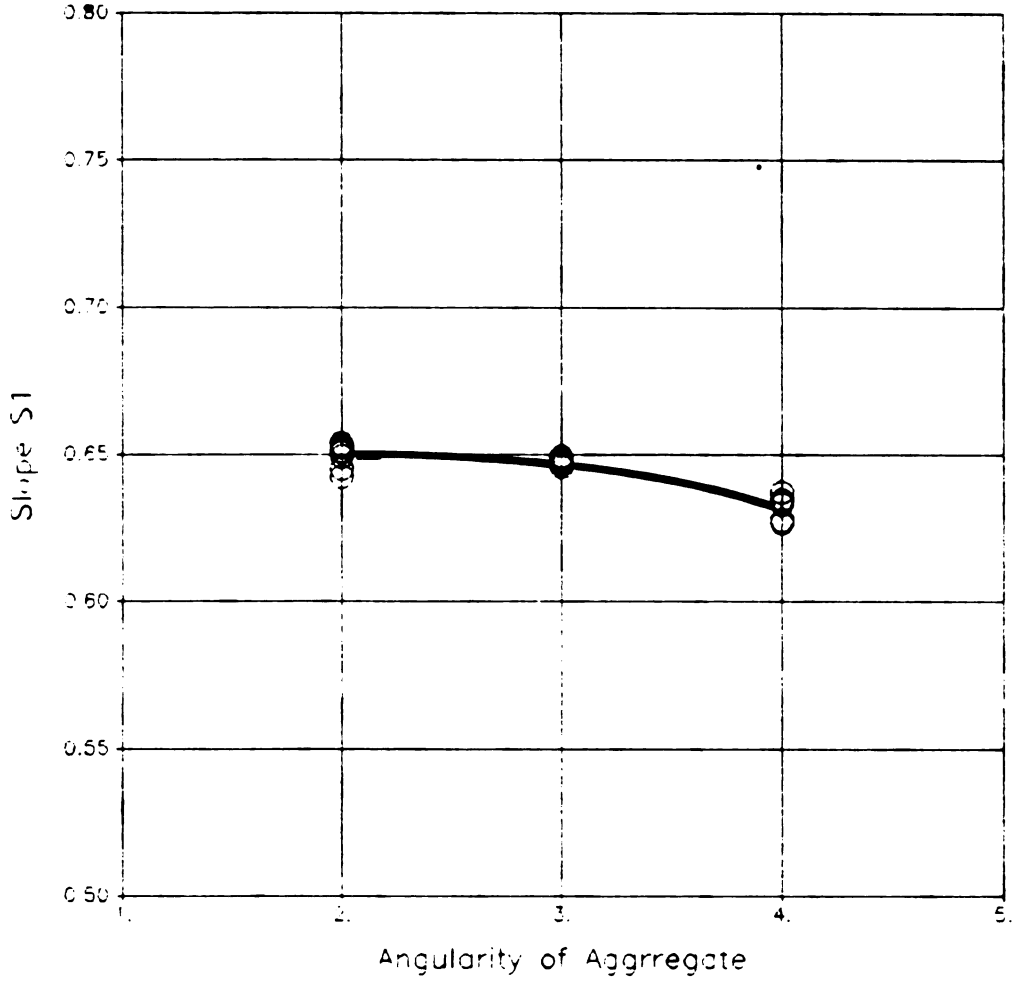



**Figure 5.8 Slope of equation 5.1 versus the angularity of aggregate.**

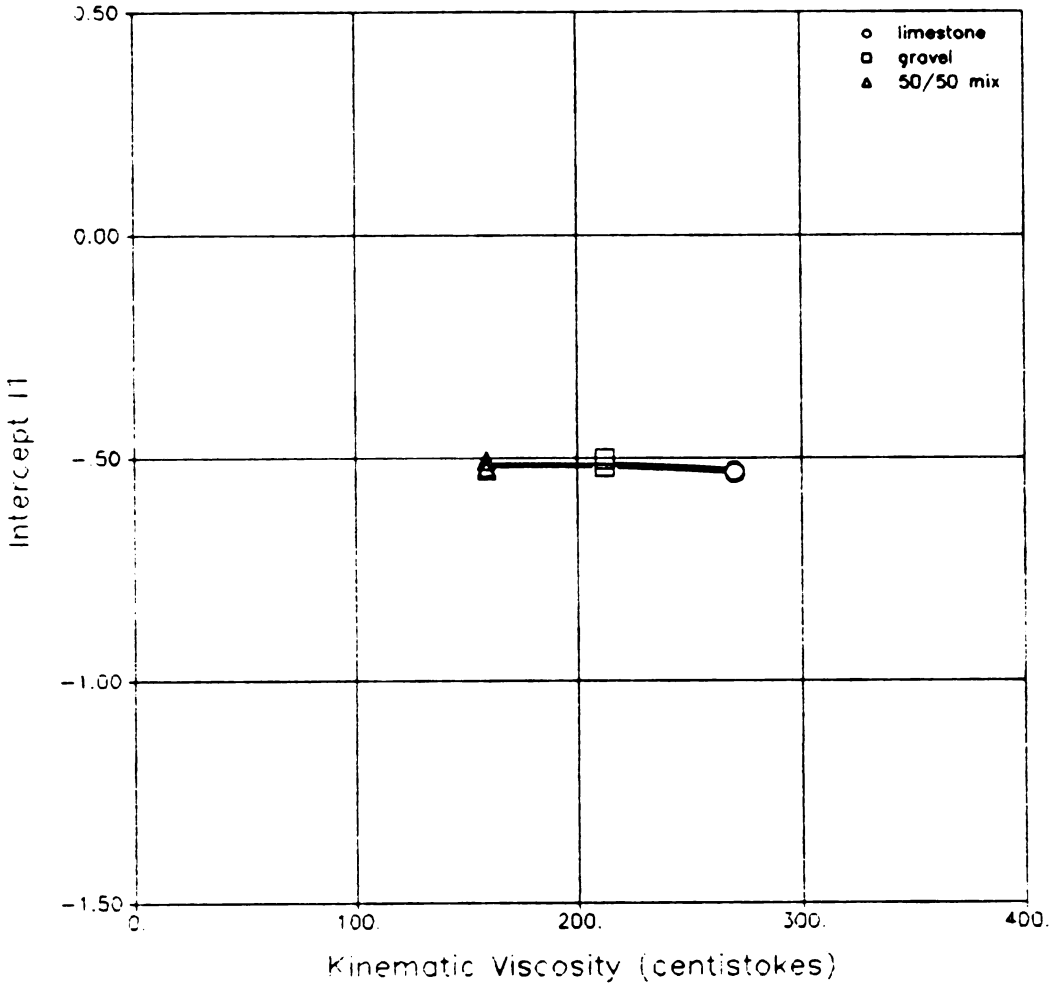



**Figure 5.9 Intercept of equation 5.1 versus the kinematic viscosity for three values of the aggregate angularity.**

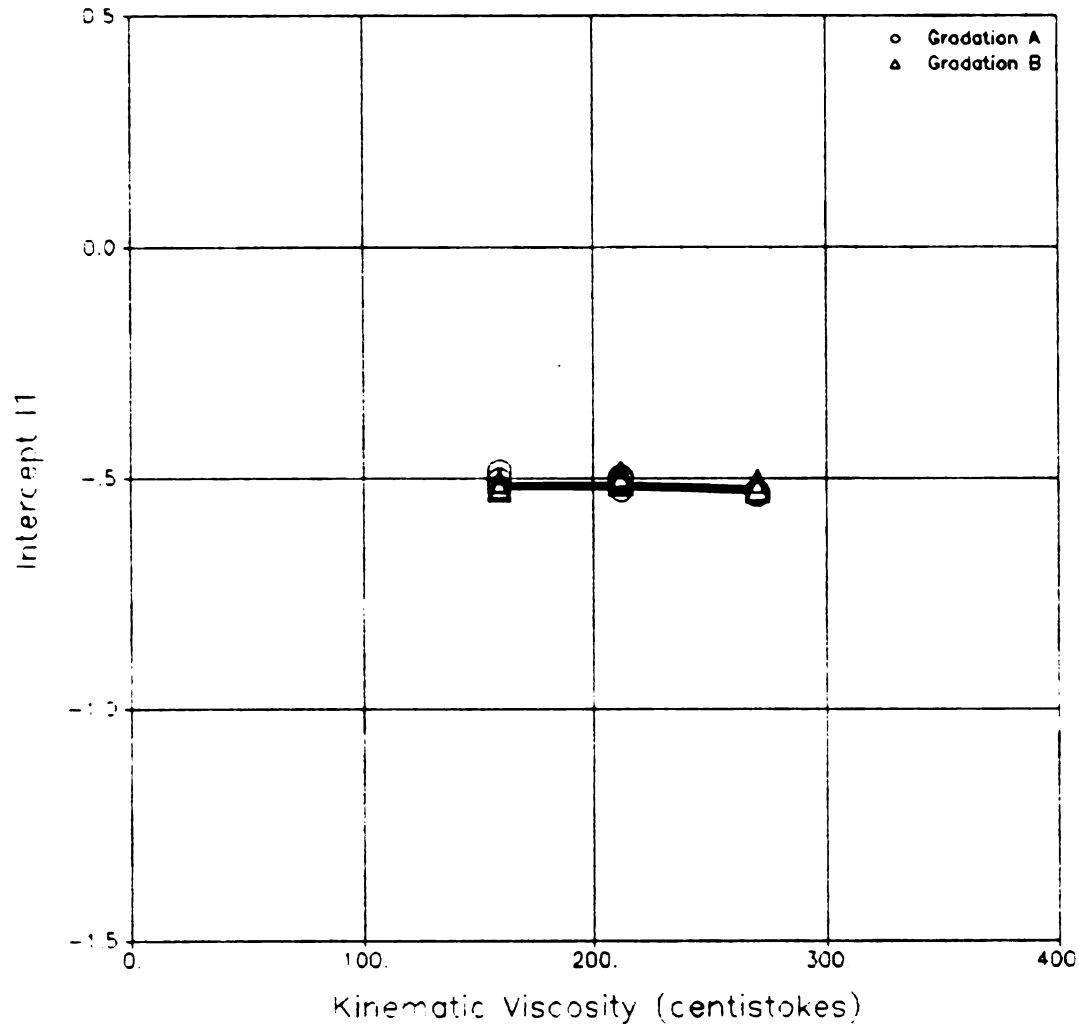



**Figure 5.10 Intercept of equation 5.1 versus the kinematic viscosity for aggregate gradations A and B.**

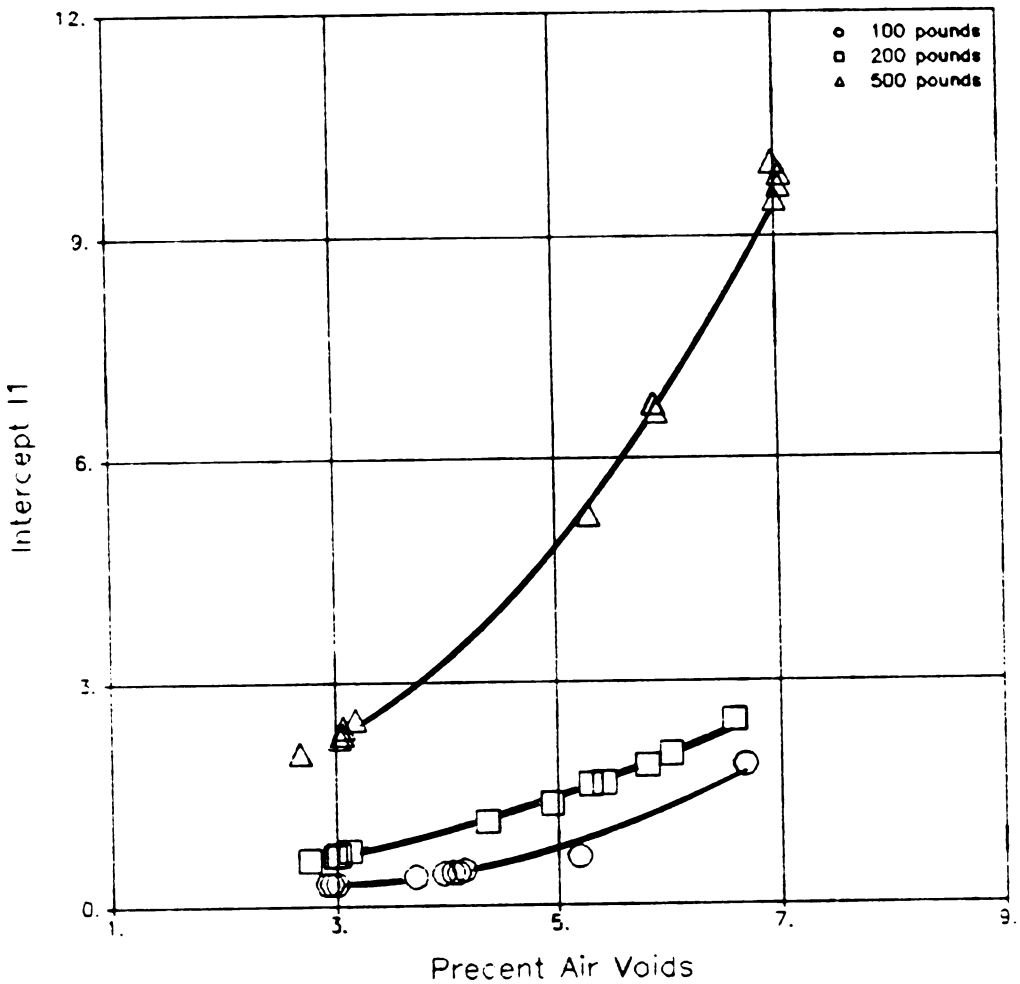



**Figure 5.11 Intercept of equation 5.1 versus the percent air voids for three levels of the cyclic load and a kinematic viscosity of 270 centistoke.**

$$\ln(I_i) = \ln(A1) + B1(AV) \qquad (5.4)$$

where: AV = percent air voids (AV = 3 to 7);

$I_i$ = intercept of equation 5.1; and

A1 and B1 are regression coefficients.

Figure 5.12 depicts the values of A1 and B1 plotted against the magnitude of the applied cyclic load. It can be noted that A1 is a function of the cyclic load while B1 is independent of the cyclic load. Next, the values of A1 were statistically correlated to the cyclic load and the resulting equation was then substituted into equation 5.4. The last step yielded an equation of the intercept $I_1$ in terms of the percent air voids and the cyclic load.

Similar steps were taken to model the effects of the other variables (kinematic viscosity, aggregate angularity, and cyclic load). Equation 5.5 represents the final regression equation which expresses the plastic deformations as a function of the specimen and test variables.

$$\ln(CD_1) = -7.378 + 2(CL)^{0.204} + 0.357(AV)$$

$$+ \{0.988 - 2.6237 \times 10^{-5}(KV)^{1.3986}\}$$

$$\times \{1.0557 - 0.01447(ANG)\} \times \ln(N) \qquad (5.5)$$

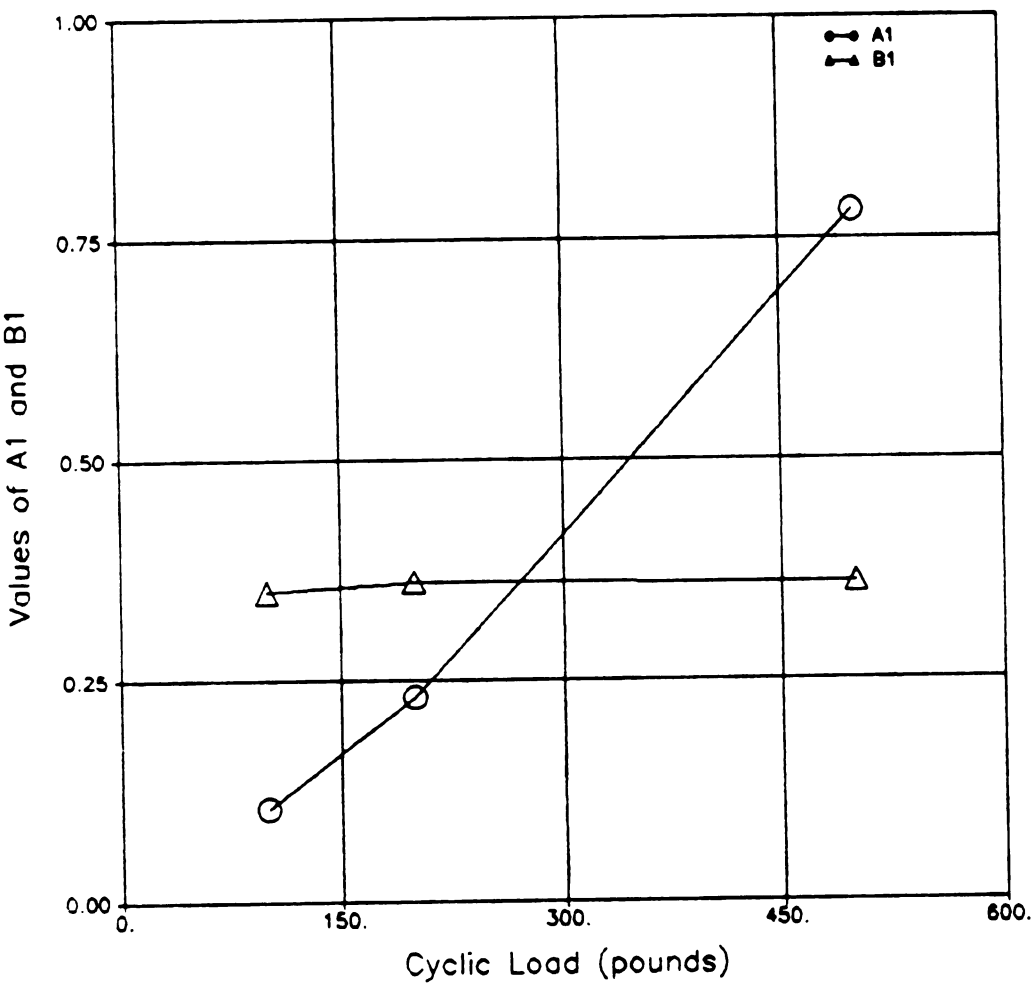



**Figure 5.12 Slope and intercept (A1 and B1) of equation 5.4 versus the applied cyclic load.**

$R^2$ = 0.98 and S.E. = 0.05

where: ln = natural logarithm;

$CD_1$ = permanent deformation at LVDT 1;

N = number of load applications;

CL = cyclic loads (pounds);

AV = percent air voids;

KV = kinematic viscosity (centistokes);

ANG = aggregate angularity;

$R^2$ = coefficient of determination; and

SE = standard error.

The advantage of the above procedure is that the effects of each variable can be analyzed separately. The disadvantages however are that: a) the interaction between the variables cannot be assessed due to the nature of the procedure; and b) the final equation was of second and third order. Since the objective herein is to obtain a simple procedure not a complicated mathematical equation, it was concluded that the analysis method which yields the simplest, yet accurate, equation be employed. Consequently, two other statistical methods were considered.

In spite of the above noted disadvantages of this procedure, several conclusions can be drawn from the analysis. These are:

a) The arithmetic or logarithmic values of the increment of the plastic deformation due to the first load

application are functions of the percent air voids and the magnitude of applied cyclic load.

b) The difference in the logarithmic (not arithmetic) values of the plastic deformation between any subsequent cycles is dependent on the aggregate angularity and the kinematic viscosity of the asphalt.

These findings, in part, support those reported by Allen and Deen (16). The implications of these findings (assuming that the laboratory behavior of compacted asphalt mixes is similar to that in the field) are:

a) In the field, the increment of the plastic deformation at a point on the surface of the pavement caused by the first vehicle of each type of vehicle (e.g., trucks, semi, cars) trafficking that pavement should be independently measured.

b) The equivalent value of S for any pavement section can be obtained by knowing the number of load applications (N) and by measuring the plastic deformations (rut depth) at any two points in time.

c) The equivalent value of the slope (S) is the same for any one pavement section trafficked by trucks, automobiles, or any mixed traffic.

d) The damage delivered to a pavement section by different type of vehicles can be assessed by knowing the plastic deformation caused by the first vehicle of each type of vehicle trafficking that

pavement section (item a) and the value of S (item b). The cumulative damage due to any number of passages is related to the magnitude of CD which can be estimated using equation 5.5. If the value of I is not measured prior to opening the pavement section to mixed traffic then the assessment of the damage due to different vehicular types becomes very tedious and involved.

### 5.4.2 GENERAL EQUATION

In this procedure, unlike the separation of variables, the entire data base is utilized to correlate the dependent and all independent variables based on a user specified equation form. The outcome of the analysis includes a tabulation of the regression coefficient(s) for each independent variable, and the coefficients of determination and standard error of the entire equation. The disadvantages of this method are:

a) Separate analysis of the resulting equation should be conducted to determine the most significant variable.
b) All variables, important or not, are included in the correlation equation.

Item b above implies that the user of the computer program should possess prior knowledge, and/or estimate, of the variables that affect the test results. Further, the inclusion of one or more variables in the equation may or

may not mean that the variable(s) do affect the test results. It may simply mean that the two sets of number are statistically related and the physical meaning of the resulting equation still needs to be examined. Nevertheless, the method, in general, yielded an equation very similar to that obtained in another method "Stepwise Correlations" except that the order of the variables in the resulting equations were different. In the general equation method, the order of the variables were the same as those dictated by the user. The variables in the resulting equation from the stepwise correlation were listed in their order of significance. This last procedure is presented in the next section.

### 5.4.3 STEPWISE CORRELATIONS

In this procedure, first, all available data (e.g. permanent deformation) and the corresponding identified variables were first entered into the memory of a microcomputer. The dependent and independent variables were then correlated using a multivariate regression program (SPSS/PC+). Unlike the general equation method, the independent variables are separately entered in several steps. In the first step, the first variable considered for entry into the equation is the one with the largest positive or negative correlation with the dependent variable. An F test is then conducted for the null hypothesis that the

coefficient of the entered variable is 0. To evaluate whether this variable (and each succeeding variable) should be used, the F value is compared to an established criterion (minimum value of 3.84). If the variable fails to meet this criterion, the procedure terminates with no independent variables in the equation. If it passes the criterion, the second variable is selected based on the highest partial correlation. If it passes the entry criterion, it also enters the equation. After each step of entering a variable, the variables already in the equation are examined for removal based on the removal criterion (minimum value of F statistic of 2.71). Again, from each step, a new regression matrix (regression coefficients and the coefficients of determination and standard error) was obtained. Variables that did not have a significant level higher than 0.05 percent relative to the previous variable were not included in the final equation. The advantages of this method are:

- In each step, the variables in the equation are listed in the order of their significance and a regression matrix was produced.
- The interaction between variables can be assessed by comparing the values of the regression constants from two consecutive regressions and partial correlation matrices.
- The method produced the simplest possible, yet

accurate, equation.

Like the general equation method and any other statistical analyses, the physical meaning of the resulting correlation equation still has to be assessed by the user. Further, a sensitivity analysis of the final equation has to be conducted to assess the rate of change of the values of the dependent variable due to changes in the values of each independent variable with all others held constant.

Due to the above stated advantages, this method was employed for the statistical analysis of all test results. It should be noted that during the analysis several transformation forms (logarithmic, semi-logarithmic, and arithmetic) were employed for the dependent and each of the independent variables. The final selection of the transformation form was based upon:

- Physical interpretations of the test results.
- Simplicity of the resulting equation.
- High value of the coefficient of determination ($R^2$) of the resulting equation.
- Examination of the residuals in order to satisfy the assumptions of the linear regression (independency, constant variance, and normality of residuals).

It should also be noted that the selection of the final form of the dependent variable based only on the value of $R^2$ may be misleading. Variations in the logarithmic values of any variable are naturally less than those of the arithmetic

values.

Nevertheless, the analysis and discussion of the test results are presented in the following section.

## 5.5 ANALYSIS OF PERMANENT DEFORMATION

The measured plastic deformations at the center of each beam specimen were correlated to the test, mix, and specimen variables using a stepwise linear multivariate regression program SPSS/PC$^+$ (77). The resulting regression matrices for beam specimens tested at 77$^o$F and those at 40$^o$F are listed in tables 5.1 and 5.2, respectively. Equations 5.6 and 5.7 are the corresponding regression equations.

For 77$^o$F:

$$\ln(CD_1) = -7.145 + 0.6481 \times \ln(N) + 1.250 \times \ln(CL) + 0.3618 \times AV - 0.002578 \times KV - 0.08064 \times ANG \quad (5.6)$$

$R^2 = 0.99$ and SE = 0.07

where: all variables are as before.

For 40$^o$F:

$$\ln(CD_1) = -1.04940 + 0.2970 \times \ln(N) + 0.3854 \times AV + 0.2855 \times \ln(CL) - 0.001270 \times KV - 0.02137 \times ANG \quad (5.7)$$

Table 5.1. Regression matrix for the cumulative plastic deformations under the loaded area, flexural beam tests at 77 °F.

| plastic deformation, CD1 | Intercept | Regression coefficients of the independent variables | | | | | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|
| | | ln(N) ($10^{-1}$) | ln(CL) | (AV) ($10^{-1}$) | (KV) ($10^{-3}$) | (ANG) ($10^{-2}$) | | |
| | 0.822 | 6.026 | - | - | - | - | 0.63 | 1.03 |
| | -6.310 | 6.341 | 1.281 | - | - | - | 0.88 | 0.60 |
| ln(CD1) | -8.006 | 6.465 | 1.242 | 3.665 | - | - | 0.99 | 0.14 |
| | -7.426 | 6.474 | 1.246 | 3.637 | -2.445 | - | 0.99 | 0.10 |
| | -7.145 | 6.481 | 1.250 | 3.618 | -2.578 | -8.064 | 0.99 | 0.07 |

ln = natural log;
CD1 = plastic deformation (inches x$10^{-4}$);
N = number of load applications;
CL = cyclic loads (100, 200 and 500 lbs);
AV = percent air voids;
KV = kinematic viscosity (centistokes);
ANG = aggregate angularity;
$R^2$ = coefficient of correlation; and
SE = standard error.

**Table 5.2. Regression matrix for the cumulative plastic deformations under the loaded area, flexural beam tests at 40 °F.**

| plastic deformation, CD1 | Intercept | Regression coefficients of the independent variables | | | | | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|
| | | ln(N) | (AV) | ln(CL) | (KV) | (ANG) | | |
| | | ($10^{-1}$) | ($10^{-1}$) | ($10^{-1}$) | ($10^{-3}$) | ($10^{-2}$) | | |
| | 1.6967 | 2.938 | - | - | - | - | 0.82 | 0.40 |
| | 0.2689 | 2.945 | 3.463 | - | - | - | 0.95 | 0.20 |
| ln(CD1) | -1.3570 | 2.970 | 3.667 | 2.868 | - | - | 0.99 | 0.07 |
| | -1.1891 | 2.970 | 3.998 | 2.863 | -1.245 | - | 0.99 | 0.05 |
| | -1.0494 | 2.970 | 3.854 | 2.855 | -1.270 | -2.137 | 0.99 | 0.05 |

ln = natural log;
CD1 = plastic deformation (inches x$10^{-4}$);
N = number of load applications;
CL = cyclic loads (100, 200 and 500 lbs);
AV = percent air voids;
KV = kinematic viscosity (centistokes);
ANG = aggregate angularity;
$R^2$ = coefficient of correlation; and
SE = standard error.

$R^2$ = 0.99 and SE = 0.05

where: all variables are as before.

It should be noted that the variables in tables 5.1 and 5.2, and in equations 5.6 and 5.7 are listed in their order of significance.

The sensitivity of the arithmetic (not logarithmic) values of $CD_1$ of equations 5.6 and 5.7 was determined. It was found that:

a) N is the most significant variable affecting $CD_1$ at 77 and 40°F. Increasing N from 1 to 100,000 cycles causes an increase in the arithmetic value of $CD_1$ by a factor of 1735 at 77°F and by a factor of 30 at 40°F.

b) CL is the second-most significant variable affecting the values of $CD_1$ at 77°F, and the third-most significant at 40°F. Increasing CL from 100 to 500 pounds causes an increase in $CD_1$ at 77°F by a factor of 7.5 and at 40°F by a factor of 1.6.

c) The effect of AV on $CD_1$ at 77°F is slightly lower than that at 40°F. Increasing AV from three to seven results in increasing $CD_1$ by factors of 4.3 and 4.7 at 77 and 40°F, respectively.

d) The effect of KV on $CD_1$ at 77°F is higher than that at 40°F. Increasing KV from 159 to 270 centistokes causes a decrease in $CD_1$ by factors of 0.75 and 0.87

at 77 and 40°F, respectively.

e) The effects of aggregate angularity on $CD_1$ at 77°F is also higher than that at 40°F. Using angular (crushed) aggregates instead of rounded ones results in a decrease in the value of $CD_1$ by factors of 0.91 and 0.97 at 77 and 40°F, respectively.

It should be noted that the gradation term, which has only two levels, is eliminated for both equations 5.6 and 5.7 during the stepwise procedure because of its insignificant effects on the results of permanent deformation. This finding is consistent with that reported by Kalcheff, et. al. (46).

The above observations imply that plastic deformation (rut potential) of compacted asphalt mixes is a function of the number of cycle, the magnitude of applied cyclic load, the percent air voids, the kinematic viscosity of asphalt, and the aggregate angularity and it can be reduced by using a lower percent air voids in the mix and a higher viscosity graded asphalt. Further, heavy vehicles cause higher rut potential (item b) and, from equations 5.6 and 5.7, it can be also noted that a lower temperature results in less rutting. These test temperature effects on the permanent deformation are also reported in the literature (40, 42, 45, 47, 50, 53, 55, 73, 76, 78, 79, 83, 86).

It should be noted that the values of the coefficient of determination of equations 5.6 and 5.7 are artificially high

because they relate to the correlation between the logarithmic values of the dependent and independent variables. Variations in the arithmetic values are much higher. This point can be illustrated by considering the regression matrix in table 5.1. The value of the coefficient of determination ($R^2$) in the third step of the analysis (in which $CD_1$ is correlated to N, CL, and AV) is 0.99. This value of $R^2$ may incorrectly indicate that the other two variables (KV and ANG) have no significant effects on $CD_1$. Arithmetic values of $CD_1$ estimated using the third step of table 5.1 varied by as much as thirty-two percent from the measured values. It is clear that a value of $R^2$ of 0.99 does not reflect this variation.

The accuracy of equations 5.6 and 5.7 was examined relative to the measured values of $CD_1$. It was found that the maximum differences between the arithmetic values of $CD_1$ estimated using equations 5.6 and 5.7 and the measured values are 7 and 9 percent, respectively.

After determining equations 5.6 and 5.7, the test results at 77 and 40$^{o}$F were combined in one analysis which included the test temperature as one of the independent variables. In this analysis, it was assumed that a semi-logarithmic relationship exists between CD1 and the test temperatures. This assumption was necessary because only two values (77 and 40$^{o}$) of the test temperature were used in this study. Table 5.3 summarizes the resulting regression

matrix of this analysis. Equation 5.8 is the corresponding equation.

$$\ln(CD_1) = -8.543 + 0.5459 \times \ln(N) + 0.04110 \times TT + 1.0399 \times \ln(CL) + 0.3650 \times AV - 0.001950 \times KV - 0.07417 \times ANG \quad (5.8)$$

$R^2 = 0.93$ and $SE = 0.45$

where: TT = test temperature;and

all variables are as before.

It can be noted that the disadvantage of this analysis is the loss of accuracy of the equation relative to equations 5.6 and 5.7. The reason for this is that the effects of the test and specimen variables (AV, CL, KV, and ANG) are also dependent on the test temperature. These effects can only be modeled by using a complex nonlinear transformation which is not practical. Nevertheless, the maximum arithmetic difference between the estimated values of $CD_1$ using equation 5.8 and the measured values were 30 percent for the $77^{o}F$ tests and 45 percent for the $40^{o}F$ tests. These differences were only 7 and 9 percent for equations 5.6 and 5.7, respectively. Hence, it is concluded herein that equations 5.6 and 5.7 are more reliable than equation 5.8 and therefore they were used to study variations of the values of $CD_1$ due to variations in the values of the

**Table 5.3 Regression matrix for the cumulative plastic deformations under the loaded area, flexural beam tests at 77 and 40 °F.**

| plastic deformation, CD1 | Intercept | Regression coefficients of the independent variables | | | | | | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|---|
| | | ln(N) | TT | ln(CL) | (AV) | (KV) | (ANG) | | |
| | | ($10^{-1}$) | ($10^{-2}$) | | ($10^{-1}$) | ($10^{-3}$) | ($10^{-2}$) | | |
| | 1.597 | 4.638 | - | - | - | - | - | 0.45 | 1.23 |
| | -2.324 | 5.145 | 5.017 | - | - | - | - | 0.64 | 0.99 |
| ln(CD1) | -8.058 | 5.356 | 4.873 | 1.057 | - | - | - | 0.82 | 0.71 |
| | -9.232 | 5.451 | 4.088 | 1.036 | 3.684 | - | - | 0.92 | 0.46 |
| | -8.839 | 5.455 | 4.096 | 1.036 | 3.708 | -1.705 | - | 0.93 | 0.45 |
| | -8.543 | 5.459 | 4.110 | 1.040 | 3.650 | -1.950 | -7.417 | 0.93 | 0.45 |

ln = natural log;
CD1 = plastic deformation (inches x$10^{-4}$);
N = number of load applications;
TT = test temperature (°F);
CL = cyclic loads (100, 200 and 500 lbs);
AV = percent air voids;
KV = kinematic viscosity (centistokes);
ANG = aggregate angularity;
$R^2$ = coefficient of correlation; and
SE = standard error.

independent variables. Similar equations were also obtained for plastic deformations measured at different lateral distances from the edge of the loaded areas (CD2, CD3, and CD4). It was noted, however, that expressing these measurements (CD2, CD3, and CD4) in terms of $CD_1$ and the lateral distance from the edge of the loaded area would provide a better understanding of the plastic shape (basin) of the beam specimens. It should be noted that the plastic basin of the beam specimen is analogous to the shape of the rut channel of a pavement section. The analysis of the plastic basin is presented in the next section.

## 5.6 ANALYSIS OF PERMANENT DEFORMATION USING DEFLECTION BASIN

The plastic basin of each beam specimen was modeled using the following equation:

$$CD(X) = (CD_1)(EXP(A \times X^B)) \quad (5.9)$$

where: CD(X) = cumulative plastic deformation of a point on the surface of the beam located at distance x from the edge of the loaded area;

X = lateral distance from the edge of the loaded area, (X=2, 4, and 6.06 inch);

EXP = exponential function;

A and B = parameters of the plastic basin; and

all else are as before.

The A and B parameters of equation 5.9 may be regarded as descriptors of the distribution of plastic deflection from the edge of the loaded area. For example, if B is equal to two, equation 5.9 resembles the normal distribution with A being proportional to the variance. Thus, as might be expected, changes in the values of A and B of a beam specimen (or in this sense, of a pavement section) reflect changes in the distribution of the plastic deflections (shape of the rut depth or the shape of the plastic deflection basin) and consequently, the distribution of the damage (distress) delivered to that specimen or pavement section. Further, the shape of the plastic deflection basin can be generally defined by its width (extent of lateral spread from the edge of the loaded area) and its depth. The width of the basin (the lateral spread) may be thought of as a measure of the stored energy and its lateral attenuation in the beam. For example, narrower and deeper basins indicate concentration of energy in the vicinity of the loaded area. These observations gave rise to the use of the A and B parameters as indicators of the beam performance under the load.

For each beam and for different number of load applications, closed form solutions of equation 5.9 were obtained and the values of the parameters A and B were

calculated. These values, for all beam specimens, are tabulated in Appendix C. It should be noted that each solution was based on the measured values of $CD_1$, $CD_2$, and $CD_3$ and their corresponding lateral distances of 0.-, 2.-, and 4.-in, respectively. The values of $CD_4$ were not used because, at low number of load applications, these values were small and in the range of the accuracy of the LVDT. The values of the parameters A and B were then statistically correlated to the number of load applications and to the test, mix and specimen variables. The regression matrices for A and B at $77^{o}F$ are summarized in tables 5.4 and 5.5, respectively. The regression matrices for A and B at $40^{o}F$ are summarized in tables 5.6 and 5.7, respectively. Equations 5.10 through 5.13 are the corresponding equations.

For $77^{o}F$:

$$A = -0.3298 - 0.07093 \times AV - 0.009660 \times \ln(N) - 0.00004082 \times CL + 0.004319 \times \ln(KV) \quad (5.10)$$

$R^2 = 0.99$, and SE = 0.06

$$B = 0.2650 + 0.04041 \times \ln(N) + 0.0002969 \times CL - 0.0001458 \times KV + 0.001756 \times AV - 0.0005330 \times ANG \quad (5.11)$$

Table 5.4 Regression matrix for the parameter A of the plastic deflection basin of the surface of the beam at 77 °F.

| parameter A | Intercept | Regression coefficients of the independent variables | | | | | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|
| | | AV | ln(N) | CL | ln(KV) | ANG | | |
| | $(10^{-1})$ | $(10^{-2})$ | $(10^{-3})$ | $(10^{-5})$ | $(10^{-3})$ | | | |
| | -3.980 | -7.038 | - | - | - | - | 0.96 | 0.02 |
| A | -3.182 | -7.111 | -9.390 | - | - | - | 0.99 | 0.01 |
| | -3.061 | -7.095 | -9.651 | -4.065 | - | - | 0.99 | 0.06 |
| | -3.298 | -7.093 | -9.660 | -4.082 | 4.319 | - | 0.99 | 0.06 |

Table 5.5 Regression matrix for the parameter B of the plastic deflection basin of the surface of the beam at 77 °F.

| parameter B | Intercept | Regression coefficients of the independent variables | | | | | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|
| | | ln(N) | CL | KV | AV | ANG | | |
| | $(10^{-1})$ | $(10^{-2})$ | $(10^{-4})$ | $(10^{-4})$ | $(10^{-3})$ | $(10^{-4})$ | | |
| | 3.332 | 3.833 | - | - | - | - | 0.74 | 0.05 |
| B | 2.375 | 4.028 | 2.963 | - | - | - | 0.99 | 0.10 |
| | 2.728 | 4.034 | 2.974 | -1.476 | - | - | 0.99 | 0.07 |
| | 2.631 | 4.041 | 2.968 | -1.450 | 1.766 | - | 0.99 | 0.06 |
| | 2.650 | 4.041 | 2.969 | -1.458 | 1.756 | -5.330 | 0.99 | 0.06 |

ln = natural log;
CD1 = plastic deformation (inches x$10^{-4}$);
N = number of load applications;
CL = cyclic loads (100, 200 and 500 lbs);
AV = percent air voids;
KV = kinematic viscosity (centistokes);
ANG = aggregate angularity;
$R^2$ = coefficient of correlation; and
SE = standard error.

Table 5.6 Regression matrix for the parameter A of the plastic deflection basin of the surface of the beam at 40 °F.

| parameter A | Intercept | Regression coefficients of the independent variables | | | | | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|
| | | ANG ($10^{-1}$) | ln(N) ($10^{-2}$) | ln(KV) ($10^{-1}$) | AV ($10^{-1}$) | CL | | |
| | -1.779 | 3.0437 | - | - | - | - | 0.18 | 0.56 |
| A | -1.096 | 3.584 | -8.785 | - | - | - | 0.33 | 0.50 |
| | -5.336 | 4.720 | -8.811 | 7.113 | - | - | 0.38 | 0.49 |
| | -4.973 | 2.806 | -10.193 | 9.890 | -2.678 | - | 0.42 | 0.47 |

Table 5.7 Regression matrix for the parameter B of the plastic deflection basin of the surface of the beam at 40 °F.

| parameter B | Intercept | Regression coefficients of the independent variables | | | | | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|
| | | ANG ($10^{-1}$) | CL ($10^{-4}$) | AV ($10^{-1}$) | ln(KV) | ln(N) | | |
| | -0.041 | 1.723 | - | - | - | - | 0.03 | 0.79 |
| B | 0.164 | 1.805 | -9.033 | - | - | - | 0.07 | 0.77 |
| | -1.366 | 3.760 | -9.102 | 2.144 | - | - | 0.09 | 0.77 |

ln = natural log;
CD1 = plastic deformation (inches x$10^{-4}$);
N = number of load applications;
CL = cyclic loads (100, 200 and 500 lbs);
AV = percent air voids;
KV = kinematic viscosity (centistokes);
ANG = aggregate angularity;
$R^2$ = coefficient of correlation; and
SE = standard error.

$R^2$ = 0.99, and SE = 0.06

For $40^{o}F$:

$$A = -4.973 + 0.2806 \times ANG - 0.10193 \times \ln(N) + 0.9890 \times \ln(KV) - 0.2678 \times CL \quad (5.12)$$

$R^2$ = 0.42, and SE = 0.47

$$B = -1.366 + 0.3760 \times ANG - 0.0009102 \times CL + 0.2144 \times AV \quad (5.13)$$

$R^2$ = 0.09, and SE = 0.77

where: all variables are as before.

Examinations of the values of the regression coefficients and the coefficient of determinations of equations 5.10 through 5.13 indicated that:

- There is little or no correlation between the values of A and B at $40^{o}F$ and the specimen and test variables. The values of A and B seem to be random and inconsistent. The reason for this is that, for most

tests at 40°F, the values of the measured plastic deformation under the center of the loaded area were very small and those of $CD_2$ and $CD_3$ were within the accuracy of the LVDT(s) (0.0001-in. ). Plastic deformations of beam specimens tested using 100, or 200 pounds cyclic load were less than 0.0004-in under the point of load application and less than 0.0001-in at a point 4-in away.

- The shape of the plastic deflection basin at 77°F changes with increasing number of load applications. At the start of the test, the basin is shallow and flat; it gets deeper and steeper as the number of load applications increases (see figure 4.4.)
- The effect of N on the values of B at 77°F is higher and opposite to its effect on A. Increasing N from 1 to 100,000 cycles causes a decrease in the value of A by 0.1112, and an increase in the value of B by 0.4652.
- At 77°F, the effects of AV and KV on the values of the parameter A are higher than those on B. Indeed, AV is the most significant variable affecting A while it is the fourth-most significant for B.
- Increasing the values of AV and CL cause deeper and steeper deflection basins.
- Increasing the values of KV and ANG result in shallower and flatter deflection basins.

The significance of the above observations and the values of the parameters A and B can be illustrated with the aid of figure 5.13. The figure shows schematic representation of typical plastic deflection basins with corresponding relative values of the number of load applications (N) and the relative values of the A and B parameters. It can be seen that higher values of N cause higher values of the B parameter, smaller values of the A parameter, and deeper basins. Implicit in this is that a higher N causes a more rapid lateral attenuation of energy, and a deeper plastic deflection basin. Thus, at the higher number of load applications, more work is done to the beam in the vicinity of the loaded area. Consequently, greater distress might be expected to occur with fewer number of load applications. Visual observations of beam specimens subjected to cyclic loading tend to confirm this. Specimens which showed smaller values of A and higher values of B failed at a fewer number of load applications. The reason for this is that, for the same value of $CD_1$, a steeper plastic deflection basin implies a higher tensile plastic strain. The higher the cumulative tensile plastic strain, the closer the beam approaches fatigue failure. Indeed, during the tests at $77^{o}F$, it was noticed that hair-size cracks were initiated when the value of $CD_2$ is about 30 percent of $CD_1$ or when the value of $CD_1$ approaches 0.45 inches. These values were 7 percent and 0.1-in for the $40^{o}F$ tests. Shortly thereafter,

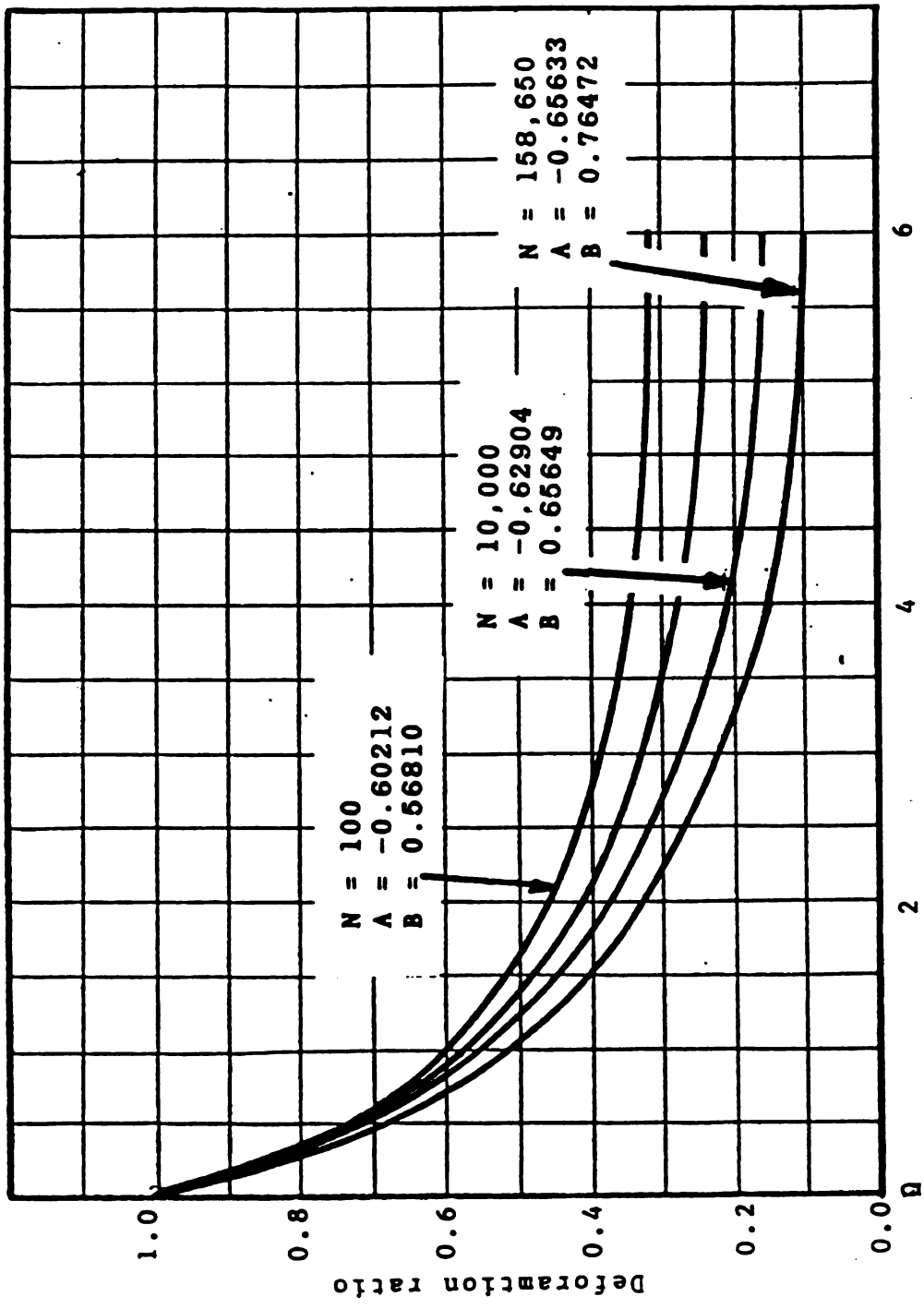



Figure 5.13 Schematic representation of the plastic deflection basin of the beam specimen at 77°F and for different number of load applications.

the beam failed. The definition of the fatigue life of the beam specimens presented in section 5.6 was based upon these observations. It should be noted that the values of 30 and 7 percent are just approximate values based upon visual observations. For example, the thirty percent value could be a function of the mix variables such as KV, AV and others. Indeed, the only difference between tests conducted at 40°F and 77°F is the kinematic viscosity of the asphalt bitumen. This scenario indicates that lower viscosity asphalts yield smaller values for the ratio $CD_2/CD_1$. The functional relationship between the viscosity of the asphalt and the value of the deflection ratio however, could not be determined in this study.

The above scenario implies that the fatigue life of the beam specimen can be estimated using either equations 5.6 and 5.7 or equations 5.9, 5.10 and 5.11. Eventually, only one fatigue life will be estimated, the one that corresponds to the smallest of the number of load applications obtained from equations 5.6 and 5.7 or equations 5.9, 5.10, and 5.11. Equations 5.12 and 5.13 were not used because of their poor accuracy. The procedures to estimate the fatigue life are explained in the following section.

## 5.7 FATIGUE LIFE

Traditionally, stress- or strain- controlled flexural tests are conducted using simply supported beams flexed in

one or two directions. Beam theory is then used to calculate the stiffness of the beam assuming that the neutral axis of the beam (the axis along which the strain is zero) is located at mid-height of the beam. In addition, fatigue life is defined by the number of load applications at which the stiffness of the beam decreases to half of its original value (26). In this study, beam specimens were continuously supported during the tests by a rubber pad which was rested on a steel block. This boundary condition was thought to better reflect field conditions than simply supported beams. During early tests, however, it was noticed that the neutral axis of the continuously supported beam was closer to the top of the beam. This implies that the asphalt mix behavior in tension is different than that in compression. Further, the deflected shape of the continuously supported beam (shown in figure 5.14) was similar to the shape of the deflected pavement under actual traffic loading. These two observations gave rise to a new problem. That is, the use of the traditional beam theory to analyze the test data and to extract the fatigue life of the test specimens is not adequate because of the assumptions involved in the theory.

Nevertheless, laboratory fatigue-life data of asphalt mixes has been accumulated in large quantities. These fatigue life data of asphalt mixes are traditionally plotted as stress or strain amplitude versus the resulting fatigue life expressed by the number of load application to fatigue

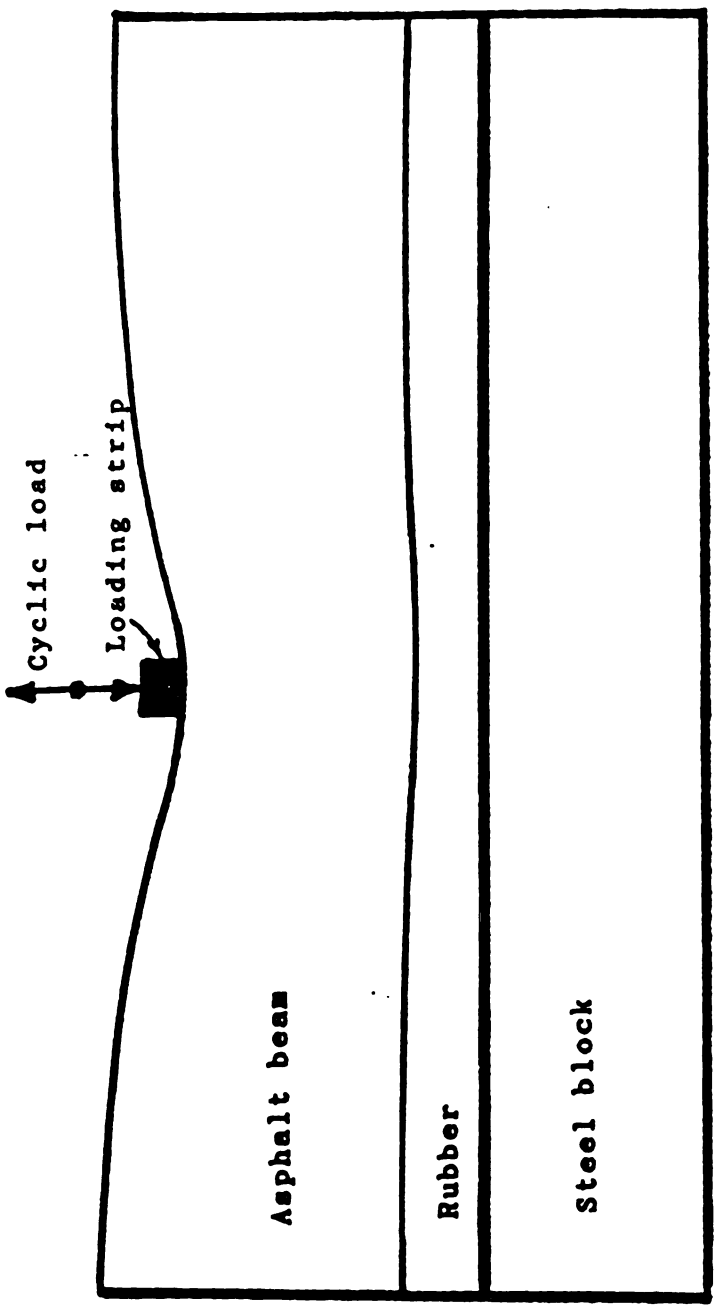



Figure 5.14 Schematic representation of the deflected shape of the beam specimen.

failure. For asphalt mixes, as for most materials, fatigue life steadily increases with decreasing stress or strain amplitude until the stress or strain level of the fatigue limit is reached. In general, stresses at or below the fatigue limit cause only elastic strains and the fatigue life becomes infinitely long. Regardless of the applied stress, it should be noted that cyclic plastic strain is ultimately responsible for fatigue damage and the consequent fatigue failure. In fact, a perfectly elastic material will never experience any fatigue damage regardless of the number of load applications.

As noted above, due to the shape of the plastic deflection basin, beam theory is inadequate and it cannot be used for data analysis. Also, the behavior of the short and square specimens would be expected to deviate significantly from the elementary beam theory that is only valid for relatively long and slender beams. Hence, the traditional definition of fatigue life based on the reduction in the value of the initial stiffness modulus is not applicable in this study. Consequently, a new definition of fatigue life was established as follows: The fatigue life of asphalt mixes tested in flexure is defined by the smaller of the number of load applications at which:

a) The measured total cumulative plastic deformation under the load reaches values of 0.45- and 0.10-inches for tests conducted at 77 and 40$^{o}$F,

respectively (equations 5.6 and 5.7).

b) The measured total cumulative plastic deformation at a point two inches away from the edge of the loaded area reaches a value of about 30 and 7 percent of that under the load for tests conducted at 77 and 40$^{o}$F, respectively (equations 5.9, 5.10, and 5.11).

It should be noted that the above definition is based on visual observations of the beam specimens which showed the initiation of hair-size cracks at the stated number of load applications.

The estimations of fatigue life based upon the above two definitions are presented and discussed in the following sections.

### 5.7.1 Fatigue Life: Total Plastic Deformation

In this method, the fatigue life ($N_{FL}$) of each beam specimen was estimated using equation 5.6 or 5.7 to calculate the value of N that corresponds to a value of $CD_1$ of 0.45- or 0.1-in for the 77 and 40 $^{o}$F tests, respectively.

For 77$^{o}$F:

$$N_{FL} = EXP(24.0032 - 1.9281 \times \ln(CL) - 0.5583 \times AV + 0.004278 \times KV + 0.07196 \times ANG) \quad (5.14)$$

For 40°F:

$$N_{FL} = EXP(26.7928 - 1.2976 \times AV - 0.96121 \times \ln(CL) + 0.004278 \times KV + 0.12442 \times ANG) \quad (5.15)$$

where: $N_{FL}$ = number of load applications to fatigue failure; and

all other parameters are as before.

A summary of the values of $N_{FL}$ for all beam specimens along with the values of the test and specimen variables and the values of the ratio of $CD_2$ to $CD_1$ is tabulated in Appendix D.

Examination of the fatigue life listed in Appendix D and equations 5.14 and 5.15 indicated that:

a) Increasing the magnitude of the cyclic load from 100 to 500 pounds (50 to 250 psi) results in a decrease of fatigue life by factors of about 22 and 5 for the 77 and 40°F tests, respectively.

b) Increasing the percent air voids from three to seven yields a decrease in the fatigue life by factors of 9 and 180 for the 77 and 40°F tests, respectively.

c) Increasing the kinematic viscosity of the asphalt binder from 159 to 270 centistokes causes an increase of the fatigue life by a factor of about 1.6 for all tests at 77 and 40°F. It should be noted that field

data does not support this observation and it indicates that higher viscosities yields lower fatigue life (higher crack potential). The reason for the difference between the laboratory and field data could be attributed to the nature of the definition of fatigue life. Recall that the fatigue life is defined by the value of N at which $CD_1$ is 0.45-in. A constant value of $CD_1$ of 0.45-in for all beams may not be reasonable. Unfortunately, visual observation of hair cracks is difficult and inaccurate. Hence, discrepancy in the data should be expected.

d) The fatigue life of asphalt mixes made using crushed aggregate is longer than those made using rounded aggregate by factors of about 1.2 and 1.3 for tests at 77 and 40$^{o}$F, respectively.

e) The variations of the fatigue life, estimated from the equations, for the most favorable and the most unfavorable combinations of the test and specimen variables are from 3,500,000 to 9,000 cycles for all tests at 77$^{o}$F; and from 75,000,000,000 to 22,000,000 cycles for the 40 $^{o}$F tests.

f) Although the value of $CD_1$ for all beams is 0.45 inches, the value of the ratio of $CD_2$ to $CD_1$ varies and it depends upon the specimen and test variables. Thus using a constant value of $CD_1$ of 0.45 does not necessarily mean that the deflection basin is the

same for all beam specimens.

The implications of the above observations based upon the definition of fatigue life are that:

1) Fatigue life of asphalt mixes can be increased by using higher viscosity asphalts, angular aggregates, and lower percent air voids in the mix.
2) The effect of the percent air voids on the fatigue life of asphalt mixes subjected to cyclic loads in cold regions (e.g., Michigan, Minnesota) is much higher than that in moderate climates (e.g., Arizona, Florida).
3) Temperature is the most important factor affecting the fatigue life of asphalt mixes.

It should be noted that the above findings do not mean that fatigue life of asphalt pavement in a cold region is higher than that of a compatible pavement in a moderate region. The cyclic strain caused by environmental changes should be assessed before such a conclusion can be made. Indeed, there is ample evidence indicating that cyclic plastic strains due to freeze-thaw cycles are much higher than those caused by traffic loads.

Further, the values of the fatigue life listed in Appendix D are expected to be much lower than those expected in the field. The reasons for this include:

1) The beam specimens were loaded using a loading strip that is fixed in one position during the entire test.

In the field, the wheel path is not fixed in one position for all vehicles. Traffic tends to weave close and away from the pavement edge (lateral wander or lateral placement). Hence, a point on the surface of the pavement will not always be located under the tire of each passing vehicle.

2) The beam specimens were loaded at the edge. The number of vehicles which travel at the edge of an inservice pavement is much lower than the total number of vehicles traveling that pavement.

To relate the laboratory fatigue life to that of inservice pavements, a study of the lateral weaving, and the edge effects should be conducted. For example, if one assumes that a point located on the surface of the pavement is subjected to direct load 50 percent of the time, and that the edge effects shorten the fatigue life by a factor of two, then it should be expected that the laboratory fatigue lives listed in Appendix D are shorter than the actual fatigue life of the pavement by, at least, a factor of four. Actual fatigue life data of inservice pavements should help the engineer to relate laboratory results to field conditions.

In addition, the observation in item f above is very important, and was to be expected. The value of the ratio of $CD_2$ to $CD_1$ can be regarded as a measure of the tensile strain. The lower the ratio, the steeper is the deflection

basin, and the higher is the tensile strain. The value of the tensile strain at failure varies and is dependent upon the test and specimen variables. Hence, one may expect that the value of the ratio of $CD_2$ to $CD_1$ is also a function of the same variables. To verify this, a statistical correlation between the ratio of $CD_2$ to $CD_1$ at 77 $^{o}F$ (listed in Appendix D) and the test and specimen variables was conducted. This resulted in the following equation.

$$\ln(CD_2/CD_1) = - 0.89264 - 0.09375 \times AV + 0.00005105 \times CL - 0.004896 \times ANG - 0.00004482 \times KV \qquad (5.16)$$

where all variables are as before.

Sensitivity analysis of equation 5.16 indicated that:

a) The percent air voids (AV) in the mix is the most significant variable affecting and $CD_2/CD_1$. Increasing AV from three to seven yields a decrease in the values of $CD_2/CD_1$ by a factor of 1.45.

b) The values of $CD_2/CD_1$ is affected by the magnitude of the cyclic load. Increasing the magnitude of CL from 100 to 500 pounds causes an increase in the ratio of $CD_2/CD_1$ by a factor of 1.02.

c) Using crushed aggregate causes a decrease in the values of $CD_2/CD_1$ by a factor of 1.01 relative to rounded aggregate.

d) Increasing kinematic viscosity causes a decrease in the values of $CD_2/CD_1$ by a factor of 1.005.

The above observations support the concept that the ratio of $CD_2/CD_1$ is a measure of the tensile strain in the beam. It should be noted that a decrease in the values of $CD_2/CD_1$ causes a decrease in the fatigue life. Item b was also expected because the shape of the deflected beam is load dependent. Higher loads cause steeper deflection basins.

Finally, figure 5.15 depicts the fatigue life of beam specimens (using equation 5.14 for $77^oF$) as a function of the applied cyclic stress. A similar plot can be obtained for the $40^oF$ tests using equation 5.15.

### 5.7.2 Fatigue Life: Plastic Deformation Ratio

The fatigue life of each beam specimen was also estimated using item b of the definition of the fatigue life of section 5.6 and equation 5.9 as follows:

$$(CD_2/CD_1) = 0.3 \text{ or } 0.07 = EXP(A \times X^B) \qquad (5.17)$$

Equations 5.10 and 5.11 (for the $77^oF$ tests) and equations 5.12 and 5.13 (for the $40^oF$) were then substituted into equation 5.9 for the parameters A and B. The resulting equation was solved to calculate the number of load applications ($N_{FL}$) at which the fatigue life is reached. Calculated values of $N_{FL}$ for the higher percent air voids

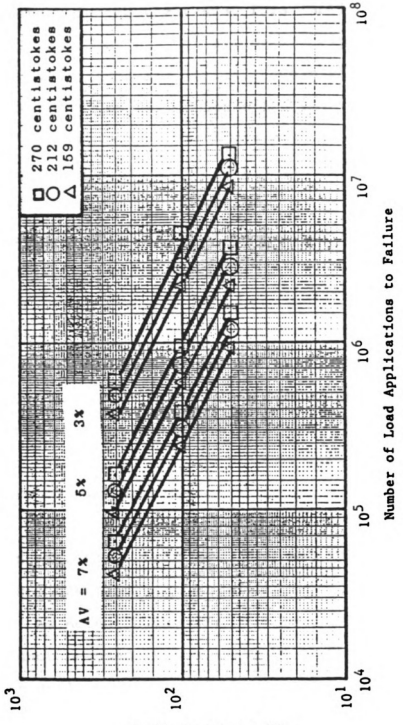



Figure 5.15 Stress-fatigue life curves for the beam specimens for 3 viscosity graded asphalts and 3 values of the percent air voids.

(AV larger than 4 percent) were much smaller than those observed during the tests. This implied that constant ratios of $CD_2/CD_1$ of 0.3 for all beams tested at 77°F and 0.07 for the 40°F tests are invalid. This was expected because the fatigue lives of the beams and the values of the plastic deformation ratios for different beams should be different. Recall that the values of 0.3 (at 77°F) and 0.07 (at 40°F) were assigned based upon the visual detection of hair-size cracks. This is neither accurate nor consistent. In addition, the accuracy of equations 5.12 and 5.13 is poor. Thus, it is recommended that this method (plastic deformation ratio) not be used until a better and more accurate techniques for the detection of crack initiation and the determination of the corresponding value of the ratio of $CD_2$ to $CD_1$ can be found. Hence, it is recommended that equations 5.15 and 5.16 be used to estimate the fatigue life of beam specimens.

## 5.8 ANALYSIS OF THE RESILIENT AND TOTAL MODULI

### 5.8.1 GENERAL

As noted in the previous section, elementary beam theory cannot be used in the analysis of the beam test data because the deflected shape of the beam specimen, and the location of the neutral axis do not satisfy the assumptions of the theory. Hence, an existing two dimensional finite element (FEM) computer program was modified based on the assumption

of plane-stress and employed in the analysis of the resilient and total moduli.

All test data was analyzed using the FEM mesh depicted in figure 5.16. It should be noted that only half the domain of the beam specimen needs to be modeled since the y-axis is an axis of symmetry. A two layer system (asphalt and rubber) was used in the analysis of each beam specimen as shown in figure 5.16. Line AB, in the figure, represents the boundary between the asphalt beam and the rubber pad, while line CD represents the boundary of the rigid support (steel block). The boundary conditions along the line of symmetry and along the rigid boundary are also shown in the figure.

The following data were used in the analysis of all the test results:

a) Poisson's ratio of the asphalt mix of 0.25. This is an average value which was obtained from cyclic load indirect tensile tests.

b) Beam dimensions; 4-in. thick and 16-in. long.

c) Modulus of elasticity and Poisson's ratio of the rubber of 3,000 psi and 0.4, respectively. These values were obtained from the rubber industry.

d) Rubber pad dimensions: 1-in. thick and 16.-in.long.

The FEM analysis was based on an iterative process as depicted in figure 5.17. First, for a given mix, specimen, and test variables, a seed (initial) modulus value of the

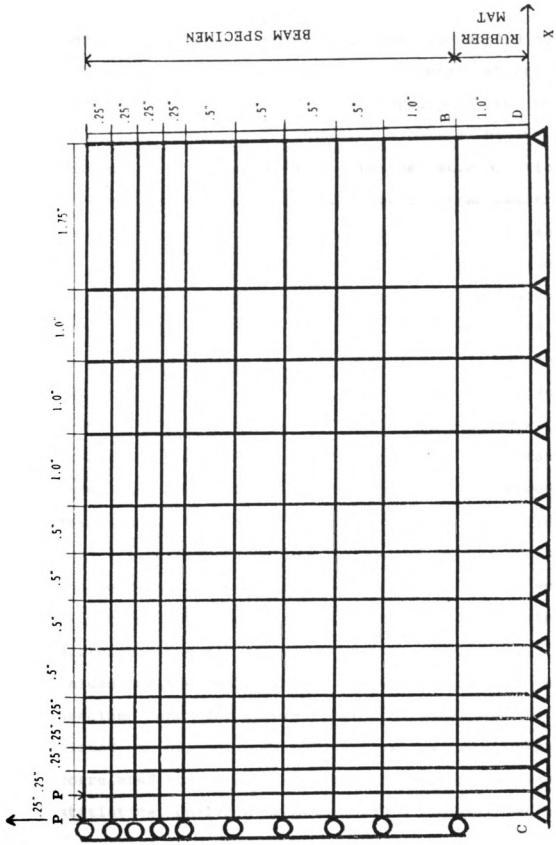
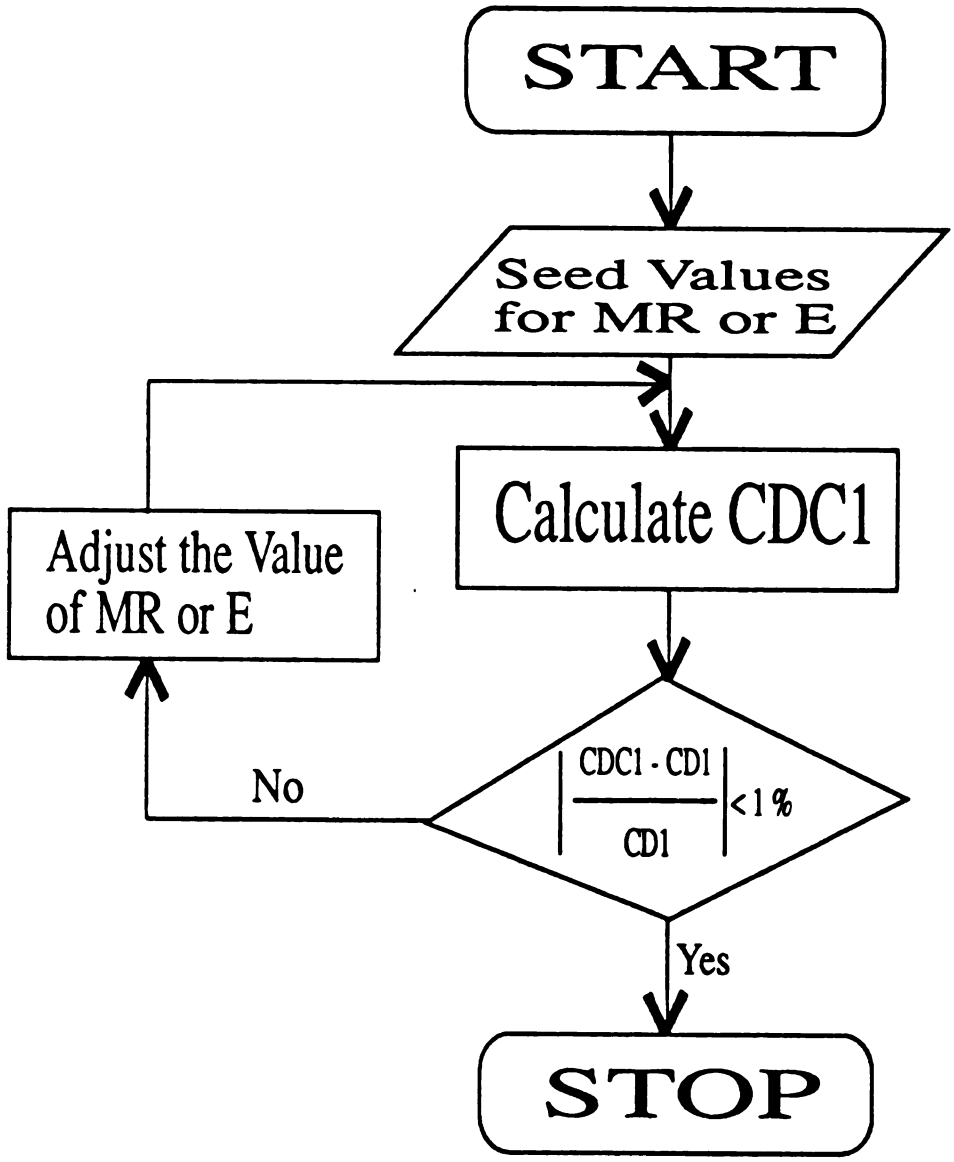



Figure 5.16 Boundary conditions and the finite element mesh.

asphalt mix was assumed and the corresponding surface deflection basin was calculated at several lateral distances from the line of symmetry that correspond to the actual locations of the LVDT(s). The calculated basin was then compared to the measured one and the ratio of calculated to measured deflection (RCM) under the load was determined. In subsequent iterations, the value of the modulus was adjusted by multiplying the value of the RCM by the value of the modulus from the previous iteration. The value of the modulus which produced an RCM values between 0.99 and 1.01 was accepted as the final modulus value of the asphalt mix and the iteration process was terminated. In general, a value of RCM between 0.99 and 1.01 was reached within a few iterations (generally 2 to 4). That is, the value of the calculated deflection under the load converged to the measured value within 2 to 4 iterations. It should be noted that the maximum percent difference between the calculated and measured deflections at LVDT 2 and 3 at 77$^{o}$F were 42 and 69 percent, respectively. For the 40$^{o}$F tests, these differences were 7 and 24 percent, respectively. The final values of the resilient and total moduli for each beam specimen and for several number of load applications are listed in Appendix E. These values were statistically correlated to the mix, specimen, and test variables. The statistical analysis is presented in the next section.




MR = Resilient modulus of asphalt mix
E = Total modulus of asphalt mix
CDC1 = Calculated deflection at the center LVDT
CD1 = Measured deflection at the center LVDT

Figure 5.17 Flow chart of the iteration procedure of the finite element computer program.

### 5.8.2 STATISTICAL ANALYSIS

Figures 5.18 an 5.19 depict,respectively, the values of the resilient (MR) and total (E) moduli of beam specimens at 3, 5, and 7 percent air voids plotted against the logarithmic values of the number of load applications (N). It can be seen that increasing N produces higher values of resilient and total moduli. That is, the resilient and total deflections decrease as the number of load applications increases (see figure 4.9). This was expected because the specimen experienced densification and plastic flow under the cyclic load. This can be explained with the aid of figure 5.20. In this figure, the logarithmic values of the cumulative permanent deformations (of the same specimens of figures 5.18 and 5.19) are plotted against the logarithmic values of the number of load applications. It can be seen that increasing N yields an increase in the permanent deformation. That is the total volume of the beam specimen decreases and hence, its density increases. Further examination of figures 5.18 and 5.19 have indicated that the rate of increase in the resilient and total moduli (the slope of the curves) are dependent on the percent air voids of the beam specimens. Lower percent air voids produces higher rates (slopes) of resilient and total moduli. This was expected because higher percent air voids results in higher plastic flow and relatively lower densification in the asphalt mix. This can also be noted in

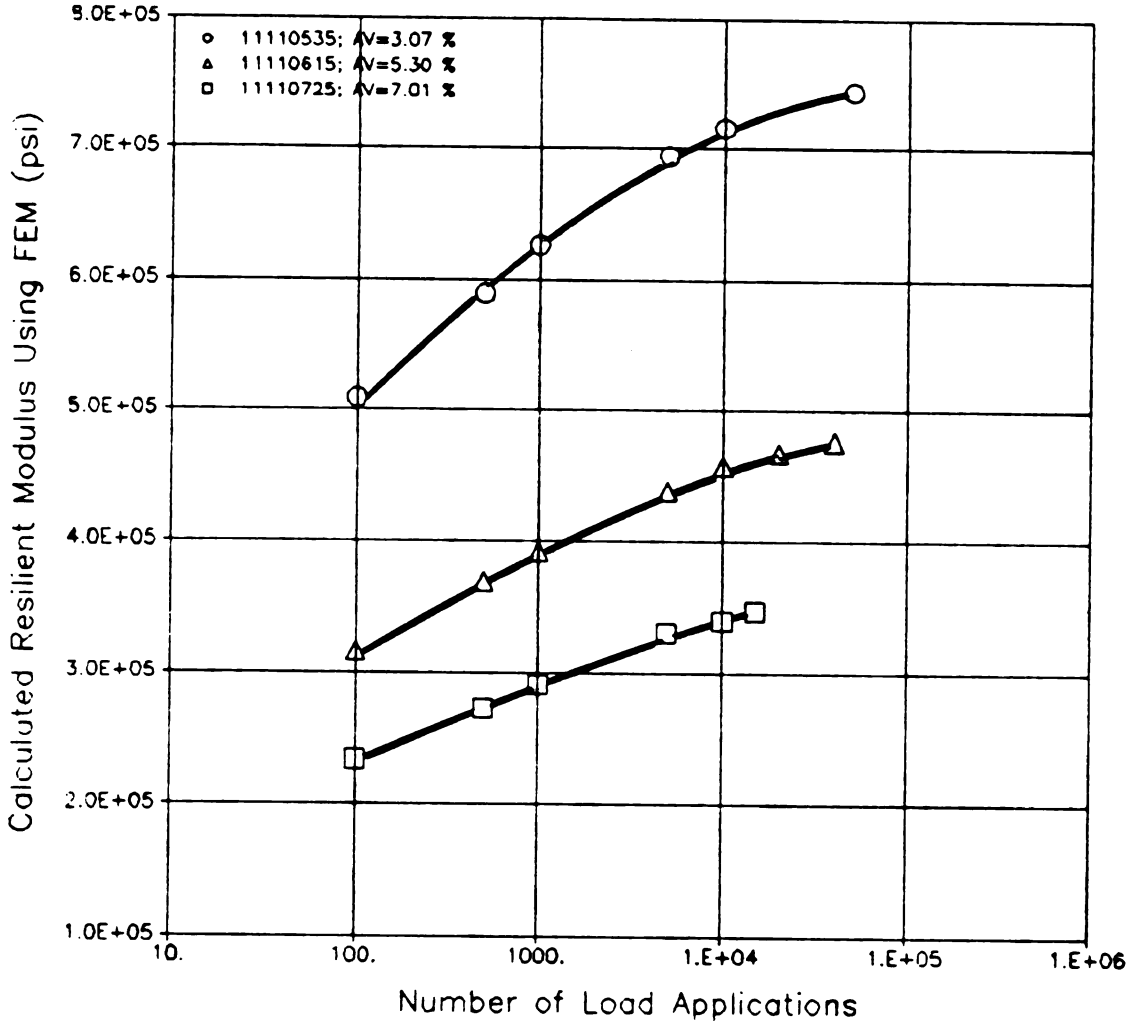



Figure 5.18 Calculated resilient modulus using FEM program versus the number of load application at different percent air voids.

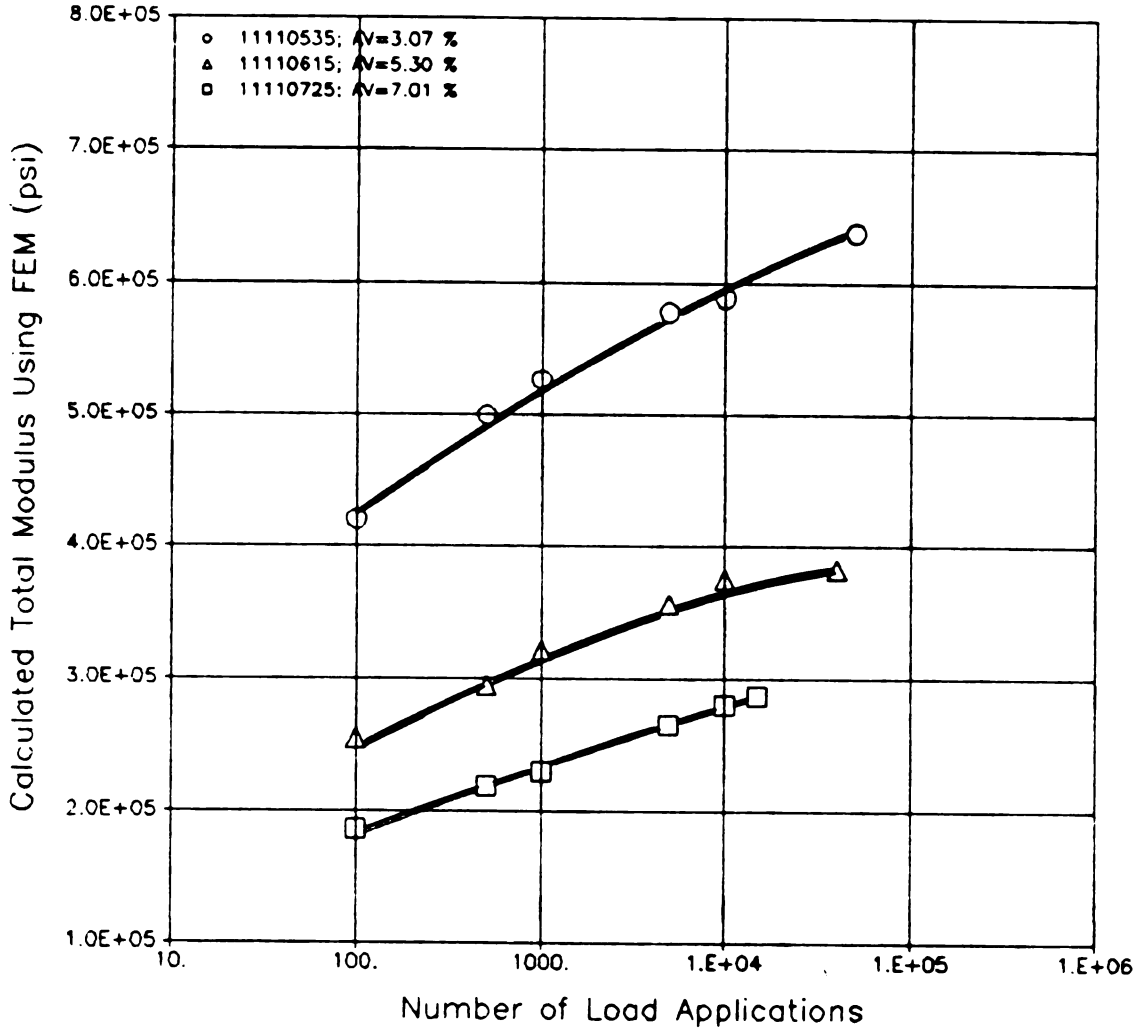



Figure 5.19 Calculated total modulus using FEM program versus the number of load application at different percent air voids.

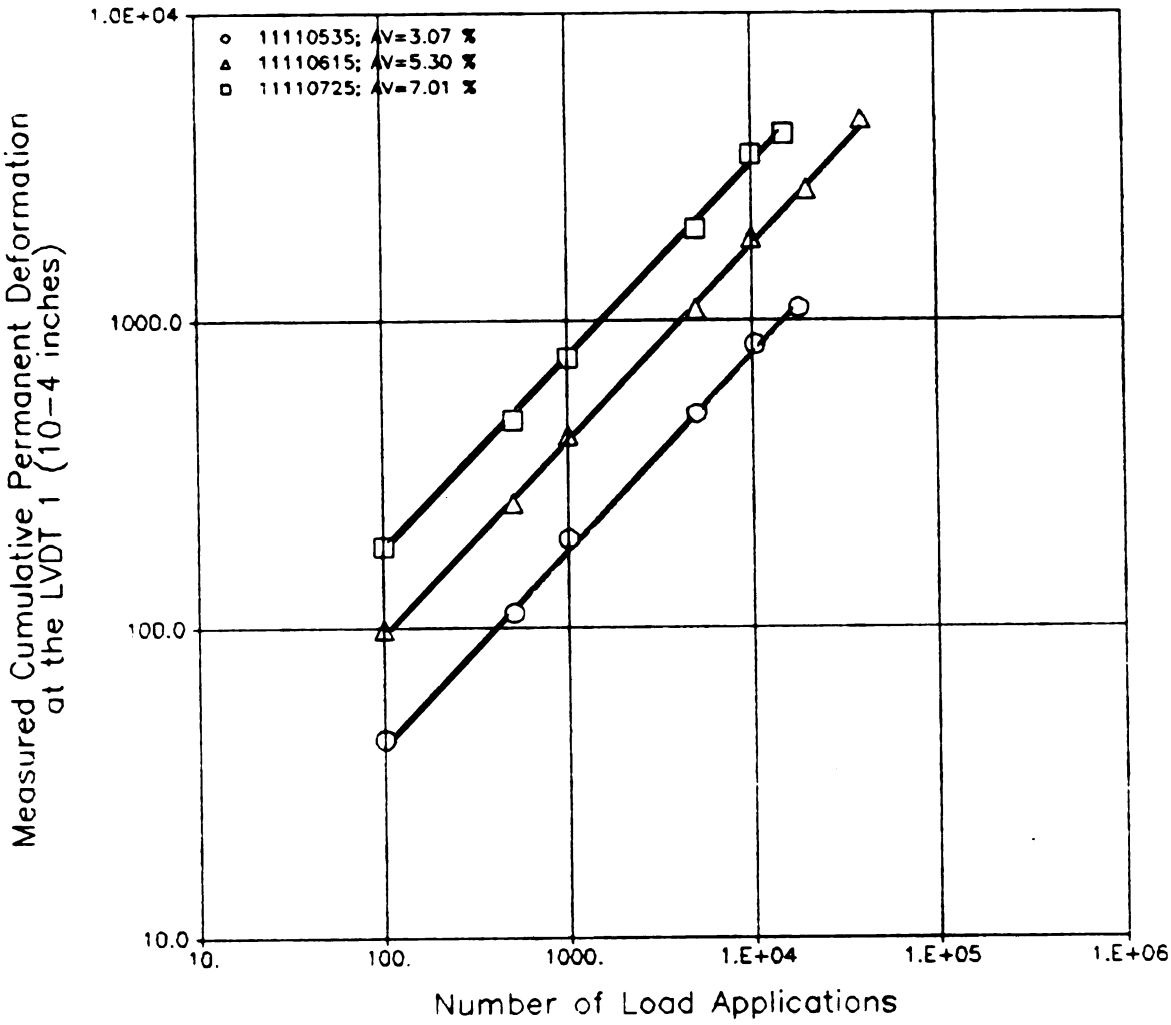



Figure 5.20 Measured cumulative permanent deformation versus the number of load application at differnt percent air voids.

figure 5.20. which indicates that the slope of the curves increases as the percent air voids increases. That is, for the same magnitude of cyclic load, the net volume change of the asphalt mix at high percent air voids is less than those at the lower percent air voids.

It should be noted that, although the slope of the curves in figures 5.18 and 5.19 increases with decreasing air voids, the percent increase in the values of MR relative to its initial value is higher for the 7 percent air voids curve than that for the 3 percent air voids. This can be illustrated with the aid of figure 5.21. In this figure, the values of the resilient modulus for any number of load application is divided (normalized) by the corresponding value of MR at load cycle number 100. It can be seen that, for the 7 percent air voids curve, the value of MR at N equal 10,000 cycles increases by a factor of 1.455 relative to its value at N equal 100 cycles. This factor is 1.405 for the 3 percent air voids. The implication of this is that asphalt pavement constructed using high percent air voids in the mix will experience (due to traffic effects) higher plastic flow (rut depth) and higher increase in the initial resilient modulus than pavement constructed at lower percent air voids.

Nevertheless, in practice, resilient modulus tests are conducted only to 100 or 500 load cycles for sample conditioning. After which the resilient modulus is

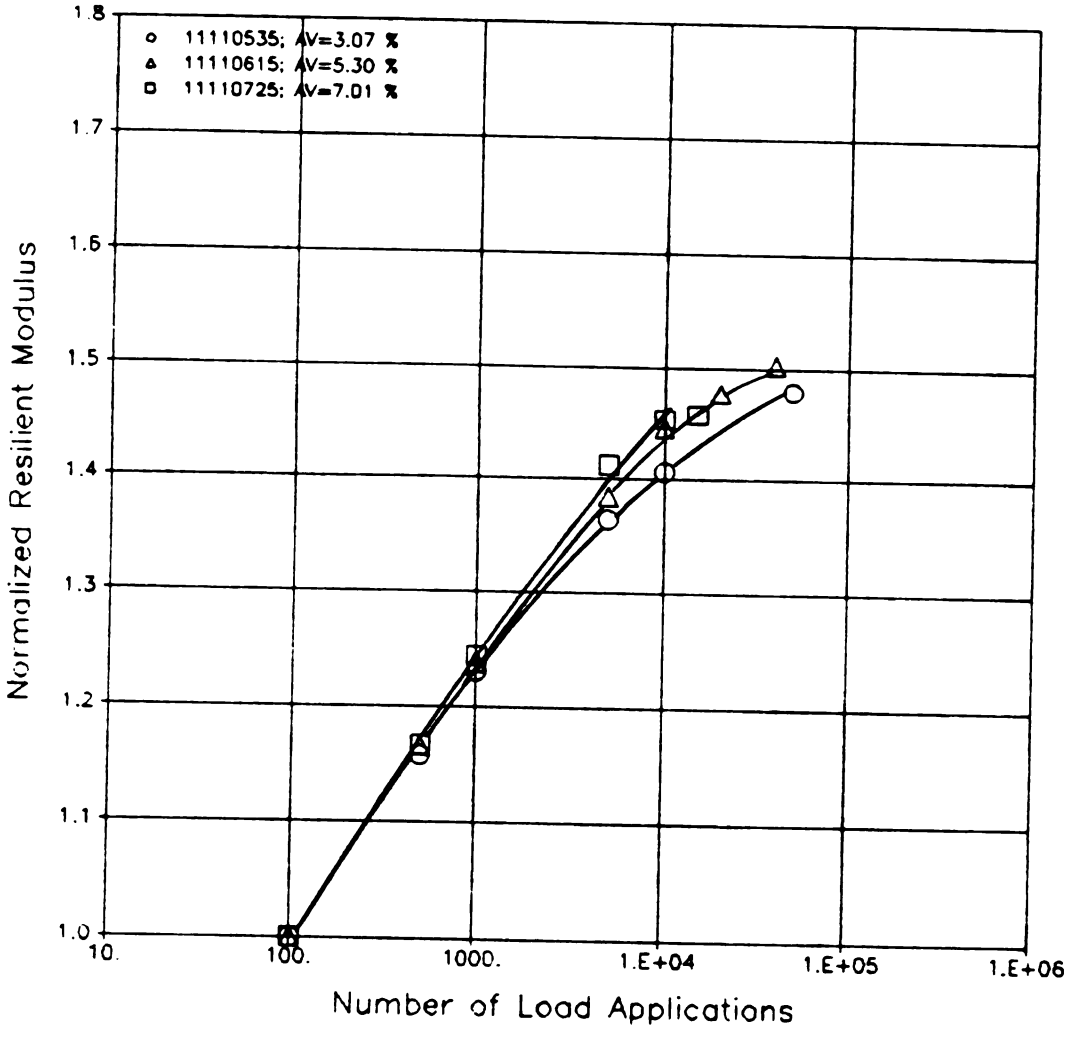



**Figure 5.21 Normalized resilient modulus versus the number of load application at different percent air voids.**

determined and tests are terminated. Hence, in the statistical analysis of this study, the values of MR and E at load cycle number 100 were correlated to the specimen, test, and asphalt mix variables. The reader should keep in mind that MR increases with increasing N and that the value of MR at load cycle number 100 is a very conservative value.

Tables 5.8 and 5.9 summarize the regression matrices of the resilient and total moduli at 77$^{o}$F, respectively. The regression coefficients, coefficient of determination ($R^2$), and standard error (SE) obtained from each step of the stepwise procedure are listed in the tables. It should be noted that the variables in the tables are listed in their order of significance. For example, the percent air voids in table 5.8 is the most significant variable while the gradation of the aggregate is the least significant one. Nevertheless, equations 5.18 and 5.19 are the corresponding equations to tables 5.8 and 5.9, respectively.

$$\ln(MR) = 13.895 - 0.1974 \times AV - 0.0007096 \times KV + 0.007225 \times ANG + 0.008685 \times GRAD \quad (5.18)$$

$$R^2 = 0.998 \text{ and } SE = 0.014$$

$$\ln(E) = 13.745 - 0.2089 \times AV - 0.000712 \times KV + 0.0108 \times ANG \quad (5.19)$$

Table 5.8 Regression matrix for the resilient modulus at 77°F.

| MR | Intercept | Regression coefficients of the independent variables | | | | $R^2$ | SE |
|---|---|---|---|---|---|---|---|
| | | $AV_{-1}$ ($10^{-1}$) | $KV_{-4}$ ($10^{-4}$) | $ANG_{-3}$ ($10^{-3}$) | $GRAD_{-3}$ ($10^{-3}$) | | |
| | 14.750 | -1.959 | - | - | - | 0.988 | 0.034 |
| ln(MR) | 13.928 | -1.967 | -7.157 | - | - | 0.997 | 0.017 |
| | 13.897 | -1.965 | -7.038 | 8.569 | - | 0.998 | 0.015 |
| | 13.895 | -1.974 | -7.096 | 7.225 | 8.685 | 0.998 | 0.014 |

ln = natural log;
MR = resilient modulus (psi);
AV = air voids (%);
ANG = angularity;
KV = kinematic viscosity (centistokes);
GRAD = gradation of aggregate;
$R^2$ = coefficient of correlation; and
SE = standard error.

T

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Table 5.9 Regression matrix for the total modulus at 77°F.

| E | Intercept | Regression coefficients of the independent variables | | | $R^2$ | SE |
|---|---|---|---|---|---|---|
| | | $AV_{-1}$ ($10^{-1}$) | $KV_{-4}$ ($10^{-4}$) | $ANG_{-2}$ ($10^{-2}$) | | |
| | 13.604 | -2.084 | - | - | 0.987 | 0.039 |
| ln(E) | 13.786 | -2.091 | -7.274 | - | 0.995 | 0.024 |
| | 13.745 | -2.089 | -7.120 | 1.108 | 0.996 | 0.022 |

ln = natural log;
E = total modulus (psi);
AV = air voids (%);
ANG = angularity;
KV = kinematic viscosity (centistokes);
$R^2$ = coefficient of correlation; and
SE = standard error.

$R^2$ = 0.996 and SE = 0.022

where: ln = natural log;
MR = resilient modulus (psi);
E = total modulus (psi); and
AV = air voids (%);
ANG = angularity;
KV = kinematic viscosity (centistokes);
GRAD = gradation of aggregate;
$R^2$ = coefficient of correlation; and
SE = standard error.

Examination of the values of the regression coefficients and the order of significance of the independent variables of tables 5.8 and 5.9, and equations 5.18 and 5.19 have indicated:

1) The resilient modulus at 77°F is affected (in order of decreasing significance ) by the air voids (AV), the kinematic viscosity (KV), the aggregate angularity (ANG), and the gradation of the aggregate (GRAD) while the total modulus is affected by AV, KV, and ANG. The effects of the AV and KV on the arithmetic values of MR are slightly lower than those on E. Increasing AV from 3 to 7 percent causes a decrease in MR and E by factors of 0.45 and 0.43, respectively. While increasing KV from 159 to 270

centistoke yields a decrease in MR and E by factors of 0.93 and 0.92, respectively. The effect of aggregate angularity on the values of MR and E is less than 1.5 percent. Finally, aggregate gradation has no significant effect (less than 1 percent) on either modulus.

The above observations were anticipated because the values of MR were calculated using the resilient deformation while the values of E were obtained using the total deformation (elastic and viscoelastic). Since asphalt binders are viscoelastic material and since the AV is a measure of the ability of the material to flow under the load (higher AV produces higher flow), one can expect that the effects of KV and AV on the viscoelastic component of the deformation are higher than those on the elastic (resilient) one.

Equations 5.18 and 5.19 indicate that MR is inversely proportional to the kinematic viscosity of the asphalt binder. That is, increasing KV (harder asphalt binder) causes a higher resilient deformation and hence a lower resilient modulus. This finding is in contrast to that reported in the literature and to that relative to plastic deformation reported in section 5.5. From an engineering view point, higher KV (harder asphalt binder) should result in lower

resilient and total deformations and consequently, higher resilient and total moduli. The test results however, do not support this view. Unfortunately, no sound explanation can be offered at this time to explain this discrepancy.

2) The magnitude of the cyclic load possesses no significant effects on the values of the resilient and total moduli. This indicates a linear behavior of the beam specimens within the range of the magnitude of the applied cyclic load. The implication of this finding is that the application of linear elasticity in the analysis of the resilient and total moduli is valid. It should be noted that results obtained from indirect tensile tests showed a nonlinear behavior (increasing cyclic load causes a decrease in the values of the resilient and total moduli). The difference in the finding between the two tests can be related to the physical dimensions of the test specimens and to the boundary conditions. Beam specimens are 4-in. thick and subjected mainly to compression while indirect tensile test specimens are 2.5-in. thick and subjected to both compression and tension.

3) The values of the regression coefficients (see tables 5.8 and 5.9) for all variables are only slightly changed as more variables are added in the stepwise

procedure (e.g., the values of the coefficient of AV in both tables change very little as additional variables entered into the analysis). This implies that there is no significant interaction between the independent variables. This conclusion was reached after examination of the partial correlation matrix (PCM) shown in table 5.10. The values of the partial correlation coefficients (PCC) listed under each variable in the table indicate the degree of dependency of that variable on the others. The value of PCC may range from -1.0 to +1.0. A negative value of PCC between any two variables implies that the variables are inversely proportional to each other while a positive value indicates direct proportionality. Nevertheless, the values of the PCC in the PCM of table 5.10 indicate some degree of interaction between AV and GRAD, and ANG and GRAD. This was expected because the percent air voids in an aggregate mix is a function of the gradation of the mix. A well graded mix possesses lower air voids than a uniform mix. Similarly, aggregate angularity affects its gradation. Angular aggregates tend to interlock causing higher friction and therefore, offer higher resistance for finer materials to enter and fill the air space between the larger size aggregates. Due to these interactions, the AV and

Table 5.10 Partial correlation matrix for resilient modulus at 77°F

| | ln(MR) | AV | AG | KV | CL | GR |
|---|---|---|---|---|---|---|
| ln(MR) | 1.000 | -.994 | .060 | -.055 | -.058 | -.286 |
| AV | -.994 | 1.000 | -.029 | -.040 | .054 | .302 |
| AG | .060 | -.029 | 1.000 | -.064 | .018 | .275 |
| KV | -.055 | -.040 | -.064 | 1.000 | .013 | .027 |
| CL | -.058 | .054 | .018 | .013 | 1.000 | -.015 |
| GR | -.286 | .302 | .275 | .027 | -.015 | 1.000 |

ln = natural log;
MR = resilient modulus (psi);
AV = air voids (%);
ANG = angularity;
KV = kinematic viscosity (centistokes);
Cl = cyclic load;
GR = gradation;
$R^2$ = coefficient of correlation; and
SE = standard error.

ANG terms in equations 5.18 and 5.19 may also include some of the effects of aggregate gradation on MR and E. Unfortunately, the separation of the effects of these variables cannot be obtained due to the limited number of gradation (only two gradations were used) employed in this study .

4) The final values of the coefficient of determination and standard error in both tables indicate a high degree of correlation between the dependent and independent variables. That is no significant scatter of the logarithmic values of the resilient and total moduli about the mean. It should be noted that the values of $R^2$ in the tables may be artificially high because of the nature of transformation (logarithmic). Variations in the arithmetic values are naturally much higher than those in the logarithmic values.

The scenario in items 1 and 3 above implies that equation 5.18 can be simplified by eliminating the gradation term (GRAD has no statistical significance on MR). Considering the third step of table 5.8, the following equation was obtained.

$$\ln(MR) = 13.897 - 0.1965 \times AV - 0.0007038 \times KV + 0.008569 \times ANG \qquad (5.20)$$

$R^2$ = 0.998 and SE = 0.015

where: all variables are as before.

The advantages of this last equation are it is simpler than equation 5.18 and that it is similar to equation 5.19.

Figures 5.22 and 5.23 depict, respectively, the values of the resilient and total moduli obtained from FEM and those calculated using equations 5.20 and 5.19. The straight lines in the figures represent the locus of points of equality. It should be noted that the maximum percent difference between the values of resilient and total moduli obtained using FEM and those from equations 5.20 and 5.19 were 6 and 7 percent, respectively.

Tables 5.11 and 5.12 summarize, respectively, the regression matrices (regression coefficients, coefficient of determination, and standard error) of the resilient and total moduli of the beam specimens tested at 40°F. Equations 5.21 and 5.22 are the resulting equations.

$$\ln(MR) = 14.736 - 0.1248 \times AV - 0.0002116 \times CL \qquad (5.21)$$

$R^2$ = 0.882 and SE = 0.049

where: CL = applied cyclic load; and
all other variables are as before.

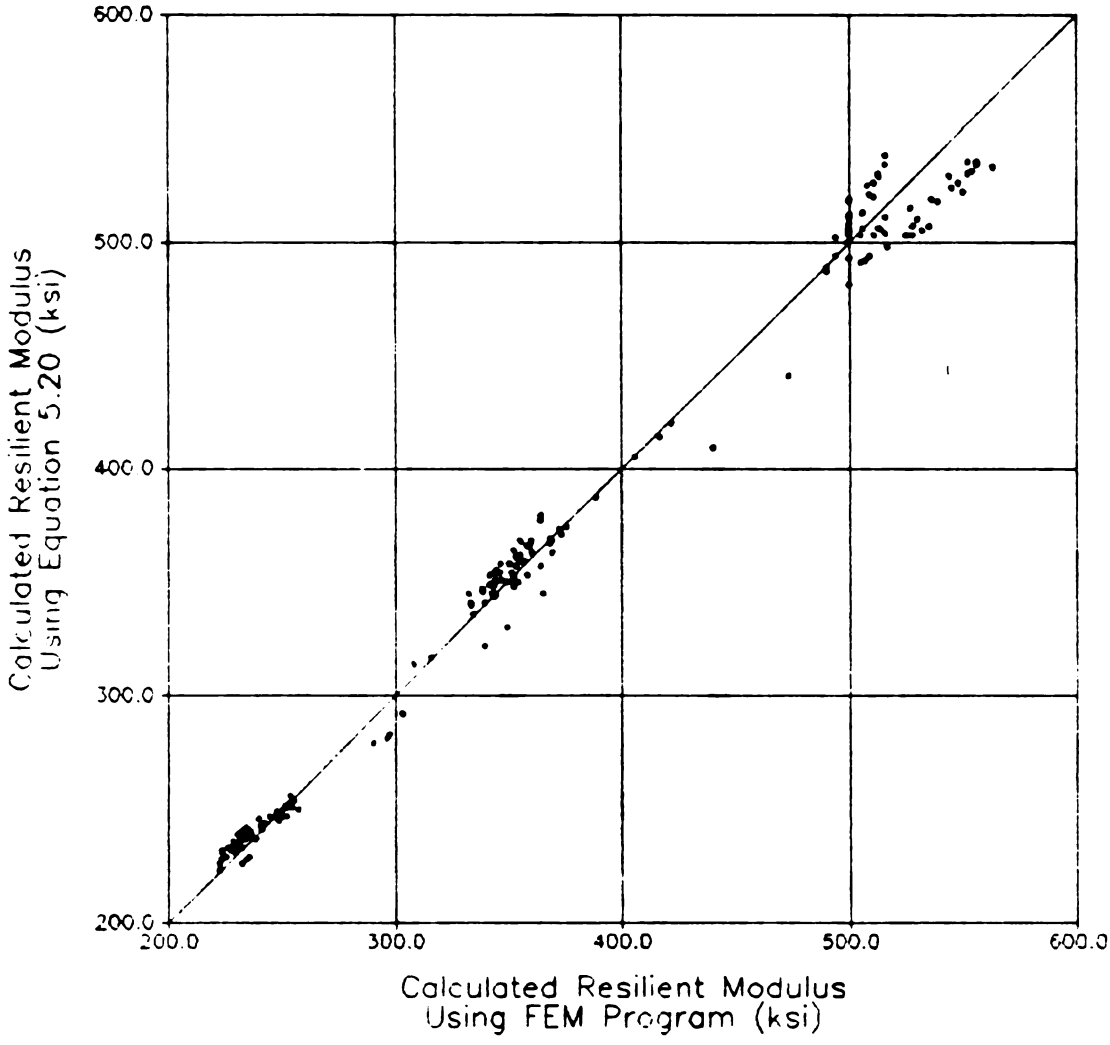


**Figure 5.22 Calculated resilient modulus using equation 5.20 versus calculated resilient modulus using FEM program.**

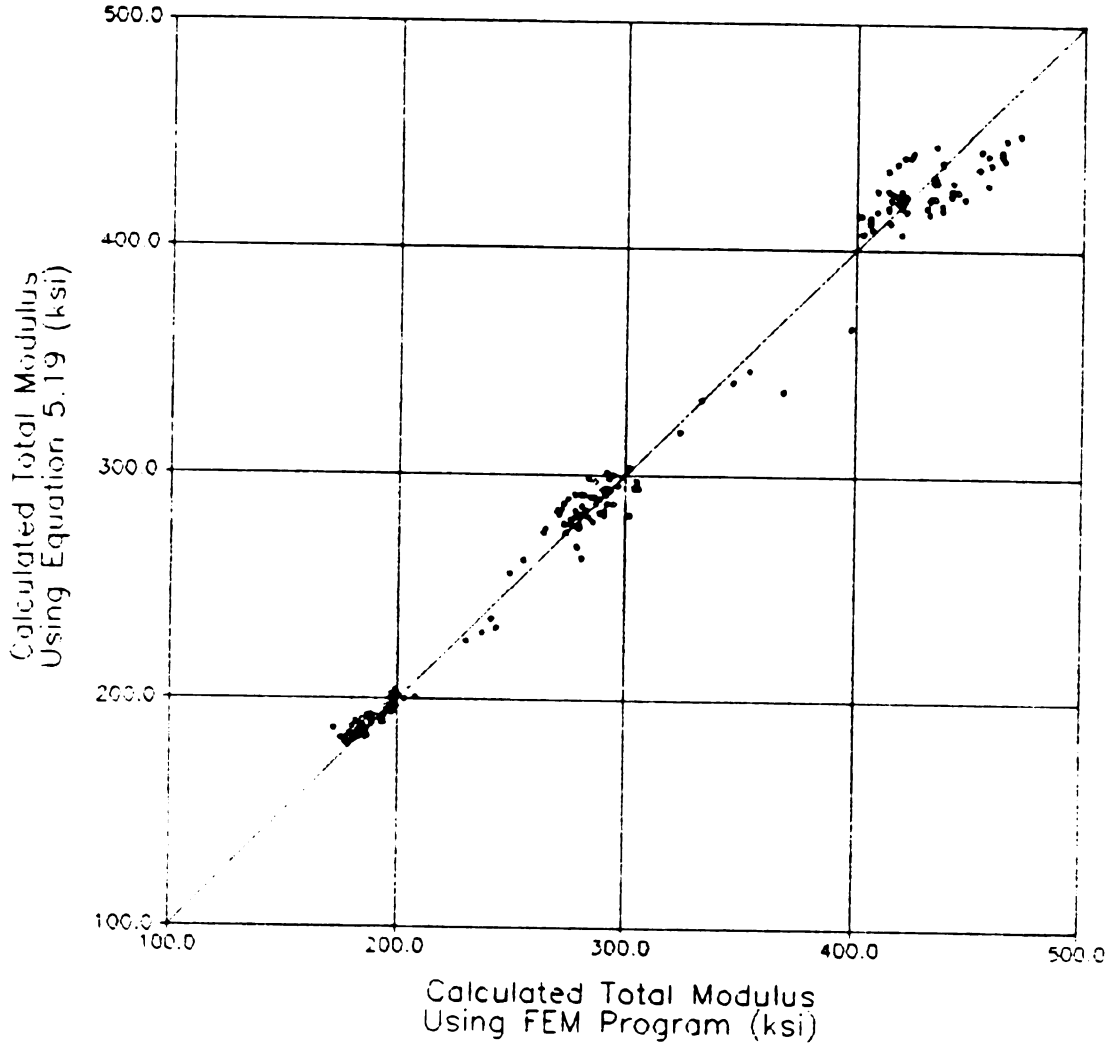


Figure 5.23 Calculated total modulus using equation 5.19 versus calculated total modulus using FEM program.

$$\ln(E) = 14.42 - 0.139 \times AV \qquad (5.22)$$

$R^2 = .679$ and SE = 0.099

where: all other variables are as before.

Examination of the values of the coefficient of correlation in tables 5.11 and 5.12, and equations 5.21 and 5.22 have indicated that:

1) The resilient modulus at 40$^{o}$F is affected (in order of decreasing significant) by the air voids (AV) and the applied cyclic load (CL), while the total modulus is affected only by AV. This implies that the total response (elastic and viscoelastic) of the specimen is linearly proportional to the magnitude of the applied cyclic load. Each component of the total response (elastic and viscoelastic), however, is nonlinearly related to CL. That is increasing CL causes an increase in both elastic and viscoelastic deformations such that the ratio of load to elastic deformation decreases while the ratio of load to viscoelastic deformation increases. This finding was not expected and it departs from that found in the literature. The reason of the discrepancy could be related to the magnitude of the total deformation which was within the accuracy of the measurement

**Table 5.11 Regression matrix for the resilient modulus at 40°F.**

| MR | Intercept | Regression coefficients of the independent variables | | $R^2$ | SE |
|---|---|---|---|---|---|
| | | $AV_{-1}$ ($10^{-1}$) | $CL_{-4}$ ($10^{-4}$) | | |
| ln(MR) | 14.671 | -1.220 | - | 0.813 | 0.060 |
| | 14.736 | -1.248 | -2.116 | 0.882 | 0.049 |

ln = natural log;
MR = resilient modulus (psi);
AV = air voids (%);
CL = cyclic load (pounds);
$R^2$ = coefficient of correlation; and
SE = standard error.

**Table 5.12 Regression matrix for the total modulus at 40°F.**

| MR | Intercept | Regression coefficients of the independent variables | $R^2$ | SE |
|---|---|---|---|---|
| | | $AV_{-1}$ ($10^{-1}$) | | |
| ln(MR) | 14.420 | -1.390 | 0.678 | 0.099 |

ln = natural log;
E = resilient modulus (psi);
AV = air voids (%);
$R^2$ = coefficient of correlation; and
SE = standard error.

system. Nevertheless, increasing AV from 3 to 7 percent caused decreases in MR and E by factors of 0.61 and 0.57, respectively. While increasing CL from 100 to 500 pounds caused a decrease in MR by a factor of 0.82.

2) The values of the coefficient of determination and standard error of tables 5.11 and 5.12 indicate a low degree of correlation between the dependent and independent variables compared to the results from 77$^{o}$F. This observation does not mean that the values of the resilient and total moduli at 40$^{o}$F are inconsistent or, in a statistical sense, random. This is mainly due, as noted above, to the magnitude of the measured deflection which was within the accuracy of the measurement system.

Figures 5.24 and 5.25 depict the values of the resilient and total moduli calculated using the FEM program and the corresponding moduli calculated using equations 5.21 and 5.22, respectively. Again, the straight line in the figures represents the locus of the points of equality. It was found that the maximum per cent difference between the values of resilient and total moduli calculated using FEM and those calculated using equations 5.20 and 5.21 were 13 and 20 percent, respectively.

A second statistical analysis was performed using the test results at 77 and 40$^{o}$F. In this analysis, the test

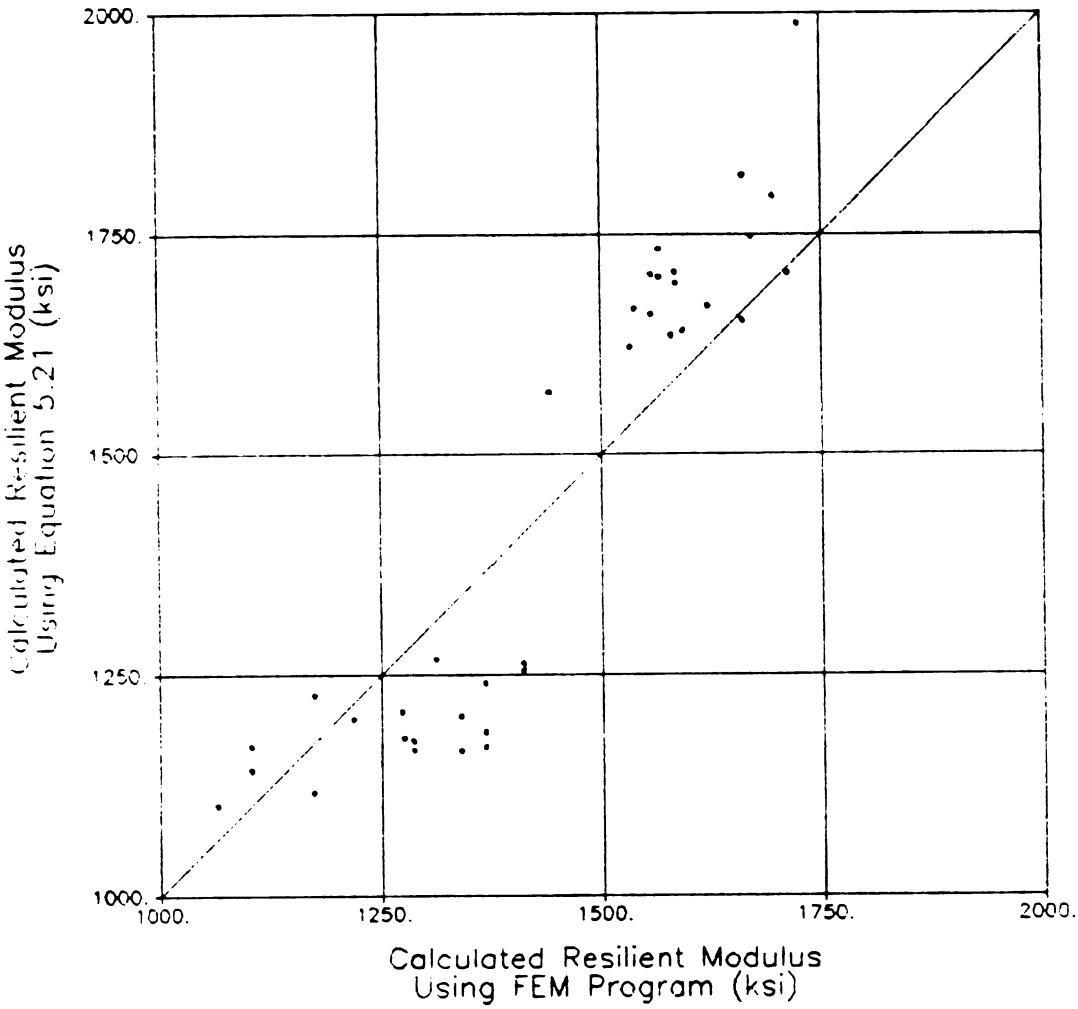


**Figure 5.24 Calculated resilient modulus using equation 5.21 versus calculated resilient modulus using FEM program.**

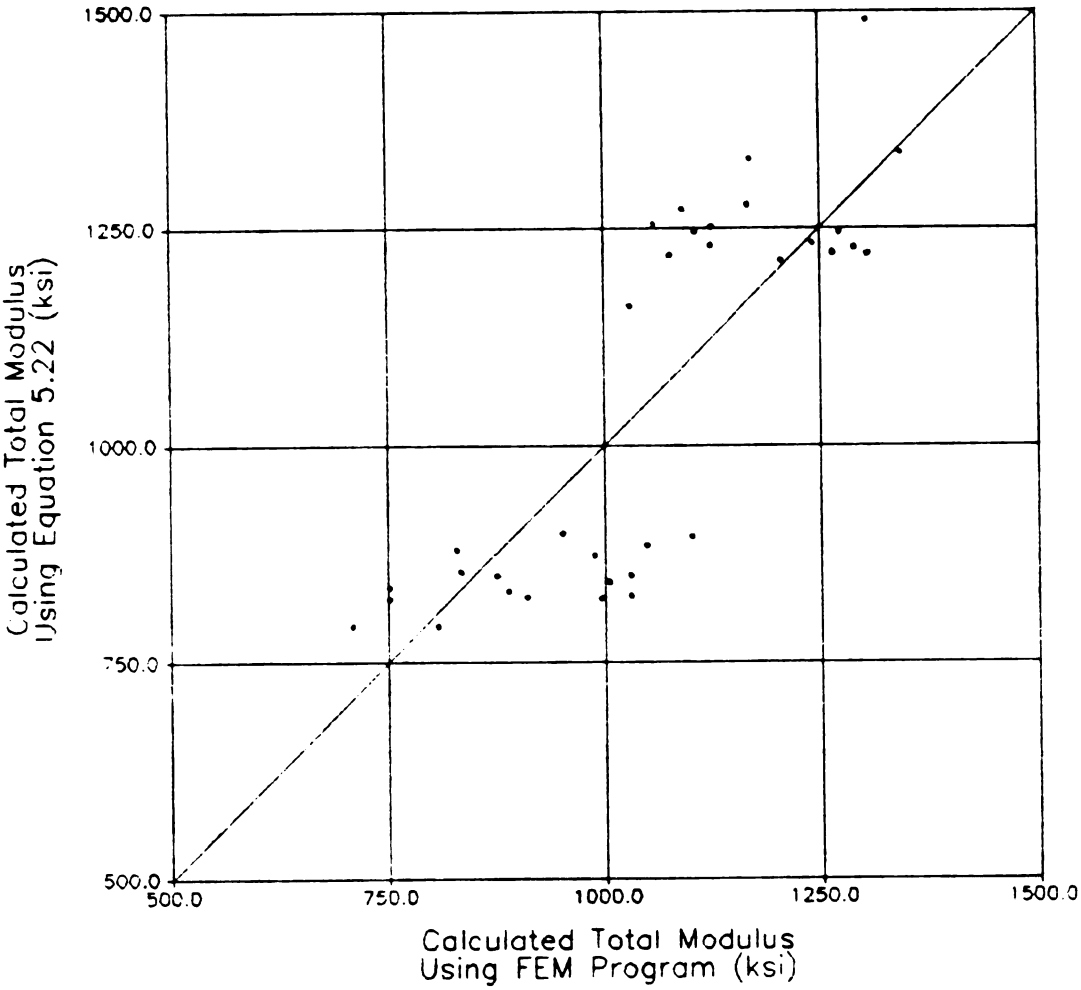


**Figure 5.25 Calculated total modulus using equation 5.22 versus calculated total modulus using FEM program.**

temperature was included as one of the independent variable. A semi-logarithmic relationship between MR or E and the test temperature (TT) was assumed based on the Asphalt Institute equation which was reported in chapter 2. Tables 5.13 and 5.15 summarize the resulting regression matrices (regression coefficients, coefficient of determination, standard error) for the resilient and the total moduli, respectively. Equations 5.23 and 5.24 are the corresponding equations.

$$\ln(MR) = 16.382 - 0.03326 \times TT - 0.1899 \times AV - 0.0004148 \times KV \quad (5.23)$$

$R^2 = 0.994$ and $SE = 0.046$

where: TT = test temperature; and
all variables are as before.

$$\ln(E) = 15.969 - 0.02982 \times TT - 0.2029 \times AV - 0.0003927 \times KV \quad (5.24)$$

$R^2 = 0.990$ and $SE = 0.057$

where: all other variables are as before.

Examination of the values of the correlation coefficient of tables 5.13 and 5.14, and equations 5.23 and 5.24 has indicated:

**Table 5.13 Regression matrix for the resilient modulus at 77 and 40 °F.**

| MR | Intercept | Regression coefficients of the independent variables | | | $R^2$ | SE |
|---|---|---|---|---|---|---|
| | | $TT_{-2}$ ($10^{-2}$) | $AV_{-1}$ ($10^{-1}$) | $KV_{-4}$ ($10^{-4}$) | | |
| ln(MR) | 15.671 | -3.755 | - | - | 0.763 | 0.291 |
| | 16.284 | -3.327 | -1.903 | - | 0.993 | 0.049 |
| | 16.382 | -3.326 | -1.899 | -4.148 | 0.994 | 0.046 |

ln = natural log;
MR = resilient modulus (psi);
TT = test temperature (°F);
AV = air voids (%);
KV = kinematic viscosity (centistokes);
$R^2$ = coefficient of correlation; and
SE = standard error.

**Table 5.14 Regression matrix for the total modulus at 77 and 40 °F.**

| E | Intercept | Regression coefficients of the independent variables | | | $R^2$ | SE |
|---|---|---|---|---|---|---|
| | | $TT_{-2}$ ($10^{-2}$) | $AV_{-1}$ ($10^{-1}$) | $KV_{-4}$ ($10^{-4}$) | | |
| ln(E) | 15.234 | -3.456 | - | - | 0.699 | 0.312 |
| | 15.877 | -2.984 | -2.032 | - | 0.989 | 0.060 |
| | 15.969 | -2.982 | -2.029 | -3.927 | 0.990 | 0.057 |

ln = natural log;
E = total modulus (psi);
TT = test temperature (°F);
AV = air voids (%);
KV = kinematic viscosity (centistokes);
$R^2$ = coefficient of correlation; and
SE = standard error.

1) Both resilient and total moduli are affected (in order of decreasing significance) by the test temperature, the percent air voids, and the kinematic viscosity of the asphalt binder. Increasing TT form 40 to 77$^{o}$F causes a decrease in MR and E by factors of 3.42 and 2.99, respectively. It should be noted that, in equations 5.23 and 5.24, the KV term is also a function of the test temperature. Lower temperatures cause higher KV (harder asphalt). In order to separate the two variables (KV and TT), the value of KV at the test temperature should be used in the analysis. Unfortunately, this data was not available to the author nor it was possible to conduct the laboratory tests because of lack of equipment. Hence, it is recommended, for future study, to obtain the values of KV at the test temperatures whenever possible and to use these values in the analysis.
2) The values of the coefficient of determination and standard error show a high degree of correlation between the dependent and the independent variables. Again, it should be noted that the values of $R^2$ in the tables may be artificially high because of the nature of the transformation (logarithmic).

It should noted that (in the range of the mix, test, and specimen variables) the maximum differences between the

values of MR and E at 77°F predicted using equations 5.23 and 5.24, and those calculated using the finite element program were found to be 7.6 and 9 percent respectively. These differences were 17 and 24.5 percent for the 40°F.

In addition, equation 5.23 was compared to the asphalt institute equation (equation 2.3) which is repeated below for convenience.

$$\text{Log MR} = 1.54536 + 0.020108(X1) - 0.0318606(X2) + 0.068142(X3) - 0.00127003(X4)^{0.4}(X5)^{1.4} \quad (2.3)$$

$R^2 = 0.968$, and S.E. = 0.0888904

$$\text{Log MR} = 3.12197 + 0.0248722(X1) - 0.0345875(X2) - 9.02594((X4)^{0.19}/(X6)^{0.9} \quad (2.4)$$

$R^2 = 0.971$, and S.E. = 0.0849186

Where: Log = logarithm to base 10;

MR = dynamic (resilient) modulus, $10^5$ psi (4 Hz loading frequency);

X1 = percent passing #200 sieve;

X2 = percent air voids in mix;

X3 = asphalt viscosity at 70 °F ($10^6$ poises);

X4 = percent asphalt by total weight of mix;

X5 = test temperature (°F);

X6 = the logarithmic value of the viscosity (in poises) of the asphalt at the test temperature;

SE = standard error of the estimate; and

$R^2$ = coefficient of determination.

The results of this comparison are illustrated in figure 5.26. The straight line in the figure represents the locus of the points of equality. Further, a sensitivity analysis of the calculated values of MR from both equation to the range of the mix, test, and specimen variables was conducted. It was found that:

1) The agreement between the values of MR obtained from both equations was found to be dependent on the value of the percent air voids. In general, the values of MR obtained using equation 5.23 were higher than, equal to, and lower than those obtained using equation 2.3 for 3, 5, and 7 percent air voids, respectively.
2) Increasing AV from 3 to 7 percent causes a decrease in MR by factors of 0.75 and 0.47 for equations 2.3 and 5.23,respectively.
3) The values of the resilient modulus from A.I. equation increase by factor of 3.81 as the temperature decreases from $77^{o}F$ to $40^{o}F$, while those of equation 5.23 increase by a factor of 3.42.

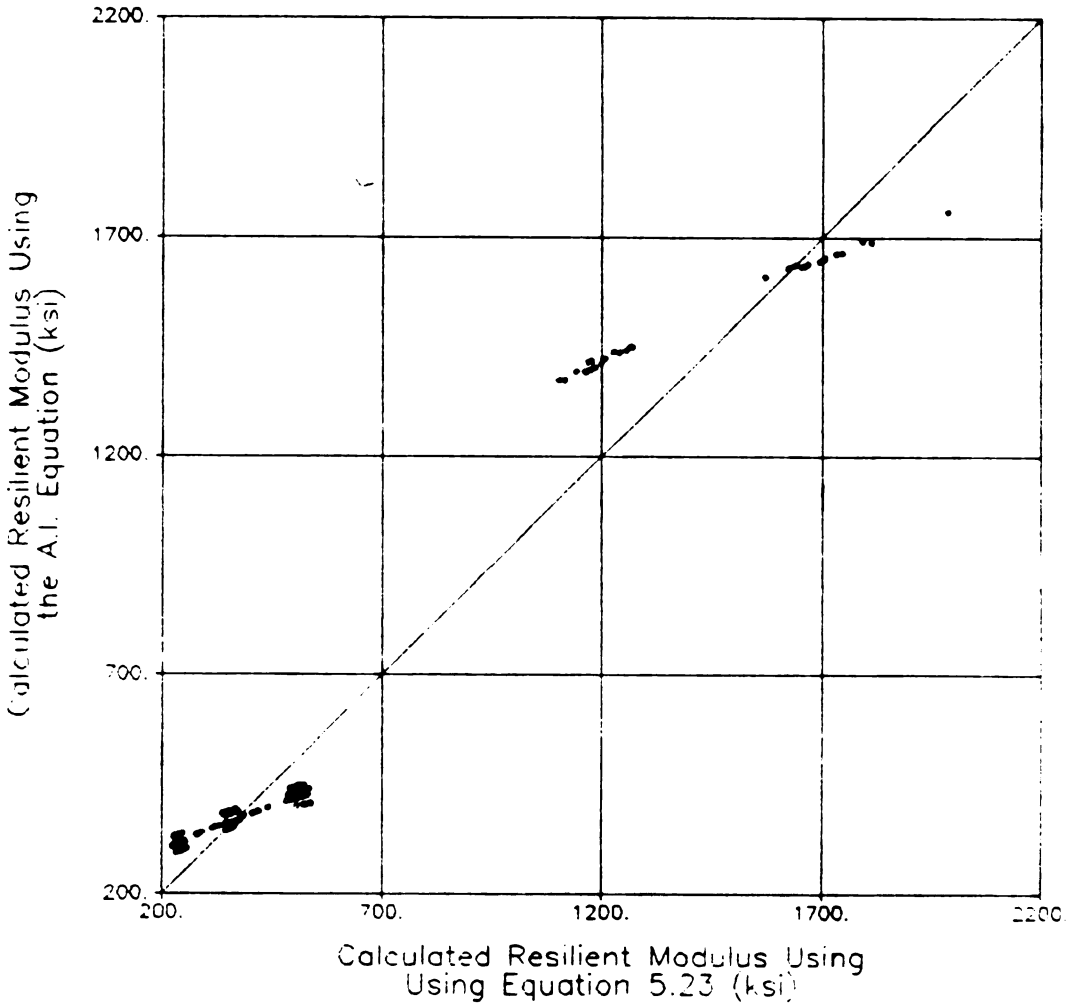


**Figure 5.26 Calculated resilient modulus using the A.I. equation versus calculated resilient modulus using equation 5.23.**

4) An increase in the kinematic viscosity of the asphalt binder from 159 to 270 centistokes leads to an increase in the value of the resilient modulus by a factor of 1.0001 for A.I. equation, and a decrease by a factor of 0.95 for equation 5.23.

5) The values of MR in equation 2.3 are also functions of the percent passing sieve number 200 (percent fine) and the percent asphalt content in the mix. These two variables were not included in this study (equation 5.23).

The above observations imply that the values of MR of equation 5.23 are more sensitive to the variation of the percent air voids than those of the A.I. equation. The effects of the test temperature on the values of MR of both equations are almost the same. In addition, although the effects of kinematic viscosity of the asphalt on the values of MR is small, the trend in both equations is not compatible as noted before.

Equations 5.23 and 5.24 were also compared to the equations 5.25 and 5.26 which were obtained from indirect tensile cyclic load tests. The tests were conducted using the same test, mix, and specimen variables as those used in this study (82).

$$\ln(M_R) = 16.092 - 0.03658 \times TT - 0.1401 \times AV - 0.0003409 \times CL + 0.04353 \times ANG + 0.0008793 \times KV \qquad (5.25)$$

$R^2$ = 0.997; and SE = 0.033

where: all variables are as before.

$$\ln(E) = 16.385 - 0.04529 \times TT - 0.1549 \times AV - 0.0003339 \times CL + 0.04258 \times ANG + 0.0008364 \times KV \quad (5.26)$$

$R^2$ = 0.998; and S.E. = 0.034

where E = total modulus (psi); and

all other variables are as before.

Figures 5.27 and 5.28 depict, respectively, the values of MR and E obtained using equations 5.25 and 5.26 plotted against those from equations 5.23 and 5.24. The straight line in the figures depict the locus of the points of equality. This comparison and a sensitivity analysis of both equations revealed that:

1) Increasing AV from 3 to 7 percent results in:
   a) decrease in MR by factors of 0.468 and 0.571 for equations 5.23 and 5.25, respectively.
   b) decrease in E by factors of 0.444 and 0.538 for equations 5.24 and 5.26, respectively.
2) Decreasing test temperatures from 77 to 40$^{o}$F yields:
   a) an increase in MR by factors of 3.42 and 3.87 for equations 5.23 and 5.25, respectively.

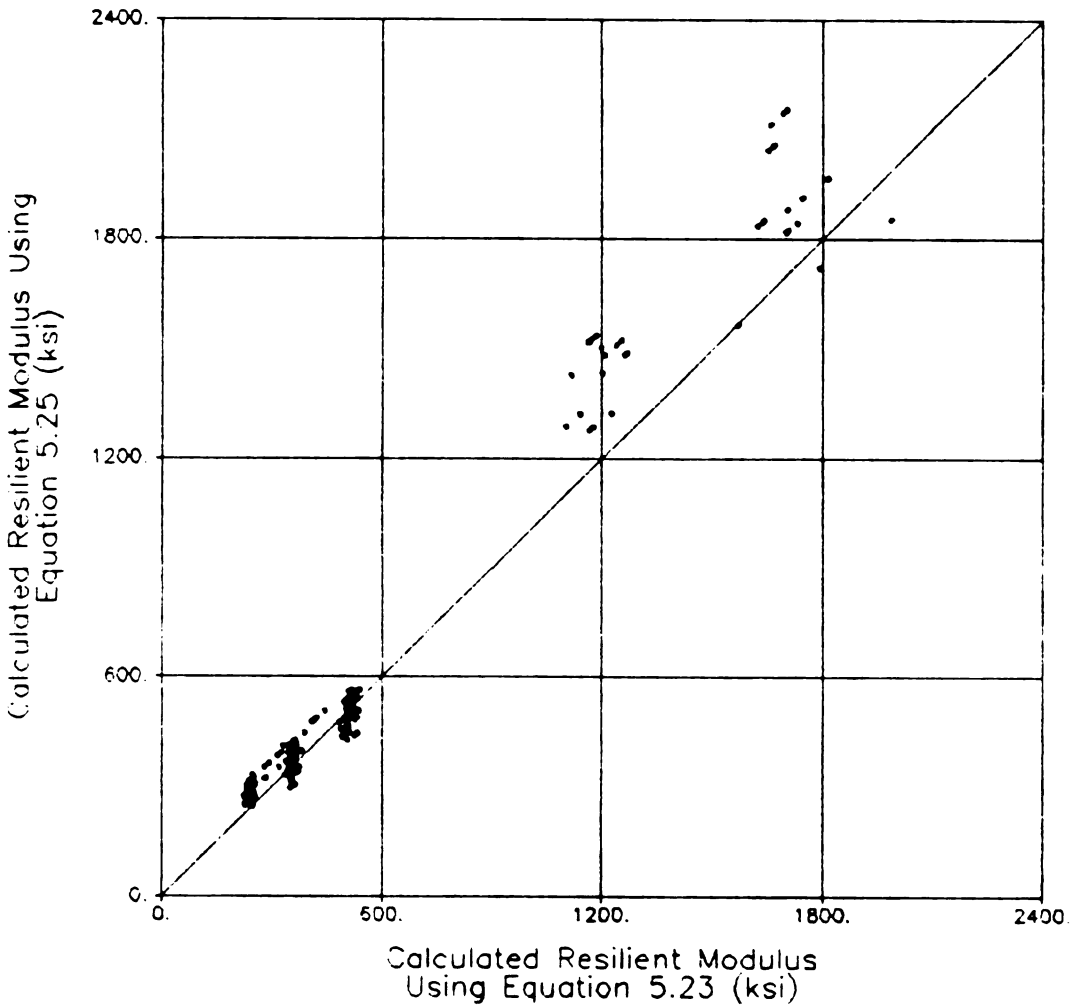


**Figure 5.27 Calculated resilient modulus using equation 5.25 versus calculated resilient modulus using equation 5.23.**

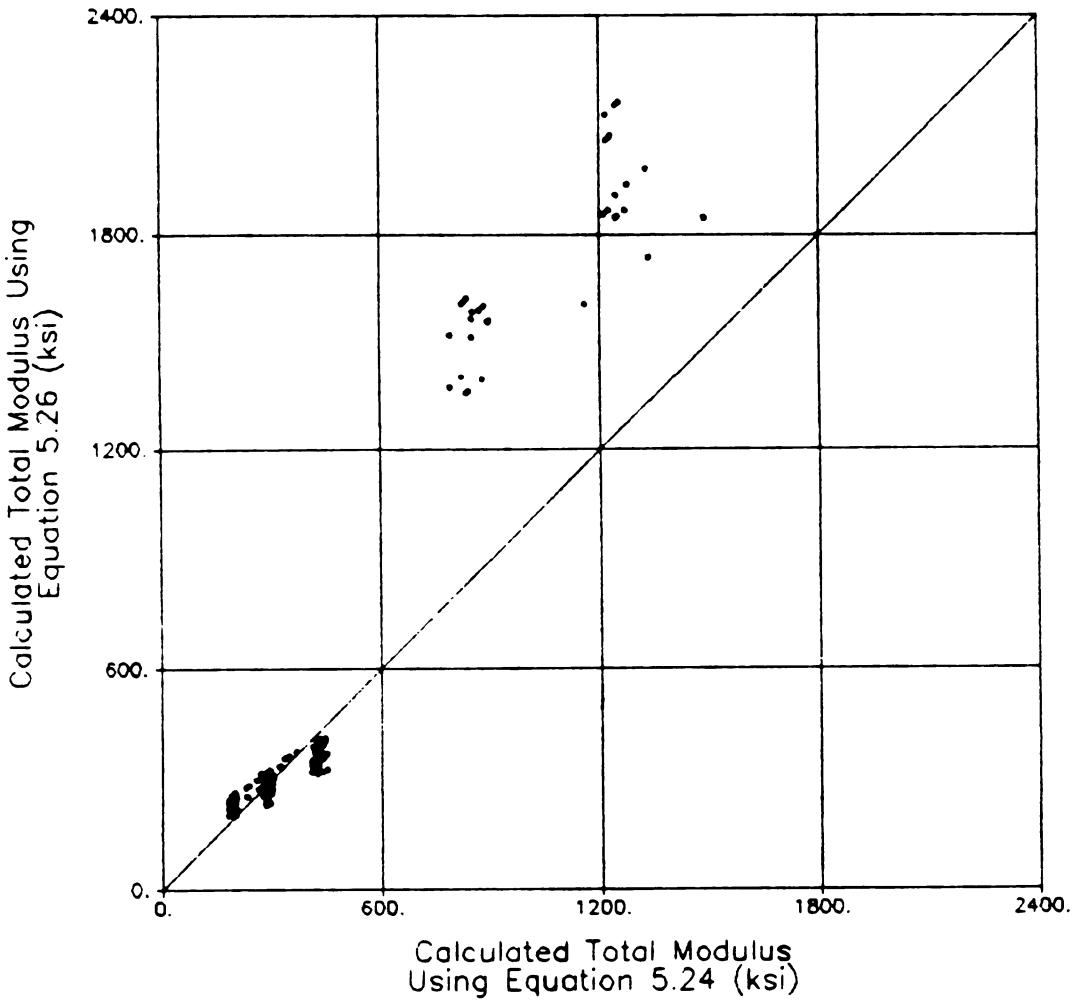


**Figure 5.28 Calculated total modulus using equation 5.26 versus calculated total modulus using equation 5.24.**

b) an increase in E by factors of 3.014 and 5.16 for equations 5.24 and 5.26, respectively.

3) Increasing kinematic viscosity from 159 to 270 centistokes causes the values of MR and E to increase by a factor of 1.1 for the indirect equations and to decrease by a factor of 0.95 for equations 5.23 and 5.25.

4) The values of the resilient and total moduli obtained from the indirect tensile tests are affected by the aggregate angularity (ANG) the magnitude of the cyclic load (CL). Increasing CL or decreasing ANG results in lower values of MR and E. The values of MR and E of equations 5.23 and 5.24, on the other hand, are independent of CL and ANG.

The above observations imply that:

1) The percent air voids of the test specimen posses similar effects on both results obtained from the indirect tensile and beam tests.

2) Although the effects of the test temperature on the values of MR are almost the same for both types of tests, its effects on E are different. Since the values of E are calculated using the measured total specimen deformation (resilient and viscoelastic) and since the values of MR are calculated using only the measured resilient deformation, one can conclude that the viscoelastic behavior of the indirect tensile

test specimens is different than that of the beam specimens. That is, the asphalt binder in the indirect tensile test specimens appears to become much stiffer, at 40°F relative to its stiffness at 77°F, than the binder in the beam specimen. Again, this could be related to the boundary conditions of the both tests.

3) Once again, the discrepancy relative to the effects of the kinematic viscosity between the two test results cannot be explained at this time.
4) The asphalt mixes in the indirect tensile test posses a nonlinear behavior (increasing load causes a decrease in the values of MR and E), while they showed a linear behavior in the beam tests.

## 5.9 SUMMARY

Laboratory test results obtained using the standard Marshall mix design procedures and flexural cyclic beam tests are presented and discussed. It is shown that statistical correlations between the structural properties of compacted asphalt mixes and their mix design parameters are useful to analyze the effects of the different mix, specimen, and test variables on the structural properties of the mix.

The statistical equations presented in this dissertation were proven to be accurate within the range of the values of

the independent variables employed in this study. Any interpolation should be checked with some laboratory test results. Extrapolation, however, is strongly discouraged.

## 5.10 IMPLEMENTATION

The statistical equations presented in this dissertation can be used to analyze the effects (in a qualitative terms) of the independent variables on the structural properties (resilient and total moduli, permanent deformations, and fatigue life) of compacted asphalt mixes. The statistical equations, however, should not be used for predicting the properties and behaviors of inservice pavements unless they are calibrated using field data. A limited field data base (4 pavement sections) has indicated that the effects of some of the independent variables on the laboratory test results are almost the same as their effects on the inservice pavements. However, the effects of the kinematic viscosity of the asphalt binder on the laboratory test results (fatigue life) are inconsistent with its effects on inservice pavements.

# CHAPTER 6

# CONCLUSIONS AND RECOMMENDATIONS

## 6.1 CONCLUSIONS

Based upon the test results, the analysis, and the findings presented in this dissertation, the following conclusions may be drawn:

1) Statistical relationships between the structural properties and the test, mix, and specimen variables have been found. These relationships can be used, in the laboratory, to assess the effect of each variable upon the structural properties of the asphalt mixes. The application of these relationships to field data need to be verified.
2) Rutting (Permanent deformation) in the flexible pavement can be improved by using a lower percent air voids, harder asphalt binder, higher aggregate angularity, or combinations thereof in the asphalt mixes.
3) Fatigue life of asphalt mixes can be increased by using a lower percent air voids, angular aggregates, or a combination thereof in the mix.
4) The use of beam theory in the analysis of resilient and total moduli of beam specimens is inadequate because of the assumptions involved in the theory.
5) The modulus of asphalt mixes can be increased by the

use of a lower percent air voids, higher aggregate angularity, or a combination thereof in the asphalt mixes.

## 6.2 RECOMMENDATIONS

The results of this study showed that it is possible to evaluate, in the laboratory, the effects of the test, mix, and specimen variables on the structural properties of asphalt mixes. It is recommended that the statistical equations presented in this dissertation be calibrated to field data prior to their use. It is further recommended that the effects of the asphalt content on the structural properties of asphalt mixes be calculated.

It was shown that the criterion used to determine the fatigue life of the beam specimens led to an erroneous conclusion relative to the effects of the kinematic viscosity of the asphalt binder. Therefore, it is recommended that, in future studies, the criterion be refined and the actual net assumed limit on the value of the cumulative plastic deformation under the load at which the fatigue life is reached be monitored and, perhaps, be related to the test, mix, and specimen variables.

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V. 2

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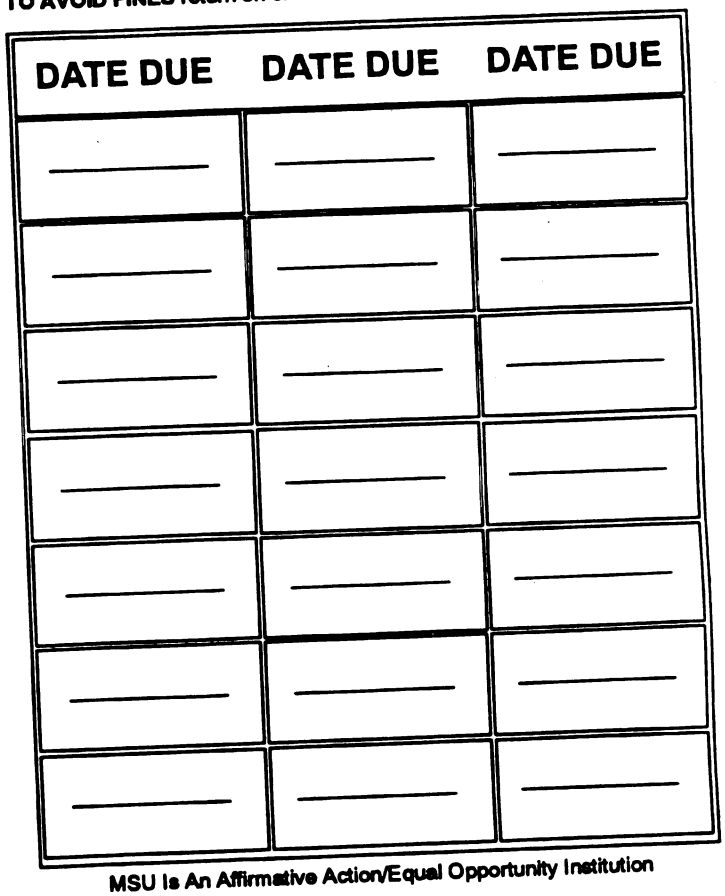


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# CHARACTERISTICS OF ASPHALT PAVING MIXTURES

# UNDER CYCLIC LOAD USING FLEXURAL TESTS
Volume II

BY

KISE LEE

A DISSERTATION

Submitted to
Michigan State University
in partial fulfilment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

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# APPENDICES

# APPENDIX A

Physical characteristics (weights, percent air voids, applied sustained and cyclic loads, and the maximum theoretical specific gravity), and the measured elastic, total, and plastic deformations at several number of load applications are presented in this Appendix.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110511 | 10000 | 449 | 4.30 | 50 | 100 | 6032.0 | 10130.0 | 2.55 | 2.91 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 150 | 16.7 | 19.4 | 7.3 | 9.0 | 10.4 | 3.4 | 7.2 | 8.4 | 2.5 | 5.6 | 6.5 | 1.8 |
| 520 | 13.9 | 16.1 | 14.8 | 7.4 | 8.5 | 6.5 | 5.7 | 6.6 | 4.6 | 4.1 | 4.7 | 3.0 |
| 1000 | 12.6 | 14.5 | 24.0 | 6.6 | 7.6 | 10.3 | 5.0 | 5.8 | 7.0 | 3.4 | 3.9 | 4.3 |
| 5000 | 9.9 | 11.4 | 60.8 | 5.1 | 5.9 | 24.3 | 3.6 | 4.2 | 15.1 | 2.1 | 2.4 | 7.8 |
| 10000 | 8.9 | 10.2 | 104.7 | 4.6 | 5.2 | 40.6 | 3.1 | 3.6 | 24.2 | 1.7 | 2.0 | 11.5 |
| 21940 | 7.9 | 9.0 | 158.4 | 4.0 | 4.5 | 59.4 | 2.6 | 3.0 | 33.7 | 1.3 | 1.5 | 14.3 |
| 164925 | 5.8 | 6.7 | 618.0 | 2.9 | 3.3 | 212.1 | 1.7 | 1.9 | 104.0 | 0.6 | 0.7 | 31.0 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110521 | 10000 | 449 | 4.30 | 50 | 100 | 6035.0 | 10138.0 | 2.55 | 2.95 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 17.9 | 20.3 | 5.7 | 9.6 | 10.9 | 2.7 | 7.8 | 8.9 | 2.0 | 6.2 | 7.0 | 1.5 |
| 500 | 14.0 | 16.3 | 14.3 | 7.4 | 8.6 | 6.3 | 5.7 | 6.6 | 4.4 | 4.1 | 4.7 | 2.9 |
| 1000 | 12.7 | 14.6 | 24.7 | 6.6 | 7.7 | 10.5 | 5.0 | 5.8 | 7.1 | 3.4 | 3.9 | 4.4 |
| 5000 | 9.9 | 11.8 | 62.7 | 5.1 | 6.1 | 25.0 | 3.6 | 4.3 | 15.5 | 2.1 | 2.5 | 8.0 |
| 10000 | 9.0 | 10.3 | 104.3 | 4.6 | 5.3 | 40.3 | 3.1 | 3.6 | 24.0 | 1.7 | 1.9 | 11.3 |
| 36235 | 7.4 | 8.7 | 215.6 | 7.2 | 11.0 | - | 7.3 | 10.7 | - | 7.0 | 9.7 | - |
| 170420 | 5.9 | 6.7 | 649.5 | 2.9 | 3.3 | 221.6 | 1.7 | 1.9 | 108.0 | 0.6 | 0.7 | 31.8 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110531 | 10000 | 449 | 4.30 | 50 | 100 | 6040.0 | 10150.0 | 2.55 | 3.00 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 18.0 | 20.7 | 5.7 | 9.7 | 11.1 | 2.7 | 7.8 | 9.0 | 2.0 | 6.2 | 7.1 | 1.5 |
| 500 | 14.2 | 16.3 | 14.6 | 7.5 | 8.6 | 6.4 | 5.7 | 6.6 | 4.5 | 4.1 | 4.7 | 2.9 |
| 1000 | 12.8 | 14.7 | 25.2 | 6.7 | 7.7 | 10.7 | 5.0 | 5.8 | 7.2 | 3.4 | 3.9 | 4.4 |
| 5010 | 10.0 | 11.7 | 62.7 | 5.1 | 6.0 | 24.8 | 3.6 | 4.2 | 15.3 | 2.1 | 2.5 | 7.9 |
| 10025 | 9.0 | 10.4 | 109.3 | 4.6 | 5.3 | 42.0 | 3.1 | 3.6 | 24.9 | 1.7 | 1.9 | 11.7 |
| 21200 | 8.1 | 9.2 | 156.7 | 2.6 | 3.1 | - | 2.1 | 2.5 | - | 1.7 | 1.9 | - |
| 164725 | 5.9 | 6.8 | 646.4 | 2.9 | 3.3 | 219.6 | 1.7 | 1.9 | 106.8 | 0.6 | 0.7 | 31.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110512 | 10000 | 449 | 4.30 | 50 | 200 | 6042.0 | 10152.0 | 2.55 | 2.98 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 155 | 33.7 | 38.1 | 17.1 | 17.6 | 19.9 | 7.7 | 13.7 | 15.5 | 5.5 | 10.2 | 11.5 | 3.8 |
| 525 | 28.1 | 31.8 | 33.8 | 14.5 | 16.4 | 14.5 | 10.8 | 12.2 | 9.8 | 7.3 | 8.3 | 6.1 |
| 1000 | 25.5 | 28.9 | 54.9 | 13.0 | 14.8 | 22.8 | 9.5 | 10.7 | 14.9 | 6.1 | 6.9 | 8.7 |
| 5000 | 20.0 | 22.9 | 142.0 | 10.0 | 11.5 | 55.1 | 6.8 | 7.8 | 32.8 | 3.7 | 4.3 | 15.9 |
| 10000 | 18.0 | 20.6 | 237.4 | 9.0 | 10.2 | 89.4 | 5.9 | 6.7 | 50.9 | 3.0 | 3.4 | 22.5 |
| 26730 | 15.6 | 17.9 | 414.0 | 7.6 | 8.8 | 149.3 | 4.7 | 5.4 | 79.5 | 2.1 | 2.4 | 30.2 |
| 169100 | 11.8 | 13.5 | 1435.9 | 5.6 | 6.4 | 476.8 | 3.1 | 3.6 | 220.3 | 1.0 | 1.1 | 58.4 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110522 | 10000 | 449 | 4.30 | 50 | 200 | 6050.0 | 10175.0 | 2.55 | 3.12 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 36.8 | 42.3 | 13.4 | 19.1 | 21.9 | 6.1 | 15.0 | 17.2 | 4.5 | 11.4 | 13.0 | 3.1 |
| 500 | 28.9 | 32.9 | 34.1 | 14.7 | 16.8 | 14.4 | 10.9 | 12.4 | 9.7 | 7.4 | 8.4 | 6.0 |
| 1000 | 26.1 | 29.6 | 58.6 | 13.2 | 14.9 | 24.0 | 9.5 | 10.8 | 15.6 | 6.1 | 6.9 | 9.0 |
| 5025 | 20.5 | 23.4 | 149.1 | 10.1 | 11.6 | 57.0 | 6.8 | 7.8 | 33.6 | 3.7 | 4.2 | 16.1 |
| 10000 | 18.5 | 20.8 | 253.9 | 9.0 | 10.2 | 94.2 | 5.8 | 6.6 | 53.2 | 2.9 | 3.3 | 23.2 |
| 158650 | 12.2 | 13.9 | 1312.1 | 5.7 | 6.5 | 430.2 | 3.1 | 3.6 | 197.3 | 1.0 | 1.1 | 51.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110532 | 10000 | 449 | 4.30 | 50 | 200 | 6040.0 | 10151.0 | 2.55 | 3.02 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 36.2 | 42.1 | 13.0 | 19.0 | 22.1 | 5.9 | 14.9 | 17.4 | 4.4 | 11.4 | 13.2 | 3.1 |
| 500 | 28.4 | 32.3 | 33.6 | 14.6 | 16.6 | 14.3 | 10.9 | 12.4 | 9.7 | 7.4 | 8.5 | 6.0 |
| 1000 | 25.6 | 29.8 | 55.5 | 13.1 | 15.2 | 23.0 | 9.5 | 11.0 | 15.0 | 6.1 | 7.1 | 8.7 |
| 5000 | 20.1 | 22.9 | 141.2 | 10.0 | 11.4 | 54.6 | 6.8 | 7.7 | 32.4 | 3.7 | 4.2 | 15.7 |
| 10000 | 18.1 | 20.8 | 240.3 | 9.0 | 10.3 | 90.2 | 5.8 | 6.7 | 51.2 | 3.0 | 3.4 | 22.6 |
| 30000 | 15.4 | 17.4 | 444.3 | 7.5 | 8.5 | 158.8 | 4.6 | 5.2 | 83.6 | 2.0 | 2.3 | 31.0 |
| 163740 | 11.9 | 13.7 | 1421.8 | 5.7 | 6.5 | 471.0 | 3.1 | 3.6 | 217.5 | 1.0 | 1.1 | 57.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110515 | 10000 | 449 | 4.30 | 50 | 500 | 6047.0 | 10166.0 | 2.55 | 3.06 |

DEFORMATION (inches·X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 91.2 | 104.6 | 44.0 | 44.5 | 51.1 | 18.7 | 31.6 | 36.2 | 12.4 | 21.3 | 24.4 | 7.8 |
| 500 | 71.6 | 81.0 | 112.7 | 34.2 | 38.7 | 44.7 | 22.7 | 25.6 | 27.0 | 13.3 | 15.0 | 14.4 |
| 1000 | 64.6 | 74.7 | 192.8 | 30.6 | 35.3 | 74.2 | 19.6 | 22.6 | 42.8 | 10.7 | 12.3 | 21.0 |
| 5000 | 50.7 | 58.8 | 481.3 | 23.5 | 27.2 | 172.4 | 13.8 | 16.0 | 89.1 | 6.1 | 7.1 | 34.8 |
| 10000 | 45.7 | 52.6 | 809.3 | 20.9 | 24.1 | 281.0 | 11.8 | 13.6 | 137.8 | 4.7 | 5.4 | 47.8 |
| 50000 | 35.9 | 41.2 | 2111.2 | 16.0 | 18.4 | 681.0 | 8.1 | 9.3 | 292.4 | 2.4 | 2.7 | 72.8 |
| 100000 | 32.4 | 36.6 | 3589.6 | 14.3 | 16.2 | 1121.2 | 6.8 | 7.7 | 452.1 | 1.7 | 1.9 | 94.7 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110525 | 10000 | 449 | 4.30 | 50 | 500 | 6047.0 | 10164.0 | 2.55 | 3.03 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 90.8 | 105.0 | 43.4 | 44.5 | 51.4 | 18.5 | 31.6 | 36.5 | 12.3 | 21.3 | 24.7 | 7.7 |
| 500 | 71.3 | 80.9 | 111.0 | 34.2 | 38.8 | 44.2 | 22.7 | 25.7 | 26.7 | 13.3 | 15.1 | 14.3 |
| 1000 | 64.3 | 73.1 | 186.4 | 30.5 | 34.7 | 72.0 | 19.6 | 22.3 | 41.6 | 10.7 | 12.2 | 20.5 |
| 5000 | 50.5 | 58.0 | 483.4 | 23.4 | 26.9 | 173.7 | 13.8 | 15.8 | 90.0 | 6.1 | 7.0 | 35.2 |
| 10000 | 45.5 | 52.9 | 819.0 | 20.9 | 24.3 | 285.3 | 11.8 | 13.7 | 140.3 | 4.7 | 5.5 | 48.8 |
| 50000 | 35.7 | 40.4 | 2070.5 | 16.0 | 18.1 | 670.2 | 8.1 | 9.2 | 288.7 | 2.4 | 2.7 | 72.2 |
| 100000 | 32.2 | 36.8 | 3508.7 | 14.3 | 16.3 | 1099.8 | 6.9 | 7.8 | 444.9 | 1.7 | 2.0 | 93.8 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110535 | 10000 | 449 | 4.30 | 50 | 500 | 6058.0 | 10185.0 | 2.55 | 3.07 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 91.5 | 103.6 | 43.7 | 44.6 | 50.5 | 18.5 | 31.7 | 35.9 | 12.3 | 21.3 | 24.2 | 7.7 |
| 500 | 71.9 | 83.2 | 111.7 | 34.3 | 39.7 | 44.3 | 22.7 | 26.3 | 26.7 | 13.3 | 15.4 | 14.2 |
| 1000 | 64.8 | 73.3 | 192.7 | 30.6 | 34.7 | 74.1 | 19.6 | 22.2 | 42.7 | 10.7 | 12.1 | 21.0 |
| 5027 | 50.8 | 59.0 | 493.1 | 23.5 | 27.3 | 176.4 | 13.8 | 16.0 | 91.1 | 6.1 | 7.1 | 35.5 |
| 10400 | 45.6 | 52.1 | 833.4 | 20.8 | 23.8 | 288.6 | 11.7 | 13.4 | 141.0 | 4.6 | 5.3 | 48.5 |
| 18000 | 42.0 | 49.1 | 1093.2 | 19.0 | 22.2 | 369.3 | 10.3 | 12.1 | 172.8 | 3.7 | 4.3 | 53.5 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11210511 | 10000 | 444 | 4.25 | 50 | 100 | 6032.0 | 10146.0 | 2.55 | 3.17 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 17.9 | 20.5 | 6.8 | 9.4 | 10.7 | 3.1 | 7.5 | 8.6 | 2.3 | 5.8 | 6.6 | 1.7 |
| 500 | 14.1 | 15.9 | 18.0 | 7.2 | 8.1 | 7.7 | 5.4 | 6.2 | 5.3 | 3.8 | 4.3 | 3.3 |
| 1000 | 12.7 | 14.4 | 30.8 | 6.4 | 7.3 | 12.7 | 4.7 | 5.4 | 8.4 | 3.1 | 3.6 | 5.0 |
| 5000 | 9.9 | 11.3 | 80.7 | 5.0 | 5.6 | 31.1 | 3.4 | 3.9 | 18.8 | 1.9 | 2.2 | 9.3 |
| 10000 | 9.0 | 10.3 | 141.6 | 4.4 | 5.1 | 53.0 | 2.9 | 3.4 | 30.6 | 1.5 | 1.8 | 13.9 |
| 30500 | 7.6 | 8.8 | 265.5 | 3.7 | 4.3 | 94.6 | 2.3 | 2.7 | 50.7 | 1.0 | 1.2 | 19.4 |
| 683000 | 4.8 | 5.4 | 2231.5 | 2.2 | 2.5 | 690.7 | 1.1 | 1.3 | 287.5 | 0.3 | 0.3 | 55.4 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11210521 | 10000 | 444 | 4.25 | 50 | 100 | 6041.0 | 10150.0 | 2.55 | 3.02 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 17.5 | 20.6 | 6.4 | 9.3 | 10.9 | 3.0 | 7.4 | 8.8 | 2.2 | 5.8 | 6.8 | 1.6 |
| 500 | 13.7 | 15.5 | 17.0 | 7.2 | 8.1 | 7.4 | 5.4 | 6.1 | 5.1 | 3.8 | 4.3 | 3.3 |
| 1000 | 12.4 | 14.0 | 29.1 | 6.4 | 7.2 | 12.2 | 4.7 | 5.4 | 8.2 | 3.2 | 3.6 | 4.9 |
| 5000 | 9.7 | 11.0 | 76.4 | 4.9 | 5.6 | 30.0 | 3.4 | 3.9 | 18.3 | 1.9 | 2.2 | 9.2 |
| 10000 | 8.8 | 10.1 | 134.5 | 4.4 | 5.1 | 51.2 | 2.9 | 3.4 | 29.9 | 1.6 | 1.8 | 13.8 |
| 30550 | 7.4 | 8.4 | 255.4 | 3.7 | 4.2 | 92.6 | 2.3 | 2.6 | 50.2 | 1.1 | 1.2 | 19.5 |
| 40000 | 7.1 | 8.2 | 327.6 | 3.5 | 4.0 | 117.4 | 2.2 | 2.5 | 62.4 | 1.0 | 1.1 | 23.2 |
| 352030 | 5.1 | 5.9 | 1255.1 | 2.4 | 2.8 | 407.9 | 1.3 | 1.5 | 182.9 | 0.4 | 0.4 | 43.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11210531 | 10000 | 444 | 4.25 | 50 | 100 | 6032.0 | 10136.0 | 2.55 | 3.03 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 150 | 16.4 | 19.1 | 8.4 | 8.7 | 10.1 | 3.8 | 6.9 | 8.0 | 2.8 | 5.2 | 6.1 | 2.0 |
| 550 | 13.5 | 15.3 | 18.0 | 7.0 | 7.9 | 7.8 | 5.3 | 6.0 | 5.3 | 3.7 | 4.2 | 3.4 |
| 1000 | 12.4 | 14.2 | 29.7 | 6.4 | 7.3 | 12.4 | 4.7 | 5.4 | 8.3 | 3.1 | 3.6 | 5.0 |
| 5000 | 9.7 | 11.2 | 76.4 | 4.9 | 5.7 | 29.9 | 3.4 | 3.9 | 18.2 | 1.9 | 2.2 | 9.2 |
| 10000 | 8.8 | 10.1 | 133.8 | 4.4 | 5.1 | 50.9 | 2.9 | 3.4 | 29.6 | 1.6 | 1.8 | 13.6 |
| 33100 | 7.3 | 8.3 | 266.2 | 3.6 | 4.1 | 96.0 | 2.3 | 2.6 | 51.6 | 1.0 | 1.1 | 19.8 |
| 145000 | 5.9 | 6.7 | 785.6 | 2.8 | 3.2 | 265.3 | 1.6 | 1.9 | 127.8 | 0.6 | 0.6 | 37.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11210512 | 10000 | 444 | 4.25 | 50 | 200 | 6034.0 | 10143.0 | 2.55 | 3.08 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 35.3 | 40.5 | 14.9 | 18.2 | 20.9 | 6.7 | 14.2 | 16.3 | 4.9 | - | - | - |
| 500 | 27.7 | 32.2 | 39.5 | 14.0 | 16.3 | 16.6 | 10.3 | 12.0 | 11.1 | - | - | - |
| 1000 | 25.0 | 28.5 | 66.9 | 12.5 | 14.3 | 27.3 | 8.9 | 10.2 | 17.5 | - | - | - |
| 5000 | 19.6 | 22.1 | 178.7 | 9.6 | 10.9 | 68.0 | 6.4 | 7.2 | 39.7 | - | - | - |
| 10000 | 17.7 | 20.0 | 304.2 | 8.6 | 9.7 | 112.4 | 5.5 | 6.2 | 62.6 | - | - | - |
| 20000 | 15.9 | 18.5 | 438.8 | 7.7 | 8.9 | 157.2 | 4.7 | 5.5 | 83.4 | - | - | - |
| 34000 | 14.7 | 17.1 | 691.2 | 7.0 | 8.2 | 241.8 | 4.2 | 4.9 | 123.4 | - | - | - |
| 164600 | 11.6 | 13.4 | 1790.0 | 5.4 | 6.2 | 583.2 | 2.9 | 3.4 | 262.5 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11210522 | 10000 | 444 | 4.25 | 50 | 200 | 6031.0 | 10140.0 | 2.55 | 3.11 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 35.4 | 41.2 | 15.1 | 18.2 | 21.2 | 6.8 | 14.2 | 16.5 | 4.9 | - | - | - |
| 500 | 27.8 | 32.1 | 39.4 | 14.1 | 16.2 | 16.5 | 10.3 | 11.9 | 11.0 | - | - | - |
| 1000 | 25.1 | 29.2 | 68.2 | 12.6 | 14.6 | 27.8 | 8.9 | 10.4 | 17.8 | - | - | - |
| 5000 | 19.7 | 22.9 | 181.4 | 9.7 | 11.2 | 68.8 | 6.4 | 7.4 | 40.1 | - | - | - |
| 10000 | 17.8 | 20.7 | 304.1 | 8.6 | 10.0 | 112.0 | 5.5 | 6.4 | 62.2 | - | - | - |
| 44000 | 14.2 | 16.1 | 743.1 | 6.8 | 7.6 | 256.1 | 4.0 | 4.5 | 127.9 | - | - | - |
| 165000 | 11.7 | 13.4 | 1968.2 | 5.4 | 6.2 | 639.0 | 2.9 | 3.3 | 286.7 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11210532 | 10000 | 444 | 4.25 | 50 | 200 | 6028.0 | 10138.0 | 2.55 | 3.15 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 35.6 | 41.5 | 15.3 | 18.3 | 21.3 | 6.8 | 14.2 | 16.5 | 4.9 | 10.6 | 12.3 | 3.4 |
| 500 | 28.0 | 32.5 | 40.3 | 14.1 | 16.3 | 16.8 | 10.3 | 11.9 | 11.2 | 6.9 | 8.0 | 6.8 |
| 1000 | 25.2 | 29.1 | 69.3 | 12.6 | 14.5 | 28.1 | 8.9 | 10.3 | 18.0 | 5.6 | 6.5 | 10.2 |
| 5000 | 19.8 | 23.1 | 183.3 | 9.7 | 11.3 | 69.2 | 6.4 | 7.4 | 40.2 | 3.4 | 3.9 | 18.8 |
| 10000 | 17.9 | 20.5 | 317.4 | 8.6 | 9.9 | 116.3 | 5.5 | 6.3 | 64.4 | 2.7 | 3.1 | 27.3 |
| 27100 | 15.4 | 17.5 | 551.9 | 7.3 | 8.3 | 193.5 | 4.4 | 5.0 | 99.9 | 1.9 | 2.1 | 36.0 |
| 49800 | 14.0 | 16.2 | 912.2 | 6.6 | 7.7 | 311.2 | 3.8 | 4.4 | 153.4 | 1.5 | 1.7 | 49.4 |
| 195000 | 11.4 | 13.0 | 2042.3 | 5.3 | 6.0 | 654.6 | 2.8 | 3.2 | 288.4 | 0.8 | 0.9 | 68.9 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11210515 | 10000 | 444 | 4.25 | 50 | 500 | 6035.0 | 10142.0 | 2.55 | 3.05 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 87.6 | 99.0 | 49.0 | 42.5 | 48.0 | 20.7 | 29.8 | 33.7 | 13.5 | 19.8 | 22.3 | 8.4 |
| 500 | 68.8 | 79.1 | 127.2 | 32.7 | 37.6 | 50.1 | 21.3 | 24.5 | 29.8 | 12.3 | 14.1 | 15.6 |
| 1000 | 62.0 | 70.1 | 219.6 | 29.2 | 32.9 | 83.9 | 18.4 | 20.8 | 47.8 | 9.8 | 11.1 | 23.0 |
| 5000 | 48.7 | 55.1 | 582.1 | 22.4 | 25.3 | 207.1 | 12.9 | 14.6 | 105.3 | 5.6 | 6.3 | 40.0 |
| 10000 | 43.9 | 49.7 | 1000.9 | 20.0 | 22.6 | 345.1 | 11.1 | 12.5 | 166.4 | 4.3 | 4.8 | 56.0 |
| 21000 | 39.3 | 45.1 | 1473.4 | 17.7 | 20.3 | 491.1 | 9.3 | 10.7 | 222.9 | 3.1 | 3.6 | 64.9 |
| 30400 | 37.2 | 42.9 | 2076.5 | 16.6 | 19.2 | 680.5 | 8.5 | 9.8 | 299.4 | 2.7 | 3.1 | 80.5 |
| 122877 | 30.2 | 34.7 | 4763.7 | 13.2 | 15.1 | 1462.9 | 6.1 | 7.0 | 566.5 | 1.4 | 1.6 | 107.6 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11210525 | 10000 | 444 | 4.25 | 50 | 500 | 6029.0 | 10134.0 | 2.55 | 3.07 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 88.0 | 101.8 | 48.8 | 42.5 | 49.2 | 20.6 | 29.8 | 34.4 | 13.4 | 19.7 | 22.8 | 8.3 |
| 500 | 69.1 | 82.5 | 129.7 | 32.7 | 39.0 | 50.9 | 21.3 | 25.4 | 30.2 | 12.2 | 14.6 | 15.8 |
| 1000 | 62.3 | 70.6 | 225.6 | 29.2 | 33.1 | 85.9 | 18.4 | 20.8 | 48.8 | 9.8 | 11.1 | 23.4 |
| 5200 | 48.6 | 55.2 | 596.4 | 22.2 | 25.2 | 211.1 | 12.8 | 14.5 | 106.7 | 5.5 | 6.2 | 40.1 |
| 10000 | 44.1 | 49.9 | 1007.7 | 20.0 | 22.6 | 346.2 | 11.0 | 12.5 | 166.4 | 4.2 | 4.8 | 55.8 |
| 20000 | 39.7 | 47.5 | 1449.4 | 17.8 | 21.3 | 482.4 | 9.4 | 11.2 | 219.2 | 3.2 | 3.8 | 64.2 |
| 98850 | 31.3 | 35.5 | 4618.3 | 13.6 | 15.5 | 1427.4 | 6.4 | 7.3 | 562.5 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11210535 | 10000 | 444 | 4.25 | 50 | 500 | 6057.0 | 10186.0 | 2.55 | 3.14 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 89.4 | 102.4 | 49.8 | 42.9 | 49.1 | 20.8 | 29.9 | 34.2 | 13.5 | 19.7 | 22.6 | 8.3 |
| 500 | 70.2 | 79.7 | 133.8 | 33.0 | 37.4 | 52.1 | 21.4 | 24.3 | 30.8 | 12.2 | 13.8 | 16.0 |
| 1000 | 63.3 | 72.4 | 230.0 | 29.4 | 33.6 | 86.9 | 18.4 | 21.1 | 49.1 | 9.7 | 11.1 | 23.4 |
| 5000 | 49.7 | 56.9 | 599.3 | 22.6 | 25.8 | 210.7 | 12.9 | 14.8 | 106.2 | 5.5 | 6.3 | 39.8 |
| 10000 | 44.8 | 51.3 | 1041.2 | 20.1 | 23.1 | 354.7 | 11.0 | 12.6 | 169.4 | 4.2 | 4.8 | 56.2 |
| 20000 | 40.4 | 46.3 | 1477.3 | 17.9 | 20.5 | 487.5 | 9.4 | 10.8 | 220.0 | 3.2 | 3.6 | 63.6 |
| 37500 | 36.7 | 41.4 | 2455.3 | 16.2 | 18.2 | 787.0 | 8.1 | 9.1 | 336.4 | 2.4 | 2.7 | 84.7 |
| 100900 | 31.7 | 36.2 | 4369.1 | 13.7 | 15.6 | 1337.1 | 6.4 | 7.3 | 521.6 | 1.5 | 1.7 | 102.3 |

WA = TOTAL WEIGHT OF DRY AGGREGATES;
WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT;
SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR;
CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER;
AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11310511 | 10000 | 424 | 4.07 | 50 | 100 | 6074.0 | 10188.0 | 2.55 | 3.00 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 17.1 | 19.6 | 6.9 | 9.1 | 10.4 | 3.2 | 7.2 | 8.3 | 2.4 | 5.6 | 6.4 | 1.7 |
| 500 | 13.4 | 15.5 | 18.1 | 7.0 | 8.0 | 7.8 | 5.3 | 6.1 | 5.4 | 3.7 | 4.2 | 3.4 |
| 1000 | 12.1 | 14.1 | 31.7 | 6.2 | 7.2 | 13.3 | 4.6 | 5.3 | 8.8 | 3.0 | 3.5 | 5.2 |
| 5000 | 9.5 | 10.8 | 86.1 | 4.8 | 5.5 | 33.7 | 3.3 | 3.8 | 20.4 | 1.9 | 2.1 | 10.2 |
| 10000 | 8.6 | 9.7 | 148.2 | 4.3 | 4.9 | 56.3 | 2.9 | 3.2 | 32.6 | 1.5 | 1.7 | 14.8 |
| 32142 | 7.2 | 8.4 | 304.2 | 3.5 | 4.1 | 109.7 | 2.2 | 2.6 | 58.7 | 1.0 | 1.1 | 22.4 |
| 172900 | 5.6 | 6.3 | 1001.7 | 2.7 | 3.0 | 335.2 | 1.5 | 1.7 | 158.0 | 0.5 | 0.6 | 43.5 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11310521 | 10000 | 424 | 4.07 | 50 | 100 | 6048.0 | 10144.0 | 2.55 | 2.99 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 17.0 | 19.6 | 6.9 | 9.0 | 10.4 | 3.2 | 7.2 | 8.3 | 2.4 | 5.6 | 6.4 | 1.7 |
| 500 | 13.4 | 15.5 | 19.2 | 6.9 | 8.1 | 8.3 | 5.3 | 6.1 | 5.7 | 3.7 | 4.2 | 3.6 |
| 1000 | 12.0 | 13.8 | 32.0 | 6.2 | 7.1 | 13.4 | 4.6 | 5.2 | 8.9 | 3.0 | 3.5 | 5.3 |
| 5000 | 9.5 | 10.7 | 87.0 | 4.8 | 5.4 | 34.0 | 3.3 | 3.7 | 20.6 | 1.9 | 2.1 | 10.3 |
| 10000 | 8.5 | 9.9 | 150.0 | 4.3 | 5.0 | 57.0 | 2.8 | 3.3 | 33.0 | 1.5 | 1.7 | 15.0 |
| 21000 | 7.6 | 8.9 | 222.5 | 3.8 | 4.4 | 81.8 | 2.4 | 2.8 | 45.1 | 1.1 | 1.3 | 18.4 |
| 50535 | 6.7 | 7.5 | 444.0 | 3.3 | 3.7 | 157.1 | 2.0 | 2.3 | 81.4 | 0.8 | 0.9 | 28.7 |
| 154500 | 5.7 | 6.5 | 844.8 | 2.7 | 3.1 | 284.3 | 1.5 | 1.8 | 135.3 | 0.5 | 0.6 | 38.2 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11310531 | 10000 | 424 | 4.07 | 50 | 100 | 6048.0 | 10145.0 | 2.55 | 3.01 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 17.0 | 19.8 | 6.9 | 9.0 | 10.5 | 3.2 | 7.2 | 8.3 | 2.4 | 5.6 | 6.5 | 1.7 |
| 200 | 15.4 | 17.6 | 10.1 | 8.1 | 9.2 | 4.5 | 6.3 | 7.2 | 3.3 | 4.7 | 5.3 | 2.2 |
| 500 | 13.4 | 15.5 | 20.0 | 7.0 | 8.0 | 8.6 | 5.3 | 6.1 | 5.9 | 3.7 | 4.2 | 3.8 |
| 1000 | 12.1 | 13.7 | 29.7 | 6.2 | 7.0 | 12.5 | 4.6 | 5.2 | 8.3 | 3.0 | 3.4 | 4.9 |
| 5000 | 9.5 | 11.0 | 95.1 | 4.8 | 5.5 | 37.2 | 3.3 | 3.8 | 22.5 | 1.9 | 2.1 | 11.2 |
| 10000 | 8.5 | 9.9 | 138.9 | 4.3 | 4.9 | 52.7 | 2.8 | 3.3 | 30.5 | 1.5 | 1.7 | 13.9 |
| 30000 | 7.2 | 8.2 | 314.6 | 3.6 | 4.0 | 113.7 | 2.2 | 2.5 | 61.1 | 1.0 | 1.1 | 23.5 |
| 164700 | 5.6 | 6.4 | 888.2 | 2.7 | 3.1 | 297.6 | 1.5 | 1.8 | 140.7 | 0.5 | 0.6 | 39.1 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11310512 | 10000 | 424 | 4.07 | 50 | 200 | 6043.0 | 10137.0 | 2.55 | 3.01 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 34.1 | 39.2 | 15.4 | 17.7 | 20.3 | 6.9 | 13.7 | 15.7 | 5.0 | 10.2 | 11.7 | 3.5 |
| 500 | 26.8 | 31.1 | 41.2 | 13.6 | 15.8 | 17.4 | 9.9 | 11.5 | 11.5 | 6.6 | 7.7 | 7.0 |
| 1000 | 24.1 | 27.5 | 70.9 | 12.2 | 13.9 | 29.0 | 8.6 | 9.8 | 18.6 | 5.4 | 6.2 | 10.5 |
| 5000 | 19.0 | 21.7 | 193.0 | 9.3 | 10.7 | 73.7 | 6.2 | 7.1 | 42.8 | 3.3 | 3.8 | 20.0 |
| 10000 | 17.1 | 19.7 | 339.3 | 8.3 | 9.6 | 125.7 | 5.3 | 6.1 | 69.7 | 2.6 | 3.0 | 29.6 |
| 30000 | 14.5 | 16.7 | 652.7 | 7.0 | 8.1 | 230.3 | 4.2 | 4.8 | 118.2 | 1.7 | 2.0 | 41.9 |
| 75200 | 12.6 | 14.5 | 1307.6 | 6.0 | 6.9 | 442.8 | 3.4 | 3.9 | 211.6 | 1.2 | 1.4 | 62.9 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11310522 | 10000 | 424 | 4.07 | 50 | 200 | 6044.0 | 10142.0 | 2.55 | 3.06 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 34.4 | 39.5 | 15.7 | 17.7 | 20.4 | 7.1 | 13.7 | 15.8 | 5.1 | - | - | - |
| 500 | 27.0 | 30.8 | 41.7 | 13.6 | 15.6 | 17.5 | 9.9 | 11.3 | 11.6 | - | - | - |
| 1000 | 24.3 | 27.5 | 72.7 | 12.2 | 13.8 | 29.6 | 8.6 | 9.8 | 18.9 | - | - | - |
| 5000 | 19.1 | 21.9 | 199.5 | 9.4 | 10.7 | 75.8 | 6.2 | 7.1 | 43.9 | - | - | - |
| 10000 | 17.2 | 19.9 | 338.0 | 8.4 | 9.7 | 124.6 | 5.3 | 6.1 | 68.8 | - | - | - |
| 30000 | 14.6 | 17.0 | 659.7 | 7.0 | 8.1 | 231.5 | 4.2 | 4.8 | 118.3 | - | - | - |
| 56700 | 13.3 | 15.4 | 1113.5 | 6.3 | 7.3 | 379.8 | 3.6 | 4.2 | 184.9 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11310532 | 10000 | 424 | 4.07 | 50 | 200 | 6061.0 | 10172.0 | 2.55 | 3.08 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 120 | 33.6 | 38.8 | 17.8 | 17.3 | 19.9 | 7.9 | 13.3 | 15.3 | 5.6 | - | - | - |
| 500 | 27.2 | 30.9 | 42.8 | 13.7 | 15.6 | 17.9 | 10.0 | 11.4 | 11.9 | - | - | - |
| 1000 | 24.5 | 28.2 | 72.8 | 12.2 | 14.1 | 29.6 | 8.7 | 10.0 | 18.9 | - | - | - |
| 5000 | 19.2 | 22.2 | 196.3 | 9.4 | 10.9 | 74.4 | 6.2 | 7.1 | 43.0 | - | - | - |
| 10000 | 17.3 | 19.7 | 343.3 | 8.4 | 9.6 | 126.2 | 5.3 | 6.1 | 69.7 | - | - | - |
| 35340 | 14.3 | 16.2 | 767.9 | 6.8 | 7.7 | 266.9 | 4.0 | 4.5 | 134.5 | - | - | - |
| 41700 | 14.0 | 16.1 | 900.4 | 6.6 | 7.7 | 310.6 | 3.9 | 4.5 | 154.6 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11310515 | 10000 | 424 | 4.07 | 50 | 500 | 6058.0 | 10164.0 | 2.55 | 3.04 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 85.8 | 97.8 | 52.2 | 41.4 | 47.2 | 22.0 | 28.8 | 32.9 | 14.3 | 18.9 | 21.6 | 8.7 |
| 500 | 67.4 | 76.7 | 138.0 | 31.9 | 36.2 | 54.1 | 20.6 | 23.5 | 31.9 | 11.7 | 13.3 | 16.5 |
| 1000 | 60.7 | 69.0 | 244.2 | 28.4 | 32.3 | 92.9 | 17.8 | 20.2 | 52.4 | 9.4 | 10.6 | 24.9 |
| 5000 | 47.7 | 53.9 | 655.9 | 21.8 | 24.6 | 232.3 | 12.5 | 14.1 | 116.9 | 5.3 | 6.0 | 43.7 |
| 10000 | 43.0 | 50.0 | 1124.1 | 19.5 | 22.6 | 385.8 | 10.7 | 12.4 | 184.0 | 4.0 | 4.7 | 60.8 |
| 30000 | 36.5 | 41.6 | 2192.4 | 20.2 | 32.0 | - | 16.0 | 24.4 | - | - | 7.6 | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11310525 | 10000 | 424 | 4.07 | 50 | 500 | 6070.0 | 10197.0 | 2.55 | 3.22 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 88.5 | 100.7 | 54.6 | 41.9 | 47.7 | 22.5 | 28.8 | 32.8 | 14.5 | 18.7 | 21.3 | 8.8 |
| 500 | 69.5 | 79.6 | 150.1 | 32.2 | 36.8 | 57.7 | 20.6 | 23.5 | 33.6 | 11.5 | 13.2 | 17.1 |
| 1000 | 62.7 | 71.8 | 257.6 | 28.7 | 32.9 | 95.9 | 17.7 | 20.3 | 53.4 | 9.2 | 10.5 | 24.9 |
| 5000 | 49.2 | 57.1 | 687.2 | 22.0 | 25.5 | 238.1 | 12.4 | 14.4 | 117.9 | 5.1 | 6.0 | 43.0 |
| 10000 | 44.4 | 50.5 | 1204.0 | 19.6 | 22.3 | 404.1 | 10.6 | 12.0 | 189.4 | 3.9 | 4.4 | 60.9 |
| 20300 | 39.9 | 45.9 | 1789.2 | 17.5 | 20.1 | 581.2 | 8.9 | 10.3 | 256.8 | 2.9 | 3.3 | 71.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11310535 | 10000 | 424 | 4.07 | 50 | 500 | 6056.0 | 10153.0 | 2.55 | 2.93 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 84.2 | 97.7 | 49.6 | 41.2 | 47.7 | 21.1 | 28.8 | 33.4 | 13.8 | 19.1 | 22.1 | 8.5 |
| 500 | 66.2 | 75.8 | 134.9 | 31.7 | 36.3 | 53.6 | 20.7 | 23.6 | 31.8 | 11.8 | 13.6 | 16.6 |
| 1000 | 59.6 | 69.1 | 235.0 | 28.3 | 32.7 | 90.6 | 17.8 | 20.6 | 51.5 | 9.5 | 11.0 | 24.7 |
| 5300 | 46.4 | 52.4 | 640.7 | 21.5 | 24.3 | 229.3 | 12.4 | 14.0 | 116.0 | 5.3 | 6.0 | 43.5 |
| 10000 | 42.2 | 49.0 | 1088.9 | 19.4 | 22.4 | 378.8 | 10.7 | 12.4 | 182.5 | 4.1 | 4.8 | 61.3 |
| 30000 | 35.8 | 40.9 | 2110.0 | 16.1 | 18.4 | 698.2 | 8.3 | 9.5 | 307.4 | 2.6 | 3.0 | 82.8 |
| 42100 | 34.0 | 38.9 | 2820.5 | 15.3 | 17.4 | 918.8 | 7.7 | 8.7 | 392.9 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110611 | 10000 | 450 | 4.31 | 50 | 100 | 5987.0 | 10143.0 | 2.55 | 4.14 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 21.5 | 24.7 | 8.8 | 10.3 | 11.8 | 3.7 | 8.0 | 9.3 | 2.7 | - | - | - |
| 500 | 16.9 | 19.3 | 22.0 | 7.9 | 9.0 | 8.6 | 5.8 | 6.6 | 5.7 | - | - | - |
| 1000 | 15.2 | 17.7 | 38.0 | 7.1 | 8.2 | 14.3 | 5.0 | 5.8 | 9.2 | - | - | - |
| 2170 | 13.5 | 15.7 | 57.0 | 6.2 | 7.2 | 20.7 | 4.3 | 4.9 | 12.7 | - | - | - |
| 5870 | 11.7 | 13.5 | 116.4 | 5.3 | 6.1 | 40.6 | 3.4 | 4.0 | 23.3 | - | - | - |
| 10350 | 10.7 | 12.1 | 149.4 | 4.8 | 5.4 | 50.7 | 3.0 | 3.4 | 28.0 | - | - | - |
| 30000 | 9.1 | 10.5 | 329.4 | 4.0 | 4.6 | 106.5 | 2.4 | 2.7 | 54.2 | - | - | - |
| 150000 | 7.2 | 8.3 | 819.8 | 3.1 | 3.5 | 245.8 | 1.6 | 1.9 | 109.4 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES;
WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT;
SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR;
CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER;
AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110621 | 10000 | 450 | 4.31 | 50 | 100 | 5991.0 | 10142.0 | 2.55 | 4.04 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 21.1 | 24.0 | 8.3 | 10.2 | 11.6 | 3.5 | 8.0 | 9.1 | 2.6 | 6.1 | 6.9 | 1.8 |
| 500 | 16.6 | 19.3 | 21.6 | 7.9 | 9.1 | 8.5 | 5.8 | 6.7 | 5.7 | 3.9 | 4.5 | 3.5 |
| 1000 | 15.0 | 17.2 | 36.0 | 7.0 | 8.1 | 13.7 | 5.0 | 5.8 | 8.9 | 3.2 | 3.7 | 5.1 |
| 5000 | 11.8 | 13.6 | 92.8 | 5.4 | 6.3 | 32.9 | 3.6 | 4.1 | 19.2 | 1.9 | 2.2 | 9.0 |
| 10000 | 10.6 | 12.2 | 155.3 | 4.8 | 5.5 | 53.4 | 3.1 | 3.5 | 29.7 | 1.5 | 1.7 | 12.7 |
| 33000 | 8.9 | 10.1 | 307.9 | 3.9 | 4.5 | 100.3 | 2.3 | 2.7 | 51.0 | 1.0 | 1.1 | 17.8 |
| 181000 | 6.9 | 7.9 | 993.4 | 3.0 | 3.4 | 298.7 | 1.6 | 1.8 | 132.0 | 0.5 | 0.5 | 32.0 |
| 351000 | 6.2 | 7.1 | 1386.4 | 2.7 | 3.0 | 404.0 | 1.3 | 1.5 | 167.9 | 0.3 | 0.4 | 34.2 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110631 | 10000 | 450 | 4.31 | 50 | 100 | 5992.0 | 10138.0 | 2.55 | 3.96 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 20.9 | 23.7 | 8.3 | 10.2 | 11.5 | 3.5 | 8.0 | 9.1 | 2.6 | 6.1 | 6.9 | 1.8 |
| 500 | 16.4 | 19.0 | 20.4 | 7.8 | 9.1 | 8.1 | 5.8 | 6.7 | 5.5 | 3.9 | 4.5 | 3.4 |
| 1170 | 14.4 | 16.9 | 39.0 | 6.8 | 8.0 | 14.9 | 4.9 | 5.7 | 9.5 | 3.1 | 3.6 | 5.4 |
| 5000 | 11.6 | 13.5 | 88.3 | 5.4 | 6.2 | 31.6 | 3.6 | 4.2 | 18.5 | 1.9 | 2.2 | 8.8 |
| 10000 | 10.5 | 11.9 | 149.9 | 4.8 | 5.5 | 52.0 | 3.1 | 3.5 | 29.1 | 1.5 | 1.7 | 12.5 |
| 30000 | 8.9 | 10.1 | 280.3 | 4.0 | 4.6 | 92.5 | 2.4 | 2.7 | 47.7 | 1.0 | 1.1 | 17.1 |
| 165000 | 6.9 | 7.8 | 906.4 | 3.0 | 3.4 | 276.2 | 1.6 | 1.8 | 123.9 | 0.5 | 0.6 | 31.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110612 | 10000 | 450 | 4.31 | 50 | 200 | 6044.0 | 10139.0 | 2.55 | 2.75 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 34.6 | 39.8 | 11.8 | 18.6 | 21.4 | 5.5 | 14.8 | 17.0 | 4.1 | 11.4 | 13.1 | 2.9 |
| 500 | 27.2 | 31.5 | 30.5 | 14.4 | 16.7 | 13.4 | 10.8 | 12.5 | 9.2 | 7.5 | 8.7 | 5.8 |
| 1000 | 24.5 | 27.9 | 50.5 | 12.9 | 14.7 | 21.5 | 9.4 | 10.8 | 14.2 | 6.2 | 7.1 | 8.4 |
| 5000 | 19.3 | 22.0 | 130.1 | 9.9 | 11.3 | 51.8 | 6.8 | 7.7 | 31.2 | 3.8 | 4.4 | 15.5 |
| 10000 | 17.4 | 20.1 | 220.4 | 8.8 | 10.2 | 85.2 | 5.9 | 6.8 | 49.2 | 3.1 | 3.5 | 22.3 |
| 42200 | 14.0 | 16.0 | 497.7 | 7.0 | 8.0 | 180.6 | 4.3 | 4.9 | 94.7 | 1.8 | 2.1 | 34.4 |
| 163500 | 11.4 | 13.2 | 1283.9 | 5.6 | 6.5 | 438.7 | 3.2 | 3.7 | 207.7 | 1.1 | 1.2 | 57.8 |
| 216000 | 11.0 | 12.7 | 1438.8 | 5.3 | 6.2 | 485.5 | 3.0 | 3.5 | 224.7 | 0.9 | 1.1 | 58.8 |
| 337750 | 10.2 | 11.7 | 2066.3 | 5.0 | 5.7 | 683.4 | 2.7 | 3.1 | 304.7 | 0.8 | 0.9 | 71.6 |
| 510000 | 9.6 | 10.9 | 2438.1 | 4.6 | 5.2 | 791.5 | 2.4 | 2.7 | 340.5 | 0.6 | 0.7 | 72.0 |
| 855300 | 8.9 | 10.1 | 3755.0 | 4.3 | 4.8 | 1190.6 | 2.1 | 2.4 | 488.9 | 0.5 | 0.5 | 89.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110622 | 10000 | 450 | 4.31 | 50 | 200 | 5936.0 | 10152.0 | 2.55 | 5.42 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 51.8 | 59.5 | 30.7 | 21.2 | 24.4 | 11.0 | 15.3 | 17.6 | 7.4 | 10.5 | 12.0 | 4.7 |
| 500 | 40.7 | 45.9 | 79.2 | 16.2 | 18.4 | 26.3 | 10.8 | 12.2 | 15.9 | 6.4 | 7.2 | 8.6 |
| 1000 | 36.6 | 42.6 | 133.6 | 14.5 | 16.8 | 42.9 | 9.3 | 10.8 | 24.8 | 5.1 | 5.9 | 12.2 |
| 5000 | 28.8 | 32.5 | 338.3 | 11.0 | 12.5 | 100.5 | 6.4 | 7.2 | 51.4 | 2.8 | 3.2 | 19.9 |
| 10000 | 25.9 | 29.5 | 574.3 | 9.8 | 11.2 | 165.0 | 5.4 | 6.2 | 79.7 | 2.1 | 2.4 | 27.1 |
| 30000 | 22.0 | 25.4 | 1050.2 | 8.2 | 9.4 | 285.8 | 4.2 | 4.8 | 125.1 | 1.3 | 1.5 | 33.8 |
| 166800 | 17.0 | 19.2 | 3358.2 | 6.1 | 6.9 | 838.1 | 2.7 | 3.0 | 308.6 | 0.5 | 0.6 | 52.7 |

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110632 | 10000 | 450 | 4.31 | 50 | 200 | 5977.0 | 10142.0 | 2.55 | 4.36 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 44.3 | 50.0 | 21.3 | 20.3 | 22.9 | 8.5 | 15.2 | 17.1 | 5.9 | 10.9 | 12.3 | 4.0 |
| 500 | 34.8 | 39.9 | 54.0 | 15.6 | 17.8 | 20.0 | 10.9 | 12.5 | 12.7 | 6.9 | 7.9 | 7.3 |
| 1000 | 31.4 | 36.5 | 90.2 | 13.9 | 16.1 | 32.4 | 9.4 | 10.9 | 19.8 | 5.5 | 6.4 | 10.5 |
| 5000 | 24.7 | 28.1 | 231.7 | 10.6 | 12.1 | 77.3 | 6.6 | 7.5 | 42.3 | 3.2 | 3.6 | 18.0 |
| 10000 | 22.2 | 25.3 | 390.5 | 9.5 | 10.8 | 126.2 | 5.6 | 6.4 | 65.5 | 2.5 | 2.8 | 25.0 |
| 36000 | 18.3 | 21.8 | 805.2 | 7.6 | 9.1 | 245.1 | 4.2 | 5.0 | 114.6 | 1.5 | 1.7 | 34.3 |
| 161600 | 14.6 | 16.8 | 2269.1 | 5.9 | 6.8 | 642.6 | 2.9 | 3.3 | 262.2 | 0.7 | 0.8 | 54.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110615 | 10000 | 450 | 4.31 | 50 | 500 | 5936.0 | 10143.0 | 2.55 | 5.30 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 127.1 | 146.5 | 99.2 | 48.2 | 55.6 | 32.8 | 30.4 | 35.0 | 19.3 | 17.8 | 20.5 | 10.6 |
| 500 | 99.9 | 115.8 | 251.5 | 36.8 | 42.7 | 77.0 | 21.1 | 24.5 | 40.2 | 10.2 | 11.9 | 17.8 |
| 1000 | 90.0 | 102.4 | 416.9 | 32.8 | 37.3 | 123.4 | 17.9 | 20.4 | 60.9 | 7.9 | 9.0 | 24.2 |
| 5000 | 70.7 | 81.4 | 1082.8 | 24.9 | 28.7 | 296.0 | 12.2 | 14.0 | 126.9 | 17.4 | 23.9 | - |
| 10000 | 63.7 | 73.0 | 1837.8 | 22.2 | 25.4 | 485.1 | 10.2 | 11.7 | 194.5 | 16.5 | 21.5 | - |
| 20000 | 57.4 | 66.7 | 2646.8 | 19.7 | 22.9 | 674.5 | 8.5 | 9.9 | 252.0 | 15.9 | 21.0 | - |
| 40000 | 51.7 | 60.1 | 4463.1 | 17.5 | 20.3 | 1097.4 | 7.1 | 8.3 | 380.3 | 15.6 | 20.4 | - |
| 44200 | 51.0 | 57.8 | 4336.6 | 17.2 | 19.5 | 1060.9 | 6.9 | 7.8 | 363.5 | 15.6 | 20.4 | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110625 | 10000 | 450 | 4.31 | 50 | 500 | 6046.0 | 10137.0 | 2.55 | 2.68 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 85.5 | 96.7 | 38.7 | 43.6 | 49.3 | 17.2 | 31.6 | 35.7 | 11.6 | 21.8 | 24.7 | 7.5 |
| 500 | 67.2 | 76.8 | 97.1 | 33.6 | 38.3 | 40.3 | 22.8 | 26.0 | 24.9 | 13.8 | 15.7 | 13.7 |
| 1000 | 60.6 | 69.7 | 163.6 | 30.0 | 34.5 | 65.8 | 19.7 | 22.7 | 39.0 | 11.1 | 12.8 | 19.9 |
| 5000 | 47.6 | 54.7 | 426.6 | 23.0 | 26.5 | 160.1 | 14.0 | 16.1 | 85.4 | 6.5 | 7.5 | 35.0 |
| 10000 | 42.9 | 49.5 | 709.9 | 20.6 | 23.8 | 258.4 | 12.0 | 13.9 | 131.2 | 5.0 | 5.8 | 48.1 |
| 26000 | 37.1 | 42.4 | 1212.1 | 17.6 | 20.0 | 422.7 | 9.7 | 11.0 | 199.5 | 3.5 | 3.9 | 61.3 |
| 51000 | 33.6 | 38.8 | 2014.8 | 15.7 | 18.2 | 681.6 | 8.3 | 9.5 | 304.5 | 2.6 | 3.0 | 81.3 |
| 166770 | 28.1 | 32.3 | 3923.3 | 12.9 | 14.9 | 1257.5 | 6.2 | 7.2 | 505.9 | 1.5 | 1.7 | 100.9 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110635 | 10000 | 450 | 4.31 | 50 | 500 | 5982.0 | 10065.0 | 2.55 | 3.18 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 92.0 | 104.9 | 45.3 | 44.3 | 50.5 | 19.0 | 31.3 | 35.6 | 12.5 | - | - | - |
| 600 | 70.3 | 80.1 | 132.7 | 33.1 | 37.7 | 51.5 | 21.5 | 24.5 | 30.5 | - | - | - |
| 1000 | 65.1 | 75.2 | 198.6 | 30.4 | 35.1 | 75.4 | 19.3 | 22.3 | 43.2 | - | - | - |
| 5050 | 51.1 | 57.9 | 512.0 | 23.3 | 26.4 | 180.7 | 13.5 | 15.3 | 92.4 | - | - | - |
| 10150 | 46.0 | 52.4 | 866.8 | 20.7 | 23.7 | 296.5 | 11.6 | 13.2 | 143.7 | - | - | - |
| 47000 | 36.5 | 42.5 | 2089.7 | 16.1 | 18.7 | 666.1 | 8.1 | 9.4 | 284.1 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110711 | 10000 | 450 | 4.31 | 50 | 100 | 5630.0 | 9722.0 | 2.55 | 6.68 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 29.5 | 34.2 | 21.1 | 11.0 | 12.7 | 6.9 | 7.9 | 9.2 | 4.6 | 5.4 | 6.3 | 2.9 |
| 500 | 23.2 | 27.0 | 55.9 | 8.4 | 9.8 | 16.8 | 5.6 | 6.5 | 10.1 | 3.2 | 3.8 | 5.4 |
| 1050 | 20.8 | 24.2 | 96.1 | 7.4 | 8.6 | 27.9 | 4.7 | 5.5 | 15.9 | 2.5 | 2.9 | 7.7 |
| 5000 | 16.4 | 18.8 | 237.3 | 5.7 | 6.5 | 63.6 | 3.3 | 3.7 | 32.0 | 1.4 | 1.6 | 12.0 |
| 10200 | 14.8 | 17.1 | 405.5 | 5.0 | 5.8 | 104.8 | 2.7 | 3.2 | 49.5 | 1.0 | 1.2 | 16.3 |
| 36700 | 12.2 | 13.8 | 876.6 | 4.0 | 4.6 | 212.2 | 2.0 | 2.2 | 88.7 | 0.6 | 0.6 | 21.8 |
| 159340 | 9.8 | 11.4 | 2382.4 | 3.1 | 3.6 | 533.7 | 1.3 | 1.6 | 190.4 | 0.3 | 0.3 | 30.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110711 | 10000 | 450 | 4.31 | 50 | 100 | 5756.0 | 9721.0 | 2.55 | 3.70 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 19.3 | 21.8 | 7.5 | 9.6 | 10.9 | 3.3 | 7.6 | 8.7 | 2.4 | 5.8 | 6.6 | 1.7 |
| 500 | 15.1 | 17.2 | 18.7 | 7.4 | 8.4 | 7.6 | 5.5 | 6.3 | 5.2 | 3.8 | 4.3 | 3.2 |
| 1000 | 13.6 | 15.5 | 31.7 | 6.6 | 7.5 | 12.5 | 4.8 | 5.5 | 8.2 | 3.1 | 3.5 | 4.8 |
| 5000 | 10.7 | 12.5 | 81.5 | 5.1 | 5.9 | 30.0 | 3.4 | 4.0 | 17.8 | 1.9 | 2.2 | 8.6 |
| 10000 | 9.7 | 11.2 | 137.7 | 4.5 | 5.3 | 49.1 | 3.0 | 3.4 | 27.9 | 1.5 | 1.7 | 12.3 |
| 30000 | 8.2 | 9.3 | 253.5 | 3.8 | 4.3 | 86.0 | 2.3 | 2.6 | 45.1 | 1.0 | 1.1 | 16.7 |
| 152000 | 6.4 | 7.5 | 774.8 | 2.9 | 3.4 | 243.9 | 1.6 | 1.9 | 112.6 | 0.5 | 0.6 | 30.0 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110721 | 10000 | 450 | 4.31 | 50 | 100 | 5685.0 | 9706.0 | 2.55 | 5.19 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 23.9 | 27.6 | 12.6 | 10.3 | 11.9 | 4.7 | 7.8 | 9.0 | 3.3 | 5.6 | 6.5 | 2.2 |
| 500 | 18.8 | 21.8 | 31.9 | 7.9 | 9.2 | 11.2 | 5.6 | 6.5 | 7.1 | 3.5 | 4.1 | 4.1 |
| 1000 | 17.0 | 19.6 | 54.9 | 7.1 | 8.1 | 18.6 | 4.8 | 5.5 | 11.4 | 2.8 | 3.3 | 6.1 |
| 5400 | 13.2 | 15.2 | 148.2 | 5.3 | 6.2 | 46.4 | 3.3 | 3.8 | 25.2 | 1.6 | 1.8 | 10.6 |
| 10400 | 11.9 | 13.9 | 237.3 | 4.8 | 5.6 | 72.0 | 2.8 | 3.3 | 37.2 | 1.2 | 1.4 | 14.1 |
| 43000 | 9.6 | 10.9 | 555.3 | 3.8 | 4.2 | 157.2 | 2.0 | 2.3 | 72.1 | 0.7 | 0.8 | 20.6 |
| 169500 | 7.8 | 8.9 | 1448.1 | 3.0 | 3.4 | 383.0 | 1.4 | 1.6 | 154.2 | 0.3 | 0.4 | 31.3 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110731 | 10000 | 450 | 4.31 | 50 | 100 | 5736.0 | 9714.0 | 2.55 | 4.09 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 20.4 | 23.0 | 8.5 | 9.8 | 11.1 | 3.5 | 7.7 | 8.7 | 2.6 | 5.8 | 6.6 | 1.8 |
| 500 | 16.0 | 18.4 | 21.7 | 7.5 | 8.7 | 8.5 | 5.6 | 6.4 | 5.7 | 3.7 | 4.3 | 3.5 |
| 1000 | 14.4 | 16.5 | 36.6 | 6.7 | 7.7 | 13.9 | 4.8 | 5.5 | 8.9 | 3.0 | 3.5 | 5.1 |
| 5000 | 11.3 | 13.2 | 94.1 | 5.2 | 6.0 | 33.2 | 3.4 | 4.0 | 19.3 | 1.8 | 2.1 | 9.1 |
| 10000 | 10.2 | 11.8 | 159.7 | 4.6 | 5.3 | 54.6 | 2.9 | 3.4 | 30.3 | 1.4 | 1.6 | 12.8 |
| 30000 | 8.7 | 10.0 | 292.7 | 3.8 | 4.4 | 95.2 | 2.3 | 2.6 | 48.6 | 0.9 | 1.1 | 17.2 |
| 159800 | 6.7 | 7.8 | 931.3 | 2.9 | 3.4 | 280.0 | 1.5 | 1.8 | 124.5 | 0.5 | 0.5 | 30.8 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110712 | 10000 | 450 | 4.31 | 50 | 200 | 5670.0 | 9725.0 | 2.55 | 5.80 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 52.3 | 60.7 | 35.5 | 20.6 | 23.9 | 12.2 | 14.6 | 17.0 | 8.1 | 9.9 | 11.5 | 5.1 |
| 500 | 41.1 | 47.7 | 89.4 | 15.8 | 18.3 | 28.5 | 10.3 | 12.0 | 17.0 | 6.0 | 6.9 | 8.9 |
| 1000 | 37.0 | 42.9 | 155.3 | 14.0 | 16.3 | 47.9 | 8.8 | 10.2 | 27.1 | 4.7 | 5.4 | 13.0 |
| 5000 | 29.1 | 33.4 | 385.1 | 10.7 | 12.3 | 109.8 | 6.1 | 7.0 | 54.9 | 2.6 | 3.0 | 20.4 |
| 10600 | 26.0 | 29.5 | 687.0 | 9.4 | 10.7 | 188.7 | 5.1 | 5.8 | 88.4 | 1.9 | 2.1 | 28.6 |
| 33400 | 21.9 | 25.3 | 1310.7 | 7.8 | 9.0 | 339.8 | 3.8 | 4.4 | 143.0 | 1.1 | 1.3 | 35.8 |
| 151100 | 17.4 | 20.0 | 3614.3 | 6.0 | 6.8 | 867.1 | 2.6 | 2.9 | 311.6 | 0.5 | 0.6 | 51.3 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110712 | 10000 | 450 | 4.31 | 50 | 200 | 5636.0 | 9725.0 | 2.55 | 6.59 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 58.3 | 66.1 | 47.5 | 21.2 | 24.1 | 15.1 | 14.6 | 16.6 | 9.7 | 9.6 | 10.8 | 5.9 |
| 500 | 45.8 | 54.0 | 119.0 | 16.2 | 19.1 | 34.9 | 10.2 | 12.0 | 20.1 | 5.6 | 6.6 | 10.1 |
| 1000 | 41.3 | 46.9 | 205.0 | 14.4 | 16.4 | 58.2 | 8.7 | 9.9 | 31.7 | 4.4 | 5.0 | 14.4 |
| 5000 | 32.4 | 38.7 | 518.3 | 11.0 | 13.1 | 135.6 | 5.9 | 7.1 | 64.5 | 2.3 | 2.8 | 22.4 |
| 18000 | 26.8 | 30.3 | 1278.5 | 8.8 | 9.9 | 313.2 | 4.3 | 4.9 | 132.1 | 1.3 | 1.5 | 34.8 |
| 30000 | 24.8 | 28.6 | 1591.5 | 8.1 | 9.3 | 379.6 | 3.8 | 4.3 | 152.0 | 1.0 | 1.2 | 35.3 |
| 61232 | 22.3 | 25.9 | 2798.7 | 7.1 | 8.3 | 642.9 | 3.1 | 3.6 | 238.5 | 0.7 | 0.8 | 45.4 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110712 | 10000 | 450 | 4.31 | 50 | 200 | 5703.0 | 9719.0 | 2.55 | 4.95 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 46.3 | 52.4 | 26.0 | 19.9 | 22.6 | 9.8 | 14.6 | 16.5 | 6.7 | 10.2 | 11.6 | 4.4 |
| 500 | 36.4 | 41.1 | 66.9 | 15.3 | 17.3 | 23.3 | 10.4 | 11.8 | 14.5 | 6.3 | 7.1 | 8.0 |
| 1000 | 32.8 | 37.6 | 112.5 | 13.6 | 15.6 | 38.0 | 8.9 | 10.3 | 22.5 | 5.1 | 5.8 | 11.5 |
| 5000 | 25.7 | 29.3 | 282.8 | 10.4 | 11.8 | 88.5 | 6.2 | 7.1 | 46.6 | 2.9 | 3.2 | 18.8 |
| 10000 | 23.2 | 27.0 | 492.3 | 9.3 | 10.8 | 149.1 | 5.3 | 6.2 | 74.4 | 2.2 | 2.5 | 26.7 |
| 30000 | 19.7 | 22.5 | 894.9 | 7.7 | 8.8 | 257.0 | 4.1 | 4.7 | 116.7 | 1.4 | 1.6 | 33.6 |
| 173100 | 15.1 | 17.5 | 2944.1 | 5.7 | 6.6 | 775.5 | 2.6 | 3.0 | 297.4 | 0.6 | 0.7 | 54.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110722 | 10000 | 450 | 4.31 | 50 | 200 | 5650.0 | 9707.0 | 2.55 | 6.02 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 110 | 53.1 | 61.7 | 41.2 | 20.5 | 23.8 | 13.8 | 14.3 | 16.6 | 9.0 | 9.5 | 11.0 | 5.6 |
| 500 | 42.3 | 49.0 | 96.1 | 15.9 | 18.4 | 29.9 | 10.3 | 11.9 | 17.6 | 5.9 | 6.8 | 9.2 |
| 1000 | 38.1 | 43.7 | 163.6 | 14.1 | 16.2 | 49.3 | 8.8 | 10.1 | 27.6 | 4.6 | 5.3 | 13.1 |
| 5000 | 29.9 | 35.2 | 420.6 | 10.8 | 12.6 | 117.0 | 6.0 | 7.1 | 57.7 | 2.5 | 2.9 | 21.1 |
| 10000 | 27.0 | 31.4 | 725.5 | 9.6 | 11.1 | 195.0 | 5.1 | 5.9 | 90.4 | 1.9 | 2.2 | 28.9 |
| 38000 | 22.1 | 25.4 | 1503.5 | 7.6 | 8.7 | 377.6 | 3.6 | 4.2 | 154.2 | 1.0 | 1.2 | 36.3 |
| 164800 | 17.7 | 20.5 | 4153.6 | 5.9 | 6.8 | 966.6 | 2.5 | 2.9 | 336.9 | 0.5 | 0.5 | 51.8 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110732 | 10000 | 450 | 4.31 | 50 | 200 | 5690.0 | 9722.0 | 2.55 | 5.29 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 48.7 | 55.0 | 29.6 | 20.2 | 22.9 | 10.7 | 14.6 | 16.5 | 7.2 | 10.1 | 11.4 | 4.6 |
| 500 | 38.2 | 43.7 | 75.5 | 15.5 | 17.7 | 25.4 | 10.4 | 11.8 | 15.5 | 6.2 | 7.1 | 8.4 |
| 1000 | 34.5 | 40.0 | 129.1 | 13.8 | 16.0 | 42.0 | 8.9 | 10.3 | 24.4 | 4.9 | 5.7 | 12.2 |
| 5000 | 27.1 | 31.2 | 325.6 | 10.5 | 12.1 | 98.1 | 6.2 | 7.1 | 50.6 | 2.7 | 3.2 | 19.8 |
| 10000 | 24.4 | 28.4 | 547.8 | 9.4 | 10.9 | 159.6 | 5.2 | 6.1 | 77.8 | 2.1 | 2.4 | 26.9 |
| 30000 | 20.7 | 23.9 | 1024.7 | 7.8 | 9.0 | 282.9 | 4.0 | 4.6 | 125.1 | 1.3 | 1.5 | 34.4 |
| 33300 | 20.4 | 23.3 | 1188.5 | 7.6 | 8.7 | 326.5 | 3.9 | 4.5 | 142.9 | 1.2 | 1.4 | 38.4 |
| 163200 | 16.0 | 18.4 | 2946.9 | 5.8 | 6.7 | 747.4 | 2.6 | 3.0 | 279.1 | 0.5 | 0.6 | 49.1 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110715 | 10000 | 450 | 4.31 | 50 | 500 | 5633.0 | 9755.0 | 2.55 | 7.05 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 155.7 | 179.9 | 185.1 | 48.6 | 56.1 | 50.3 | 27.9 | 32.2 | 26.9 | 14.7 | 17.0 | 13.2 |
| 500 | 122.3 | 138.2 | 471.2 | 36.9 | 41.7 | 117.9 | 18.9 | 21.3 | 55.0 | 7.9 | 9.0 | 21.0 |
| 1000 | 110.2 | 124.5 | 792.4 | 32.7 | 37.0 | 191.2 | 15.9 | 17.9 | 83.6 | 5.9 | 6.7 | 28.1 |
| 5000 | 86.6 | 98.9 | 2015.6 | 24.8 | 28.3 | 446.4 | 10.4 | 11.9 | 165.5 | 2.8 | 3.2 | 38.9 |
| 11200 | 76.7 | 87.0 | 3730.1 | 21.5 | 24.4 | 790.6 | 8.4 | 9.5 | 267.5 | 1.8 | 2.1 | 50.6 |
| 12000 | 75.9 | 87.9 | 3500.4 | 21.3 | 24.6 | 739.1 | 8.2 | 9.5 | 248.1 | 1.8 | 2.0 | 46.0 |
| 13100 | 74.9 | 84.6 | 4081.6 | 20.9 | 23.6 | 857.7 | 8.0 | 9.0 | 284.9 | 1.7 | 1.9 | 51.4 |

WA = TOTAL WEIGHT OF DRY AGGREGATES;
WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT;
SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR;
CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER;
AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110715 | 10000 | 450 | 4.31 | 50 | 500 | 5635.0 | 9758.0 | 2.55 | 7.04 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 155.6 | 178.9 | 184.0 | 48.6 | 55.9 | 50.1 | 27.9 | 32.0 | 26.8 | 14.7 | 16.9 | 13.2 |
| 500 | 122.2 | 141.5 | 461.8 | 36.9 | 42.7 | 115.6 | 18.9 | 21.9 | 54.0 | 7.9 | 9.2 | 20.6 |
| 1000 | 110.2 | 124.7 | 795.5 | 32.7 | 37.1 | 192.1 | 15.9 | 18.0 | 84.0 | 5.9 | 6.7 | 28.3 |
| 5000 | 86.5 | 99.8 | 1991.8 | 24.8 | 28.6 | 441.5 | 10.4 | 12.0 | 163.8 | 2.8 | 3.2 | 38.5 |
| 8000 | 80.6 | 93.3 | 3002.8 | 22.8 | 26.4 | 648.8 | 9.2 | 10.6 | 228.3 | 2.2 | 2.5 | 47.5 |
| 10000 | 78.0 | 90.3 | 3133.9 | 21.9 | 25.4 | 668.9 | 8.6 | 10.0 | 229.5 | 1.9 | 2.2 | 44.8 |
| 12100 | 75.8 | 87.1 | 3898.7 | 21.2 | 24.4 | 823.5 | 8.2 | 9.4 | 276.3 | 1.7 | 2.0 | 51.1 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110725 | 10000 | 450 | 4.31 | 50 | 500 | 5656.0 | 9710.0 | 2.55 | 5.92 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 132.8 | 153.5 | 124.9 | 47.0 | 54.3 | 38.5 | 28.6 | 33.1 | 21.9 | 16.2 | 18.7 | 11.5 |
| 500 | 104.3 | 121.3 | 312.8 | 35.8 | 41.6 | 89.1 | 19.7 | 22.9 | 44.7 | 9.1 | 10.6 | 18.8 |
| 1000 | 94.0 | 109.4 | 534.8 | 31.8 | 37.0 | 147.2 | 16.7 | 19.4 | 69.6 | 6.9 | 8.1 | 26.0 |
| 5000 | 73.9 | 86.0 | 1374.3 | 24.2 | 28.2 | 348.5 | 11.2 | 13.0 | 141.9 | 3.4 | 4.0 | 38.5 |
| 10000 | 66.6 | 77.4 | 2287.8 | 21.5 | 25.0 | 559.7 | 9.3 | 10.9 | 212.3 | 2.5 | 2.9 | 48.7 |
| 20000 | 60.0 | 69.1 | 3245.6 | 19.1 | 22.0 | 765.8 | 7.8 | 9.0 | 269.4 | 1.7 | 2.0 | 51.3 |
| 22544 | 58.9 | 68.5 | 3895.9 | 18.7 | 21.7 | 913.4 | 7.5 | 8.7 | 317.0 | 1.6 | 1.9 | 58.3 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110725 | 10000 | 450 | 4.31 | 50 | 500 | 5632.0 | 9750.0 | 2.55 | 7.00 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 154.7 | 176.7 | 181.8 | 48.5 | 55.4 | 49.7 | 27.9 | 31.8 | 26.6 | 14.7 | 16.8 | 13.1 |
| 500 | 121.5 | 139.0 | 467.4 | 36.8 | 42.1 | 117.5 | 18.9 | 21.6 | 55.0 | 8.0 | 9.1 | 21.1 |
| 1000 | 109.5 | 127.1 | 755.7 | 32.7 | 37.9 | 183.3 | 15.9 | 18.5 | 80.4 | 6.0 | 6.9 | 27.1 |
| 5000 | 86.0 | 99.0 | 1970.1 | 24.7 | 28.5 | 438.6 | 10.5 | 12.0 | 163.2 | 2.8 | 3.2 | 38.5 |
| 10000 | 77.5 | 88.3 | 3419.6 | 21.9 | 24.9 | 733.1 | 8.7 | 9.9 | 252.3 | 2.0 | 2.2 | 49.6 |
| 15000 | 73.0 | 82.5 | 3999.6 | 20.4 | 23.1 | 838.6 | 7.7 | 8.7 | 275.2 | 1.6 | 1.8 | 48.0 |
| 16000 | 72.3 | 84.1 | 4633.8 | 20.2 | 23.5 | 968.2 | 7.6 | 8.8 | 315.2 | 1.5 | 1.7 | 53.9 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110735 | 10000 | 450 | 4.31 | 50 | 500 | 5660.0 | 9715.0 | 2.55 | 5.90 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 132.4 | 150.8 | 123.3 | 47.0 | 53.5 | 38.1 | 28.7 | 32.6 | 21.7 | 16.2 | 18.5 | 11.4 |
| 500 | 104.0 | 119.2 | 312.2 | 35.8 | 41.0 | 89.2 | 19.7 | 22.6 | 44.8 | 9.1 | 10.5 | 18.9 |
| 1000 | 93.8 | 106.4 | 533.6 | 31.8 | 36.1 | 147.3 | 16.7 | 19.0 | 69.8 | 7.0 | 7.9 | 26.2 |
| 5000 | 73.6 | 83.2 | 1384.1 | 24.2 | 27.3 | 352.1 | 11.2 | 12.7 | 143.6 | 3.5 | 3.9 | 39.1 |
| 10000 | 66.4 | 75.9 | 2289.5 | 21.5 | 24.9 | 561.9 | 9.4 | 10.9 | 213.6 | 2.5 | 2.9 | 49.2 |
| 20200 | 59.7 | 69.2 | 3288.6 | 19.0 | 22.1 | 777.9 | 7.8 | 9.0 | 274.0 | 1.7 | 2.0 | 52.3 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110735 | 10000 | 450 | 4.31 | 50 | 500 | 5636.0 | 9755.0 | 2.55 | 6.98 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 154.3 | 177.1 | 181.7 | 48.5 | 55.7 | 49.8 | 27.9 | 32.0 | 26.7 | 14.8 | 16.9 | 13.2 |
| 500 | 121.2 | 140.2 | 452.6 | 36.8 | 42.6 | 114.2 | 18.9 | 21.9 | 53.5 | 8.0 | 9.2 | 20.6 |
| 1000 | 109.2 | 126.7 | 775.1 | 32.7 | 37.9 | 188.5 | 15.9 | 18.5 | 82.8 | 6.0 | 6.9 | 28.0 |
| 5000 | 85.8 | 97.7 | 1962.9 | 24.7 | 28.2 | 438.3 | 10.5 | 11.9 | 163.4 | 2.8 | 3.2 | 38.7 |
| 10000 | 77.3 | 88.5 | 3372.7 | 21.9 | 25.1 | 725.3 | 8.7 | 9.9 | 250.2 | 2.0 | 2.2 | 49.3 |
| 20200 | 69.6 | 79.5 | 4728.0 | 19.4 | 22.1 | 978.3 | 7.1 | 8.2 | 310.3 | 1.3 | 1.5 | 49.6 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110511 | 10000 | 416 | 3.99 | 50 | 100 | 6149.0 | 10349.0 | 2.54 | 2.95 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 18.3 | 21.4 | 6.2 | 9.8 | 11.5 | 2.9 | 8.0 | 9.3 | 2.2 | 6.3 | 7.3 | 1.6 |
| 500 | 14.4 | 16.7 | 16.3 | 7.6 | 8.8 | 7.2 | 5.8 | 6.8 | 5.0 | 4.2 | 4.8 | 3.3 |
| 1000 | 13.0 | 14.8 | 28.0 | 6.8 | 7.7 | 11.9 | 5.1 | 5.8 | 8.1 | 3.4 | 3.9 | 4.9 |
| 5020 | 10.2 | 11.5 | 73.1 | 5.2 | 5.9 | 29.0 | 3.7 | 4.1 | 18.0 | 2.1 | 2.4 | 9.2 |
| 10300 | 9.1 | 10.5 | 128.1 | 4.6 | 5.3 | 49.4 | 3.2 | 3.6 | 29.2 | 1.7 | 2.0 | 13.7 |
| 31220 | 7.7 | 8.9 | 239.7 | 3.9 | 4.5 | 88.0 | 2.5 | 2.9 | 48.4 | 1.2 | 1.3 | 19.4 |
| 176550 | 6.0 | 6.9 | 824.3 | 2.9 | 3.4 | 280.4 | 1.7 | 1.9 | 135.9 | 0.6 | 0.7 | 39.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES;
WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT;
SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR;
CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER;
AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110521 | 10000 | 416 | 3.99 | 50 | 100 | 6145.0 | 10348.0 | 2.54 | 3.03 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 18.5 | 21.2 | 6.5 | 9.9 | 11.3 | 3.0 | 8.0 | 9.2 | 2.3 | 6.3 | 7.2 | 1.7 |
| 500 | 14.6 | 16.6 | 17.0 | 7.6 | 8.7 | 7.4 | 5.9 | 6.7 | 5.2 | 4.2 | 4.7 | 3.3 |
| 1050 | 13.0 | 14.8 | 29.7 | 6.8 | 7.7 | 12.5 | 5.0 | 5.7 | 8.4 | 3.4 | 3.8 | 5.1 |
| 5000 | 10.3 | 11.7 | 75.7 | 5.2 | 6.0 | 29.8 | 3.7 | 4.2 | 18.4 | 2.1 | 2.4 | 9.4 |
| 10000 | 9.3 | 10.5 | 128.5 | 4.7 | 5.3 | 49.2 | 3.2 | 3.6 | 29.0 | 1.7 | 1.9 | 13.6 |
| 35000 | 7.7 | 8.7 | 269.2 | 3.8 | 4.3 | 97.5 | 2.4 | 2.7 | 53.0 | 1.1 | 1.3 | 20.6 |
| 150600 | 6.2 | 7.2 | 767.7 | 3.0 | 3.5 | 260.6 | 1.8 | 2.0 | 127.1 | 0.6 | 0.7 | 37.7 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110531 | 10000 | 416 | 3.99 | 50 | 100 | 6144.0 | 10341.0 | 2.54 | 2.96 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 18.3 | 21.2 | 6.3 | 9.8 | 11.4 | 2.9 | 8.0 | 9.2 | 2.2 | 6.3 | 7.3 | 1.6 |
| 500 | 14.4 | 16.5 | 16.3 | 7.6 | 8.7 | 7.1 | 5.8 | 6.7 | 5.0 | 4.2 | 4.8 | 3.2 |
| 1100 | 12.8 | 14.5 | 29.6 | 6.7 | 7.6 | 12.6 | 5.0 | 5.7 | 8.5 | 3.4 | 3.8 | 5.1 |
| 5000 | 10.2 | 11.6 | 74.2 | 5.2 | 5.9 | 29.5 | 3.7 | 4.2 | 18.2 | 2.1 | 2.4 | 9.4 |
| 10200 | 9.1 | 10.4 | 126.4 | 4.6 | 5.3 | 48.7 | 3.2 | 3.6 | 28.8 | 1.7 | 1.9 | 13.6 |
| 33500 | 7.7 | 8.7 | 250.8 | 3.8 | 4.3 | 91.8 | 2.5 | 2.8 | 50.2 | 1.1 | 1.3 | 19.9 |
| 159300 | 6.1 | 7.0 | 772.6 | 3.0 | 3.4 | 263.8 | 1.7 | 2.0 | 128.8 | 0.6 | 0.7 | 38.2 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110512 | 10000 | 416 | 3.99 | 50 | 200 | 6134.0 | 10321.0 | 2.54 | 2.91 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 36.3 | 41.1 | 13.7 | 19.2 | 21.7 | 6.3 | 15.2 | 17.2 | 4.6 | 11.6 | 13.1 | 3.3 |
| 500 | 28.5 | 32.2 | 36.4 | 14.8 | 16.7 | 15.7 | 11.0 | 12.5 | 10.7 | 7.6 | 8.6 | 6.7 |
| 1000 | 25.7 | 29.2 | 61.6 | 13.2 | 15.1 | 25.8 | 9.6 | 10.9 | 16.9 | 6.2 | 7.1 | 9.9 |
| 5000 | 20.2 | 23.0 | 161.6 | 10.2 | 11.6 | 63.1 | 6.9 | 7.9 | 37.6 | 3.8 | 4.4 | 18.4 |
| 10600 | 18.0 | 20.5 | 289.2 | 9.0 | 10.2 | 109.3 | 5.9 | 6.7 | 62.1 | 3.0 | 3.4 | 27.4 |
| 20900 | 16.3 | 18.5 | 412.7 | 8.1 | 9.2 | 151.4 | 5.1 | 5.8 | 82.2 | 2.3 | 2.7 | 32.7 |
| 158700 | 12.0 | 14.0 | 1706.6 | 5.8 | 6.7 | 572.2 | 3.2 | 3.7 | 266.7 | 1.0 | 1.2 | 72.2 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110522 | 10000 | 416 | 3.99 | 50 | 200 | 6128.0 | 10317.0 | 2.54 | 3.00 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 36.8 | 42.3 | 14.1 | 19.3 | 22.2 | 6.4 | 15.2 | 17.5 | 4.7 | 11.5 | 13.3 | 3.4 |
| 500 | 28.9 | 33.3 | 36.7 | 14.9 | 17.1 | 15.7 | 11.0 | 12.7 | 10.6 | 7.5 | 8.7 | 6.6 |
| 1000 | 26.0 | 30.9 | 64.3 | 13.3 | 15.8 | 26.7 | 9.6 | 11.4 | 17.4 | 6.2 | 7.4 | 10.1 |
| 5000 | 20.4 | 23.5 | 165.1 | 10.2 | 11.8 | 63.9 | 6.9 | 7.9 | 37.9 | 3.8 | 4.4 | 18.3 |
| 10000 | 18.4 | 20.9 | 289.6 | 9.1 | 10.3 | 108.7 | 5.9 | 6.7 | 61.7 | 3.0 | 3.4 | 27.1 |
| 31300 | 15.5 | 17.7 | 549.9 | 7.6 | 8.6 | 196.4 | 4.6 | 5.3 | 103.0 | 2.0 | 2.3 | 37.9 |
| 176600 | 12.0 | 13.7 | 1877.5 | 5.7 | 6.5 | 620.3 | 3.1 | 3.6 | 284.4 | 1.0 | 1.1 | 74.0 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110532 | 10000 | 416 | 3.99 | 50 | 200 | 6126.0 | 10321.0 | 2.54 | 3.10 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 37.4 | 43.0 | 14.9 | 19.4 | 22.3 | 6.7 | 15.2 | 17.5 | 4.9 | 11.5 | 13.2 | 3.5 |
| 500 | 29.4 | 33.6 | 38.8 | 14.9 | 17.1 | 16.4 | 11.1 | 12.7 | 11.1 | 7.5 | 8.6 | 6.8 |
| 1000 | 26.5 | 30.0 | 65.9 | 13.4 | 15.1 | 27.0 | 9.6 | 10.9 | 17.5 | 6.2 | 7.0 | 10.1 |
| 5000 | 20.8 | 23.8 | 172.1 | 10.3 | 11.8 | 65.8 | 6.9 | 7.9 | 38.8 | 3.7 | 4.3 | 18.6 |
| 10400 | 18.6 | 21.5 | 305.1 | 9.1 | 10.5 | 113.1 | 5.9 | 6.8 | 63.6 | 2.9 | 3.4 | 27.5 |
| 30000 | 15.9 | 18.4 | 550.4 | 7.7 | 8.8 | 194.7 | 4.7 | 5.4 | 101.6 | 2.0 | 2.3 | 37.1 |
| 166000 | 12.3 | 14.2 | 1845.4 | 5.8 | 6.7 | 604.2 | 3.2 | 3.6 | 275.8 | 1.0 | 1.1 | 71.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110515 | 10000 | 416 | 3.99 | 50 | 500 | 6124.0 | 10319.0 | 2.54 | 3.12 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 120 | 91.1 | 104.6 | 56.4 | 44.0 | 50.5 | 23.6 | 30.9 | 35.4 | 15.4 | 20.4 | 23.4 | 9.5 |
| 500 | 73.6 | 85.6 | 128.7 | 34.9 | 40.6 | 50.6 | 23.0 | 26.7 | 30.4 | 13.3 | 15.5 | 16.1 |
| 1000 | 66.3 | 76.8 | 224.7 | 31.1 | 36.0 | 85.8 | 19.8 | 22.9 | 49.2 | 10.7 | 12.4 | 23.9 |
| 5000 | 52.1 | 61.4 | 588.9 | 23.9 | 28.1 | 209.2 | 13.9 | 16.4 | 107.3 | 6.1 | 7.2 | 41.4 |
| 10000 | 46.9 | 53.7 | 998.8 | 21.3 | 24.4 | 343.9 | 11.9 | 13.6 | 167.3 | 4.7 | 5.3 | 57.3 |
| 33200 | 39.2 | 44.8 | 1994.4 | 17.5 | 19.9 | 650.0 | 9.0 | 10.3 | 286.6 | 2.8 | 3.2 | 77.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110525 | 10000 | 416 | 3.99 | 50 | 500 | 6129.0 | 10317.0 | 2.54 | 2.97 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 91.6 | 105.2 | 47.3 | 45.1 | 51.8 | 20.3 | 32.1 | 36.9 | 13.5 | 21.7 | 24.9 | 8.5 |
| 500 | 71.9 | 82.6 | 124.7 | 34.7 | 39.8 | 49.9 | 23.0 | 26.5 | 30.2 | 13.5 | 15.6 | 16.2 |
| 1000 | 64.8 | 73.6 | 213.1 | 31.0 | 35.2 | 82.7 | 19.9 | 22.6 | 47.9 | 10.9 | 12.4 | 23.7 |
| 5000 | 50.9 | 58.0 | 586.2 | 23.8 | 27.1 | 204.7 | 14.0 | 16.0 | 106.2 | 6.3 | 7.1 | 41.7 |
| 10000 | 45.9 | 52.1 | 952.2 | 21.2 | 24.1 | 333.7 | 12.0 | 13.6 | 164.5 | 4.8 | 5.5 | 57.5 |
| 20600 | 41.2 | 47.3 | 1413.7 | 18.8 | 21.6 | 479.4 | 10.2 | 11.7 | 223.2 | 3.6 | 4.1 | 68.0 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110535 | 10000 | 416 | 3.99 | 50 | 500 | 6114.0 | 10306.0 | 2.54 | 3.17 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 84.3 | 108.0 | 50.2 | 45.4 | 52.0 | 21.0 | 32.0 | 36.6 | 13.8 | 21.4 | 24.5 | 8.6 |
| 500 | 74.1 | 84.5 | 131.6 | 34.9 | 39.8 | 51.5 | 22.9 | 26.1 | 30.8 | 13.3 | 15.1 | 16.2 |
| 1000 | 66.8 | 75.9 | 219.7 | 31.2 | 35.4 | 83.3 | 19.8 | 22.5 | 47.6 | 10.6 | 12.1 | 23.1 |
| 5000 | 52.5 | 59.7 | 590.0 | 23.9 | 27.2 | 208.3 | 13.9 | 15.8 | 106.4 | 6.0 | 6.9 | 40.7 |
| 10000 | 47.3 | 54.9 | 1016.0 | 21.3 | 24.8 | 347.6 | 11.9 | 13.8 | 168.3 | 4.6 | 5.4 | 57.2 |
| 30000 | 40.1 | 46.4 | 1915.1 | 17.8 | 20.6 | 623.0 | 9.2 | 10.6 | 275.6 | 2.9 | 3.4 | 75.1 |
| 66000 | 35.6 | 41.1 | 3471.5 | 15.6 | 18.0 | 1088.6 | 7.6 | 8.8 | 449.1 | 2.0 | 2.3 | 101.6 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110611 | 10000 | 416 | 3.99 | 50 | 100 | 5926.0 | 10103.0 | 2.54 | 4.74 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 23.4 | 26.5 | 11.7 | 10.6 | 11.9 | 4.6 | 8.1 | 9.1 | 3.3 | 5.9 | 6.7 | 2.3 |
| 500 | 18.4 | 20.8 | 31.3 | 8.1 | 9.2 | 11.5 | 5.8 | 6.6 | 7.5 | 3.7 | 4.2 | 4.4 |
| 1000 | 16.6 | 19.3 | 53.4 | 7.2 | 8.4 | 18.9 | 5.0 | 5.8 | 11.8 | 3.0 | 3.5 | 6.4 |
| 5000 | 13.0 | 15.0 | 139.5 | 5.5 | 6.4 | 45.9 | 3.5 | 4.1 | 25.7 | 1.8 | 2.0 | 11.4 |
| 10000 | 11.7 | 13.4 | 239.5 | 4.9 | 5.6 | 76.3 | 3.0 | 3.4 | 40.5 | 1.4 | 1.6 | 16.1 |
| 30300 | 9.9 | 11.4 | 454.3 | 4.1 | 4.7 | 137.3 | 2.3 | 2.7 | 66.8 | 0.9 | 1.0 | 21.7 |
| 160300 | 7.7 | 8.8 | 1464.4 | 3.1 | 3.5 | 408.4 | 1.6 | 1.8 | 171.2 | 0.4 | 0.5 | 37.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110621 | 10000 | 416 | 3.99 | 50 | 100 | 5923.0 | 10111.0 | 2.54 | 4.91 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 24.0 | 27.7 | 12.5 | 10.6 | 12.3 | 4.8 | 8.1 | 9.3 | 3.4 | 5.9 | 6.8 | 2.3 |
| 500 | 18.9 | 21.5 | 32.7 | 8.2 | 9.3 | 11.8 | 5.8 | 6.6 | 7.6 | 3.7 | 4.2 | 4.4 |
| 1000 | 17.0 | 19.6 | 57.4 | 7.3 | 8.4 | 20.0 | 5.0 | 5.8 | 12.4 | 3.0 | 3.5 | 6.7 |
| 5400 | 13.2 | 15.2 | 155.5 | 5.5 | 6.3 | 50.0 | 3.4 | 4.0 | 27.6 | 1.7 | 1.9 | 11.9 |
| 10900 | 11.9 | 13.7 | 270.0 | 4.9 | 5.6 | 84.1 | 2.9 | 3.4 | 43.9 | 1.3 | 1.5 | 16.9 |
| 31050 | 10.2 | 11.8 | 485.8 | 4.1 | 4.8 | 143.8 | 2.3 | 2.7 | 69.0 | 0.8 | 1.0 | 21.8 |
| 168930 | 7.9 | 9.1 | 1633.3 | 3.1 | 3.5 | 445.3 | 1.5 | 1.7 | 183.0 | 0.4 | 0.4 | 38.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110631 | 10000 | 416 | 3.99 | 50 | 100 | 5910.0 | 10092.0 | 2.54 | 4.85 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 24.1 | 27.5 | 12.7 | 10.6 | 12.1 | 4.9 | 8.1 | 9.2 | 3.5 | 5.9 | 6.7 | 2.4 |
| 500 | 19.0 | 21.6 | 33.6 | 8.2 | 9.3 | 12.0 | 5.8 | 6.6 | 7.8 | 3.7 | 4.2 | 4.5 |
| 1000 | 17.1 | 19.8 | 58.1 | 7.3 | 8.4 | 20.1 | 5.0 | 5.8 | 12.4 | 3.0 | 3.5 | 6.7 |
| 5000 | 13.4 | 15.3 | 150.1 | 5.6 | 6.3 | 48.3 | 3.5 | 4.0 | 26.7 | 1.7 | 2.0 | 11.6 |
| 10000 | 12.1 | 13.8 | 261.5 | 5.0 | 5.7 | 81.4 | 3.0 | 3.4 | 42.7 | 1.3 | 1.5 | 16.6 |
| 50000 | 9.5 | 10.8 | 676.1 | 3.8 | 4.3 | 194.7 | 2.0 | 2.3 | 89.4 | 0.7 | 0.8 | 25.4 |
| 100000 | 8.6 | 9.7 | 1173.1 | 3.4 | 3.8 | 326.6 | 1.7 | 2.0 | 140.7 | 0.5 | 0.6 | 33.9 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110612 | 10000 | 416 | 3.99 | 50 | 200 | 5901.0 | 10078.0 | 2.54 | 4.97 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 48.3 | 54.6 | 29.1 | 20.7 | 23.4 | 10.9 | 15.1 | 17.1 | 7.4 | 10.6 | 11.9 | 4.8 |
| 500 | 38.0 | 43.6 | 75.5 | 15.9 | 18.2 | 26.2 | 10.8 | 12.4 | 16.2 | 6.5 | 7.5 | 8.9 |
| 1000 | 34.2 | 38.7 | 130.3 | 14.1 | 16.0 | 43.8 | 9.3 | 10.5 | 25.8 | 5.2 | 5.9 | 13.1 |
| 5000 | 26.9 | 31.3 | 342.5 | 10.8 | 12.6 | 106.7 | 6.4 | 7.5 | 56.0 | 2.9 | 3.4 | 22.5 |
| 10000 | 24.2 | 28.1 | 574.7 | 9.6 | 11.2 | 173.3 | 5.5 | 6.4 | 86.0 | 2.2 | 2.6 | 30.6 |
| 30000 | 20.5 | 23.6 | 1095.4 | 8.0 | 9.2 | 313.2 | 4.2 | 4.9 | 141.5 | 1.4 | 1.6 | 40.3 |
| 169200 | 15.8 | 18.1 | 3740.9 | 6.0 | 6.8 | 981.8 | 2.7 | 3.1 | 375.1 | 0.6 | 0.7 | 68.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110622 | 10000 | 416 | 3.99 | 50 | 200 | 5914.0 | 10109.0 | 2.54 | 5.09 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) ELA. | TOT. | PLA. | LVDT #2(2.0 IN.) ELA. | TOT. | PLA. | LVDT #3(4.0 IN.) ELA. | TOT. | PLA. | LVDT #4(6.0625 IN.) ELA. | TOT. | PLA. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 49.3 | 55.9 | 29.8 | 20.9 | 23.7 | 11.0 | 15.2 | 17.2 | 7.5 | 10.5 | 12.0 | 4.8 |
| 500 | 38.7 | 44.1 | 78.0 | 16.0 | 18.2 | 26.7 | 10.8 | 12.3 | 16.4 | 6.5 | 7.4 | 9.0 |
| 1000 | 34.9 | 40.2 | 137.0 | 14.3 | 16.4 | 45.5 | 9.3 | 10.7 | 25.7 | 5.2 | 6.0 | 13.4 |
| 5000 | 27.4 | 31.3 | 358.1 | 10.9 | 12.4 | 110.2 | 6.4 | 7.3 | 57.4 | 2.9 | 3.3 | 22.8 |
| 10000 | 24.7 | 28.2 | 616.3 | 9.7 | 11.1 | 183.4 | 5.5 | 6.3 | 90.3 | 2.2 | 2.5 | 31.7 |
| 30000 | 21.0 | 24.4 | 1130.1 | 8.1 | 9.4 | 318.8 | 4.2 | 4.9 | 142.7 | 1.4 | 1.6 | 40.1 |
| 162310 | 16.3 | 18.7 | 3761.2 | 6.0 | 6.9 | 975.7 | 2.7 | 3.2 | 370.3 | 0.6 | 0.7 | 67.2 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110632 | 10000 | 416 | 3.99 | 50 | 200 | 5915.0 | 10111.0 | 2.54 | 5.09 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) ELA. | TOT. | PLA. | LVDT #2(2.0 IN.) ELA. | TOT. | PLA. | LVDT #3(4.0 IN.) ELA. | TOT. | PLA. | LVDT #4(6.0625 IN.) ELA. | TOT. | PLA. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 49.3 | 55.9 | 30.3 | 20.9 | 23.7 | 11.2 | 15.2 | 17.2 | 7.6 | 10.5 | 12.0 | 4.9 |
| 500 | 38.7 | 45.1 | 79.3 | 16.0 | 18.6 | 27.2 | 10.8 | 12.5 | 16.7 | 6.5 | 7.5 | 9.1 |
| 1000 | 34.9 | 39.6 | 137.2 | 14.3 | 16.1 | 45.5 | 9.3 | 10.5 | 26.7 | 5.2 | 5.9 | 13.4 |
| 5000 | 27.4 | 31.2 | 353.2 | 10.9 | 12.4 | 108.6 | 6.4 | 7.3 | 56.6 | 2.9 | 3.3 | 22.4 |
| 10000 | 24.7 | 28.5 | 610.7 | 9.7 | 11.2 | 181.7 | 5.5 | 6.3 | 89.4 | 2.2 | 2.5 | 31.4 |
| 30000 | 21.0 | 24.3 | 1142.3 | 8.1 | 9.3 | 322.1 | 4.2 | 4.9 | 144.2 | 1.4 | 1.6 | 40.5 |
| 164500 | 16.2 | 18.3 | 3819.2 | 6.0 | 6.8 | 989.6 | 2.7 | 3.1 | 374.9 | 0.6 | 0.7 | 67.8 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110615 | 10000 | 416 | 3.99 | 50 | 500 | 5913.0 | 10107.0 | 2.54 | 5.09 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 123.1 | 143.0 | 101.5 | 47.8 | 55.5 | 34.3 | 30.4 | 35.3 | 20.4 | 18.0 | 20.9 | 11.3 |
| 500 | 96.7 | 112.3 | 286.3 | 36.5 | 42.4 | 83.5 | 21.2 | 24.6 | 44.0 | 10.4 | 12.1 | 19.8 |
| 1000 | 87.2 | 99.3 | 458.5 | 32.5 | 37.0 | 139.0 | 18.0 | 20.5 | 69.4 | 8.1 | 9.2 | 28.0 |
| 5000 | 68.5 | 79.7 | 1194.5 | 24.8 | 28.8 | 334.6 | 12.2 | 14.2 | 145.6 | 4.2 | 4.9 | 43.7 |
| 10000 | 61.7 | 71.2 | 2038.0 | 22.0 | 25.4 | 551.5 | 10.3 | 11.9 | 224.7 | 3.0 | 3.5 | 57.8 |
| 30700 | 51.9 | 58.8 | 3938.3 | 18.1 | 20.5 | 1005.3 | 7.6 | 8.7 | 364.0 | 1.7 | 1.9 | 69.7 |
| 31700 | 52.2 | 59.4 | 4210.7 | 18.2 | 20.7 | 1076.6 | 7.7 | 8.8 | 391.2 | 1.7 | 2.0 | 75.5 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110625 | 10000 | 416 | 3.99 | 50 | 500 | 5914.0 | 10103.0 | 2.54 | 5.01 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 121.8 | 137.7 | 98.1 | 47.7 | 53.9 | 33.5 | 30.4 | 34.4 | 19.9 | 18.1 | 20.5 | 11.1 |
| 500 | 95.6 | 111.3 | 258.2 | 36.4 | 42.4 | 81.6 | 21.2 | 24.7 | 43.3 | 10.5 | 12.2 | 19.6 |
| 1000 | 86.2 | 99.6 | 434.3 | 32.4 | 37.5 | 132.8 | 18.1 | 20.9 | 66.7 | 8.1 | 9.4 | 27.1 |
| 5000 | 67.7 | 79.8 | 1148.9 | 24.7 | 29.1 | 324.8 | 12.3 | 14.5 | 142.2 | 4.2 | 5.0 | 43.1 |
| 10000 | 61.0 | 70.9 | 2003.0 | 22.0 | 25.5 | 547.1 | 10.3 | 12.0 | 224.4 | 3.1 | 3.6 | 58.4 |
| 30800 | 51.5 | 59.9 | 3784.3 | 18.1 | 21.1 | 976.7 | 7.8 | 9.0 | 357.5 | 1.8 | 2.1 | 89.9 |
| 35000 | 50.6 | 58.0 | 4506.8 | 17.7 | 20.4 | 1155.6 | 7.5 | 8.6 | 417.2 | 1.7 | 1.9 | 78.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110635 | 10000 | 416 | 3.99 | 50 | 500 | 5902.0 | 10080.0 | 2.54 | 4.98 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 120.9 | 139.2 | 97.6 | 47.5 | 54.7 | 33.4 | 30.4 | 35.0 | 19.9 | 18.1 | 20.9 | 11.1 |
| 500 | 95.0 | 108.2 | 250.8 | 36.3 | 41.4 | 79.6 | 21.2 | 24.1 | 42.3 | 10.5 | 12.0 | 19.2 |
| 1000 | 85.6 | 99.6 | 432.7 | 32.3 | 37.6 | 132.8 | 18.1 | 21.0 | 66.9 | 8.2 | 9.5 | 27.3 |
| 5000 | 67.2 | 75.9 | 1147.9 | 24.6 | 27.8 | 325.8 | 12.3 | 13.9 | 143.0 | 4.2 | 4.8 | 43.5 |
| 10600 | 60.1 | 68.6 | 2017.6 | 21.7 | 24.8 | 551.7 | 10.2 | 11.6 | 225.7 | 3.0 | 3.5 | 58.2 |
| 30300 | 51.3 | 58.9 | 3686.3 | 18.1 | 20.8 | 956.1 | 7.8 | 8.9 | 351.8 | 1.8 | 2.1 | 69.5 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110711 | 10000 | 416 | 3.99 | 50 | 100 | 5715.0 | 9896.0 | 2.54 | 6.78 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 30.5 | 35.3 | 24.7 | 11.3 | 13.0 | 7.9 | 8.0 | 9.3 | 5.3 | 5.5 | 6.3 | 3.4 |
| 500 | 24.0 | 27.5 | 85.6 | 8.6 | 9.8 | 19.5 | 5.6 | 6.5 | 11.7 | 3.3 | 3.7 | 6.2 |
| 1000 | 21.6 | 24.8 | 112.9 | 7.6 | 8.7 | 32.4 | 4.8 | 5.5 | 18.4 | 2.6 | 2.9 | 8.9 |
| 5000 | 17.0 | 19.5 | 288.9 | 5.8 | 6.7 | 76.5 | 3.3 | 3.8 | 38.2 | 1.4 | 1.6 | 14.2 |
| 10000 | 15.3 | 17.4 | 496.0 | 5.2 | 5.9 | 126.8 | 2.8 | 3.2 | 59.5 | 1.0 | 1.2 | 19.3 |
| 31900 | 12.9 | 15.0 | 979.2 | 4.2 | 4.9 | 235.8 | 2.1 | 2.4 | 99.0 | 0.6 | 0.7 | 24.8 |
| 175800 | 10.0 | 11.4 | 3295.9 | 3.1 | 3.6 | 725.1 | 1.3 | 1.5 | 252.7 | 0.2 | 0.3 | 38.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110721 | 10000 | 416 | 3.99 | 50 | 100 | 5711.0 | 9896.0 | 2.54 | 6.87 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 30.9 | 35.9 | 25.7 | 11.3 | 13.1 | 8.2 | 8.0 | 9.3 | 5.4 | 5.5 | 6.3 | 3.4 |
| 500 | 24.3 | 27.7 | 66.7 | 8.6 | 9.8 | 19.6 | 5.6 | 6.4 | 11.7 | 3.3 | 3.7 | 6.2 |
| 1000 | 21.9 | 24.8 | 116.3 | 7.7 | 8.7 | 33.1 | 4.8 | 5.5 | 18.7 | 2.6 | 2.9 | 9.0 |
| 5300 | 17.0 | 19.7 | 314.1 | 5.8 | 6.7 | 82.2 | 3.2 | 3.7 | 40.6 | 1.3 | 1.6 | 14.8 |
| 10000 | 15.5 | 18.0 | 512.2 | 5.2 | 6.0 | 129.7 | 2.8 | 3.2 | 60.5 | 1.0 | 1.2 | 19.5 |
| 31000 | 13.1 | 14.9 | 997.0 | 4.3 | 4.9 | 238.1 | 2.1 | 2.4 | 99.6 | 0.6 | 0.7 | 24.8 |
| 171000 | 10.1 | 11.6 | 3267.8 | 3.2 | 3.6 | 712.8 | 1.3 | 1.5 | 247.3 | 0.2 | 0.3 | 37.6 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110731 | 10000 | 416 | 3.99 | 50 | 100 | 5703.0 | 9886.0 | 2.54 | 6.92 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 31.1 | 35.6 | 25.9 | 11.3 | 13.0 | 8.2 | 8.0 | 9.2 | 5.4 | 5.4 | 6.2 | 3.4 |
| 500 | 24.4 | 28.4 | 67.6 | 8.6 | 10.0 | 19.8 | 5.6 | 6.5 | 11.8 | 3.2 | 3.8 | 6.2 |
| 1000 | 22.0 | 24.8 | 116.3 | 7.7 | 8.6 | 32.9 | 4.8 | 5.4 | 18.6 | 2.5 | 2.9 | 8.9 |
| 5000 | 17.3 | 20.0 | 308.0 | 5.8 | 6.7 | 80.4 | 3.3 | 3.8 | 39.8 | 1.4 | 1.6 | 14.6 |
| 10000 | 15.6 | 17.9 | 519.9 | 5.2 | 6.0 | 131.0 | 2.8 | 3.2 | 60.9 | 1.0 | 1.2 | 19.5 |
| 30000 | 13.2 | 15.1 | 982.7 | 4.3 | 4.9 | 236.2 | 2.1 | 2.4 | 98.8 | 0.6 | 0.7 | 24.7 |
| 170000 | 10.2 | 11.8 | 3367.1 | 3.2 | 3.7 | 730.5 | 1.3 | 1.5 | 252.5 | 0.2 | 0.3 | 38.2 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110712 | 10000 | 416 | 3.99 | 50 | 200 | 5700.0 | 9894.0 | 2.54 | 7.09 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 63.7 | 73.1 | 62.4 | 22.0 | 25.3 | 18.8 | 14.8 | 17.0 | 11.8 | 9.5 | 10.8 | 7.0 |
| 500 | 50.0 | 56.5 | 165.4 | 16.8 | 18.9 | 46.0 | 10.3 | 11.6 | 25.7 | 5.5 | 6.2 | 12.5 |
| 1000 | 45.1 | 52.2 | 276.6 | 14.9 | 17.2 | 74.3 | 8.7 | 10.1 | 39.3 | 4.2 | 4.9 | 17.2 |
| 5000 | 35.4 | 41.0 | 730.9 | 11.3 | 13.1 | 180.7 | 5.9 | 6.8 | 83.1 | 2.2 | 2.6 | 27.3 |
| 10000 | 31.9 | 36.3 | 1267.2 | 10.0 | 11.4 | 302.1 | 5.0 | 5.6 | 130.0 | 1.6 | 1.8 | 36.8 |
| 30900 | 26.9 | 31.0 | 2387.0 | 8.3 | 9.5 | 536.0 | 3.7 | 4.2 | 205.1 | 0.9 | 1.1 | 43.9 |
| 68500 | 23.9 | 27.5 | 4348.8 | 7.2 | 8.3 | 935.7 | 3.0 | 3.4 | 327.2 | 0.6 | 0.7 | 55.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110722 | 10000 | 416 | 3.99 | 50 | 200 | 5701.0 | 9892.0 | 2.54 | 7.04 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 63.2 | 73.6 | 61.2 | 22.0 | 25.6 | 18.5 | 14.8 | 17.3 | 11.7 | 9.5 | 11.0 | 6.9 |
| 500 | 49.7 | 56.5 | 161.8 | 16.7 | 19.0 | 45.2 | 10.3 | 11.7 | 25.4 | 5.5 | 6.3 | 12.3 |
| 1000 | 44.8 | 50.5 | 274.4 | 14.9 | 16.8 | 74.0 | 8.8 | 9.9 | 39.3 | 4.3 | 4.8 | 17.3 |
| 5200 | 35.0 | 39.5 | 743.9 | 11.2 | 12.7 | 184.5 | 5.9 | 6.6 | 84.8 | 2.2 | 2.5 | 27.8 |
| 10000 | 31.7 | 36.3 | 1222.1 | 10.0 | 11.5 | 282.9 | 5.0 | 5.7 | 126.4 | 1.6 | 1.9 | 36.0 |
| 30000 | 26.9 | 30.9 | 2306.0 | 8.3 | 9.5 | 521.5 | 3.7 | 4.3 | 200.9 | 0.9 | 1.1 | 43.6 |
| 64335 | 24.0 | 27.5 | 4137.3 | - | - | - | - | - | - | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110732 | 10000 | 416 | 3.99 | 50 | 200 | 5697.0 | 9885.0 | 2.54 | 7.04 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 63.2 | 71.5 | 61.0 | 22.0 | 24.8 | 18.5 | 14.8 | 16.8 | 11.6 | 9.5 | 10.7 | 6.9 |
| 500 | 49.6 | 56.1 | 161.1 | 16.7 | 18.9 | 45.0 | 10.3 | 11.6 | 25.2 | 5.5 | 6.2 | 12.3 |
| 1000 | 44.7 | 51.1 | 278.2 | 14.9 | 17.0 | 75.1 | 8.7 | 10.0 | 39.8 | 4.3 | 4.9 | 17.5 |
| 5000 | 35.1 | 39.8 | 716.6 | 11.3 | 12.8 | 178.1 | 5.9 | 6.7 | 82.2 | 2.2 | 2.5 | 27.1 |
| 10000 | 31.7 | 36.5 | 1246.5 | 10.0 | 11.5 | 298.8 | 5.0 | 5.7 | 129.0 | 1.6 | 1.9 | 36.7 |
| 30000 | 26.9 | 30.5 | 2281.6 | 8.3 | 9.4 | 516.0 | 3.7 | 4.2 | 198.8 | 0.9 | 1.1 | 43.1 |
| 52652 | 24.7 | 28.5 | 3657.7 | - | - | - | - | - | - | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110715 | 10000 | 416 | 3.99 | 50 | 500 | 5698.0 | 9889.0 | 2.54 | 7.07 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 158.7 | 180.1 | 207.3 | 49.3 | 56.0 | 56.1 | 28.2 | 31.9 | 29.9 | 14.8 | 16.7 | 14.6 |
| 550 | 122.9 | 141.4 | 572.2 | 36.8 | 42.4 | 141.9 | 18.6 | 21.4 | 85.3 | 7.6 | 8.8 | 24.4 |
| 1000 | 112.3 | 130.4 | 922.1 | 33.2 | 38.6 | 221.6 | 16.0 | 18.6 | 96.4 | 5.9 | 6.9 | 32.2 |
| 5000 | 88.2 | 101.1 | 2380.5 | 25.1 | 28.8 | 524.9 | 10.5 | 12.1 | 193.5 | 2.8 | 3.2 | 45.0 |
| 10000 | 79.5 | 90.6 | 4198.5 | 22.3 | 25.4 | 891.5 | 8.7 | 9.9 | 303.8 | 1.9 | 2.2 | 58.7 |
| 13365 | 76.1 | 87.0 | 4661.0 | - | - | - | - | - | - | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110725 | 10000 | 416 | 3.99 | 50 | 500 | 5701.0 | 9896.0 | 2.54 | 7.09 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 158.3 | 182.3 | 206.8 | 49.4 | 56.5 | 55.8 | 28.2 | 32.2 | 29.7 | 14.7 | 16.9 | 14.5 |
| 500 | 125.1 | 144.8 | 545.7 | 37.5 | 43.4 | 135.6 | 19.1 | 22.1 | 62.9 | 7.9 | 9.2 | 23.8 |
| 1000 | 112.8 | 127.4 | 933.0 | 33.2 | 37.6 | 223.6 | 16.0 | 18.1 | 97.1 | 5.9 | 6.7 | 32.3 |
| 5000 | 88.6 | 101.2 | 2400.0 | 25.1 | 28.7 | 527.8 | 10.5 | 12.0 | 194.2 | 2.8 | 3.2 | 45.1 |
| 10000 | 79.8 | 92.8 | 4150.0 | 22.3 | 25.9 | 878.7 | 8.7 | 10.1 | 298.8 | 1.9 | 2.2 | 57.5 |
| 11432 | 78.2 | 89.2 | 4628.8 | 21.8 | 24.8 | 972.9 | 8.4 | 9.6 | 325.7 | 1.8 | 2.0 | 60.3 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21110735 | 10000 | 416 | 3.99 | 50 | 500 | 5696.0 | 9890.0 | 2.54 | 7.12 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 159.9 | 181.7 | 211.1 | 49.4 | 56.1 | 56.8 | 28.1 | 31.9 | 30.2 | 14.7 | 16.7 | 14.7 |
| 500 | 125.6 | 143.0 | 547.2 | 37.5 | 42.6 | 135.5 | 19.0 | 21.7 | 62.6 | 7.9 | 9.0 | 23.7 |
| 1000 | 113.2 | 128.6 | 932.3 | 33.2 | 37.8 | 222.5 | 16.0 | 18.1 | 96.4 | 5.9 | 6.7 | 32.0 |
| 5000 | 88.9 | 103.4 | 2432.8 | 25.1 | 29.2 | 532.8 | 10.5 | 12.2 | 195.4 | 2.8 | 3.2 | 45.2 |
| 10000 | 80.2 | 91.2 | 4200.3 | 22.3 | 25.3 | 885.7 | 8.7 | 9.9 | 300.2 | 1.9 | 2.2 | 57.5 |
| 11050 | 79.0 | 90.7 | 4485.1 | - | - | - | - | - | - | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110511 | 10000 | 434 | 4.16 | 50 | 100 | 6127.0 | 10308.0 | 2.54 | 2.97 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 110 | 18.0 | 20.7 | 6.7 | 9.7 | 11.1 | 3.1 | 7.8 | 8.9 | 2.3 | 6.1 | 7.0 | 1.7 |
| 500 | 14.4 | 16.6 | 16.0 | 7.6 | 8.7 | 7.0 | 5.8 | 6.7 | 4.9 | 4.1 | 4.8 | 3.2 |
| 1000 | 12.9 | 14.7 | 27.7 | 6.8 | 7.7 | 11.8 | 5.1 | 5.7 | 7.9 | 3.4 | 3.9 | 4.8 |
| 5000 | 10.2 | 11.6 | 72.1 | 5.2 | 5.9 | 28.6 | 3.6 | 4.1 | 17.6 | 2.1 | 2.4 | 9.0 |
| 10000 | 9.2 | 10.4 | 122.3 | 4.6 | 5.3 | 47.1 | 3.2 | 3.6 | 27.8 | 1.7 | 1.9 | 13.1 |
| 30500 | 7.8 | 8.9 | 233.4 | 3.9 | 4.5 | 85.5 | 2.5 | 2.9 | 47.0 | 1.2 | 1.3 | 18.8 |
| 162050 | 6.0 | 7.0 | 745.8 | 2.9 | 3.4 | 253.8 | 1.7 | 2.0 | 123.5 | 0.6 | 0.7 | 36.3 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110521 | 10000 | 434 | 4.16 | 50 | 100 | 6128.0 | 10310.0 | 2.54 | 2.98 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 18.3 | 20.9 | 6.1 | 9.8 | 11.2 | 2.8 | 7.9 | 9.1 | 2.1 | 6.2 | 7.1 | 1.6 |
| 520 | 14.3 | 16.3 | 16.6 | 7.5 | 8.6 | 7.2 | 5.8 | 6.6 | 5.1 | 4.1 | 4.7 | 3.3 |
| 1000 | 13.0 | 14.7 | 28.1 | 6.8 | 7.7 | 11.9 | 5.1 | 5.8 | 8.0 | 3.4 | 3.9 | 4.9 |
| 5250 | 10.1 | 11.5 | 73.9 | 5.2 | 5.9 | 29.2 | 3.6 | 4.1 | 18.0 | 2.1 | 2.4 | 9.2 |
| 10400 | 9.1 | 10.8 | 121.8 | 4.6 | 5.5 | 46.8 | 3.1 | 3.7 | 27.6 | 1.7 | 2.0 | 12.9 |
| 30000 | 7.8 | 8.9 | 229.8 | 3.9 | 4.4 | 84.3 | 2.5 | 2.9 | 46.4 | 1.2 | 1.3 | 18.6 |
| 165600 | 6.0 | 6.9 | 758.6 | 2.9 | 3.4 | 257.8 | 1.7 | 2.0 | 125.1 | 0.6 | 0.7 | 36.6 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110531 | 10000 | 434 | 4.16 | 50 | 100 | 6138.0 | 10333.0 | 2.54 | 3.06 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 18.6 | 21.4 | 6.4 | 9.9 | 11.4 | 2.9 | 8.0 | 9.2 | 2.2 | 6.2 | 7.2 | 1.6 |
| 500 | 14.6 | 16.7 | 17.0 | 7.6 | 8.7 | 7.4 | 5.8 | 6.7 | 5.1 | 4.1 | 4.7 | 3.3 |
| 1000 | 13.2 | 14.9 | 28.8 | 6.8 | 7.7 | 12.1 | 5.1 | 5.8 | 8.1 | 3.4 | 3.9 | 4.9 |
| 5000 | 10.3 | 11.9 | 75.2 | 5.2 | 6.0 | 29.5 | 3.7 | 4.2 | 18.1 | 4.9 | 6.5 | - |
| 10000 | 9.3 | 10.7 | 126.3 | 4.7 | 5.4 | 48.1 | 3.2 | 3.6 | 28.3 | 4.3 | 5.4 | - |
| 30000 | 7.9 | 9.1 | 240.5 | 3.9 | 4.5 | 87.3 | 2.5 | 2.9 | 47.8 | 3.0 | 3.7 | - |
| 162900 | 6.1 | 7.3 | 784.9 | 3.0 | 3.5 | 264.4 | 1.7 | 2.0 | 127.5 | 2.0 | 2.2 | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110512 | 10000 | 434 | 4.16 | 50 | 200 | 6142.0 | 10341.0 | 2.54 | 3.08 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 37.3 | 43.3 | 14.5 | 19.4 | 22.5 | 6.6 | 15.2 | 17.6 | 4.8 | 11.5 | 13.3 | 3.4 |
| 500 | 29.3 | 34.1 | 37.2 | 14.9 | 17.4 | 15.7 | 11.1 | 12.9 | 10.6 | 7.5 | 8.7 | 6.5 |
| 1000 | 26.4 | 30.0 | 64.8 | 13.3 | 15.2 | 26.6 | 9.6 | 10.9 | 17.3 | 6.1 | 7.0 | 10.0 |
| 5000 | 20.7 | 23.6 | 168.1 | 10.3 | 11.7 | 64.4 | 6.9 | 7.8 | 38.0 | 3.7 | 4.3 | 18.2 |
| 10000 | 18.7 | 21.5 | 285.7 | 9.2 | 10.6 | 106.2 | 5.9 | 6.8 | 59.8 | 3.0 | 3.4 | 26.1 |
| 30600 | 15.8 | 17.9 | 553.3 | 7.6 | 8.6 | 185.8 | 4.6 | 5.2 | 102.0 | 2.0 | 2.2 | 37.2 |
| 167400 | 12.2 | 13.9 | 1777.9 | 5.8 | 6.5 | 582.7 | 3.1 | 3.6 | 285.8 | 1.0 | 1.1 | 68.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110522 | 10000 | 434 | 4.16 | 50 | 200 | 6132.0 | 10322.0 | 2.54 | 3.05 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 37.1 | 42.4 | 14.2 | 19.3 | 22.1 | 6.5 | 15.2 | 17.3 | 4.7 | 11.5 | 13.1 | 3.3 |
| 500 | 29.1 | 33.9 | 38.4 | 14.9 | 17.3 | 16.3 | 11.0 | 12.8 | 11.0 | 7.5 | 8.7 | 6.8 |
| 1000 | 26.2 | 29.7 | 63.1 | 13.3 | 15.1 | 26.0 | 9.6 | 10.9 | 16.9 | 6.2 | 7.0 | 9.8 |
| 5000 | 20.6 | 23.4 | 165.7 | 10.2 | 11.6 | 63.7 | 6.9 | 7.8 | 37.6 | 3.7 | 4.2 | 18.1 |
| 10300 | 18.5 | 21.3 | 293.3 | 9.1 | 10.5 | 109.3 | 5.9 | 6.8 | 61.6 | 2.9 | 3.4 | 26.8 |
| 30000 | 15.8 | 17.9 | 529.1 | 7.6 | 8.7 | 188.0 | 4.7 | 5.3 | 98.3 | 2.0 | 2.3 | 36.1 |
| 164500 | 12.2 | 14.0 | 1747.8 | 5.8 | 6.6 | 575.3 | 3.2 | 3.6 | 263.6 | 1.0 | 1.1 | 68.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110532 | 10000 | 434 | 4.16 | 50 | 200 | 6127.0 | 10311.0 | 2.54 | 3.02 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 36.8 | 41.9 | 14.3 | 19.3 | 21.9 | 6.5 | 15.1 | 17.2 | 4.8 | 11.5 | 13.1 | 3.4 |
| 500 | 28.9 | 33.4 | 36.6 | 14.8 | 17.1 | 15.6 | 11.0 | 12.7 | 10.6 | 7.5 | 8.7 | 6.5 |
| 1000 | 26.1 | 29.9 | 62.3 | 13.3 | 15.2 | 25.8 | 9.6 | 11.0 | 16.8 | 6.2 | 7.1 | 9.7 |
| 5000 | 20.5 | 23.7 | 165.1 | 10.2 | 11.8 | 63.7 | 6.9 | 8.0 | 37.7 | 3.8 | 4.4 | 18.2 |
| 10000 | 18.4 | 21.0 | 280.1 | 9.1 | 10.4 | 104.9 | 5.9 | 6.8 | 59.4 | 3.0 | 3.4 | 26.0 |
| 30500 | 15.6 | 18.6 | 535.5 | 7.6 | 9.0 | 190.9 | 4.6 | 5.5 | 100.0 | 2.0 | 2.4 | 36.8 |
| 168000 | 12.1 | 14.0 | 1734.0 | 5.7 | 6.6 | 572.6 | 3.1 | 3.7 | 262.7 | 1.0 | 1.1 | 68.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110515 | 10000 | 434 | 4.16 | 50 | 500 | 6134.0 | 10333.0 | 2.54 | 3.16 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 94.3 | 107.3 | 50.4 | 45.4 | 51.7 | 21.2 | 32.0 | 36.4 | 13.9 | 21.3 | 24.3 | 8.7 |
| 500 | 74.1 | 84.5 | 130.8 | 34.9 | 39.9 | 51.2 | 22.9 | 26.1 | 30.6 | 13.2 | 15.1 | 16.1 |
| 1000 | 66.7 | 77.3 | 222.6 | 31.2 | 36.1 | 84.5 | 19.8 | 22.9 | 48.3 | 10.6 | 12.3 | 23.4 |
| 5000 | 52.4 | 60.7 | 576.3 | 23.9 | 27.7 | 203.7 | 13.9 | 16.1 | 104.0 | 14.0 | 14.0 | - |
| 10000 | 47.3 | 54.1 | 994.7 | 21.3 | 24.4 | 340.7 | 11.9 | 13.6 | 164.9 | 13.4 | 13.4 | - |
| 30000 | 40.1 | 46.5 | 1867.6 | 17.8 | 20.6 | 608.2 | 9.2 | 10.7 | 269.0 | 12.0 | 12.0 | - |
| 63188 | 35.8 | 41.6 | 3263.5 | 15.7 | 18.2 | 1026.7 | 7.7 | 8.9 | 425.1 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110525 | 10000 | 434 | 4.16 | 50 | 500 | 6118.0 | 10294.0 | 2.54 | 2.99 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 91.5 | 103.3 | 46.3 | 44.9 | 50.7 | 19.8 | 31.9 | 36.0 | 13.1 | 21.5 | 24.3 | 8.3 |
| 500 | 71.9 | 82.1 | 120.3 | 34.6 | 39.5 | 48.0 | 22.9 | 26.2 | 29.0 | 13.4 | 15.3 | 15.5 |
| 1000 | 64.8 | 73.3 | 209.8 | 30.9 | 34.9 | 81.2 | 19.8 | 22.4 | 46.9 | 10.8 | 12.2 | 23.1 |
| 5200 | 50.6 | 57.2 | 554.2 | 23.5 | 26.6 | 199.5 | 13.8 | 15.6 | 103.0 | 6.1 | 6.9 | 40.0 |
| 10000 | 45.9 | 53.2 | 930.7 | 21.1 | 24.5 | 325.3 | 11.9 | 13.8 | 159.9 | 4.8 | 5.5 | 55.6 |
| 30200 | 38.9 | 44.8 | 1729.5 | 17.6 | 20.3 | 574.9 | 9.2 | 10.7 | 258.5 | 3.0 | 3.5 | 72.3 |
| 98000 | 32.6 | 37.9 | 4039.7 | 14.5 | 16.8 | 1271.7 | 7.0 | 8.1 | 515.3 | 1.8 | 2.0 | 109.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110535 | 10000 | 434 | 4.16 | 50 | 500 | 6136.0 | 10322.0 | 2.54 | 2.96 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 91.3 | 105.0 | 45.7 | 45.0 | 51.8 | 19.6 | 32.0 | 36.8 | 13.0 | 21.6 | 24.9 | 8.2 |
| 500 | 71.7 | 81.2 | 118.9 | 34.6 | 39.2 | 47.6 | 23.0 | 26.0 | 26.8 | 13.5 | 15.3 | 15.4 |
| 1000 | 64.6 | 74.6 | 209.3 | 30.9 | 35.7 | 81.3 | 19.9 | 22.9 | 47.1 | 10.9 | 12.5 | 23.2 |
| 5000 | 50.8 | 57.8 | 539.9 | 23.7 | 27.0 | 195.4 | 14.0 | 15.9 | 101.4 | 6.2 | 7.1 | 39.8 |
| 10000 | 45.8 | 52.2 | 923.3 | 21.2 | 24.1 | 323.9 | 12.0 | 13.7 | 159.7 | 4.8 | 5.5 | 55.8 |
| 30000 | 38.8 | 45.1 | 1726.6 | 17.6 | 20.5 | 576.4 | 9.3 | 10.8 | 260.1 | 3.1 | 3.6 | 73.3 |
| 112800 | 31.8 | 36.1 | 4404.7 | 14.2 | 16.1 | 1383.2 | 6.8 | 7.7 | 555.2 | 1.7 | 1.9 | 114.0 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110711 | 10000 | 434 | 4.16 | 50 | 100 | 5694.0 | 9865.0 | 2.54 | 6.92 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 31.0 | 35.3 | 26.2 | 11.3 | 12.8 | 8.3 | 8.0 | 9.1 | 5.5 | 5.4 | 6.2 | 3.5 |
| 500 | 24.4 | 28.3 | 67.0 | 8.6 | 10.0 | 19.6 | 5.6 | 6.5 | 11.6 | 3.2 | 3.7 | 6.1 |
| 1000 | 22.0 | 25.0 | 115.0 | 7.6 | 8.7 | 32.5 | 4.8 | 5.4 | 18.3 | 2.5 | 2.9 | 8.7 |
| 5000 | 17.2 | 19.9 | 300.3 | 5.8 | 6.7 | 78.3 | 3.3 | 3.8 | 38.7 | 9.8 | 16.3 | - |
| 10000 | 15.5 | 17.6 | 509.3 | 5.2 | 5.8 | 128.1 | 2.7 | 3.1 | 59.5 | 8.4 | 13.7 | - |
| 34800 | 12.9 | 14.8 | 1059.3 | 4.2 | 4.8 | 249.7 | 2.0 | 2.3 | 102.6 | 5.5 | 9.7 | - |
| 185700 | 10.2 | 11.7 | 3201.2 | 3.2 | 3.7 | 694.4 | 1.3 | 1.5 | 240.1 | 2.6 | 4.7 | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110721 | 10000 | 434 | 4.16 | 50 | 100 | 5705.0 | 9886.0 | 2.54 | 6.95 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 135 | 29.8 | 34.1 | 31.6 | 10.7 | 12.3 | 9.8 | 7.5 | 8.6 | 6.4 | 4.9 | 5.6 | 3.9 |
| 500 | 24.5 | 27.9 | 68.5 | 8.6 | 9.8 | 20.0 | 5.6 | 6.4 | 11.9 | 3.2 | 3.7 | 6.2 |
| 1150 | 21.6 | 24.4 | 129.2 | 7.5 | 8.4 | 36.2 | 4.6 | 5.2 | 20.1 | 2.4 | 2.7 | 9.4 |
| 5000 | 17.3 | 19.8 | 305.8 | 5.8 | 6.6 | 79.5 | 3.3 | 3.7 | 39.2 | 1.4 | 1.5 | 14.3 |
| 10000 | 15.6 | 17.9 | 515.7 | 5.2 | 5.9 | 129.4 | 2.8 | 3.1 | 60.0 | 1.0 | 1.1 | 19.1 |
| 32000 | 13.1 | 15.0 | 994.1 | 4.2 | 4.8 | 234.7 | 2.0 | 2.3 | 97.1 | 0.6 | 0.7 | 23.7 |
| 162650 | 10.3 | 12.0 | 3212.5 | 3.2 | 3.7 | 695.6 | 1.3 | 1.5 | 240.5 | 0.2 | 0.3 | 36.6 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110731 | 10000 | 434 | 4.16 | 50 | 100 | 5708.0 | 9896.0 | 2.54 | 7.01 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 160 | 29.3 | 33.7 | 36.4 | 10.5 | 12.0 | 11.2 | 7.2 | 8.3 | 7.2 | 4.7 | 5.4 | 4.3 |
| 500 | 24.7 | 28.1 | 68.5 | 8.6 | 9.8 | 19.9 | 5.6 | 6.4 | 11.8 | 3.2 | 3.6 | 6.1 |
| 1000 | 22.3 | 25.4 | 119.5 | 7.7 | 8.8 | 33.5 | 4.8 | 5.5 | 18.8 | 2.5 | 2.9 | 8.9 |
| 5100 | 17.5 | 19.7 | 310.4 | 5.8 | 6.6 | 80.1 | 3.2 | 3.7 | 39.3 | 1.3 | 1.5 | 14.2 |
| 11000 | 15.6 | 17.7 | 556.8 | 5.1 | 5.8 | 138.1 | 2.7 | 3.1 | 63.2 | 1.0 | 1.1 | 19.6 |
| 20500 | 14.2 | 16.0 | 772.2 | 4.6 | 5.2 | 185.4 | 2.3 | 2.6 | 79.9 | 0.7 | 0.8 | 21.6 |
| 169500 | 10.3 | 12.3 | 3342.5 | 3.2 | 3.8 | 717.0 | 1.3 | 1.6 | 245.4 | 0.2 | 0.3 | 36.4 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110712 | 10000 | 434 | 4.16 | 50 | 200 | 5709.0 | 9896.0 | 2.54 | 6.99 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 62.8 | 71.4 | 59.7 | 21.9 | 24.9 | 18.1 | 14.8 | 16.8 | 11.4 | 9.5 | 10.7 | 6.8 |
| 500 | 49.3 | 56.6 | 152.5 | 16.7 | 19.2 | 42.8 | 10.3 | 11.8 | 24.0 | 5.5 | 6.3 | 11.7 |
| 1000 | 44.4 | 50.9 | 259.5 | 14.8 | 17.0 | 70.3 | 8.7 | 10.0 | 37.4 | 4.3 | 4.9 | 16.4 |
| 5200 | 34.7 | 39.6 | 700.1 | 11.2 | 12.8 | 174.5 | 5.8 | 6.7 | 80.3 | 2.2 | 2.5 | 26.3 |
| 10400 | 31.3 | 36.1 | 1214.2 | 9.9 | 11.4 | 291.8 | 4.9 | 5.7 | 125.7 | 1.6 | 1.8 | 35.5 |
| 23500 | 27.7 | 31.6 | 1906.2 | 8.6 | 9.8 | 438.8 | 4.0 | 4.5 | 173.8 | 1.1 | 1.2 | 40.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110722 | 10000 | 434 | 4.16 | 50 | 200 | 5689.0 | 9853.0 | 2.54 | 6.88 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 61.6 | 70.2 | 57.8 | 21.7 | 24.8 | 17.8 | 14.7 | 16.8 | 11.3 | 9.5 | 10.8 | 6.7 |
| 500 | 48.4 | 56.0 | 147.9 | 16.5 | 19.2 | 42.0 | 10.2 | 11.9 | 23.7 | 5.5 | 6.4 | 11.6 |
| 1000 | 43.6 | 49.7 | 257.2 | 14.7 | 16.8 | 70.5 | 8.7 | 9.9 | 37.7 | 4.3 | 4.9 | 16.7 |
| 5500 | 33.8 | 38.5 | 699.5 | 11.0 | 12.5 | 175.9 | 5.8 | 6.6 | 81.0 | 2.2 | 2.5 | 26.6 |
| 10400 | 30.7 | 35.7 | 1148.3 | 9.9 | 11.5 | 279.3 | 4.9 | 5.7 | 121.1 | 1.6 | 1.9 | 34.7 |
| 27800 | 26.5 | 31.5 | 2002.5 | 8.3 | 9.9 | 462.5 | 3.8 | 4.5 | 181.5 | 1.0 | 1.2 | 40.9 |
| 52500 | 24.1 | 27.9 | 3381.8 | 7.4 | 8.6 | 750.6 | 3.2 | 3.7 | 274.7 | 0.7 | 0.8 | 51.8 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110732 | 10000 | 434 | 4.16 | 50 | 200 | 5716.0 | 9908.0 | 2.54 | 6.98 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 62.8 | 72.6 | 59.3 | 21.9 | 25.3 | 18.0 | 14.8 | 17.1 | 11.4 | 9.5 | 10.9 | 6.8 |
| 500 | 49.4 | 56.4 | 155.5 | 16.7 | 19.1 | 43.7 | 10.3 | 11.8 | 24.5 | 5.5 | 6.3 | 11.9 |
| 1000 | 44.5 | 50.6 | 267.7 | 14.8 | 16.9 | 72.6 | 8.7 | 9.9 | 38.6 | 4.3 | 4.9 | 17.0 |
| 5750 | 34.2 | 40.9 | 756.7 | 11.0 | 13.1 | 187.6 | 5.7 | 6.8 | 85.5 | 2.1 | 2.5 | 27.5 |
| 10900 | 31.1 | 35.1 | 1245.0 | 9.9 | 11.1 | 298.5 | 4.9 | 5.5 | 128.0 | 1.6 | 1.8 | 35.8 |
| 26800 | 27.2 | 30.7 | 2067.0 | 8.4 | 9.5 | 472.6 | 3.8 | 4.3 | 184.7 | 1.0 | 1.1 | 41.4 |
| 62100 | 23.9 | 27.3 | 3904.1 | 7.3 | 8.3 | 853.4 | 3.1 | 3.5 | 303.7 | 0.6 | 0.7 | 53.6 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110715 | 10000 | 434 | 4.16 | 50 | 500 | 5708.0 | 9876.0 | 2.54 | 6.75 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 110 | 149.5 | 168.7 | 194.9 | 48.0 | 54.2 | 54.3 | 27.7 | 31.2 | 29.2 | 14.6 | 16.5 | 14.3 |
| 500 | 119.1 | 137.7 | 469.7 | 37.1 | 42.8 | 121.3 | 19.2 | 22.2 | 57.3 | 8.2 | 9.5 | 22.3 |
| 1000 | 107.4 | 125.0 | 806.4 | 32.9 | 38.3 | 200.9 | 16.2 | 18.9 | 89.1 | 6.2 | 7.2 | 30.6 |
| 5500 | 83.2 | 94.8 | 2224.0 | 24.5 | 28.0 | 506.3 | 10.4 | 11.9 | 189.2 | 2.8 | 3.2 | 44.6 |
| 10100 | 75.9 | 87.1 | 3490.6 | 22.1 | 25.3 | 769.1 | 8.8 | 10.2 | 268.7 | 2.0 | 2.3 | 54.0 |
| 12450 | 73.6 | 83.2 | 3777.9 | 21.3 | 24.1 | 823.0 | 8.4 | 9.4 | 280.7 | 1.8 | 2.1 | 53.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110725 | 10000 | 434 | 4.16 | 50 | 500 | 5716.0 | 9903.0 | 2.54 | 6.92 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 110 | 153.4 | 178.3 | 205.3 | 48.3 | 56.2 | 56.2 | 27.6 | 32.1 | 29.9 | 14.4 | 16.7 | 14.5 |
| 580 | 119.6 | 136.9 | 552.4 | 36.4 | 41.6 | 138.8 | 18.5 | 21.1 | 64.0 | 7.6 | 8.7 | 23.9 |
| 1000 | 110.2 | 127.7 | 868.0 | 33.1 | 38.4 | 212.0 | 16.1 | 18.7 | 93.0 | 6.0 | 7.0 | 31.4 |
| 5500 | 85.3 | 99.1 | 2349.7 | 24.6 | 28.6 | 524.1 | 10.3 | 12.0 | 193.1 | 18.4 | 21.3 | - |
| 10000 | 78.0 | 90.7 | 3887.3 | 22.2 | 25.8 | 839.4 | 8.8 | 10.2 | 289.1 | 18.4 | 20.4 | - |
| 13800 | 74.3 | 85.5 | 4346.3 | 21.0 | 24.1 | 922.1 | 8.0 | 9.2 | 305.8 | 17.5 | 18.5 | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 31110735 | 10000 | 434 | 4.16 | 50 | 500 | 5710.0 | 9897.0 | 2.54 | 6.98 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 110 | 154.5 | 176.9 | 210.0 | 48.4 | 55.4 | 57.1 | 27.5 | 31.5 | 30.3 | 14.3 | 16.4 | 14.7 |
| 530 | 122.1 | 141.1 | 532.3 | 36.9 | 42.7 | 133.5 | 18.8 | 21.8 | 61.9 | 7.8 | 9.0 | 23.4 |
| 1000 | 111.0 | 128.0 | 877.6 | 33.1 | 38.2 | 212.9 | 16.0 | 18.5 | 93.0 | 6.0 | 6.9 | 31.2 |
| 5400 | 86.2 | 101.3 | 2429.5 | 24.7 | 29.1 | 538.7 | 10.3 | 12.1 | 197.9 | 2.7 | 3.2 | 45.5 |
| 6820 | 83.2 | 95.9 | 3020.2 | 23.7 | 27.4 | 661.3 | 9.7 | 11.2 | 236.7 | 2.4 | 2.8 | 51.2 |
| 8800 | 80.1 | 92.7 | 3333.6 | 22.7 | 26.3 | 719.8 | 9.0 | 10.5 | 250.3 | 2.1 | 2.4 | 50.6 |
| 10800 | 77.7 | 89.3 | 4119.7 | 21.9 | 25.2 | 879.7 | 8.6 | 9.8 | 298.7 | 1.9 | 2.2 | 57.0 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21210611 | 10000 | 419 | 4.02 | 50 | 100 | 5918.0 | 10114.0 | 2.54 | 4.99 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 130 | 22.6 | 25.6 | 17.4 | 9.8 | 11.1 | 6.5 | 7.3 | 8.2 | 4.5 | - | - | - |
| 500 | 18.5 | 21.4 | 39.8 | 7.8 | 9.1 | 14.1 | 5.5 | 6.3 | 8.9 | - | - | - |
| 1030 | 16.6 | 18.9 | 69.7 | 7.0 | 7.9 | 23.8 | 4.7 | 5.3 | 14.4 | - | - | - |
| 5000 | 13.1 | 15.0 | 183.5 | 5.3 | 6.1 | 58.2 | 3.3 | 3.8 | 31.5 | - | - | - |
| 10000 | 11.8 | 13.4 | 329.5 | 4.8 | 5.4 | 101.1 | 2.8 | 3.2 | 51.9 | - | - | - |
| 24050 | 10.3 | 12.0 | 545.5 | 4.1 | 4.8 | 160.4 | 2.3 | 2.6 | 76.7 | - | - | - |
| 177800 | 7.6 | 8.8 | 2245.4 | 2.9 | 3.4 | 598.8 | 1.4 | 1.6 | 237.6 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21210621 | 10000 | 419 | 4.02 | 50 | 100 | 5912.0 | 10104.0 | 2.54 | 4.99 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 110 | 23.2 | 26.4 | 15.6 | 10.1 | 11.5 | 5.9 | 7.5 | 8.6 | 4.1 | 5.3 | 6.1 | 2.7 |
| 500 | 18.4 | 20.8 | 39.6 | 7.8 | 8.9 | 14.0 | 5.5 | 6.2 | 8.9 | 3.4 | 3.9 | 5.1 |
| 1020 | 16.6 | 19.2 | 70.4 | 7.0 | 8.1 | 24.0 | 4.7 | 5.4 | 14.6 | 2.7 | 3.2 | 7.7 |
| 5600 | 12.8 | 14.6 | 203.4 | 5.2 | 6.0 | 64.1 | 3.2 | 3.6 | 34.4 | 1.5 | 1.7 | 14.3 |
| 10600 | 11.7 | 13.5 | 334.2 | 4.7 | 5.5 | 102.2 | 2.8 | 3.2 | 52.3 | 1.2 | 1.4 | 19.4 |
| 24500 | 10.3 | 11.6 | 543.6 | 4.1 | 4.6 | 159.7 | 2.3 | 2.6 | 76.2 | 0.8 | 0.9 | 24.2 |
| 177100 | 7.6 | 8.6 | 2264.7 | 2.9 | 3.3 | 603.8 | 1.4 | 1.6 | 239.6 | 0.3 | 0.4 | 47.2 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21210631 | 10000 | 419 | 4.02 | 50 | 100 | 5911.0 | 10112.0 | 2.54 | 5.12 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 23.9 | 27.2 | 15.4 | 10.3 | 11.7 | 5.8 | 7.7 | 8.7 | 4.0 | 5.5 | 6.2 | 2.7 |
| 500 | 18.8 | 21.6 | 41.7 | 7.9 | 9.0 | 14.5 | 5.5 | 6.3 | 9.2 | 3.4 | 3.9 | 5.2 |
| 1000 | 17.0 | 19.3 | 71.8 | 7.0 | 8.0 | 24.2 | 4.7 | 5.4 | 14.6 | 2.7 | 3.1 | 7.6 |
| 5000 | 13.3 | 15.1 | 194.6 | 5.4 | 6.1 | 80.8 | 3.3 | 3.7 | 32.7 | 1.6 | 1.8 | 13.6 |
| 10620 | 11.9 | 13.8 | 358.3 | 4.7 | 5.5 | 108.0 | 2.8 | 3.2 | 54.8 | 1.2 | 1.3 | 20.1 |
| 23600 | 10.5 | 12.2 | 553.7 | 4.1 | 4.8 | 160.7 | 2.3 | 2.6 | 76.2 | 0.8 | 1.0 | 24.0 |
| 154400 | 8.0 | 9.2 | 2094.1 | 3.0 | 3.5 | 553.9 | 1.4 | 1.7 | 220.4 | 0.3 | 0.4 | 44.1 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21210612 | 10000 | 419 | 4.02 | 50 | 200 | 5905.0 | 10106.0 | 2.54 | 5.18 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 48.2 | 55.1 | 34.4 | 20.1 | 22.9 | 12.5 | 14.3 | 16.4 | 8.3 | 9.8 | 11.1 | 5.3 |
| 520 | 37.7 | 43.8 | 96.9 | 15.3 | 17.7 | 32.5 | 10.1 | 11.7 | 19.5 | 5.9 | 6.8 | 10.4 |
| 1000 | 34.2 | 39.0 | 166.8 | 13.7 | 15.6 | 54.3 | 8.7 | 9.9 | 31.2 | 4.7 | 5.4 | 15.2 |
| 5120 | 26.7 | 30.8 | 456.1 | 10.4 | 12.0 | 137.3 | 6.0 | 6.9 | 69.6 | 2.6 | 3.0 | 26.5 |
| 10700 | 23.9 | 27.7 | 806.6 | 9.2 | 10.6 | 234.4 | 5.0 | 5.8 | 111.8 | 1.9 | 2.2 | 37.2 |
| 23650 | 21.3 | 24.0 | 1287.6 | 8.0 | 9.1 | 359.9 | 4.2 | 4.7 | 160.0 | 1.4 | 1.5 | 45.1 |
| 51700 | 18.9 | 21.4 | 2336.7 | 7.0 | 8.0 | 628.3 | 3.4 | 3.9 | 259.4 | 0.9 | 1.1 | 60.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21210622 | 10000 | 419 | 4.02 | 50 | 200 | 5911.0 | 10116.0 | 2.54 | 5.18 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 48.3 | 57.1 | 34.5 | 20.1 | 23.8 | 12.5 | 14.3 | 17.0 | 8.3 | 9.8 | 11.6 | 5.3 |
| 500 | 37.9 | 43.4 | 94.1 | 15.4 | 17.6 | 31.7 | 10.2 | 11.8 | 19.1 | 6.0 | 6.8 | 10.2 |
| 1000 | 34.2 | 39.3 | 162.2 | 13.7 | 15.7 | 52.8 | 8.7 | 10.0 | 30.3 | 4.7 | 5.4 | 14.8 |
| 5000 | 26.8 | 30.6 | 464.3 | 10.5 | 11.9 | 140.0 | 6.0 | 6.9 | 71.2 | 2.6 | 3.0 | 27.2 |
| 10000 | 24.2 | 28.1 | 778.4 | 9.3 | 10.8 | 227.0 | 5.1 | 5.9 | 108.9 | 2.0 | 2.3 | 36.7 |
| 30500 | 20.5 | 23.3 | 1550.3 | 7.7 | 8.8 | 428.1 | 3.9 | 4.4 | 185.9 | 1.2 | 1.4 | 49.5 |
| 67800 | 18.2 | 21.1 | 2873.7 | 6.7 | 7.8 | 762.5 | 3.2 | 3.7 | 306.6 | 0.8 | 1.0 | 66.9 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21210632 | 10000 | 419 | 4.02 | 50 | 200 | 5913.0 | 10111.0 | 2.54 | 5.06 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 47.5 | 55.1 | 33.0 | 20.0 | 23.2 | 12.1 | 14.3 | 16.6 | 8.1 | 9.8 | 11.4 | 5.2 |
| 500 | 37.3 | 43.0 | 89.3 | 15.3 | 17.6 | 30.4 | 10.2 | 11.7 | 18.4 | 6.0 | 6.9 | 9.9 |
| 1000 | 33.6 | 38.0 | 155.9 | 13.6 | 15.4 | 51.4 | 8.7 | 9.9 | 29.7 | 4.8 | 5.4 | 14.6 |
| 5000 | 26.4 | 30.1 | 424.1 | 10.4 | 11.9 | 129.5 | 6.1 | 6.9 | 66.3 | 2.7 | 3.0 | 25.6 |
| 10000 | 23.8 | 27.4 | 750.7 | 9.3 | 10.7 | 221.7 | 5.1 | 5.9 | 107.2 | 2.0 | 2.3 | 36.6 |
| 30000 | 20.2 | 23.3 | 1445.5 | 7.7 | 8.9 | 404.6 | 3.9 | 4.5 | 177.6 | 1.2 | 1.4 | 48.2 |
| 71600 | 17.7 | 20.0 | 2873.4 | 6.6 | 7.5 | 770.3 | 3.2 | 3.6 | 311.0 | 0.8 | 0.9 | 68.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21210615 | 10000 | 419 | 4.02 | 50 | 500 | 5918.0 | 10117.0 | 2.54 | 5.03 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 118.2 | 134.3 | 108.7 | 45.7 | 51.9 | 36.6 | 28.6 | 32.5 | 21.4 | 16.7 | 18.9 | 11.6 |
| 500 | 92.8 | 107.4 | 293.7 | 34.9 | 40.4 | 91.6 | 19.9 | 23.0 | 47.6 | 9.6 | 11.1 | 20.9 |
| 1000 | 83.7 | 97.1 | 517.8 | 31.1 | 36.0 | 156.2 | 16.9 | 19.6 | 76.8 | 7.4 | 8.6 | 30.2 |
| 5000 | 65.7 | 74.3 | 1421.5 | 23.7 | 26.7 | 396.3 | 11.5 | 13.0 | 169.2 | 3.8 | 4.3 | 49.2 |
| 10000 | 59.2 | 66.6 | 2433.3 | 21.0 | 24.3 | 655.3 | 9.6 | 11.2 | 261.8 | 2.8 | 3.2 | 65.2 |
| 16500 | 53.6 | 61.6 | 3513.1 | 18.8 | 21.6 | 914.7 | 8.1 | 9.3 | 341.5 | 2.0 | 2.3 | 71.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21210625 | 10000 | 419 | 4.02 | 50 | 500 | 5920.0 | 10122.0 | 2.54 | 5.05 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 118.6 | 135.0 | 111.3 | 45.7 | 52.1 | 37.4 | 28.6 | 32.6 | 21.8 | 16.6 | 18.9 | 11.8 |
| 500 | 93.2 | 105.5 | 301.3 | 34.9 | 39.6 | 93.7 | 19.9 | 22.5 | 48.6 | 9.6 | 10.8 | 21.3 |
| 1000 | 84.0 | 97.0 | 523.0 | 31.1 | 35.9 | 157.4 | 16.9 | 19.5 | 77.2 | 7.4 | 8.5 | 30.3 |
| 5000 | 66.0 | 74.9 | 1400.9 | 23.7 | 26.9 | 389.5 | 11.5 | 13.0 | 166.0 | 3.8 | 4.3 | 48.2 |
| 10000 | 59.4 | 67.4 | 2514.9 | 21.0 | 23.9 | 675.5 | 9.6 | 10.9 | 269.3 | 2.7 | 3.1 | 66.8 |
| 16500 | 55.1 | 64.0 | 3215.0 | 19.3 | 22.4 | 842.0 | 8.5 | 9.8 | 319.2 | 2.1 | 2.5 | 69.9 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21210635 | 10000 | 418 | 4.02 | 50 | 500 | 5916.0 | 10110.0 | 2.54 | 4.98 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 117.3 | 135.7 | 106.4 | 45.6 | 52.7 | 36.0 | 28.6 | 33.1 | 21.1 | 16.7 | 19.3 | 11.5 |
| 500 | 92.2 | 105.3 | 290.6 | 34.8 | 39.8 | 91.1 | 19.9 | 22.8 | 47.5 | 9.6 | 11.0 | 20.9 |
| 1000 | 83.1 | 94.7 | 514.7 | 31.0 | 35.3 | 156.2 | 17.0 | 19.3 | 77.0 | 7.4 | 8.5 | 30.5 |
| 5000 | 65.2 | 74.5 | 1398.1 | 23.6 | 27.0 | 382.0 | 11.5 | 13.1 | 168.1 | 3.8 | 4.4 | 49.2 |
| 10000 | 58.8 | 68.0 | 2430.1 | 21.0 | 24.3 | 658.3 | 9.7 | 11.2 | 264.1 | 2.8 | 3.2 | 66.2 |
| 27600 | 50.5 | 57.8 | 4427.9 | 17.7 | 20.2 | 1139.5 | 7.4 | 8.5 | 412.1 | 1.7 | 1.9 | 79.5 |
| 27850 | 50.4 | 57.3 | 4790.2 | 17.6 | 20.0 | 1232.2 | 7.4 | 8.4 | 445.1 | 8.3 | 8.7 | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21310611 | 10000 | 416 | 3.99 | 50 | 100 | 5910.0 | 10100.0 | 2.54 | 4.99 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 23.0 | 26.1 | 15.4 | 10.0 | 11.3 | 5.8 | 7.4 | 8.4 | 4.0 | 5.3 | 6.0 | 2.7 |
| 500 | 18.1 | 21.0 | 42.7 | 7.6 | 8.9 | 15.0 | 5.3 | 6.1 | 9.4 | 3.3 | 3.8 | 5.3 |
| 1000 | 16.3 | 18.7 | 75.7 | 6.8 | 7.8 | 25.7 | 4.5 | 5.2 | 15.5 | 2.6 | 3.0 | 8.1 |
| 5000 | 12.8 | 14.8 | 211.2 | 5.2 | 6.0 | 66.6 | 3.2 | 3.7 | 35.7 | 1.5 | 1.7 | 14.8 |
| 10700 | 11.4 | 13.1 | 383.3 | 4.6 | 5.3 | 116.6 | 2.7 | 3.1 | 58.9 | 1.1 | 1.3 | 21.5 |
| 29500 | 9.8 | 11.2 | 717.8 | 3.9 | 4.4 | 207.9 | 2.1 | 2.4 | 96.5 | 0.7 | 0.8 | 28.9 |
| 163900 | 7.6 | 8.8 | 2543.5 | 2.9 | 3.4 | 677.0 | 1.4 | 1.6 | 267.2 | 0.3 | 0.4 | 52.4 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21310621 | 10000 | 416 | 3.99 | 50 | 100 | 5923.0 | 10118.0 | 2.54 | 4.93 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 150 | 21.5 | 25.5 | 20.1 | 9.3 | 11.1 | 7.5 | 6.8 | 8.1 | 5.1 | 4.7 | 5.6 | 3.3 |
| 550 | 17.7 | 20.0 | 44.1 | 7.5 | 8.5 | 15.5 | 5.2 | 5.9 | 9.7 | 3.2 | 3.6 | 5.4 |
| 1040 | 16.1 | 18.2 | 75.8 | 6.8 | 7.7 | 25.9 | 4.5 | 5.1 | 15.6 | 2.6 | 3.0 | 8.1 |
| 5000 | 12.7 | 14.6 | 203.0 | 5.2 | 6.0 | 64.4 | 3.2 | 3.6 | 34.7 | 1.5 | 1.7 | 14.5 |
| 10000 | 11.4 | 13.3 | 361.3 | 4.6 | 5.4 | 110.9 | 2.7 | 3.2 | 56.6 | 1.2 | 1.3 | 21.0 |
| 32000 | 9.6 | 10.9 | 727.5 | 3.8 | 4.3 | 211.2 | 2.1 | 2.3 | 97.7 | 0.7 | 0.8 | 28.9 |
| 167500 | 7.5 | 8.7 | 2555.3 | 2.9 | 3.3 | 683.8 | 1.4 | 1.6 | 270.7 | 0.3 | 0.4 | 53.3 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21310631 | 10000 | 416 | 3.99 | 50 | 100 | 5910.0 | 10094.0 | 2.54 | 4.91 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 22.7 | 26.4 | 14.9 | 9.9 | 11.5 | 5.7 | 7.4 | 8.6 | 3.9 | 5.3 | 6.1 | 2.6 |
| 500 | 17.8 | 20.5 | 41.1 | 7.6 | 8.7 | 14.6 | 5.3 | 6.1 | 9.2 | 3.3 | 3.8 | 5.2 |
| 1000 | 16.1 | 18.4 | 72.9 | 6.8 | 7.8 | 25.0 | 4.5 | 5.2 | 15.1 | 2.6 | 3.0 | 7.9 |
| 5050 | 12.6 | 14.8 | 202.6 | 5.2 | 6.1 | 64.4 | 3.2 | 3.7 | 34.7 | 1.5 | 1.8 | 14.5 |
| 10500 | 11.3 | 12.9 | 368.7 | 4.6 | 5.2 | 113.2 | 2.7 | 3.1 | 57.6 | 1.1 | 1.3 | 21.3 |
| 18500 | 10.4 | 12.0 | 506.7 | 4.2 | 4.8 | 151.4 | 2.3 | 2.7 | 73.6 | 0.9 | 1.0 | 24.4 |
| 161600 | 7.5 | 8.6 | 2426.1 | 2.9 | 3.3 | 652.2 | 1.4 | 1.6 | 259.7 | 0.3 | 0.4 | 51.8 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21310612 | 10000 | 416 | 3.99 | 50 | 200 | 5914.0 | 10103.0 | 2.54 | 4.94 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 150 | 42.9 | 49.0 | 44.5 | 18.1 | 20.6 | 16.1 | 12.7 | 14.5 | 10.5 | 8.4 | 9.5 | 6.4 |
| 500 | 35.9 | 41.7 | 94.8 | 14.8 | 17.2 | 32.5 | 9.8 | 11.4 | 19.6 | 5.8 | 6.7 | 10.5 |
| 1000 | 32.3 | 37.6 | 184.7 | 13.2 | 15.4 | 54.7 | 8.4 | 9.8 | 31.5 | 4.6 | 5.3 | 15.4 |
| 5000 | 25.4 | 29.2 | 458.9 | 10.1 | 11.6 | 141.3 | 5.8 | 6.7 | 72.1 | 2.6 | 2.9 | 27.7 |
| 10200 | 22.8 | 26.1 | 813.5 | 8.9 | 10.2 | 242.0 | 4.9 | 5.7 | 116.5 | 1.9 | 2.2 | 39.4 |
| 28000 | 19.6 | 22.4 | 1523.9 | 7.5 | 8.6 | 431.6 | 3.9 | 4.4 | 190.1 | 1.2 | 1.4 | 52.1 |
| 48000 | 18.1 | 20.7 | 2424.6 | 6.9 | 7.9 | 668.7 | 3.4 | 3.9 | 280.0 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21310622 | 10000 | 416 | 3.99 | 50 | 200 | 5911.0 | 10102.0 | 2.54 | 4.99 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 46.0 | 52.0 | 34.1 | 19.4 | 21.9 | 12.5 | 13.8 | 15.7 | 8.3 | 9.4 | 10.6 | 5.3 |
| 500 | 36.1 | 41.4 | 96.2 | 14.8 | 17.0 | 32.8 | 9.8 | 11.2 | 19.7 | 5.7 | 6.6 | 10.5 |
| 1000 | 32.6 | 37.5 | 188.1 | 13.2 | 15.2 | 55.5 | 8.4 | 9.7 | 31.8 | 4.6 | 5.3 | 15.6 |
| 5000 | 25.6 | 29.7 | 475.6 | 10.1 | 11.7 | 145.5 | 5.8 | 6.8 | 74.0 | 2.5 | 2.9 | 28.3 |
| 10000 | 23.1 | 26.6 | 830.4 | 9.0 | 10.4 | 245.7 | 5.0 | 5.7 | 118.0 | 1.9 | 2.2 | 39.8 |
| 30000 | 19.6 | 22.4 | 1628.1 | 7.5 | 8.5 | 456.6 | 3.8 | 4.3 | 199.0 | 7.2 | 4.2 | - |
| 33000 | 19.3 | 22.2 | 1908.0 | 7.4 | 8.5 | 532.7 | 3.7 | 4.3 | 230.1 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21310632 | 10000 | 416 | 3.99 | 50 | 200 | 5913.0 | 10104.0 | 2.54 | 4.97 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 45.9 | 52.1 | 34.3 | 19.4 | 22.0 | 12.6 | 13.8 | 15.7 | 8.4 | 9.4 | 10.7 | 5.3 |
| 500 | 36.0 | 41.3 | 93.9 | 14.8 | 17.0 | 32.1 | 9.8 | 11.3 | 19.3 | 5.8 | 6.6 | 10.3 |
| 1000 | 32.5 | 36.9 | 168.4 | 13.2 | 15.0 | 55.7 | 8.4 | 9.6 | 32.0 | 4.6 | 5.2 | 15.7 |
| 5000 | 25.5 | 28.9 | 471.3 | 10.1 | 11.4 | 144.5 | 5.8 | 6.6 | 73.6 | 2.5 | 2.9 | 28.2 |
| 10000 | 23.0 | 26.5 | 815.8 | 9.0 | 10.3 | 241.9 | 5.0 | 5.7 | 116.3 | 1.9 | 2.2 | 39.3 |
| 29000 | 19.6 | 22.5 | 1552.6 | 7.5 | 8.6 | 437.1 | 3.8 | 4.4 | 191.4 | 1.2 | 1.4 | 51.8 |
| 123300 | 15.8 | 18.2 | 4687.0 | 5.9 | 6.8 | 1228.1 | 2.7 | 3.1 | 466.4 | 0.6 | 0.7 | 86.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21310615 | 10000 | 416 | 3.99 | 50 | 500 | 5913.0 | 10105.0 | 2.54 | 4.98 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 120 | 111.8 | 126.5 | 131.2 | 43.0 | 48.7 | 43.7 | 26.5 | 29.9 | 25.0 | 15.0 | 17.8 | - |
| 500 | 90.3 | 102.9 | 318.5 | 33.9 | 38.6 | 99.2 | 19.2 | 21.8 | 51.1 | 14.7 | 17.2 | - |
| 1000 | 81.4 | 92.1 | 555.5 | 30.2 | 34.1 | 167.4 | 16.3 | 18.4 | 81.5 | 15.0 | 17.2 | - |
| 5000 | 63.9 | 74.0 | 1539.1 | 23.0 | 26.6 | 428.5 | 11.0 | 12.8 | 181.1 | 15.0 | 16.0 | - |
| 10100 | 57.5 | 66.8 | 2736.9 | 20.4 | 23.7 | 735.7 | 9.2 | 10.7 | 290.6 | 14.0 | 14.5 | - |
| 22000 | 51.2 | 58.8 | 4363.1 | 17.9 | 20.5 | 1127.6 | 7.6 | 8.7 | 411.1 | 13.8 | 12.8 | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21310625 | 10000 | 416 | 3.99 | 50 | 500 | 5918.0 | 10129.0 | 2.54 | 5.19 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 118.6 | 134.3 | 123.7 | 44.7 | 50.7 | 40.6 | 27.5 | 31.1 | 23.3 | 15.6 | 17.7 | 12.3 |
| 500 | 93.2 | 107.0 | 346.0 | 34.2 | 39.2 | 105.2 | 19.0 | 21.8 | 53.4 | 8.9 | 10.2 | 22.7 |
| 1000 | 84.0 | 95.5 | 611.8 | 30.4 | 34.5 | 179.9 | 16.2 | 18.4 | 86.3 | 6.8 | 7.8 | 32.8 |
| 5100 | 65.8 | 74.4 | 1693.6 | 23.0 | 26.1 | 459.4 | 10.9 | 12.3 | 190.4 | 3.4 | 3.9 | 52.8 |
| 10000 | 59.5 | 67.7 | 2998.2 | 20.6 | 23.4 | 786.1 | 9.1 | 10.4 | 304.8 | 2.5 | 2.8 | 72.2 |
| 20756 | 53.3 | 62.0 | 4551.4 | 18.1 | 21.1 | 1149.8 | 7.6 | 8.8 | 413.0 | 1.7 | 2.0 | 80.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 21310635 | 10000 | 416 | 3.99 | 50 | 500 | 5899.0 | 10087.0 | 2.54 | 5.06 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 116.0 | 134.9 | 118.3 | 44.4 | 51.6 | 39.8 | 27.4 | 31.9 | 22.9 | - | - | - |
| 500 | 91.1 | 103.0 | 326.9 | 33.9 | 38.3 | 100.9 | 19.1 | 21.5 | 51.7 | - | - | - |
| 1000 | 82.1 | 94.7 | 576.4 | 30.2 | 34.8 | 172.0 | 16.2 | 18.7 | 83.3 | - | - | - |
| 5000 | 64.5 | 73.4 | 1606.8 | 23.0 | 26.1 | 443.1 | 11.0 | 12.5 | 186.0 | - | - | - |
| 9850 | 58.3 | 67.5 | 2789.0 | 20.5 | 23.7 | 743.4 | 9.2 | 10.7 | 282.1 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110511 | 10000 | 467 | 4.46 | 50 | 100 | 6176.0 | 10388.0 | 2.54 | 3.02 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 18.2 | 21.2 | 6.0 | 9.7 | 11.3 | 2.8 | 7.9 | 9.1 | 2.1 | 6.2 | 7.2 | 1.5 |
| 500 | 14.3 | 16.5 | 14.9 | 7.5 | 8.6 | 6.5 | 5.8 | 6.6 | 4.5 | 4.1 | 4.7 | 2.9 |
| 1000 | 12.9 | 14.7 | 25.0 | 6.7 | 7.6 | 10.6 | 5.0 | 5.7 | 7.1 | 3.4 | 3.9 | 4.3 |
| 5000 | 10.1 | 11.8 | 64.2 | 5.2 | 6.0 | 25.3 | 3.6 | 4.2 | 15.6 | 2.1 | 2.4 | 8.0 |
| 10000 | 9.1 | 10.6 | 108.4 | 4.6 | 5.4 | 41.5 | 3.1 | 3.6 | 24.5 | 1.7 | 2.0 | 11.5 |
| 30300 | 7.7 | 8.9 | 203.7 | 3.8 | 4.4 | 74.4 | 2.5 | 2.8 | 40.8 | 1.1 | 1.3 | 16.2 |
| 157000 | 6.0 | 7.0 | 635.0 | 2.9 | 3.4 | 215.4 | 1.7 | 2.0 | 104.7 | 0.6 | 0.7 | 30.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110521 | 10000 | 467 | 4.46 | 50 | 100 | 6172.0 | 10375.0 | 2.54 | 2.93 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 17.9 | 20.8 | 5.7 | 9.7 | 11.2 | 2.7 | 7.8 | 9.1 | 2.0 | 6.2 | 7.2 | 1.5 |
| 500 | 14.1 | 16.0 | 14.3 | 7.5 | 8.5 | 6.3 | 5.7 | 6.5 | 4.4 | 4.1 | 4.7 | 2.9 |
| 1000 | 12.7 | 14.3 | 24.3 | 6.7 | 7.5 | 10.4 | 5.0 | 5.6 | 7.0 | 3.4 | 3.8 | 4.3 |
| 5300 | 9.9 | 11.5 | 63.9 | 5.1 | 5.9 | 25.4 | 3.6 | 4.1 | 15.7 | 2.1 | 2.4 | 8.0 |
| 10000 | 9.0 | 10.5 | 105.9 | 4.6 | 5.3 | 40.9 | 3.1 | 3.6 | 24.3 | 1.7 | 2.0 | 11.5 |
| 30000 | 7.6 | 8.8 | 182.4 | 3.8 | 4.4 | 70.9 | 2.5 | 2.8 | 38.2 | 7.5 | 9.0 | - |
| 166200 | 5.9 | 6.9 | 623.3 | 2.9 | 3.4 | 213.0 | 1.7 | 2.0 | 103.8 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES;
WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT;
SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR;
CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER;
AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110531 | 10000 | 467 | 4.46 | 50 | 100 | 6177.0 | 10381.0 | 2.54 | 2.90 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 17.9 | 20.6 | 5.7 | 9.7 | 11.1 | 2.7 | 7.8 | 9.0 | 2.0 | 6.2 | 7.1 | 1.5 |
| 500 | 14.0 | 16.0 | 14.2 | 7.4 | 8.5 | 6.3 | 5.7 | 6.5 | 4.4 | 4.1 | 4.7 | 2.9 |
| 1000 | 12.6 | 14.7 | 24.0 | 6.7 | 7.7 | 10.3 | 5.0 | 5.8 | 7.0 | 3.4 | 3.9 | 4.3 |
| 5150 | 9.9 | 11.5 | 63.7 | 5.1 | 5.9 | 25.4 | 3.6 | 4.2 | 15.7 | 2.1 | 2.4 | 8.1 |
| 10000 | 9.0 | 10.4 | 103.4 | 4.6 | 5.3 | 40.1 | 3.1 | 3.6 | 23.8 | 1.7 | 2.0 | 11.3 |
| 30000 | 7.6 | 8.8 | 191.4 | 3.8 | 4.4 | 70.8 | 2.5 | 2.9 | 39.2 | 0.7 | 2.4 | - |
| 189900 | 5.8 | 6.6 | 684.0 | 2.8 | 3.3 | 233.2 | 1.6 | 1.9 | 112.8 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110512 | 10000 | 467 | 4.46 | 50 | 200 | 6170.0 | 10373.0 | 2.54 | 2.95 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 36.0 | 41.7 | 13.0 | 19.0 | 22.0 | 5.9 | 14.9 | 17.3 | 4.4 | 11.4 | 13.2 | 3.1 |
| 500 | 28.3 | 32.3 | 32.3 | 14.6 | 16.7 | 13.8 | 10.9 | 12.4 | 9.4 | 7.4 | 8.5 | 5.9 |
| 1000 | 25.5 | 29.3 | 54.8 | 13.1 | 15.0 | 22.8 | 9.5 | 10.9 | 14.9 | 6.1 | 7.0 | 8.7 |
| 5000 | 20.0 | 22.6 | 142.4 | 10.0 | 11.4 | 55.4 | 6.8 | 7.7 | 32.9 | 3.7 | 4.2 | 16.0 |
| 10000 | 18.0 | 20.6 | 242.7 | 9.0 | 10.3 | 91.6 | 5.9 | 6.7 | 52.1 | 3.0 | 3.4 | 23.0 |
| 28600 | 15.6 | 17.8 | 409.1 | 7.6 | 8.7 | 147.9 | 4.7 | 5.4 | 78.7 | 2.1 | 2.4 | 29.9 |
| 144000 | 12.1 | 14.1 | 1301.8 | 5.8 | 6.7 | 436.4 | 3.2 | 3.8 | 204.2 | 1.1 | 1.2 | 56.0 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110522 | 10000 | 467 | 4.46 | 50 | 200 | 6169.0 | 10372.0 | 2.54 | 2.96 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 150 | 33.9 | 39.4 | 16.7 | 17.8 | 20.7 | 7.5 | 13.8 | 16.1 | 5.4 | 10.3 | 11.9 | 3.7 |
| 500 | 28.3 | 32.9 | 32.8 | 14.6 | 17.0 | 14.1 | 10.9 | 12.6 | 9.5 | 7.4 | 8.6 | 5.9 |
| 1100 | 25.2 | 28.8 | 58.9 | 12.9 | 14.7 | 24.4 | 9.3 | 10.6 | 15.9 | 6.0 | 6.8 | 9.2 |
| 5200 | 19.9 | 23.0 | 146.4 | 10.0 | 11.5 | 56.8 | 6.7 | 7.8 | 33.7 | 3.7 | 4.3 | 16.2 |
| 10100 | 18.0 | 20.6 | 239.0 | 9.0 | 10.3 | 90.0 | 5.8 | 6.7 | 51.2 | 3.0 | 3.4 | 22.6 |
| 27400 | 15.5 | 17.6 | 420.0 | 7.6 | 8.6 | 151.5 | 4.7 | 5.3 | 80.4 | 2.1 | 2.3 | 30.3 |
| 175550 | 11.8 | 13.4 | 1495.1 | 5.6 | 6.4 | 496.2 | 3.1 | 3.5 | 228.2 | 1.0 | 1.1 | 59.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110532 | 10000 | 467 | 4.46 | 50 | 200 | 6166.0 | 10369.0 | 2.54 | 2.99 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 36.2 | 41.0 | 12.6 | 19.0 | 21.5 | 5.7 | 14.9 | 16.9 | 4.2 | 11.4 | 12.9 | 3.0 |
| 500 | 28.4 | 32.9 | 32.9 | 14.6 | 16.9 | 14.0 | 10.9 | 12.6 | 9.5 | 7.4 | 8.6 | 5.9 |
| 1400 | 24.4 | 28.0 | 69.8 | 12.4 | 14.2 | 28.6 | 8.8 | 10.2 | 18.3 | 5.5 | 6.4 | 10.3 |
| 5000 | 20.1 | 22.8 | 141.5 | 10.1 | 11.4 | 54.8 | 6.8 | 7.7 | 32.5 | 3.7 | 4.2 | 15.7 |
| 12300 | 17.6 | 20.0 | 274.2 | 8.7 | 9.9 | 102.1 | 5.6 | 6.4 | 57.1 | 2.8 | 3.1 | 24.4 |
| 20100 | 16.3 | 18.6 | 340.2 | 8.0 | 9.1 | 124.0 | 5.0 | 5.7 | 67.1 | 2.3 | 2.6 | 26.6 |
| 167500 | 11.9 | 13.5 | 1439.9 | 5.7 | 6.4 | 477.3 | 3.1 | 3.5 | 219.8 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110515 | 10000 | 467 | 4.46 | 50 | 500 | 6168.0 | 10372.0 | 2.54 | 2.98 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 90.4 | 105.2 | 42.8 | 44.5 | 51.7 | 18.3 | 31.6 | 36.8 | 12.1 | 21.3 | 24.8 | 7.7 |
| 500 | 71.0 | 83.5 | 110.9 | 34.2 | 40.2 | 44.3 | 22.7 | 26.7 | 26.8 | 13.3 | 15.7 | 14.3 |
| 1000 | 64.0 | 74.5 | 188.0 | 30.5 | 35.5 | 72.9 | 19.6 | 22.8 | 42.2 | 10.7 | 12.5 | 20.8 |
| 5000 | 50.3 | 58.2 | 470.6 | 23.4 | 27.1 | 169.9 | 13.8 | 16.0 | 88.1 | 6.1 | 7.1 | 34.5 |
| 10000 | 45.3 | 51.3 | 813.5 | 20.9 | 23.7 | 284.7 | 11.8 | 13.4 | 140.1 | 4.7 | 5.4 | 48.8 |
| 30000 | 38.4 | 44.1 | 1492.1 | 17.4 | 20.0 | 496.8 | 9.2 | 10.5 | 223.8 | 3.0 | 3.5 | 62.9 |
| 102631 | 32.0 | 36.4 | 3493.4 | 14.2 | 16.2 | 1098.9 | 6.8 | 7.8 | 444.1 | 1.7 | 1.9 | 93.2 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110525 | 10000 | 467 | 4.46 | 50 | 500 | 6161.0 | 10371.0 | 2.54 | 3.13 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 150 | 87.1 | 99.5 | 59.8 | 41.9 | 47.9 | 24.8 | 29.1 | 33.2 | 15.9 | - | - | - |
| 500 | 72.7 | 87.0 | 115.4 | 34.4 | 41.2 | 45.3 | 22.6 | 27.1 | 27.1 | - | - | - |
| 1000 | 65.5 | 75.8 | 194.5 | 30.7 | 35.5 | 74.1 | 19.5 | 22.6 | 42.5 | - | - | - |
| 5000 | 51.5 | 58.4 | 506.0 | 23.8 | 27.2 | 179.4 | 13.7 | 15.8 | 91.9 | - | - | - |
| 11500 | 45.4 | 52.9 | 942.2 | 20.5 | 23.9 | 321.8 | 11.3 | 13.2 | 154.6 | - | - | - |
| 30000 | 39.3 | 44.4 | 1543.7 | 17.5 | 19.8 | 504.5 | 9.1 | 10.2 | 223.9 | - | - | - |
| 65100 | 35.0 | 40.8 | 2815.6 | 15.4 | 17.9 | 887.8 | 7.5 | 8.8 | 388.0 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110535 | 10000 | 467 | 4.46 | 50 | 500 | 6170.0 | 10375.0 | 2.54 | 2.98 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 90.4 | 102.5 | 43.9 | 44.5 | 50.4 | 18.8 | 31.6 | 35.9 | 12.5 | 21.4 | 24.2 | 7.9 |
| 500 | 71.0 | 81.7 | 110.6 | 34.2 | 39.4 | 44.2 | 22.7 | 26.1 | 26.7 | 13.3 | 15.3 | 14.3 |
| 1000 | 64.0 | 72.5 | 188.2 | 30.5 | 34.6 | 73.0 | 19.6 | 22.2 | 42.3 | - | - | - |
| 5300 | 49.8 | 57.9 | 488.8 | 23.2 | 27.0 | 176.1 | 13.6 | 15.9 | 90.9 | - | - | - |
| 10300 | 45.1 | 51.3 | 821.5 | 20.8 | 23.7 | 287.3 | 11.7 | 13.4 | 141.1 | - | - | - |
| 30000 | 38.4 | 44.0 | 1485.6 | 17.4 | 20.0 | 494.9 | 9.2 | 10.5 | 223.1 | - | - | - |
| 82200 | 34.4 | 39.5 | 2597.5 | 15.4 | 17.7 | 836.8 | 7.7 | 8.9 | 354.2 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110611 | 10000 | 467 | 4.46 | 50 | 100 | 5858.0 | 10168.0 | 2.54 | 5.03 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 24.1 | 28.0 | 12.0 | 10.6 | 12.3 | 4.6 | 8.0 | 9.3 | 3.2 | 5.8 | 6.7 | 2.2 |
| 500 | 18.9 | 21.5 | 30.4 | 8.1 | 9.2 | 10.8 | 5.7 | 6.5 | 6.9 | 3.6 | 4.1 | 4.0 |
| 1000 | 17.1 | 19.4 | 51.9 | 7.2 | 8.2 | 17.8 | 4.9 | 5.6 | 11.0 | 2.9 | 3.3 | 5.9 |
| 5000 | 13.4 | 15.2 | 131.4 | 5.5 | 6.3 | 41.9 | 3.4 | 3.9 | 23.1 | 1.7 | 1.9 | 9.9 |
| 10000 | 12.1 | 13.7 | 227.2 | 4.9 | 5.6 | 70.1 | 2.9 | 3.3 | 36.6 | 1.3 | 1.5 | 14.1 |
| 30250 | 10.2 | 11.7 | 421.9 | 4.1 | 4.7 | 123.5 | 2.3 | 2.6 | 58.8 | 0.8 | 0.9 | 18.4 |
| 143700 | 8.1 | 9.2 | 1209.9 | 3.1 | 3.6 | 328.1 | 1.5 | 1.8 | 135.5 | 0.4 | 0.5 | 29.4 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110621 | 10000 | 467 | 4.46 | 50 | 100 | 5926.0 | 10106.0 | 2.54 | 4.93 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 23.6 | 26.9 | 11.8 | 10.4 | 11.9 | 4.6 | 7.9 | 9.0 | 3.2 | 5.8 | 6.6 | 2.2 |
| 500 | 18.6 | 20.9 | 29.6 | 8.0 | 9.0 | 10.6 | 5.7 | 6.4 | 6.8 | 3.6 | 4.1 | 4.0 |
| 1000 | 16.7 | 19.2 | 50.8 | 7.1 | 8.2 | 17.6 | 4.9 | 5.6 | 10.9 | 2.9 | 3.4 | 5.9 |
| 5500 | 12.9 | 15.0 | 136.2 | 5.4 | 6.2 | 43.7 | 3.4 | 3.9 | 24.0 | 1.6 | 1.9 | 10.3 |
| 10700 | 11.7 | 13.6 | 226.5 | 4.8 | 5.6 | 70.4 | 2.9 | 3.4 | 36.8 | 1.3 | 1.5 | 14.1 |
| 30000 | 10.0 | 11.6 | 398.8 | 4.0 | 4.7 | 118.0 | 2.3 | 2.6 | 56.7 | 0.8 | 1.0 | 18.0 |
| 192000 | 7.6 | 8.6 | 1411.0 | 3.0 | 3.4 | 381.4 | 1.4 | 1.6 | 154.4 | 0.4 | 0.4 | 31.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110631 | 10000 | 467 | 4.46 | 50 | 100 | 5960.0 | 10183.0 | 2.54 | 5.18 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 24.7 | 28.0 | 12.8 | 10.6 | 12.1 | 4.8 | 8.0 | 9.1 | 3.4 | 5.8 | 6.6 | 2.3 |
| 500 | 19.4 | 22.0 | 32.6 | 8.2 | 9.3 | 11.4 | 5.7 | 6.5 | 7.3 | 3.6 | 4.1 | 4.2 |
| 1000 | 17.5 | 20.1 | 54.7 | 7.3 | 8.4 | 18.5 | 4.9 | 5.7 | 11.3 | 2.9 | 3.3 | 6.0 |
| 5000 | 13.7 | 15.5 | 139.7 | 5.6 | 6.3 | 43.8 | 3.4 | 3.9 | 23.9 | 1.7 | 1.9 | 10.2 |
| 10000 | 12.4 | 14.3 | 239.3 | 4.9 | 5.7 | 72.6 | 2.9 | 3.4 | 37.5 | 1.3 | 1.5 | 14.2 |
| 50000 | 9.7 | 11.1 | 602.5 | 3.8 | 4.3 | 169.2 | 2.0 | 2.3 | 76.3 | 0.6 | 0.7 | 21.0 |
| 100000 | 8.8 | 10.1 | 1031.1 | 3.4 | 3.9 | 279.8 | 1.7 | 1.9 | 118.2 | 0.5 | 0.5 | 27.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110612 | 10000 | 467 | 4.46 | 50 | 200 | 5956.0 | 10169.0 | 2.54 | 5.08 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 130 | 46.7 | 54.2 | 32.9 | 19.7 | 22.9 | 12.0 | 14.2 | 16.4 | 8.0 | 9.6 | 11.2 | 5.1 |
| 500 | 38.2 | 43.3 | 70.8 | 15.8 | 17.9 | 24.3 | 10.6 | 12.1 | 14.9 | - | - | - |
| 1000 | 34.4 | 38.9 | 118.9 | 14.1 | 15.9 | 39.5 | 9.1 | 10.3 | 23.1 | - | - | - |
| 6000 | 26.3 | 29.8 | 345.4 | 10.4 | 11.8 | 105.4 | 6.1 | 6.9 | 54.1 | - | - | - |
| 10100 | 24.3 | 27.5 | 524.6 | 9.5 | 10.8 | 156.1 | 5.4 | 6.1 | 76.8 | - | - | - |
| 30200 | 20.6 | 23.4 | 937.4 | 7.9 | 9.0 | 284.4 | 4.1 | 4.7 | 118.2 | - | - | - |
| 186800 | 15.7 | 17.8 | 3307.1 | 5.8 | 6.6 | 852.0 | 2.6 | 3.0 | 318.3 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110622 | 10000 | 467 | 4.46 | 50 | 200 | 5963.0 | 10183.0 | 2.54 | 4.85 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 46.9 | 54.6 | 25.3 | 20.4 | 23.7 | 9.6 | 14.9 | 17.4 | 6.6 | 10.5 | 12.2 | 4.3 |
| 500 | 36.9 | 42.4 | 65.9 | 15.6 | 17.9 | 23.2 | 10.6 | 12.2 | 14.4 | 6.5 | 7.5 | 8.0 |
| 1000 | 33.2 | 37.7 | 111.1 | 13.9 | 15.8 | 37.8 | 9.2 | 10.4 | 22.4 | 5.2 | 5.9 | 11.5 |
| 5000 | 26.1 | 29.6 | 281.9 | 10.6 | 12.1 | 89.0 | 6.4 | 7.2 | 47.0 | 2.9 | 3.3 | 19.1 |
| 10000 | 23.5 | 28.2 | 475.3 | 9.5 | 11.4 | 145.3 | 5.4 | 6.5 | 72.6 | 2.3 | 2.7 | 26.2 |
| 27900 | 20.2 | 22.8 | 843.0 | 8.0 | 9.0 | 245.2 | 4.3 | 4.8 | 112.5 | 1.5 | 1.7 | 33.1 |
| 191500 | 15.1 | 17.1 | 3100.9 | 5.8 | 6.5 | 820.5 | 2.6 | 3.0 | 312.8 | 0.6 | 0.6 | 56.4 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110632 | 10000 | 467 | 4.46 | 50 | 200 | 5961.0 | 10168.0 | 2.54 | 4.96 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 47.7 | 55.0 | 26.4 | 20.5 | 23.6 | 9.9 | 15.0 | 17.2 | 6.7 | 10.4 | 12.0 | 4.4 |
| 500 | 37.5 | 43.2 | 67.4 | 15.7 | 18.1 | 23.4 | 10.6 | 12.3 | 14.5 | 6.4 | 7.4 | 8.0 |
| 1000 | 33.8 | 38.5 | 112.8 | 14.0 | 15.9 | 38.0 | 9.2 | 10.4 | 22.4 | 5.1 | 5.9 | 11.4 |
| 5100 | 26.5 | 30.6 | 298.6 | 10.7 | 12.3 | 93.1 | 6.3 | 7.3 | 48.8 | 2.9 | 3.3 | 19.5 |
| 10800 | 23.6 | 27.2 | 511.5 | 9.4 | 10.8 | 153.8 | 5.3 | 6.1 | 75.9 | 2.1 | 2.5 | 26.6 |
| 30000 | 20.3 | 23.3 | 912.2 | 7.9 | 9.1 | 261.1 | 4.2 | 4.8 | 118.0 | 1.4 | 1.6 | 33.6 |
| 166100 | 15.7 | 18.3 | 2973.0 | 5.9 | 6.9 | 781.9 | 2.7 | 3.2 | 299.4 | 0.6 | 0.7 | 55.2 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110615 | 10000 | 467 | 4.46 | 50 | 500 | 5960.0 | 10169.0 | 2.54 | 4.99 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 150 | 112.9 | 131.3 | 114.2 | 44.0 | 51.1 | 38.3 | 27.4 | 31.9 | 22.1 | 15.7 | 18.2 | 11.7 |
| 500 | 94.2 | 107.8 | 229.1 | 35.9 | 41.1 | 72.5 | 20.9 | 23.9 | 38.5 | 10.4 | 11.9 | 17.4 |
| 1000 | 84.9 | 98.8 | 381.5 | 32.0 | 37.2 | 116.8 | 17.8 | 20.7 | 58.7 | 8.0 | 9.3 | 23.9 |
| 5400 | 65.9 | 76.0 | 1028.6 | 24.1 | 27.7 | 290.1 | 11.9 | 13.7 | 126.1 | 4.0 | 4.7 | 37.6 |
| 11100 | 59.2 | 67.7 | 1766.2 | 21.3 | 24.3 | 480.6 | 9.9 | 11.4 | 195.2 | - | - | - |
| 30100 | 51.0 | 59.3 | 3105.8 | 18.0 | 20.9 | 803.7 | 7.7 | 9.0 | 295.0 | - | - | - |
| 51000 | 47.1 | 53.4 | 4678.3 | 16.4 | 18.6 | 1178.4 | 6.7 | 7.6 | 408.5 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110625 | 10000 | 467 | 4.46 | 50 | 500 | 5966.0 | 10166.0 | 2.54 | 4.82 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 116.9 | 133.0 | 84.3 | 46.8 | 53.2 | 29.4 | 30.1 | 34.2 | 17.6 | 18.1 | 20.6 | 9.9 |
| 500 | 91.9 | 106.3 | 216.6 | 35.8 | 41.4 | 70.0 | 21.1 | 24.4 | 37.5 | 10.6 | 12.3 | 17.2 |
| 1000 | 82.8 | 93.5 | 364.6 | 31.8 | 36.0 | 113.9 | 18.0 | 20.3 | 58.0 | 8.2 | 9.3 | 24.0 |
| 5000 | 65.0 | 74.2 | 931.6 | 24.3 | 27.7 | 289.4 | 12.3 | 14.0 | 119.7 | 4.3 | 4.9 | 37.1 |
| 10000 | 58.6 | 68.2 | 1586.7 | 21.6 | 25.1 | 443.4 | 10.3 | 12.0 | 184.9 | 3.2 | 3.7 | 49.4 |
| 30000 | 49.7 | 56.7 | 2902.5 | 17.9 | 20.4 | 767.9 | 7.8 | 8.9 | 287.0 | 1.9 | 2.1 | 58.3 |
| 53800 | 45.5 | 51.8 | 4510.7 | 16.2 | 18.5 | 1158.6 | 6.7 | 7.6 | 406.9 | 1.4 | 1.5 | 70.0 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110635 | 10000 | 467 | 4.46 | 50 | 500 | 5933.0 | 10130.0 | 2.54 | 5.09 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 125 | 117.1 | 135.9 | 107.3 | 45.3 | 52.5 | 35.9 | 28.4 | 32.9 | 20.9 | 16.4 | 19.1 | 11.3 |
| 500 | 95.1 | 109.3 | 238.6 | 35.9 | 41.2 | 74.7 | 20.8 | 23.9 | 39.4 | 10.2 | 11.7 | 17.7 |
| 1000 | 85.8 | 98.2 | 398.9 | 32.0 | 36.6 | 120.8 | 17.7 | 20.3 | 60.3 | 7.9 | 9.0 | 24.3 |
| 5100 | 67.2 | 75.8 | 1036.9 | 24.3 | 27.4 | 290.0 | 12.0 | 13.5 | 125.7 | 4.1 | 4.6 | 37.5 |
| 10200 | 60.5 | 69.3 | 1707.4 | 21.6 | 24.7 | 461.2 | 10.1 | 11.5 | 187.3 | 3.0 | 3.4 | 47.9 |
| 21600 | 54.1 | 61.2 | 2846.5 | 19.0 | 21.5 | 688.3 | 8.3 | 9.4 | 259.2 | 2.0 | 2.3 | 54.9 |
| 27700 | 52.1 | 59.8 | 3338.3 | 18.2 | 20.9 | 857.4 | 7.8 | 8.9 | 314.5 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110711 | 10000 | 467 | 4.46 | 50 | 100 | 5737.0 | 9942.0 | 2.54 | 7.03 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 31.1 | 35.1 | 25.0 | 11.2 | 12.6 | 7.8 | 7.9 | 8.9 | 5.2 | 5.3 | 6.0 | 3.2 |
| 500 | 24.5 | 28.0 | 63.8 | 8.5 | 9.8 | 18.5 | 5.5 | 6.3 | 10.9 | 3.2 | 3.6 | 5.7 |
| 1000 | 22.0 | 25.6 | 107.0 | 7.6 | 8.8 | 29.9 | 4.7 | 5.5 | 16.8 | 2.5 | 2.9 | 8.0 |
| 5300 | 17.2 | 19.7 | 280.4 | 5.7 | 6.5 | 72.1 | 3.2 | 3.6 | 35.3 | 1.3 | 1.5 | 12.7 |
| 10000 | 15.6 | 17.6 | 463.3 | 5.1 | 5.8 | 115.3 | 2.7 | 3.1 | 53.2 | 1.0 | 1.1 | 16.9 |
| 25500 | 13.6 | 15.7 | 758.3 | 4.4 | 5.1 | 179.7 | 2.1 | 2.5 | 75.7 | 0.6 | 0.7 | 19.4 |
| 148700 | 10.4 | 11.8 | 2569.7 | 3.2 | 3.6 | 554.3 | 1.3 | 1.5 | 192.6 | 0.2 | 0.3 | 29.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110721 | 10000 | 467 | 4.46 | 50 | 100 | 5735.0 | 9937.0 | 2.54 | 7.01 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 120 | 30.2 | 34.6 | 27.7 | 10.8 | 12.4 | 8.6 | 7.6 | 8.7 | 5.8 | 5.0 | 5.8 | 3.5 |
| 510 | 24.3 | 28.7 | 63.5 | 8.5 | 10.0 | 18.4 | 5.5 | 6.5 | 10.9 | 3.1 | 3.7 | 5.7 |
| 1000 | 22.0 | 25.5 | 105.2 | 7.6 | 8.8 | 29.5 | 4.7 | 5.5 | 16.6 | 2.5 | 2.9 | 7.9 |
| 5420 | 17.1 | 19.3 | 281.9 | 5.7 | 6.4 | 72.5 | 3.2 | 3.6 | 35.4 | 1.3 | 1.5 | 12.7 |
| 11580 | 15.2 | 17.6 | 506.1 | 5.0 | 5.8 | 125.3 | 2.6 | 3.0 | 57.1 | 0.9 | 1.1 | 17.6 |
| 16800 | 14.4 | 16.7 | 587.6 | 4.7 | 5.4 | 142.6 | 2.4 | 2.8 | 62.7 | 0.8 | 0.9 | 17.8 |
| 167300 | 10.2 | 11.6 | 2722.1 | 3.1 | 3.6 | 584.7 | 1.3 | 1.5 | 200.7 | 0.2 | 0.3 | 30.0 |

WA = TOTAL WEIGHT OF DRY AGGREGATES;
WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT;
SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR;
CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER;
AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110731 | 10000 | 467 | 4.46 | 50 | 100 | 5738.0 | 9946.0 | 2.54 | 7.05 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 31.3 | 35.6 | 25.3 | 11.2 | 12.8 | 7.9 | 7.9 | 9.1 | 5.2 | 5.3 | 6.1 | 3.3 |
| 500 | 24.6 | 28.2 | 64.2 | 8.5 | 9.8 | 18.5 | 5.5 | 6.4 | 10.9 | 3.2 | 3.6 | 5.7 |
| 1000 | 22.1 | 25.5 | 109.2 | 7.6 | 8.7 | 30.4 | 4.7 | 5.4 | 17.1 | 2.5 | 2.8 | 8.1 |
| 5000 | 17.4 | 19.7 | 275.3 | 5.8 | 6.5 | 70.8 | 3.2 | 3.6 | 34.7 | 1.3 | 1.5 | 12.6 |
| 11700 | 15.3 | 17.8 | 516.0 | 5.0 | 5.8 | 127.0 | 2.6 | 3.0 | 57.6 | 0.9 | 1.1 | 17.6 |
| 26800 | 13.5 | 15.3 | 809.0 | 4.3 | 4.9 | 190.6 | 2.1 | 2.4 | 79.8 | 0.6 | 0.7 | 20.1 |
| 159000 | 10.3 | 11.9 | 2661.6 | 3.2 | 3.7 | 574.4 | 1.3 | 1.5 | 197.5 | 0.2 | 0.3 | 29.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110712 | 10000 | 467 | 4.46 | 50 | 200 | 5720.0 | 9911.0 | 2.54 | 7.01 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 61.9 | 70.5 | 55.5 | 21.6 | 24.5 | 16.8 | 14.6 | 16.6 | 10.6 | 8.3 | 10.6 | 6.3 |
| 500 | 48.6 | 55.6 | 141.9 | 16.4 | 18.8 | 39.8 | 10.1 | 11.6 | 22.3 | 5.4 | 6.2 | 10.9 |
| 1000 | 43.8 | 49.8 | 240.5 | 14.6 | 16.6 | 65.1 | 8.6 | 9.8 | 34.6 | 4.2 | 4.8 | 15.2 |
| 5600 | 33.8 | 39.2 | 653.5 | 10.9 | 12.6 | 161.9 | 5.6 | 6.5 | 74.0 | - | - | - |
| 10000 | 31.0 | 36.1 | 1018.4 | 9.8 | 11.4 | 244.8 | 4.9 | 5.7 | 105.8 | - | - | - |
| 27000 | 26.7 | 30.7 | 1791.9 | 8.3 | 9.5 | 408.7 | 3.8 | 4.3 | 159.4 | - | - | - |
| 102200 | 21.9 | 25.4 | 4461.2 | 6.6 | 7.6 | 947.1 | 2.6 | 3.0 | 317.5 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110722 | 10000 | 467 | 4.46 | 50 | 200 | 5736.0 | 9946.0 | 2.54 | 7.10 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 130 | 60.5 | 71.4 | 66.8 | 20.8 | 24.5 | 19.8 | 13.8 | 16.3 | 12.2 | 8.5 | 10.1 | 7.0 |
| 500 | 49.4 | 56.9 | 147.6 | 16.5 | 19.0 | 40.9 | 10.1 | 11.7 | 22.9 | 5.4 | 6.2 | 11.1 |
| 1000 | 44.5 | 50.8 | 247.0 | 14.7 | 16.7 | 66.2 | 8.6 | 9.8 | 35.0 | 4.2 | 4.8 | 15.3 |
| 5250 | 34.7 | 39.7 | 637.8 | 11.1 | 12.6 | 156.9 | 5.7 | 6.6 | 71.7 | 2.1 | 2.4 | 23.3 |
| 7500 | 32.9 | 38.2 | 876.4 | 10.4 | 12.0 | 211.7 | 5.2 | 6.1 | 93.5 | 1.8 | 2.1 | 28.1 |
| 10300 | 31.4 | 36.2 | 1007.7 | 9.8 | 11.4 | 239.4 | 4.8 | 5.6 | 102.5 | - | - | - |
| 30000 | 26.7 | 30.9 | 2147.8 | 8.2 | 9.4 | 482.0 | 3.7 | 4.2 | 184.6 | - | - | - |
| 110500 | 22.0 | 24.9 | 4540.9 | 6.5 | 7.4 | 949.6 | 2.6 | 2.9 | 312.7 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110732 | 10000 | 467 | 4.46 | 50 | 200 | 5734.0 | 9950.0 | 2.54 | 7.19 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 63.8 | 72.9 | 58.9 | 21.8 | 24.9 | 17.5 | 14.6 | 16.7 | 11.0 | 9.3 | 10.6 | 6.5 |
| 500 | 50.1 | 56.7 | 150.1 | 16.6 | 18.8 | 41.2 | 10.1 | 11.5 | 22.9 | 5.4 | 6.1 | 11.0 |
| 1000 | 45.1 | 51.8 | 255.0 | 14.7 | 16.9 | 67.6 | 8.6 | 9.9 | 35.6 | 4.1 | 4.7 | 15.4 |
| 5000 | 35.5 | 40.8 | 679.4 | 11.2 | 12.8 | 185.9 | 5.8 | 6.7 | 75.7 | 2.1 | 2.5 | 24.6 |
| 10000 | 32.0 | 37.1 | 1118.9 | 9.9 | 11.5 | 263.4 | 4.9 | 5.6 | 112.4 | 1.6 | 1.8 | 31.4 |
| 50000 | 25.1 | 28.6 | 2824.5 | 7.5 | 8.6 | 610.1 | 3.2 | 3.6 | 219.0 | 0.7 | 0.8 | 40.1 |
| 100000 | 22.6 | 26.0 | 4792.4 | 6.6 | 7.6 | 996.6 | 2.6 | 3.0 | 329.5 | 0.5 | 0.5 | 48.3 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110715 | 10000 | 467 | 4.46 | 50 | 500 | 5728.0 | 9934.0 | 2.54 | 7.12 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 157.6 | 178.1 | 194.1 | 48.6 | 55.3 | 52.2 | 27.7 | 31.4 | 27.7 | - | - | - |
| 500 | 123.8 | 143.9 | 489.2 | 36.9 | 42.9 | 121.0 | 18.7 | 21.8 | 55.9 | - | - | - |
| 1000 | 111.6 | 127.5 | 823.2 | 32.7 | 37.4 | 196.4 | 15.7 | 18.0 | 85.0 | - | - | - |
| 5000 | 87.6 | 101.4 | 2131.6 | 24.8 | 28.6 | 466.5 | 10.3 | 11.9 | 170.9 | - | - | - |
| 10800 | 78.1 | 90.8 | 3733.3 | 21.6 | 25.2 | 783.3 | 8.3 | 9.7 | 262.8 | - | - | - |
| 11300 | 77.6 | 87.6 | 3556.5 | 21.5 | 24.2 | 744.4 | 8.2 | 9.3 | 248.4 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110725 | 10000 | 467 | 4.46 | 50 | 500 | 5741.0 | 9942.0 | 2.54 | 6.94 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 153.8 | 175.9 | 178.5 | 48.5 | 55.4 | 49.0 | 27.8 | 31.8 | 26.3 | 14.7 | 16.8 | 12.9 |
| 500 | 120.8 | 140.0 | 460.2 | 36.8 | 42.6 | 116.3 | 18.9 | 21.9 | 54.4 | 7.9 | 9.2 | 20.9 |
| 1000 | 108.9 | 123.8 | 781.2 | 32.7 | 37.1 | 190.5 | 15.9 | 18.1 | 83.5 | 5.9 | 6.8 | 28.2 |
| 5000 | 85.5 | 98.8 | 1997.6 | 24.7 | 28.6 | 447.1 | 10.5 | 12.1 | 186.3 | 2.8 | 3.2 | 39.3 |
| 10000 | 77.1 | 88.9 | 3321.6 | 21.9 | 25.3 | 716.0 | 8.7 | 10.0 | 246.5 | 2.0 | 2.2 | 48.4 |
| 13300 | 73.9 | 85.4 | 3729.7 | 20.8 | 24.1 | 791.5 | 8.0 | 9.2 | 263.5 | 1.7 | 1.9 | 47.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12110735 | 10000 | 467 | 4.46 | 50 | 500 | 5723.0 | 9913.0 | 2.54 | 6.97 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 145 | 145.6 | 184.7 | 232.6 | 45.4 | 51.3 | 62.5 | 25.4 | 28.7 | 32.4 | 12.8 | 14.4 | 15.1 |
| 500 | 120.9 | 138.8 | 454.9 | 36.7 | 42.2 | 114.6 | 18.8 | 21.6 | 53.5 | 7.9 | 9.1 | 20.5 |
| 1000 | 109.0 | 128.0 | 782.5 | 32.6 | 38.3 | 192.6 | 15.8 | 18.6 | 84.3 | 5.9 | 6.9 | 28.3 |
| 5100 | 85.4 | 96.9 | 2035.3 | 24.6 | 27.9 | 453.5 | 10.3 | 11.7 | 168.0 | 2.8 | 3.1 | 39.3 |
| 8700 | 78.8 | 90.5 | 3073.6 | 22.4 | 25.7 | 665.3 | 9.0 | 10.3 | 232.1 | 2.1 | 2.4 | 47.2 |
| 9700 | 77.5 | 89.1 | 2998.9 | 22.0 | 25.2 | 645.3 | 8.7 | 10.0 | 222.4 | 2.0 | 2.3 | 43.9 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11110715 | 10000 | 450 | 4.31 | 50 | 500 | 5746.0 | 9955.0 | 2.55 | 7.10 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 160.1 | 182.2 | 188.2 | 49.6 | 56.5 | 50.8 | 28.4 | 32.3 | 27.1 | 14.9 | 17.0 | 13.3 |
| 500 | 125.7 | 143.9 | 474.1 | 37.7 | 43.1 | 117.9 | 19.2 | 22.0 | 54.8 | 8.0 | 9.2 | 20.9 |
| 1000 | 113.3 | 130.2 | 803.7 | 33.4 | 38.4 | 182.7 | 16.2 | 18.6 | 83.9 | 6.0 | 6.9 | 28.1 |
| 5000 | 89.0 | 102.7 | 2038.4 | 25.3 | 29.2 | 448.5 | 10.6 | 12.2 | 165.5 | 2.8 | 3.2 | 38.6 |
| 11200 | 78.9 | 89.8 | 3757.3 | 22.0 | 25.0 | 781.1 | 8.5 | 9.7 | 286.3 | 1.8 | 2.1 | 49.9 |
| 12000 | 78.1 | 88.3 | 3585.7 | 21.7 | 24.5 | 752.1 | 8.3 | 9.4 | 251.1 | 1.8 | 2.0 | 46.1 |
| 13100 | 77.0 | 86.9 | 4132.8 | 21.4 | 24.1 | 862.6 | 8.1 | 9.2 | 285.1 | 1.7 | 1.9 | 51.0 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12210711 | 10000 | 469 | 4.48 | 50 | 100 | 5719.0 | 9940.0 | 2.54 | 7.32 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 31.3 | 35.4 | 30.8 | 10.8 | 12.2 | 9.3 | 7.5 | 8.4 | 6.0 | 4.9 | 5.5 | 3.6 |
| 500 | 24.6 | 28.4 | 80.1 | 8.2 | 9.5 | 22.2 | 5.2 | 6.0 | 12.7 | 2.8 | 3.3 | 6.4 |
| 1000 | 22.2 | 25.4 | 141.2 | 7.3 | 8.4 | 37.8 | 4.4 | 5.0 | 20.5 | 2.2 | 2.5 | 9.3 |
| 5000 | 17.4 | 19.9 | 371.9 | 5.5 | 6.3 | 91.7 | 3.0 | 3.4 | 43.4 | 1.2 | 1.3 | 14.8 |
| 10000 | 15.7 | 18.1 | 634.1 | 4.9 | 5.7 | 150.8 | 2.5 | 2.9 | 66.8 | 0.9 | 1.0 | 19.8 |
| 30000 | 13.3 | 15.3 | 1207.4 | 4.1 | 4.7 | 270.9 | 1.9 | 2.2 | 107.2 | 0.5 | 0.6 | 24.3 |
| 159200 | 10.4 | 12.0 | 3914.0 | 3.0 | 3.5 | 801.9 | 1.2 | 1.4 | 261.6 | 0.2 | 0.2 | 35.6 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12210721 | 10000 | 469 | 4.48 | 50 | 100 | 5731.0 | 9924.0 | 2.54 | 6.86 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 29.4 | 33.9 | 25.8 | 10.6 | 12.3 | 8.1 | 7.4 | 8.6 | 5.3 | 4.9 | 5.7 | 3.3 |
| 500 | 23.1 | 26.6 | 68.7 | 8.1 | 9.3 | 20.0 | 5.2 | 6.0 | 11.7 | 2.9 | 3.4 | 6.0 |
| 1000 | 20.8 | 23.9 | 116.5 | 7.2 | 8.3 | 32.8 | 4.4 | 5.1 | 18.2 | 2.3 | 2.6 | 8.5 |
| 5100 | 16.3 | 18.5 | 323.2 | 5.4 | 6.2 | 83.8 | 3.0 | 3.4 | 40.6 | 1.2 | 1.4 | 14.4 |
| 10000 | 14.7 | 16.6 | 530.5 | 4.9 | 5.5 | 132.8 | 2.5 | 2.9 | 60.6 | - | - | - |
| 30000 | 12.5 | 14.5 | 1030.0 | 4.0 | 4.7 | 243.5 | 1.9 | 2.2 | 99.6 | - | - | - |
| 167000 | 9.6 | 11.1 | 3406.5 | 4.8 | 5.6 | - | 1.2 | 1.4 | 248.4 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12210731 | 10000 | 469 | 4.48 | 50 | 100 | 5732.0 | 9954.0 | 2.54 | 7.22 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 120 | 30.1 | 34.5 | 33.4 | 10.5 | 12.0 | 10.0 | 7.2 | 8.2 | 6.4 | 4.6 | 5.3 | 3.8 |
| 500 | 24.3 | 27.6 | 78.8 | 8.2 | 9.3 | 22.1 | 5.2 | 5.9 | 12.7 | 2.9 | 3.3 | 6.4 |
| 1000 | 21.9 | 24.9 | 132.8 | 7.3 | 8.3 | 36.0 | 4.4 | 5.0 | 19.6 | 2.2 | 2.5 | 9.0 |
| 5200 | 17.1 | 19.6 | 360.6 | 5.5 | 6.3 | 89.8 | 3.0 | 3.4 | 42.6 | - | - | - |
| 10000 | 15.5 | 17.6 | 618.6 | 4.9 | 5.6 | 148.9 | 2.5 | 2.9 | 66.4 | - | - | - |
| 30000 | 13.1 | 15.1 | 1145.0 | 4.1 | 4.7 | 260.0 | 1.9 | 2.2 | 103.7 | - | - | - |
| 191300 | 10.0 | 11.3 | 4195.3 | 2.9 | 3.4 | 861.6 | 1.1 | 1.3 | 277.4 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12210712 | 10000 | 469 | 4.48 | 50 | 200 | 5735.0 | 9950.0 | 2.54 | 7.10 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 60.8 | 69.4 | 63.8 | 20.7 | 23.7 | 18.9 | 13.7 | 15.7 | 11.7 | 8.6 | 9.8 | 6.8 |
| 500 | 47.8 | 54.5 | 167.1 | 15.8 | 18.0 | 45.8 | 9.5 | 10.8 | 25.1 | 4.9 | 5.6 | 11.8 |
| 1000 | 43.1 | 50.0 | 288.2 | 14.0 | 16.3 | 76.3 | 8.0 | 9.3 | 39.5 | 3.8 | 4.4 | 16.8 |
| 6400 | 32.6 | 36.9 | 903.4 | 10.2 | 11.5 | 217.2 | 5.1 | 5.8 | 95.1 | 1.7 | 2.0 | 28.5 |
| 10000 | 30.5 | 34.7 | 1286.0 | 9.4 | 10.8 | 302.0 | 4.5 | 5.2 | 126.5 | 1.4 | 1.6 | 34.3 |
| 28500 | 26.1 | 30.0 | 2412.7 | 7.9 | 9.1 | 535.7 | 3.4 | 4.0 | 200.8 | 0.8 | 1.0 | 41.7 |
| 54000 | 23.7 | 27.4 | 3933.0 | 7.0 | 8.1 | 843.6 | 2.9 | 3.3 | 294.0 | 0.6 | 0.7 | 50.6 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12210722 | 10000 | 469 | 4.48 | 50 | 200 | 5738.0 | 9953.0 | 2.54 | 7.07 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 60.6 | 70.1 | 63.6 | 20.7 | 24.0 | 18.9 | 13.7 | 15.9 | 11.7 | 8.6 | 9.9 | 6.8 |
| 500 | 47.6 | 55.2 | 163.7 | 15.8 | 18.3 | 45.0 | 9.5 | 11.0 | 24.7 | 4.9 | 5.7 | 11.7 |
| 1000 | 42.9 | 49.6 | 289.4 | 14.0 | 16.2 | 76.8 | 8.1 | 9.3 | 39.8 | 3.8 | 4.4 | 16.9 |
| 5500 | 33.2 | 37.9 | 809.0 | 10.5 | 11.9 | 196.6 | 5.3 | 6.0 | 87.5 | 1.9 | 2.1 | 27.2 |
| 10000 | 30.4 | 34.6 | 1300.7 | 9.4 | 10.8 | 306.4 | 4.5 | 5.2 | 128.5 | 9.1 | 10.6 | - |
| 29000 | 25.9 | 29.7 | 2422.7 | 7.8 | 9.0 | 539.2 | 8.7 | 10.2 | - | - | - | - |
| 70900 | 22.7 | 26.0 | 4729.4 | 6.7 | 7.7 | 1002.7 | 2.7 | 3.1 | 339.2 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12210732 | 10000 | 469 | 4.48 | 50 | 200 | 5739.0 | 9942.0 | 2.54 | 6.91 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 59.2 | 68.5 | 58.7 | 20.6 | 23.8 | 17.8 | 13.7 | 15.9 | 11.1 | 8.6 | 10.0 | 6.5 |
| 500 | 46.5 | 53.5 | 154.4 | 15.7 | 18.0 | 43.2 | 9.5 | 10.9 | 23.9 | 5.0 | 5.7 | 11.4 |
| 1000 | 41.9 | 47.4 | 267.8 | 13.9 | 15.7 | 72.3 | 8.1 | 9.1 | 37.8 | 3.9 | 4.4 | 16.3 |
| 5000 | 32.9 | 37.3 | 701.2 | 10.6 | 12.0 | 174.4 | 5.5 | 6.2 | 78.1 | 2.0 | 2.3 | 25.5 |
| 10000 | 29.7 | 34.0 | 1232.7 | 9.4 | 10.8 | 295.7 | 4.6 | 5.2 | 125.5 | 1.5 | 1.7 | 34.8 |
| 50000 | 23.3 | 26.8 | 3219.6 | 7.1 | 8.2 | 709.0 | 3.0 | 3.4 | 253.4 | 0.6 | 0.7 | 46.0 |
| 80000 | 21.7 | 25.3 | 4746.4 | 6.5 | 7.6 | 1018.9 | 2.6 | 3.1 | 344.7 | 0.5 | 0.6 | 54.0 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12210715 | 10000 | 469 | 4.48 | 50 | 500 | 5755.0 | 9966.0 | 2.54 | 6.86 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 147.5 | 171.3 | 191.7 | 46.3 | 53.7 | 52.4 | 26.1 | 30.3 | 27.6 | - | - | - |
| 500 | 115.9 | 134.4 | 518.3 | 35.1 | 40.8 | 130.7 | 17.7 | 20.5 | 59.9 | - | - | - |
| 1030 | 104.0 | 119.3 | 887.4 | 31.0 | 35.6 | 215.0 | 14.8 | 16.9 | 92.1 | - | - | - |
| 5000 | 82.0 | 93.8 | 2353.3 | 23.6 | 27.0 | 524.2 | 9.8 | 11.2 | 190.8 | - | - | - |
| 10000 | 73.9 | 84.1 | 4049.2 | 20.9 | 23.8 | 868.6 | 8.1 | 9.2 | 292.1 | - | - | - |
| 12500 | 71.5 | 81.1 | 4312.0 | 20.1 | 22.8 | 913.7 | 7.6 | 8.6 | 299.3 | - | - | - |
| 13000 | 71.1 | 81.5 | 4773.5 | 20.0 | 22.9 | 1009.4 | 7.5 | 8.6 | 329.1 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12210725 | 10000 | 469 | 4.48 | 50 | 500 | 5756.0 | 9963.0 | 2.54 | 6.80 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 146.3 | 169.8 | 189.2 | 46.2 | 53.6 | 52.0 | 26.2 | 30.4 | 27.5 | 13.6 | 15.7 | 13.3 |
| 500 | 114.9 | 131.9 | 495.4 | 35.1 | 40.3 | 125.5 | 17.7 | 20.4 | 57.8 | 7.3 | 8.4 | 21.7 |
| 1000 | 103.6 | 117.1 | 859.2 | 31.1 | 35.2 | 210.0 | 14.9 | 16.9 | 90.6 | 5.5 | 6.2 | 29.9 |
| 5000 | 81.3 | 94.5 | 2277.7 | 23.6 | 27.4 | 511.1 | 9.8 | 11.4 | 187.0 | 2.6 | 3.0 | 42.9 |
| 10000 | 73.3 | 83.3 | 3970.8 | 20.9 | 23.7 | 858.2 | 8.1 | 9.2 | 290.3 | 1.8 | 2.0 | 55.3 |
| 12100 | 71.2 | 82.6 | 4122.4 | 20.2 | 23.4 | 881.8 | 7.7 | 8.9 | 291.6 | 1.6 | 1.9 | 52.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12210735 | 10000 | 469 | 4.48 | 50 | 500 | 5717.0 | 9923.0 | 2.54 | 7.15 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 152.8 | 172.7 | 214.9 | 46.4 | 52.4 | 56.8 | 25.7 | 29.1 | 29.4 | 13.1 | 14.7 | 13.9 |
| 500 | 120.0 | 137.1 | 563.4 | 35.2 | 40.2 | 137.0 | 17.4 | 19.8 | 61.6 | 6.9 | 7.9 | 22.4 |
| 1000 | 108.2 | 122.4 | 985.6 | 31.2 | 35.3 | 231.0 | 14.6 | 16.5 | 97.2 | 5.1 | 5.8 | 30.9 |
| 5000 | 85.0 | 96.3 | 2544.3 | 23.6 | 26.7 | 546.9 | 9.5 | 10.8 | 194.0 | 2.4 | 2.7 | 42.5 |
| 10000 | 76.6 | 86.8 | 4488.2 | 20.9 | 23.7 | 828.6 | 7.8 | 8.9 | 303.9 | 1.6 | 1.8 | 54.9 |
| 13000 | 73.6 | 84.9 | 4835.9 | 19.9 | 23.0 | 886.1 | 7.3 | 8.4 | 312.6 | 1.4 | 1.6 | 52.2 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12310711 | 10000 | 443 | 4.24 | 50 | 100 | 5749.0 | 9963.0 | 2.55 | 7.25 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 30.4 | 34.6 | 31.8 | 10.5 | 11.9 | 9.6 | 7.2 | 8.2 | 6.1 | 4.6 | 5.3 | 3.7 |
| 500 | 23.8 | 27.3 | 85.0 | 8.0 | 9.1 | 23.6 | 5.0 | 5.7 | 13.4 | 2.7 | 3.1 | 6.7 |
| 1000 | 21.5 | 24.9 | 146.9 | 7.1 | 8.2 | 39.4 | 4.2 | 4.9 | 21.2 | 2.1 | 2.4 | 9.5 |
| 5000 | 16.9 | 19.3 | 406.3 | 5.4 | 6.1 | 100.3 | 2.9 | 3.3 | 47.0 | 1.1 | 1.3 | 15.9 |
| 10000 | 15.2 | 17.2 | 698.9 | 4.8 | 5.4 | 166.3 | 2.4 | 2.7 | 72.9 | 0.8 | 0.9 | 21.3 |
| 28000 | 13.0 | 15.1 | 1268.2 | 4.0 | 4.6 | 285.8 | 1.8 | 2.1 | 112.8 | 0.5 | 0.6 | 25.7 |
| 167440 | 10.0 | 11.6 | 4651.7 | 2.9 | 3.4 | 951.1 | 1.1 | 1.3 | 305.0 | 0.2 | 0.2 | 39.9 |

WA = TOTAL WEIGHT OF DRY AGGREGATES;
WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT;
SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR;
CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER;
AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12310721 | 10000 | 443 | 4.24 | 50 | 100 | 5753.0 | 9964.0 | 2.55 | 7.17 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 30.1 | 34.5 | 30.8 | 10.5 | 12.0 | 9.3 | 7.2 | 8.2 | 6.0 | 4.7 | 5.4 | 3.6 |
| 500 | 23.6 | 27.5 | 83.2 | 8.0 | 9.3 | 23.3 | 5.0 | 5.8 | 13.3 | 2.7 | 3.2 | 6.6 |
| 1000 | 21.3 | 24.3 | 143.3 | 7.1 | 8.1 | 38.7 | 4.2 | 4.8 | 20.9 | 2.1 | 2.4 | 9.4 |
| 5000 | 16.7 | 19.0 | 395.8 | 5.4 | 6.1 | 98.5 | 2.9 | 3.3 | 46.3 | 1.1 | 1.3 | 15.8 |
| 10300 | 15.0 | 17.4 | 689.3 | 4.7 | 5.5 | 165.2 | 2.4 | 2.8 | 72.6 | 0.8 | 0.9 | 21.2 |
| 30900 | 12.7 | 14.8 | 1310.5 | 3.9 | 4.6 | 296.2 | 1.8 | 2.1 | 116.3 | 0.5 | 0.5 | 26.0 |
| 144300 | 10.1 | 11.7 | 4037.6 | 3.0 | 3.5 | 839.6 | 1.2 | 1.4 | 276.1 | 0.2 | 0.2 | 38.6 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12310731 | 10000 | 443 | 4.24 | 50 | 100 | 5748.0 | 9954.0 | 2.55 | 7.13 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 29.9 | 34.3 | 30.3 | 10.4 | 12.0 | 9.2 | 7.2 | 8.2 | 5.9 | - | - | - |
| 500 | 23.5 | 27.3 | 83.2 | 7.9 | 9.2 | 23.4 | 5.0 | 5.8 | 13.4 | - | - | - |
| 1000 | 21.1 | 24.6 | 141.3 | 7.1 | 8.2 | 38.3 | 4.2 | 4.9 | 20.8 | - | - | - |
| 5500 | 16.4 | 19.0 | 415.3 | 5.3 | 6.1 | 103.3 | 2.8 | 3.3 | 48.3 | - | - | - |
| 10600 | 14.8 | 16.8 | 686.3 | 4.7 | 5.3 | 184.9 | 2.4 | 2.7 | 72.4 | - | - | - |
| 30000 | 12.7 | 14.3 | 1290.2 | 3.9 | 4.4 | 293.4 | 1.8 | 2.0 | 115.9 | - | - | - |
| 128200 | 10.2 | 11.5 | 3719.0 | 3.1 | 3.4 | 781.6 | 1.2 | 1.4 | 261.4 | - | - | - |
| 130000 | 10.2 | 11.5 | 3401.4 | 3.0 | 3.5 | 714.6 | 1.2 | 1.4 | 238.8 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12310712 | 10000 | 443 | 4.24 | 50 | 200 | 5740.0 | 9935.0 | 2.55 | 7.09 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) ELA. | TOT. | PLA. | LVDT #2(2.0 IN.) ELA. | TOT. | PLA. | LVDT #3(4.0 IN.) ELA. | TOT. | PLA. | LVDT #4(6.0625 IN.) ELA. | TOT. | PLA. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 59.3 | 67.9 | 66.6 | 20.1 | 23.0 | 19.6 | 13.1 | 15.1 | 12.0 | 8.1 | 9.3 | 6.9 |
| 500 | 46.6 | 52.8 | 183.0 | 15.3 | 17.3 | 49.8 | 9.1 | 10.3 | 27.0 | 4.6 | 5.3 | 12.6 |
| 1000 | 42.0 | 47.9 | 316.7 | 13.6 | 15.5 | 83.2 | 7.7 | 8.8 | 42.6 | 3.6 | 4.1 | 17.8 |
| 5700 | 32.3 | 36.9 | 912.6 | 10.1 | 11.5 | 219.2 | 5.0 | 5.7 | 95.7 | 1.7 | 2.0 | 28.8 |
| 22180 | 26.4 | 30.4 | 2506.5 | 8.0 | 9.2 | 560.3 | 3.5 | 4.0 | 212.6 | 0.9 | 1.0 | 46.1 |
| 31570 | 25.0 | 29.1 | 2899.9 | 7.5 | 8.7 | 636.0 | 3.2 | 3.7 | 232.0 | 0.7 | 0.9 | 45.6 |
| 52000 | 23.2 | 26.9 | 4488.2 | 6.9 | 8.0 | 958.0 | 2.8 | 3.2 | 329.9 | 0.6 | 0.6 | 55.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12310722 | 10000 | 443 | 4.24 | 50 | 200 | 5745.0 | 9947.0 | 2.55 | 7.13 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) ELA. | TOT. | PLA. | LVDT #2(2.0 IN.) ELA. | TOT. | PLA. | LVDT #3(4.0 IN.) ELA. | TOT. | PLA. | LVDT #4(6.0625 IN.) ELA. | TOT. | PLA. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 59.7 | 68.1 | 68.1 | 20.1 | 23.0 | 20.0 | 13.2 | 15.0 | 12.2 | 8.1 | 9.2 | 7.0 |
| 500 | 46.9 | 55.9 | 183.8 | 15.3 | 18.3 | 49.8 | 9.1 | 10.8 | 26.9 | 4.6 | 5.5 | 12.5 |
| 1000 | 42.3 | 48.1 | 319.4 | 13.6 | 15.5 | 83.6 | 7.7 | 8.8 | 42.6 | 3.6 | 4.1 | 17.8 |
| 5200 | 33.0 | 38.4 | 898.1 | 10.2 | 11.9 | 215.8 | 5.1 | 6.0 | 94.8 | 1.8 | 2.1 | 29.0 |
| 10300 | 29.8 | 34.1 | 1528.1 | 9.1 | 10.4 | 354.1 | 4.3 | 4.9 | 145.3 | 1.3 | 1.5 | 38.1 |
| 27000 | 25.8 | 29.9 | 2863.5 | 7.7 | 8.9 | 586.2 | 3.3 | 3.9 | 216.9 | 0.8 | 0.9 | 44.3 |
| 55200 | 23.2 | 26.3 | 4685.8 | 6.8 | 7.7 | 991.9 | 2.7 | 3.1 | 337.9 | 0.5 | 0.6 | 55.7 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12310732 | 10000 | 443 | 4.24 | 50 | 200 | 5763.0 | 9969.0 | 2.55 | 7.02 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 58.9 | 67.1 | 65.3 | 20.1 | 22.9 | 19.4 | 13.2 | 15.0 | 11.9 | 8.2 | 9.3 | 6.9 |
| 500 | 46.2 | 53.1 | 180.9 | 15.3 | 17.6 | 49.6 | 9.1 | 10.5 | 27.0 | 4.7 | 5.4 | 12.6 |
| 1000 | 41.7 | 47.1 | 305.8 | 13.6 | 15.3 | 81.0 | 7.7 | 8.7 | 41.6 | 3.6 | 4.1 | 17.5 |
| 5500 | 32.3 | 36.9 | 898.1 | 10.1 | 11.6 | 218.0 | 5.1 | 5.8 | 96.0 | 1.8 | 2.0 | 29.3 |
| 10900 | 29.1 | 33.5 | 1504.2 | 9.0 | 10.4 | 352.2 | 4.3 | 4.9 | 144.9 | 1.3 | 1.5 | 38.0 |
| 30000 | 25.0 | 28.6 | 2771.3 | 7.6 | 8.6 | 614.7 | 3.3 | 3.7 | 226.9 | 0.8 | 0.9 | 45.7 |
| 57000 | 22.7 | 26.2 | 4586.3 | 6.8 | 7.8 | 982.5 | 2.7 | 3.1 | 336.9 | 0.5 | 0.6 | 56.0 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12310715 | 10000 | 443 | 4.24 | 50 | 500 | 5748.0 | 9948.0 | 2.55 | 7.08 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 148.1 | 172.3 | 221.0 | 45.0 | 52.3 | 58.5 | 24.7 | 28.8 | 30.0 | 12.4 | 14.4 | 14.0 |
| 500 | 116.4 | 131.8 | 605.2 | 34.1 | 38.6 | 147.2 | 16.7 | 18.9 | 65.6 | 6.6 | 7.4 | 23.5 |
| 1000 | 104.9 | 121.8 | 1034.4 | 30.3 | 35.1 | 242.6 | 14.0 | 16.2 | 101.0 | - | - | - |
| 2000 | 94.5 | 108.7 | 1513.1 | 26.8 | 30.9 | 342.0 | 11.7 | 13.4 | 132.7 | - | - | - |
| 5000 | 82.4 | 95.0 | 3117.1 | 22.9 | 26.4 | 670.4 | 9.1 | 10.5 | 235.2 | - | - | - |
| 7000 | 78.3 | 90.2 | 3587.9 | 21.6 | 24.8 | 757.5 | 8.3 | 9.6 | 255.7 | - | - | - |
| 9000 | 75.4 | 86.2 | 4600.4 | 20.6 | 23.6 | 957.9 | - | - | - | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12310725 | 10000 | 443 | 4.24 | 50 | 500 | 5743.0 | 9943.0 | 2.55 | 7.13 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 149.0 | 172.2 | 224.9 | 45.0 | 52.0 | 59.2 | 24.7 | 28.5 | 30.3 | 12.3 | 14.3 | 14.1 |
| 500 | 117.1 | 134.5 | 602.4 | 34.1 | 39.2 | 145.8 | 16.6 | 19.1 | 64.7 | 6.5 | 7.5 | 23.1 |
| 1000 | 105.5 | 119.7 | 1043.7 | 30.3 | 34.3 | 243.4 | 13.9 | 15.8 | 101.0 | - | - | - |
| 2000 | 95.1 | 109.0 | 1547.6 | 26.8 | 30.8 | 347.8 | 11.6 | 13.3 | 134.4 | - | - | - |
| 5000 | 82.9 | 94.1 | 3153.6 | 22.9 | 26.0 | 674.3 | 9.1 | 10.3 | 235.6 | - | - | - |
| 8000 | 77.2 | 89.5 | 3872.8 | 21.1 | 24.4 | 807.0 | 8.0 | 9.2 | 267.0 | - | - | - |
| 9000 | 75.9 | 86.6 | 4653.3 | 20.6 | 23.6 | 963.3 | 7.7 | 8.8 | 314.3 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 12310735 | 10000 | 443 | 4.24 | 50 | 500 | 5767.0 | 9974.0 | 2.55 | 6.99 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 146.8 | 169.9 | 214.4 | 45.0 | 52.1 | 57.3 | 24.9 | 28.8 | 29.5 | 12.5 | 14.5 | 13.9 |
| 500 | 115.3 | 130.7 | 582.8 | 34.2 | 38.7 | 143.3 | 16.8 | 19.0 | 64.2 | 6.7 | 7.6 | 23.2 |
| 1000 | 103.9 | 120.8 | 1016.2 | 30.3 | 35.2 | 240.9 | 14.1 | 16.4 | 101.0 | 4.9 | 5.7 | 31.9 |
| 5000 | 81.6 | 93.2 | 2712.4 | 22.9 | 26.2 | 589.7 | 9.2 | 10.5 | 208.5 | 2.3 | 2.6 | 45.4 |
| 6000 | 79.4 | 90.8 | 3343.4 | 22.2 | 25.4 | 719.6 | 8.8 | 10.0 | 249.3 | 2.1 | 2.4 | 51.7 |
| 7000 | 77.6 | 87.8 | 3432.4 | 21.6 | 24.4 | 732.6 | 8.4 | 9.5 | 249.3 | 1.9 | 2.2 | 49.5 |
| 8000 | 76.1 | 86.9 | 4056.5 | - | - | - | - | - | - | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22110611 | 10000 | 447 | 4.28 | 50 | 100 | 5859.0 | 10045.0 | 2.52 | 4.78 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 23.2 | 26.2 | 12.3 | 10.4 | 11.7 | 4.8 | 7.9 | 8.9 | 3.4 | 5.8 | 6.5 | 2.3 |
| 500 | 18.2 | 21.2 | 31.3 | 8.0 | 9.3 | 11.4 | 5.7 | 6.6 | 7.4 | 3.7 | 4.2 | 4.3 |
| 1000 | 16.4 | 18.7 | 54.9 | 7.1 | 8.1 | 19.3 | 4.9 | 5.6 | 12.0 | 2.9 | 3.4 | 6.5 |
| 5000 | 12.9 | 14.8 | 144.9 | 5.4 | 6.2 | 47.4 | 3.4 | 3.9 | 26.4 | 1.7 | 2.0 | 11.6 |
| 10000 | 11.6 | 13.5 | 246.5 | 4.8 | 5.6 | 78.0 | 2.9 | 3.4 | 41.2 | 1.3 | 1.5 | 16.2 |
| 30000 | 9.8 | 11.3 | 460.6 | 4.0 | 4.6 | 138.4 | 2.3 | 2.6 | 67.0 | 0.9 | 1.0 | 21.5 |
| 163000 | 7.6 | 8.8 | 1512.7 | 3.0 | 3.5 | 418.8 | 1.5 | 1.7 | 174.0 | 0.4 | 0.4 | 37.7 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22110621 | 10000 | 447 | 4.28 | 50 | 100 | 5838.0 | 10011.0 | 2.52 | 4.80 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 23.2 | 26.8 | 12.5 | 10.4 | 12.0 | 4.9 | 7.9 | 9.1 | 3.4 | 5.8 | 6.7 | 2.4 |
| 500 | 18.2 | 20.7 | 31.9 | 8.0 | 9.0 | 11.6 | 5.7 | 6.4 | 7.5 | 3.6 | 4.1 | 4.4 |
| 1000 | 16.4 | 18.5 | 54.5 | 7.1 | 8.0 | 19.1 | 4.9 | 5.5 | 11.9 | 2.9 | 3.3 | 6.4 |
| 5500 | 12.7 | 14.6 | 151.4 | 5.3 | 6.1 | 49.1 | 3.4 | 3.8 | 27.1 | 1.6 | 1.9 | 11.7 |
| 10200 | 11.6 | 13.3 | 254.9 | 4.8 | 5.5 | 80.4 | 2.9 | 3.3 | 42.3 | 1.3 | 1.5 | 16.5 |
| 27800 | 10.0 | 11.3 | 447.3 | 4.1 | 4.6 | 134.5 | 2.3 | 2.6 | 65.4 | 0.9 | 1.0 | 21.3 |
| 189865 | 7.5 | 8.5 | 1684.4 | 2.9 | 3.3 | 461.4 | 1.4 | 1.6 | 188.4 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22110631 | 10000 | 447 | 4.28 | 50 | 100 | 5826.0 | 10000.0 | 2.52 | 4.93 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 23.6 | 26.7 | 13.0 | 10.4 | 11.8 | 5.0 | 7.9 | 8.9 | 3.5 | 5.7 | 6.5 | 2.4 |
| 500 | 18.5 | 20.9 | 33.5 | 8.0 | 9.0 | 12.0 | 5.6 | 6.4 | 7.7 | 3.6 | 4.1 | 4.5 |
| 1000 | 16.7 | 19.2 | 57.1 | 7.1 | 8.2 | 19.8 | 4.9 | 5.6 | 12.2 | 2.9 | 3.3 | 6.6 |
| 5000 | 13.1 | 15.5 | 152.0 | 5.4 | 6.4 | 48.9 | 3.4 | 4.0 | 27.0 | 1.7 | 2.0 | 11.7 |
| 10300 | 11.8 | 13.3 | 266.7 | 4.8 | 5.5 | 82.9 | 2.9 | 3.3 | 43.3 | 1.3 | 1.4 | 16.7 |
| 24100 | 10.4 | 11.9 | 423.6 | 4.2 | 4.8 | 126.5 | 2.4 | 2.7 | 61.7 | 0.9 | 1.0 | 20.3 |
| 180000 | 7.7 | 8.8 | 1697.8 | 3.0 | 3.4 | 459.6 | 1.5 | 1.7 | 186.6 | 0.4 | 0.4 | 38.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22110612 | 10000 | 447 | 4.28 | 50 | 200 | 5838.0 | 10023.0 | 2.52 | 4.96 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 47.5 | 55.3 | 29.0 | 20.4 | 23.7 | 10.8 | 14.8 | 17.3 | 7.4 | 10.3 | 12.0 | 4.8 |
| 500 | 37.3 | 42.4 | 77.3 | 15.6 | 17.7 | 26.8 | 10.5 | 12.0 | 16.5 | 6.4 | 7.2 | 9.1 |
| 1000 | 33.6 | 38.4 | 131.2 | 13.9 | 15.9 | 44.1 | 9.1 | 10.4 | 25.9 | 5.1 | 5.8 | 13.1 |
| 5000 | 26.4 | 30.4 | 348.5 | 10.6 | 12.2 | 108.5 | 6.3 | 7.3 | 56.8 | 2.9 | 3.3 | 22.7 |
| 10000 | 23.8 | 27.0 | 590.2 | 9.5 | 10.7 | 177.8 | 5.4 | 6.1 | 88.0 | 2.2 | 2.5 | 31.1 |
| 30000 | 20.2 | 23.5 | 1106.2 | 7.9 | 9.1 | 316.0 | 4.1 | 4.8 | 142.3 | 1.4 | 1.6 | 40.3 |
| 167200 | 15.6 | 18.1 | 3676.0 | 5.9 | 6.8 | 964.6 | 2.7 | 3.1 | 367.6 | 0.6 | 0.7 | 67.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22110622 | 10000 | 447 | 4.28 | 50 | 200 | 5821.0 | 10000.0 | 2.52 | 5.04 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 48.0 | 55.0 | 30.2 | 20.4 | 23.4 | 11.2 | 14.8 | 17.0 | 7.6 | 10.3 | 11.8 | 4.9 |
| 500 | 37.7 | 43.4 | 78.7 | 15.6 | 18.0 | 27.1 | 10.5 | 12.1 | 16.6 | 6.3 | 7.3 | 9.1 |
| 1000 | 34.0 | 38.7 | 134.6 | 13.9 | 15.9 | 44.8 | 9.0 | 10.3 | 26.2 | 5.0 | 5.7 | 13.2 |
| 5000 | 26.7 | 30.1 | 355.5 | 10.6 | 12.0 | 109.7 | 6.3 | 7.1 | 57.1 | 2.8 | 3.2 | 22.6 |
| 10000 | 24.0 | 27.6 | 615.3 | 9.5 | 10.9 | 183.7 | 5.3 | 6.1 | 90.4 | 2.2 | 2.5 | 31.7 |
| 26800 | 20.7 | 24.0 | 1058.1 | 8.0 | 9.3 | 301.1 | 4.2 | 4.9 | 136.1 | 1.4 | 1.6 | 39.1 |
| 169010 | 15.7 | 18.0 | 3796.7 | 5.9 | 6.7 | 986.1 | 2.7 | 3.0 | 372.5 | 0.6 | 0.7 | 66.7 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22110632 | 10000 | 447 | 4.28 | 50 | 200 | 5825.0 | 10012.0 | 2.52 | 5.11 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 48.5 | 56.3 | 30.6 | 20.5 | 23.8 | 11.3 | 14.8 | 17.2 | 7.6 | 10.3 | 11.9 | 4.9 |
| 550 | 37.5 | 42.8 | 84.7 | 15.4 | 17.6 | 28.8 | 10.3 | 11.7 | 17.5 | 6.1 | 7.0 | 9.4 |
| 1000 | 34.3 | 40.2 | 138.4 | 14.0 | 16.3 | 45.7 | 9.0 | 10.6 | 26.7 | 5.0 | 5.9 | 13.4 |
| 5600 | 26.5 | 30.8 | 384.4 | 10.5 | 12.1 | 117.1 | 6.1 | 7.1 | 60.1 | 2.7 | 3.1 | 23.2 |
| 10850 | 24.0 | 28.0 | 666.4 | 9.4 | 10.9 | 196.7 | 5.2 | 6.1 | 95.7 | 2.1 | 2.4 | 32.8 |
| 20250 | 21.9 | 25.4 | 900.9 | 8.4 | 9.8 | 257.9 | 4.5 | 5.2 | 118.9 | 1.6 | 1.8 | 36.0 |
| 36000 | 20.1 | 22.6 | 1420.0 | 7.6 | 8.6 | 395.2 | 3.9 | 4.4 | 173.0 | 1.2 | 1.4 | 46.1 |
| 164600 | 16.0 | 18.5 | 3537.9 | 5.9 | 6.8 | 912.8 | 2.7 | 3.1 | 343.5 | 0.6 | 0.7 | 61.3 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22110615 | 10000 | 447 | 4.28 | 50 | 500 | 5805.0 | 9968.0 | 2.52 | 4.98 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 118.5 | 135.4 | 98.2 | 46.4 | 53.1 | 33.5 | 29.6 | 33.8 | 19.9 | 17.6 | 20.1 | 11.0 |
| 500 | 93.1 | 106.2 | 254.6 | 35.5 | 40.5 | 80.6 | 20.6 | 23.5 | 42.6 | 10.2 | 11.6 | 19.2 |
| 1000 | 83.9 | 95.4 | 438.6 | 31.6 | 35.9 | 134.2 | 17.6 | 20.0 | 67.3 | 7.9 | 9.0 | 27.3 |
| 5000 | 65.9 | 75.8 | 1154.9 | 24.1 | 27.7 | 326.8 | 11.9 | 13.7 | 142.7 | 4.1 | 4.7 | 43.1 |
| 10000 | 59.4 | 68.0 | 1960.6 | 21.4 | 24.5 | 536.0 | 10.1 | 11.5 | 219.4 | 3.0 | 3.4 | 56.8 |
| 20000 | 53.5 | 61.3 | 2887.8 | 19.0 | 21.8 | 762.5 | 8.4 | 9.7 | 291.2 | 2.1 | 2.4 | 63.7 |
| 30000 | 50.4 | 57.0 | 3912.9 | 17.8 | 20.1 | 1012.2 | 7.6 | 8.6 | 370.6 | 1.7 | 2.0 | 72.6 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22110625 | 10000 | 447 | 4.28 | 50 | 500 | 5825.0 | 10010.0 | 2.52 | 5.08 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 120.7 | 136.8 | 102.7 | 46.8 | 53.0 | 34.7 | 29.6 | 33.6 | 20.5 | - | - | - |
| 500 | 94.8 | 108.5 | 263.5 | 35.7 | 40.9 | 82.4 | 20.6 | 23.6 | 43.3 | - | - | - |
| 1000 | 85.5 | 99.0 | 458.0 | 31.8 | 36.8 | 138.5 | 17.6 | 20.3 | 69.0 | - | - | - |
| 5500 | 66.2 | 77.0 | 1265.7 | 23.8 | 27.7 | 352.1 | 11.6 | 13.5 | 151.2 | - | - | - |
| 10300 | 60.2 | 69.5 | 2083.0 | 21.4 | 24.7 | 561.6 | 10.0 | 11.5 | 227.1 | - | - | - |
| 27000 | 52.1 | 58.9 | 3614.2 | 18.2 | 20.5 | 928.1 | 7.8 | 8.8 | 340.1 | - | - | - |
| 31000 | 51.1 | 59.4 | 4354.3 | 17.8 | 20.7 | 1110.4 | 7.5 | 8.7 | 400.9 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22110635 | 10000 | 447 | 4.28 | 50 | 500 | 5824.0 | 10010.0 | 2.52 | 5.11 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 121.1 | 140.9 | 101.6 | 46.8 | 54.5 | 34.2 | 29.6 | 34.4 | 20.2 | 17.4 | 20.3 | 11.1 |
| 500 | 95.1 | 109.1 | 269.0 | 35.8 | 41.0 | 83.9 | 20.6 | 23.6 | 44.0 | 10.1 | 11.6 | 19.6 |
| 1000 | 85.8 | 98.5 | 464.7 | 31.8 | 36.5 | 140.2 | 17.5 | 20.1 | 69.7 | 7.8 | 8.9 | 27.9 |
| 5000 | 67.4 | 77.9 | 1219.0 | 24.2 | 28.0 | 339.8 | 11.9 | 13.8 | 146.9 | 4.0 | 4.6 | 43.6 |
| 10000 | 60.7 | 69.1 | 2078.2 | 21.5 | 24.5 | 559.6 | 10.0 | 11.4 | 226.5 | 2.9 | 3.3 | 57.6 |
| 23200 | 53.5 | 61.7 | 3333.1 | 18.7 | 21.5 | 860.2 | 8.1 | 9.3 | 319.6 | 1.9 | 2.2 | 65.8 |
| 33000 | 50.8 | 59.7 | 4518.4 | 17.6 | 20.7 | 1145.3 | 7.4 | 8.6 | 409.8 | 1.6 | 1.9 | 76.5 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32110611 | 10000 | 460 | 4.40 | 50 | 100 | 5825.0 | 9990.0 | 2.53 | 5.20 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 24.4 | 27.6 | 14.0 | 10.5 | 11.9 | 5.2 | 7.9 | 8.9 | 3.7 | - | - | - |
| 500 | 19.2 | 21.6 | 36.9 | 8.0 | 9.1 | 12.9 | 5.6 | 6.3 | 8.2 | - | - | - |
| 1000 | 17.3 | 19.6 | 62.4 | 7.2 | 8.1 | 21.0 | 4.8 | 5.5 | 12.8 | - | - | - |
| 5000 | 13.6 | 15.6 | 164.1 | 5.5 | 6.3 | 51.3 | 3.4 | 3.9 | 27.8 | - | - | - |
| 10000 | 12.2 | 14.0 | 261.8 | 4.9 | 5.6 | 85.2 | 2.9 | 3.3 | 43.8 | - | - | - |
| 27000 | 10.5 | 12.2 | 488.4 | 4.1 | 4.8 | 140.7 | 2.3 | 2.6 | 66.6 | - | - | - |
| 184700 | 7.9 | 8.9 | 1835.3 | 3.0 | 3.4 | 480.9 | 1.4 | 1.6 | 189.8 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32110621 | 10000 | 460 | 4.40 | 50 | 100 | 5871.0 | 10060.0 | 2.53 | 5.08 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 24.1 | 28.1 | 13.3 | 10.5 | 12.2 | 5.0 | 7.9 | 9.2 | 3.5 | 5.7 | 6.6 | 2.4 |
| 500 | 19.0 | 21.8 | 34.9 | 8.0 | 9.2 | 12.3 | 5.6 | 6.5 | 7.8 | 3.6 | 4.1 | 4.5 |
| 1000 | 17.1 | 19.7 | 60.5 | 7.2 | 8.2 | 20.6 | 4.9 | 5.6 | 12.6 | 2.9 | 3.3 | 6.7 |
| 5000 | 13.4 | 15.3 | 154.7 | 5.5 | 6.3 | 48.0 | 3.4 | 3.9 | 26.7 | 1.6 | 1.9 | 11.4 |
| 10345 | 12.0 | 14.4 | 274.9 | 4.9 | 5.8 | 84.0 | 2.9 | 3.5 | 43.4 | 1.3 | 1.5 | 16.4 |
| 25000 | 10.5 | 12.0 | 444.1 | 4.2 | 4.8 | 130.1 | 2.3 | 2.7 | 82.5 | 0.9 | 1.0 | 20.0 |
| 162000 | 8.0 | 9.1 | 1606.4 | 3.1 | 3.5 | 429.4 | 1.5 | 1.7 | 173.5 | 0.4 | 0.4 | 35.7 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32110631 | 10000 | 460 | 4.40 | 50 | 100 | 5839.0 | 10013.0 | 2.53 | 5.18 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 24.4 | 27.8 | 14.1 | 10.5 | 12.0 | 5.3 | 7.9 | 9.0 | 3.7 | 5.7 | 6.5 | 2.5 |
| 500 | 19.2 | 21.9 | 36.4 | 8.0 | 9.2 | 12.7 | 5.6 | 6.4 | 8.1 | 3.5 | 4.0 | 4.6 |
| 1000 | 17.3 | 19.8 | 62.1 | 7.2 | 8.2 | 20.9 | 4.8 | 5.5 | 12.7 | 2.8 | 3.3 | 6.7 |
| 5000 | 13.6 | 15.7 | 162.4 | 5.5 | 6.3 | 50.8 | 3.4 | 3.9 | 27.6 | 1.6 | 1.9 | 11.7 |
| 10850 | 12.1 | 13.8 | 293.4 | 4.8 | 5.5 | 88.5 | 2.8 | 3.2 | 45.2 | 1.2 | 1.4 | 16.8 |
| 30000 | 10.4 | 11.9 | 525.1 | 4.1 | 4.6 | 150.7 | 2.2 | 2.5 | 70.8 | 0.8 | 0.9 | 21.6 |
| 164300 | 8.0 | 9.1 | 1718.2 | 3.0 | 3.4 | 453.5 | 1.5 | 1.6 | 181.4 | 0.4 | 0.4 | 36.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32110612 | 10000 | 460 | 4.40 | 50 | 200 | 5842.0 | 10014.0 | 2.53 | 5.13 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 48.4 | 55.4 | 30.9 | 20.4 | 23.3 | 11.3 | 14.7 | 16.9 | 7.7 | 10.2 | 11.6 | 4.9 |
| 500 | 38.0 | 43.8 | 81.0 | 15.6 | 18.0 | 27.6 | 10.5 | 12.1 | 16.8 | 6.2 | 7.2 | 9.1 |
| 1000 | 34.3 | 39.9 | 137.5 | 13.9 | 16.2 | 45.3 | 9.0 | 10.4 | 26.4 | 5.0 | 5.8 | 13.2 |
| 5100 | 26.8 | 31.0 | 361.2 | 10.6 | 12.2 | 110.3 | 6.2 | 7.2 | 56.9 | 2.8 | 3.2 | 22.2 |
| 10000 | 24.3 | 28.0 | 607.0 | 9.5 | 10.9 | 179.4 | 5.3 | 6.1 | 87.6 | 2.1 | 2.4 | 30.4 |
| 28000 | 20.8 | 24.0 | 1080.7 | 7.9 | 9.2 | 303.7 | 4.1 | 4.8 | 135.6 | 1.4 | 1.6 | 38.1 |
| 206700 | 15.4 | 17.6 | 4320.7 | 5.7 | 6.4 | 1098.8 | 2.5 | 2.8 | 402.0 | 0.5 | 0.6 | 66.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32110622 | 10000 | 460 | 4.40 | 50 | 200 | 5870.0 | 10049.0 | 2.53 | 4.95 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 47.4 | 54.9 | 29.1 | 20.3 | 23.5 | 10.8 | 14.8 | 17.1 | 7.4 | 10.3 | 11.9 | 4.8 |
| 500 | 37.2 | 43.2 | 76.2 | 15.6 | 18.0 | 26.4 | 10.5 | 12.2 | 16.3 | 6.3 | 7.3 | 8.9 |
| 1000 | 33.6 | 38.6 | 130.4 | 13.9 | 16.0 | 43.8 | 9.0 | 10.4 | 25.7 | 5.1 | 5.8 | 13.0 |
| 5000 | 26.4 | 30.9 | 338.1 | 10.6 | 12.4 | 105.3 | 6.3 | 7.4 | 55.0 | 2.8 | 3.3 | 21.9 |
| 11300 | 23.3 | 26.7 | 617.3 | 9.2 | 10.6 | 184.9 | 5.2 | 6.0 | 90.4 | 2.1 | 2.4 | 31.2 |
| 26000 | 20.6 | 23.6 | 965.2 | 8.0 | 9.2 | 277.6 | 4.3 | 4.9 | 126.4 | 1.4 | 1.7 | 36.9 |
| 170200 | 15.5 | 18.0 | 3648.2 | 5.8 | 6.8 | 956.2 | 2.7 | 3.1 | 383.1 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32110632 | 10000 | 460 | 4.40 | 50 | 200 | 5868.0 | 10038.0 | 2.53 | 4.85 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 46.7 | 53.5 | 27.7 | 20.2 | 23.2 | 10.5 | 14.8 | 16.9 | 7.1 | 10.3 | 11.8 | 4.6 |
| 500 | 36.7 | 42.1 | 72.2 | 15.5 | 17.8 | 25.3 | 10.5 | 12.1 | 15.6 | 6.4 | 7.3 | 8.6 |
| 1000 | 33.0 | 37.7 | 124.3 | 13.8 | 15.8 | 42.2 | 9.0 | 10.3 | 24.9 | 5.1 | 5.8 | 12.7 |
| 5000 | 25.9 | 30.0 | 324.6 | 10.5 | 12.2 | 102.2 | 6.3 | 7.3 | 53.7 | 2.9 | 3.3 | 21.6 |
| 10000 | 23.4 | 26.4 | 552.1 | 9.4 | 10.6 | 168.2 | 5.4 | 6.1 | 83.7 | 2.2 | 2.5 | 29.9 |
| 24000 | 20.5 | 23.7 | 906.4 | 8.1 | 9.4 | 264.7 | 4.4 | 5.0 | 122.3 | 1.5 | 1.8 | 36.8 |
| 161500 | 15.4 | 18.0 | 3342.8 | 5.9 | 6.9 | 889.0 | 2.7 | 3.2 | 342.7 | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32110615 | 10000 | 460 | 4.40 | 50 | 500 | 5861.0 | 10036.0 | 2.53 | 4.99 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 118.9 | 136.3 | 96.8 | 46.5 | 53.3 | 33.0 | 29.6 | 33.9 | 19.6 | - | - | - |
| 500 | 93.4 | 107.8 | 257.4 | 35.6 | 41.0 | 81.3 | 20.6 | 23.8 | 43.0 | - | - | - |
| 1000 | 84.2 | 96.2 | 433.9 | 31.6 | 36.2 | 132.6 | 17.6 | 20.1 | 66.4 | - | - | - |
| 5000 | 66.1 | 76.8 | 1147.3 | 24.1 | 28.0 | 324.2 | 11.9 | 13.9 | 141.3 | - | - | - |
| 10000 | 59.6 | 68.9 | 1814.0 | 21.4 | 24.8 | 522.5 | 10.1 | 11.6 | 213.3 | - | - | - |
| 25000 | 51.9 | 60.0 | 3204.4 | 18.3 | 21.2 | 835.4 | 7.9 | 9.2 | 311.0 | - | - | - |
| 30000 | 50.5 | 58.4 | 3812.0 | 17.8 | 20.5 | 1010.5 | 7.6 | 8.8 | 369.0 | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32110625 | 10000 | 460 | 4.40 | 50 | 500 | 5870.0 | 10048.0 | 2.53 | 4.95 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) ELA. | TOT. | PLA. | LVDT #2(2.0 IN.) ELA. | TOT. | PLA. | LVDT #3(4.0 IN.) ELA. | TOT. | PLA. | LVDT #4(6.0625 IN.) ELA. | TOT. | PLA. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 118.5 | 133.9 | 97.2 | 46.6 | 52.6 | 33.3 | 29.6 | 33.5 | 19.8 | 17.6 | 19.9 | 11.0 |
| 500 | 93.1 | 105.3 | 255.9 | 35.6 | 40.2 | 81.2 | 20.7 | 23.4 | 43.0 | 10.2 | 11.6 | 19.3 |
| 1000 | 83.9 | 95.4 | 433.7 | 31.7 | 36.0 | 133.1 | 17.6 | 20.0 | 66.7 | 7.9 | 9.0 | 27.0 |
| 5000 | 65.9 | 76.6 | 1130.3 | 24.1 | 28.1 | 320.6 | 12.0 | 13.9 | 140.1 | 4.1 | 4.8 | 42.3 |
| 13900 | 56.5 | 64.1 | 2353.6 | 20.3 | 23.0 | 634.5 | 9.3 | 10.5 | 251.5 | 2.6 | 2.9 | 60.3 |
| 30300 | 50.3 | 56.8 | 3629.1 | 17.8 | 20.1 | 940.7 | 7.6 | 8.6 | 344.3 | 1.7 | 2.0 | 67.3 |
| 32000 | 49.9 | 56.9 | 4114.2 | 17.8 | 20.1 | 1063.5 | 7.5 | 8.5 | 386.9 | 1.7 | 1.9 | 74.5 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32110635 | 10000 | 460 | 4.40 | 50 | 500 | 5880.0 | 10063.0 | 2.53 | 4.91 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) ELA. | TOT. | PLA. | LVDT #2(2.0 IN.) ELA. | TOT. | PLA. | LVDT #3(4.0 IN.) ELA. | TOT. | PLA. | LVDT #4(6.0625 IN.) ELA. | TOT. | PLA. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 118.0 | 134.1 | 95.1 | 46.6 | 52.9 | 32.7 | 29.7 | 33.8 | 19.5 | 17.7 | 20.1 | 10.8 |
| 500 | 92.7 | 104.7 | 246.9 | 35.6 | 40.2 | 78.7 | 20.7 | 23.4 | 41.8 | 10.3 | 11.6 | 18.9 |
| 1000 | 83.5 | 96.4 | 418.2 | 31.7 | 36.6 | 128.9 | 17.7 | 20.4 | 64.8 | 8.0 | 9.2 | 26.4 |
| 5000 | 65.6 | 76.3 | 1098.8 | 24.1 | 28.1 | 313.3 | 12.0 | 14.0 | 137.4 | 4.1 | 4.8 | 41.7 |
| 10000 | 59.1 | 68.5 | 1873.2 | 21.5 | 24.9 | 516.0 | 10.1 | 11.7 | 212.1 | 3.0 | 3.5 | 55.3 |
| 20000 | 53.3 | 61.6 | 2700.3 | 19.1 | 22.1 | 718.5 | 8.5 | 9.8 | 275.7 | 2.2 | 2.5 | 60.7 |
| 35000 | 49.0 | 55.7 | 4236.4 | 17.3 | 19.7 | 1095.8 | 7.3 | 8.4 | 396.6 | 1.6 | 1.8 | 75.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11120511 | 10000 | 450 | 4.31 | 50 | 100 | 6144.0 | 10329.0 | 2.55 | 3.06 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 120 | 9.7 | 13.2 | 12.3 | 8.6 | 11.7 | 31.0 | 8.3 | 11.2 | 36.3 | 7.9 | 10.6 | 39.0 |
| 560 | 9.3 | 12.6 | 19.3 | 8.2 | 11.1 | 37.3 | 7.8 | 10.5 | 42.8 | 7.3 | 9.8 | 45.0 |
| 1000 | 8.9 | 11.7 | 22.2 | 7.8 | 10.3 | 40.3 | 7.4 | 9.8 | 45.8 | 6.9 | 9.0 | 47.5 |
| 5000 | 7.9 | 9.7 | 33.1 | 6.9 | 8.5 | 49.1 | 6.4 | 7.9 | 56.8 | 5.8 | 7.1 | 58.5 |
| 13600 | 8.4 | 11.5 | 49.0 | 7.4 | 10.0 | 56.6 | 6.8 | 9.3 | 65.5 | 6.0 | 8.2 | 67.5 |
| 20000 | 8.0 | 10.5 | 52.7 | 7.0 | 9.1 | 61.7 | 6.4 | 8.4 | 68.8 | 5.6 | 7.3 | 70.7 |
| 27900 | 7.5 | 9.2 | 54.8 | 6.5 | 8.0 | 64.1 | 6.0 | 7.4 | 71.6 | 5.2 | 6.4 | 73.4 |
| 172800 | 7.1 | 8.7 | 93.1 | 6.1 | 7.5 | 75.1 | 5.5 | 6.8 | 83.1 | 4.5 | 5.5 | 74.9 |
| 338300 | 6.9 | 8.5 | 113.4 | 6.0 | 7.4 | 78.1 | 5.3 | 6.6 | 86.1 | 4.2 | 5.2 | 86.4 |
| 715700 | 7.0 | 9.0 | 146.9 | 6.1 | 7.8 | 84.6 | 5.4 | 6.9 | 91.1 | 4.1 | 5.3 | 93.4 |
| 861900 | 7.0 | 9.1 | 155.6 | 6.1 | 7.8 | 84.6 | 5.3 | 6.9 | 91.1 | 4.0 | 5.2 | 93.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11120521 | 10000 | 449 | 4.30 | 50 | 100 | 6162.0 | 10357.0 | 2.55 | 3.03 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 10.0 | 13.9 | 11.8 | 8.9 | 12.3 | 44.5 | 8.5 | 11.8 | 44.4 | 8.1 | 11.2 | 43.0 |
| 500 | 8.7 | 11.0 | 17.2 | 7.7 | 9.7 | 50.0 | 7.3 | 9.2 | 48.8 | 6.8 | 8.6 | 47.2 |
| 1000 | 9.0 | 12.0 | 22.2 | 7.9 | 10.5 | 54.0 | 7.5 | 10.0 | 52.3 | 6.9 | 9.2 | 50.8 |
| 5000 | 8.0 | 10.1 | 33.5 | 7.1 | 8.9 | 66.0 | 6.6 | 8.3 | 63.4 | 5.9 | 7.5 | 59.8 |
| 10500 | 8.4 | 11.4 | 44.6 | 7.4 | 10.0 | 73.2 | 6.8 | 9.2 | 69.4 | 6.1 | 8.2 | 63.9 |
| 155600 | 7.6 | 10.1 | 96.2 | 6.6 | 8.8 | 110.4 | 6.0 | 7.9 | 96.1 | 4.9 | 6.5 | 79.4 |
| 187200 | 7.8 | 10.6 | 104.1 | 6.7 | 9.2 | 115.2 | 6.1 | 8.2 | 100.1 | 4.9 | 6.7 | 82.0 |
| 333040 | 6.7 | 8.0 | 108.0 | 5.8 | 6.9 | 124.8 | 5.2 | 6.2 | 107.0 | 4.1 | 4.9 | 85.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11120531 | 10000 | 449 | 4.30 | 50 | 100 | 6162.0 | 10367.0 | 2.55 | 3.17 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 10.0 | 13.7 | 12.2 | 8.9 | 12.1 | 27.4 | 8.5 | 11.6 | 30.1 | 8.1 | 11.0 | 30.1 |
| 500 | 8.8 | 11.1 | 18.0 | 7.8 | 9.8 | 33.4 | 7.4 | 9.3 | 35.0 | 6.9 | 8.7 | 35.3 |
| 1000 | 9.2 | 12.4 | 23.6 | 8.1 | 10.9 | 37.2 | 7.6 | 10.3 | 39.0 | 7.1 | 9.5 | 39.4 |
| 5000 | 8.7 | 11.6 | 37.4 | 7.6 | 10.2 | 50.9 | 7.1 | 9.5 | 51.8 | 6.4 | 8.5 | 51.6 |
| 10000 | 8.5 | 11.4 | 45.7 | 7.4 | 9.9 | 59.5 | 6.9 | 9.2 | 59.2 | 6.1 | 8.1 | 58.2 |
| 166500 | 7.7 | 10.1 | 102.2 | 6.6 | 8.7 | 102.2 | 6.0 | 7.8 | 97.1 | 4.8 | 6.4 | 84.0 |
| 352725 | 7.8 | 10.6 | 131.7 | 6.7 | 9.1 | 121.9 | 6.0 | 8.1 | 107.5 | 4.7 | 6.4 | 95.1 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11120512 | 10000 | 449 | 4.30 | 50 | 200 | 6160.0 | 10360.0 | 2.55 | 3.12 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 19.3 | 24.3 | 13.4 | 17.0 | 21.4 | 31.5 | 16.2 | 20.4 | 29.2 | 15.4 | 19.4 | 25.8 |
| 510 | 19.7 | 26.6 | 23.1 | 17.3 | 23.3 | 38.0 | 16.3 | 22.0 | 35.9 | 15.1 | 20.4 | 27.8 |
| 1020 | 19.3 | 26.0 | 28.3 | 16.9 | 22.8 | 40.6 | 15.8 | 21.4 | 39.4 | 14.5 | 19.6 | 31.4 |
| 5000 | 17.1 | 21.5 | 41.9 | 14.9 | 18.8 | 49.5 | 13.8 | 17.3 | 48.3 | 12.2 | 15.4 | 41.2 |
| 10000 | 16.5 | 20.5 | 50.7 | 14.4 | 17.9 | 53.4 | 13.2 | 16.4 | 52.3 | 11.5 | 14.4 | 45.2 |
| 31000 | 16.7 | 21.7 | 73.8 | 14.5 | 18.8 | 59.4 | 13.1 | 17.1 | 58.5 | 11.1 | 14.5 | 50.6 |
| 161500 | 16.3 | 21.8 | 122.7 | 14.1 | 18.9 | 72.3 | 12.5 | 16.8 | 68.5 | 10.0 | 13.4 | 60.1 |
| 327700 | 14.7 | 18.2 | 139.3 | 12.7 | 15.7 | 89.0 | 11.2 | 13.8 | 84.5 | 8.6 | 10.7 | 74.6 |
| 501370 | 15.0 | 19.2 | 163.0 | 12.9 | 16.5 | 91.4 | 11.3 | 14.5 | 86.0 | 8.6 | 10.9 | 77.6 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11120522 | 10000 | 449 | 4.30 | 50 | 200 | 6124.0 | 10303.0 | 2.55 | 3.16 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 18.9 | 23.3 | 13.4 | 16.6 | 20.5 | 16.3 | 15.9 | 19.5 | 16.2 | 15.0 | 18.5 | 15.5 |
| 500 | 17.9 | 21.9 | 21.2 | 15.7 | 19.2 | 20.3 | 14.8 | 18.1 | 19.7 | 13.7 | 16.8 | 17.8 |
| 1000 | 18.4 | 23.7 | 27.3 | 16.1 | 20.7 | 23.3 | 15.1 | 19.4 | 21.9 | 13.8 | 17.8 | 18.8 |
| 5100 | 16.8 | 20.8 | 42.2 | 14.6 | 18.1 | 37.3 | 13.5 | 16.7 | 30.6 | 12.0 | 14.9 | 20.8 |
| 10400 | 18.1 | 24.7 | 57.2 | 15.7 | 21.5 | 47.3 | 14.4 | 19.7 | 35.9 | 12.6 | 17.2 | 20.8 |
| 20300 | 17.7 | 24.2 | 69.5 | 15.4 | 21.0 | 59.6 | 14.0 | 19.1 | 41.9 | 12.0 | 16.4 | 19.8 |
| 176900 | 14.8 | 18.2 | 117.1 | 12.8 | 15.7 | 112.1 | 11.4 | 13.9 | 66.9 | 9.0 | 11.0 | 12.8 |
| 516800 | 15.5 | 20.4 | 172.4 | 13.3 | 17.5 | 139.6 | 11.8 | 15.3 | 76.9 | 8.8 | 11.5 | 4.8 |
| 691600 | 15.8 | 21.6 | 194.0 | 13.6 | 18.5 | 146.6 | 11.8 | 16.1 | 78.4 | 8.8 | 12.0 | 3.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11120532 | 10000 | 449 | 4.30 | 50 | 200 | 6140.0 | 10327.0 | 2.55 | 3.12 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 130 | 19.8 | 25.9 | 15.1 | 17.4 | 22.8 | 21.0 | 16.6 | 21.7 | 23.5 | 15.7 | 20.5 | 25.0 |
| 500 | 18.6 | 23.7 | 21.8 | 16.3 | 20.8 | 24.0 | 15.4 | 19.6 | 27.0 | 14.2 | 18.2 | 28.0 |
| 1000 | 17.1 | 20.4 | 25.0 | 14.9 | 17.9 | 26.0 | 14.0 | 16.8 | 29.0 | 12.8 | 15.4 | 30.0 |
| 5000 | 17.4 | 22.5 | 43.0 | 15.2 | 19.6 | 32.0 | 14.1 | 18.1 | 33.0 | 12.5 | 16.1 | 32.5 |
| 10200 | 16.8 | 21.3 | 52.1 | 14.6 | 18.5 | 36.0 | 13.4 | 17.0 | 35.0 | 11.7 | 14.9 | 34.0 |
| 20000 | 15.6 | 18.8 | 60.2 | 13.5 | 16.3 | 40.0 | 12.4 | 14.9 | 37.0 | 10.6 | 12.7 | 34.0 |
| 177600 | 16.1 | 21.4 | 125.5 | 13.9 | 18.4 | 55.0 | 12.3 | 16.4 | 42.5 | 9.8 | 13.0 | 31.0 |
| 341000 | 15.3 | 19.8 | 147.7 | 13.2 | 17.1 | 61.3 | 11.6 | 15.0 | 45.5 | 9.0 | 11.6 | 28.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11120515 | 10000 | 449 | 4.30 | 50 | 500 | 6112.0 | 10282.0 | 2.55 | 3.15 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 49.4 | 59.8 | 17.2 | 42.9 | 51.9 | 30.0 | 40.1 | 48.5 | 33.8 | 37.1 | 44.9 | 28.3 |
| 500 | 49.1 | 62.2 | 28.8 | 42.4 | 53.7 | 36.3 | 39.1 | 49.5 | 38.8 | 35.2 | 44.6 | 33.3 |
| 1000 | 45.6 | 54.7 | 33.4 | 39.3 | 47.2 | 40.0 | 36.0 | 43.2 | 41.8 | 31.9 | 38.3 | 35.8 |
| 5600 | 47.0 | 61.4 | 60.0 | 40.3 | 52.7 | 50.0 | 36.2 | 47.4 | 48.0 | 30.8 | 40.2 | 38.8 |
| 10000 | 46.5 | 61.3 | 71.7 | 39.9 | 52.6 | 55.0 | 35.6 | 46.9 | 51.0 | 29.7 | 39.1 | 40.0 |
| 19500 | 45.2 | 59.1 | 86.4 | 38.7 | 50.6 | 61.3 | 34.2 | 44.8 | 54.8 | 27.9 | 36.5 | 40.8 |
| 170900 | 44.0 | 60.1 | 169.6 | 37.4 | 51.0 | 87.8 | 32.1 | 43.8 | 64.8 | 23.7 | 32.4 | 34.3 |
| 346100 | 38.8 | 47.7 | 187.7 | 32.9 | 40.4 | 99.3 | 27.8 | 34.2 | 68.3 | 19.8 | 24.3 | 32.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11120525 | 10000 | 449 | 4.30 | 50 | 500 | 6124.0 | 10301.0 | 2.55 | 3.14 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 49.0 | 58.8 | 17.0 | 42.5 | 51.1 | 27.0 | 39.8 | 47.8 | 24.3 | 36.8 | 44.2 | 18.8 |
| 500 | 52.6 | 71.4 | 30.7 | 45.5 | 61.7 | 39.0 | 41.9 | 56.9 | 36.3 | 37.8 | 51.2 | 30.5 |
| 1100 | 48.5 | 62.1 | 36.4 | 41.8 | 53.6 | 47.0 | 38.3 | 49.1 | 45.1 | 33.9 | 43.4 | 38.0 |
| 5400 | 46.9 | 61.2 | 59.0 | 40.3 | 52.6 | 67.9 | 36.3 | 47.3 | 63.3 | 30.8 | 40.2 | 56.3 |
| 10400 | 45.1 | 57.8 | 70.0 | 38.7 | 49.5 | 78.6 | 34.5 | 44.2 | 73.0 | 28.8 | 36.9 | 63.8 |
| 23200 | 40.9 | 48.8 | 82.3 | 35.0 | 41.7 | 92.4 | 30.9 | 36.9 | 85.1 | 25.1 | 29.9 | 72.5 |
| 123900 | 41.3 | 52.3 | 142.6 | 35.1 | 44.5 | 121.8 | 30.3 | 38.4 | 106.5 | 22.8 | 28.9 | 84.0 |
| 338200 | 39.6 | 49.8 | 189.5 | 33.6 | 42.2 | 142.8 | 28.5 | 35.8 | 119.6 | 20.3 | 25.5 | 90.0 |
| 470000 | 41.5 | 55.3 | 220.7 | 35.2 | 46.8 | 150.2 | 29.7 | 39.5 | 123.4 | 20.7 | 27.5 | 91.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11120535 | 10000 | 449 | 4.30 | 50 | 500 | 6121.0 | 10300.0 | 2.55 | 3.19 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 110 | 50.3 | 61.8 | 18.2 | 43.6 | 53.6 | 35.5 | 40.7 | 50.0 | 35.5 | 37.6 | 46.2 | 37.3 |
| 500 | 53.1 | 72.1 | 31.3 | 45.8 | 62.3 | 40.8 | 42.2 | 57.4 | 40.0 | 38.0 | 51.6 | 42.3 |
| 1000 | 52.0 | 70.8 | 38.4 | 44.8 | 61.1 | 42.5 | 41.0 | 55.9 | 41.8 | 36.4 | 49.5 | 43.5 |
| 5100 | 49.4 | 67.3 | 61.7 | 42.4 | 57.7 | 49.5 | 38.1 | 51.9 | 45.8 | 32.4 | 44.1 | 47.3 |
| 10500 | 42.8 | 51.7 | 67.6 | 36.7 | 44.3 | 53.0 | 32.7 | 39.5 | 47.8 | 27.2 | 32.8 | 48.3 |
| 27000 | 43.3 | 54.4 | 92.6 | 36.9 | 46.4 | 59.0 | 32.5 | 40.9 | 51.8 | 26.1 | 32.9 | 49.8 |
| 184100 | 42.6 | 55.9 | 169.3 | 36.1 | 47.4 | 74.0 | 30.9 | 40.6 | 61.8 | 22.7 | 29.8 | 53.8 |
| 510000 | 42.8 | 58.4 | 236.5 | 36.2 | 49.3 | 85.0 | 30.4 | 41.5 | 68.3 | 21.0 | 28.7 | 51.3 |
| 1061500 | 40.6 | 53.7 | 284.0 | 34.2 | 45.3 | 86.6 | 28.3 | 37.5 | 68.3 | 18.6 | 24.6 | 52.3 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11320511 | 10000 | 424 | 4.07 | 50 | 100 | 6127.0 | 10290.0 | 2.55 | 3.18 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 9.4 | 12.8 | 13.2 | 8.3 | 11.3 | 20.9 | 7.9 | 10.8 | 47.2 | 7.5 | 10.3 | 38.3 |
| 550 | 8.2 | 10.2 | 20.5 | 7.2 | 9.0 | 24.7 | 6.8 | 8.5 | 49.2 | 6.3 | 7.9 | 39.8 |
| 1000 | 8.4 | 10.9 | 25.7 | 7.3 | 9.5 | 26.3 | 6.9 | 9.0 | 51.2 | 6.3 | 8.3 | 40.6 |
| 5000 | 7.4 | 8.9 | 39.1 | 6.4 | 7.8 | 26.7 | 6.0 | 7.2 | 55.0 | 5.3 | 6.5 | 43.4 |
| 10200 | 7.3 | 8.9 | 49.3 | 6.4 | 7.8 | 29.1 | 5.9 | 7.2 | 60.9 | 5.1 | 6.3 | 46.2 |
| 30975 | 7.4 | 9.6 | 73.1 | 6.5 | 8.3 | 33.8 | 5.9 | 7.6 | 62.3 | 5.0 | 6.4 | 51.1 |
| 327866 | 6.7 | 8.4 | 147.0 | 5.8 | 7.3 | 38.4 | 5.1 | 6.4 | 74.3 | 4.0 | 5.0 | 72.1 |
| 511050 | 7.0 | 9.4 | 178.9 | 6.0 | 8.1 | 42.5 | 5.3 | 7.1 | 75.5 | 4.1 | 5.4 | 73.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11320521 | 10000 | 424 | 4.07 | 50 | 100 | 6145.0 | 10329.0 | 2.55 | 3.30 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 9.2 | 11.9 | 13.2 | 8.1 | 10.5 | 7.7 | 7.7 | 10.0 | 6.0 | 7.3 | 9.5 | 5.4 |
| 500 | 8.3 | 10.3 | 20.7 | 7.3 | 9.0 | 9.1 | 6.9 | 8.5 | 7.5 | 6.4 | 7.9 | 7.1 |
| 1000 | 8.4 | 10.9 | 26.6 | 7.4 | 9.5 | 10.1 | 6.9 | 8.9 | 8.2 | 6.4 | 8.2 | 8.1 |
| 5500 | 8.4 | 11.5 | 47.4 | 7.3 | 10.0 | 13.5 | 6.8 | 9.3 | 11.7 | 6.0 | 8.2 | 11.7 |
| 10000 | 7.6 | 9.4 | 52.0 | 6.6 | 8.2 | 15.1 | 6.0 | 7.5 | 13.1 | 5.3 | 6.6 | 13.0 |
| 30140 | 7.2 | 8.9 | 72.4 | 6.3 | 7.7 | 18.1 | 5.7 | 7.0 | 16.1 | 4.8 | 6.0 | 15.6 |
| 167820 | 7.4 | 9.9 | 132.9 | 6.4 | 8.5 | 23.1 | 5.7 | 7.6 | 21.1 | 4.5 | 6.1 | 19.9 |
| 497250 | 6.5 | 7.9 | 168.4 | 5.6 | 6.8 | 26.0 | 4.9 | 5.9 | 23.0 | 3.7 | 4.5 | 20.9 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11320531 | 10000 | 424 | 4.07 | 50 | 100 | 6145.0 | 10306.0 | 2.55 | 2.98 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 160 | 9.1 | 12.3 | 14.2 | 8.0 | 10.9 | 18.9 | 7.6 | 10.4 | 13.3 | 7.2 | 9.8 | 7.7 |
| 500 | 7.9 | 9.7 | 18.2 | 6.9 | 8.5 | 20.4 | 6.6 | 8.1 | 14.4 | 6.1 | 7.5 | 8.5 |
| 1000 | 8.5 | 11.5 | 24.8 | 7.5 | 10.1 | 21.5 | 7.0 | 9.5 | 14.9 | 6.5 | 8.8 | 9.0 |
| 5000 | 7.4 | 9.1 | 37.1 | 6.4 | 7.9 | 25.9 | 6.0 | 7.4 | 19.4 | 5.4 | 6.6 | 11.5 |
| 11500 | 7.4 | 9.3 | 49.2 | 6.4 | 8.1 | 28.8 | 5.9 | 7.5 | 20.9 | 5.2 | 6.6 | 12.7 |
| 36300 | 7.5 | 9.9 | 73.6 | 6.5 | 8.6 | 31.7 | 5.9 | 7.9 | 23.4 | 5.0 | 6.7 | 13.4 |
| 362000 | 7.0 | 9.4 | 151.3 | 6.1 | 8.2 | 38.4 | 5.4 | 7.2 | 28.4 | 4.2 | 5.7 | 14.6 |
| 682000 | 6.4 | 7.9 | 169.9 | 5.5 | 6.8 | 40.5 | 4.8 | 6.0 | 29.4 | 3.7 | 4.5 | 15.3 |
| 699350 | 6.6 | 8.5 | 177.2 | 5.7 | 7.3 | 41.0 | 5.0 | 6.4 | 29.5 | 3.8 | 4.8 | 16.0 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11320512 | 10000 | 424 | 4.07 | 50 | 200 | 6108.0 | 10265.0 | 2.55 | 3.28 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 19.7 | 26.4 | 16.4 | 17.2 | 23.1 | 13.9 | 16.3 | 21.9 | 13.9 | 15.4 | 20.7 | 12.6 |
| 500 | 18.7 | 25.1 | 26.8 | 16.3 | 21.9 | 17.3 | 15.3 | 20.5 | 16.9 | 14.1 | 18.9 | 14.5 |
| 1000 | 16.6 | 20.1 | 30.1 | 14.4 | 17.5 | 19.2 | 13.4 | 16.4 | 18.2 | 12.2 | 14.9 | 15.2 |
| 5000 | 15.6 | 18.8 | 48.9 | 13.5 | 16.3 | 25.5 | 12.4 | 14.9 | 22.7 | 10.9 | 13.1 | 18.3 |
| 10200 | 16.3 | 20.9 | 65.0 | 14.1 | 18.1 | 28.6 | 12.8 | 16.5 | 25.3 | 11.1 | 14.2 | 19.3 |
| 21900 | 16.6 | 22.4 | 86.1 | 14.4 | 19.4 | 32.0 | 13.0 | 17.5 | 27.8 | 11.0 | 14.8 | 20.8 |
| 135600 | 14.6 | 18.3 | 140.3 | 12.5 | 15.7 | 39.8 | 11.1 | 13.9 | 33.0 | 8.7 | 11.0 | 22.2 |
| 493400 | 15.0 | 20.1 | 223.5 | 12.8 | 17.2 | 44.7 | 11.1 | 14.9 | 36.5 | 8.2 | 11.1 | 22.6 |
| 843950 | 14.0 | 17.7 | 249.5 | 11.9 | 15.1 | 46.8 | 10.2 | 13.0 | 37.8 | 7.4 | 9.3 | 22.6 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11320522 | 10000 | 424 | 4.07 | 50 | 200 | 6125.0 | 10295.0 | 2.55 | 3.30 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 19.9 | 26.8 | 16.6 | 17.4 | 23.5 | 22.1 | 16.5 | 22.3 | 20.8 | 15.5 | 21.0 | 16.0 |
| 500 | 17.2 | 21.1 | 24.7 | 15.0 | 18.4 | 28.9 | 14.0 | 17.3 | 25.7 | 12.9 | 15.9 | 19.1 |
| 1000 | 18.0 | 23.7 | 32.8 | 15.7 | 20.6 | 33.7 | 14.6 | 19.2 | 28.7 | 13.3 | 17.5 | 20.1 |
| 5000 | 16.5 | 21.0 | 51.9 | 14.3 | 18.1 | 50.0 | 13.1 | 16.7 | 39.6 | 11.6 | 14.7 | 23.7 |
| 10000 | 17.4 | 23.9 | 69.3 | 15.1 | 20.6 | 59.6 | 13.7 | 18.8 | 45.5 | 11.9 | 16.3 | 26.6 |
| 27600 | 15.8 | 20.3 | 88.7 | 13.6 | 17.5 | 73.6 | 12.3 | 15.8 | 54.2 | 10.3 | 13.2 | 28.9 |
| 344800 | 14.2 | 17.6 | 187.0 | 6.3 | 9.3 | - | 6.0 | 8.9 | - | 5.7 | 8.8 | - |
| 501150 | 13.5 | 16.2 | 202.4 | 11.5 | 13.8 | 107.6 | 10.0 | 12.0 | 70.5 | 7.4 | 8.9 | 30.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11320532 | 10000 | 424 | 4.07 | 50 | 200 | 6141.0 | 10315.0 | 2.55 | 3.20 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 19.9 | 27.1 | 16.2 | 17.4 | 23.8 | 22.1 | 16.6 | 22.6 | 20.8 | 15.6 | 21.3 | 16.0 |
| 500 | 18.9 | 25.7 | 26.5 | 16.5 | 22.4 | 28.9 | 15.5 | 21.1 | 25.7 | 14.3 | 19.4 | 19.1 |
| 1000 | 18.5 | 25.2 | 32.8 | 16.1 | 21.9 | 33.7 | 15.0 | 20.5 | 28.7 | 13.7 | 18.7 | 20.1 |
| 5000 | 17.0 | 22.3 | 52.0 | 14.7 | 19.4 | 50.0 | 13.5 | 17.8 | 39.6 | 11.9 | 15.7 | 23.7 |
| 11100 | 16.6 | 21.8 | 64.4 | 14.4 | 18.9 | 59.6 | 13.1 | 17.3 | 45.5 | 11.4 | 15.0 | 26.8 |
| 31800 | 14.9 | 18.2 | 81.5 | 12.9 | 15.7 | 73.6 | 11.6 | 14.2 | 54.2 | 9.8 | 11.9 | 28.9 |
| 171600 | 14.7 | 19.2 | 152.0 | 12.7 | 15.6 | 91.0 | 11.2 | 14.0 | 66.6 | 9.5 | 12.0 | 32.1 |
| 349400 | 14.6 | 18.9 | 188.1 | 12.0 | 15.2 | 101.0 | 13.0 | 16.0 | 71.0 | 10.5 | 12.0 | 34.0 |
| 627900 | 14.3 | 18.4 | 209.5 | 12.3 | 15.8 | 107.6 | 12.5 | 15.0 | 72.0 | 10.2 | 11.7 | 34.5 |
| 720000 | 14.2 | 18.6 | 219.5 | 12.5 | 15.6 | 110.0 | 12.6 | 15.2 | 72.2 | 10.1 | 11.2 | 34.0 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11320515 | 10000 | 424 | 4.07 | 50 | 500 | 6180.0 | 10380.0 | 2.53 | 2.43 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 45.7 | 58.2 | 15.1 | 40.2 | 51.2 | 44.3 | 37.7 | 48.0 | 44.2 | 35.0 | 44.6 | 42.7 |
| 500 | 43.8 | 56.4 | 25.0 | 38.4 | 49.4 | 52.0 | 35.6 | 45.8 | 49.2 | 32.2 | 41.4 | 45.8 |
| 1000 | 41.7 | 52.2 | 30.1 | 36.5 | 45.7 | 56.8 | 33.6 | 42.1 | 52.2 | 30.0 | 37.6 | 46.9 |
| 5000 | 42.9 | 58.0 | 53.4 | 37.3 | 50.6 | 69.3 | 33.8 | 45.8 | 57.1 | 29.1 | 39.4 | 43.8 |
| 10150 | 37.2 | 44.8 | 58.9 | 32.4 | 38.9 | 75.6 | 29.1 | 35.0 | 60.1 | 24.5 | 29.5 | 43.2 |
| 35900 | 37.7 | 47.7 | 91.5 | 32.6 | 41.3 | 86.7 | 28.9 | 36.6 | 64.6 | 23.3 | 29.5 | 41.2 |
| 157900 | 34.4 | 41.8 | 138.3 | 29.7 | 36.1 | 98.5 | 25.8 | 31.3 | 69.5 | 19.5 | 23.7 | 38.1 |
| 334600 | 36.3 | 47.6 | 188.2 | 31.3 | 41.0 | 104.3 | 26.8 | 35.1 | 71.5 | 19.5 | 25.6 | 36.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11320525 | 10000 | 424 | 4.07 | 50 | 500 | 6180.0 | 10363.0 | 2.55 | 2.96 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 46.4 | 56.8 | 17.5 | 40.3 | 49.3 | 61.3 | 37.6 | 46.0 | 60.0 | 34.7 | 42.5 | 65.0 |
| 500 | 44.7 | 55.6 | 29.2 | 38.7 | 48.1 | 73.8 | 35.6 | 44.3 | 70.0 | 32.0 | 39.7 | 75.0 |
| 1000 | 43.9 | 54.7 | 36.2 | 37.9 | 47.2 | 79.3 | 34.7 | 43.2 | 75.5 | 30.6 | 38.2 | 80.0 |
| 5000 | 44.8 | 59.9 | 63.8 | 38.6 | 51.6 | 92.6 | 34.6 | 46.3 | 85.5 | 29.4 | 39.3 | 87.5 |
| 10700 | 41.6 | 52.9 | 76.6 | 35.7 | 45.4 | 98.1 | 31.8 | 40.4 | 90.5 | 26.3 | 33.5 | 89.5 |
| 20750 | 43.7 | 59.5 | 100.7 | 37.4 | 51.0 | 104.1 | 33.0 | 45.0 | 94.5 | 26.7 | 36.4 | 91.5 |
| 191200 | 39.9 | 53.4 | 195.6 | 34.0 | 45.4 | 125.4 | 29.0 | 38.7 | 107.0 | 21.2 | 28.3 | 92.8 |
| 351450 | 38.9 | 51.6 | 234.2 | 33.0 | 43.8 | 131.4 | 27.9 | 37.0 | 109.8 | 19.7 | 26.1 | 92.8 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 11320535 | 10000 | 424 | 4.07 | 50 | 500 | 6024.0 | 10150.0 | 2.55 | 3.64 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 53.5 | 71.0 | 24.3 | 45.8 | 60.8 | 22.4 | 42.4 | 56.3 | 21.4 | 38.8 | 51.5 | 20.5 |
| 500 | 51.6 | 69.5 | 40.5 | 44.0 | 59.2 | 27.7 | 40.1 | 54.0 | 25.9 | 35.5 | 47.9 | 24.4 |
| 1000 | 45.6 | 55.5 | 45.2 | 38.8 | 47.2 | 31.2 | 35.1 | 42.7 | 28.4 | 30.6 | 37.3 | 25.9 |
| 5300 | 46.6 | 61.2 | 81.4 | 39.4 | 51.8 | 41.4 | 35.0 | 45.9 | 35.4 | 29.1 | 38.2 | 30.4 |
| 10225 | 47.5 | 64.8 | 103.7 | 40.1 | 54.7 | 46.8 | 35.3 | 48.1 | 38.9 | 28.7 | 39.1 | 32.8 |
| 30000 | 44.0 | 57.5 | 138.3 | 37.0 | 48.4 | 56.1 | 32.0 | 41.9 | 46.1 | 24.9 | 32.6 | 38.2 |
| 153100 | 38.6 | 46.6 | 210.9 | 32.3 | 39.0 | 68.8 | 27.2 | 32.8 | 57.9 | 19.5 | 23.5 | 46.7 |
| 325300 | 37.2 | 44.4 | 262.8 | 31.1 | 37.1 | 75.4 | 25.8 | 30.8 | 62.9 | 17.6 | 21.0 | 50.4 |
| 501200 | 37.1 | 44.8 | 303.6 | 30.9 | 37.3 | 79.5 | 25.5 | 30.8 | 66.2 | 16.8 | 20.3 | 53.3 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22120611 | 10000 | 447 | 4.28 | 50 | 100 | 5790.0 | 9835.0 | 2.52 | 4.89 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 10.9 | 14.0 | 22.4 | 9.3 | 12.0 | 13.0 | 8.8 | 11.3 | 8.6 | 8.3 | 10.7 | 4.3 |
| 500 | 10.4 | 13.4 | 36.4 | 8.8 | 11.4 | 14.9 | 8.3 | 10.7 | 9.6 | 7.6 | 9.8 | 4.8 |
| 1000 | 10.1 | 12.9 | 44.4 | 8.6 | 10.9 | 16.1 | 7.9 | 10.1 | 10.5 | 7.2 | 9.2 | 5.0 |
| 7700 | 9.3 | 11.6 | 80.0 | 7.8 | 9.7 | 22.9 | 7.1 | 8.9 | 14.5 | 6.1 | 7.6 | 7.0 |
| 10500 | 10.0 | 13.6 | 95.7 | 8.4 | 11.5 | 24.4 | 7.6 | 10.4 | 15.1 | 6.5 | 8.9 | 7.2 |
| 134600 | 8.9 | 11.7 | 198.6 | 7.4 | 9.8 | 34.9 | 6.5 | 8.6 | 19.8 | 5.0 | 6.6 | 6.5 |
| 309300 | 8.4 | 10.8 | 247.5 | 7.0 | 9.0 | 37.1 | 6.0 | 7.7 | 19.3 | 4.5 | 5.7 | 4.5 |
| 1011900 | 8.2 | 10.5 | 354.5 | 6.8 | 8.7 | 40.9 | 5.7 | 7.3 | 19.6 | 3.9 | 5.0 | 2.2 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22120621 | 10000 | 447 | 4.28 | 50 | 100 | 5770.0 | 9805.0 | 2.52 | 4.94 |

DEFORMATION (inches X 0.0001)

| CYCLE NUMBER | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 11.2 | 14.7 | 23.4 | 9.5 | 12.5 | 10.1 | 9.0 | 11.8 | 6.4 | 8.5 | 11.1 | 4.8 |
| 500 | 10.9 | 14.5 | 38.6 | 9.2 | 12.3 | 13.0 | 8.6 | 11.5 | 8.6 | 7.9 | 10.6 | 7.3 |
| 1000 | 9.7 | 11.8 | 43.3 | 8.2 | 10.0 | 15.0 | 7.6 | 9.3 | 10.1 | 6.9 | 8.4 | 8.4 |
| 5000 | 9.8 | 12.7 | 74.7 | 8.3 | 10.7 | 22.4 | 7.5 | 9.8 | 14.5 | 6.6 | 8.5 | 12.2 |
| 10000 | 9.8 | 13.0 | 94.0 | 8.2 | 11.0 | 27.2 | 7.5 | 9.9 | 17.5 | 6.4 | 8.5 | 14.9 |
| 30500 | 9.8 | 13.6 | 136.4 | 8.2 | 11.4 | 35.8 | 7.4 | 10.2 | 22.2 | 6.0 | 8.4 | 19.0 |
| 185800 | 8.6 | 11.1 | 218.2 | 7.2 | 9.3 | 52.3 | 6.2 | 8.0 | 31.5 | 4.7 | 6.1 | 24.2 |
| 330538 | 8.5 | 11.0 | 259.7 | 7.1 | 9.1 | 60.0 | 6.1 | 7.8 | 34.6 | 4.5 | 5.8 | 27.0 |
| 515900 | 8.6 | 11.4 | 304.9 | 7.1 | 9.5 | 67.6 | 6.1 | 8.1 | 37.6 | 4.4 | 5.8 | 29.3 |
| 676900 | 8.3 | 10.7 | 321.1 | 6.9 | 8.8 | 69.0 | 5.8 | 7.5 | 38.8 | 4.1 | 5.3 | 30.3 |
| 695700 | 8.6 | 11.5 | 335.6 | 7.1 | 9.5 | 69.5 | 6.0 | 8.0 | 39.0 | 4.2 | 5.7 | 30.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22120631 | 10000 | 447 | 4.28 | 50 | 100 | 5805.0 | 9975.0 | 2.52 | 5.08 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 11.9 | 16.2 | 25.5 | 10.1 | 13.8 | 9.3 | 9.6 | 13.1 | 8.7 | 9.0 | 12.3 | 8.7 |
| 500 | 10.8 | 14.0 | 39.3 | 9.1 | 11.9 | 10.8 | 8.5 | 11.1 | 9.7 | 7.8 | 10.1 | 9.7 |
| 1240 | 9.9 | 12.1 | 48.7 | 8.3 | 10.2 | 11.9 | 7.7 | 9.4 | 10.9 | 6.9 | 8.5 | 10.5 |
| 5000 | 10.5 | 14.3 | 82.2 | 8.8 | 12.0 | 14.6 | 8.0 | 11.0 | 14.3 | 7.0 | 9.5 | 13.7 |
| 10000 | 10.5 | 14.6 | 103.4 | 8.8 | 12.3 | 17.0 | 8.0 | 11.1 | 16.5 | 6.8 | 9.5 | 15.6 |
| 49400 | 9.5 | 12.5 | 158.3 | 7.9 | 10.5 | 26.1 | 7.0 | 9.3 | 24.3 | 5.6 | 7.4 | 23.9 |
| 171600 | 8.8 | 11.4 | 223.2 | 7.3 | 9.4 | 33.4 | 6.4 | 8.2 | 31.5 | 4.8 | 6.2 | 31.2 |
| 359000 | 8.8 | 11.4 | 282.4 | 7.3 | 9.5 | 38.3 | 6.2 | 8.1 | 35.9 | 4.5 | 5.9 | 35.0 |
| 511400 | 8.8 | 11.7 | 319.5 | 7.3 | 9.7 | 40.8 | 6.2 | 8.2 | 38.3 | 4.4 | 5.9 | 37.2 |
| 706000 | 8.7 | 11.4 | 349.6 | 7.2 | 9.4 | 43.2 | 6.1 | 8.0 | 40.7 | 4.2 | 5.6 | 39.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22120612 | 10000 | 447 | 4.28 | 50 | 200 | 5772.0 | 9900.0 | 2.52 | 4.83 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 21.8 | 26.9 | 25.6 | 18.5 | 22.9 | 42.6 | 17.4 | 21.5 | 41.8 | 16.3 | 20.1 | 41.3 |
| 500 | 22.9 | 31.2 | 45.7 | 19.4 | 26.4 | 47.4 | 18.0 | 24.5 | 46.9 | 16.3 | 22.2 | 45.6 |
| 1000 | 21.6 | 28.3 | 54.2 | 18.2 | 23.9 | 51.9 | 16.8 | 22.0 | 50.0 | 15.0 | 19.7 | 48.1 |
| 5000 | 19.3 | 23.9 | 82.7 | 16.2 | 20.1 | 63.1 | 14.7 | 18.2 | 60.5 | 12.6 | 15.6 | 52.7 |
| 10000 | 19.6 | 25.3 | 105.8 | 16.5 | 21.2 | 69.4 | 14.8 | 19.0 | 66.1 | 12.4 | 16.0 | 54.7 |
| 136200 | 18.7 | 25.0 | 239.5 | 15.6 | 20.7 | 76.7 | 13.4 | 17.9 | 72.1 | 10.1 | 13.5 | 57.2 |
| 11111 | 20.5 | 27.7 | 114.5 | 17.2 | 23.2 | 93.0 | 15.4 | 20.8 | 85.8 | 12.9 | 17.4 | 59.6 |
| 322900 | 17.2 | 21.7 | 293.2 | 14.3 | 18.0 | 100.8 | 12.1 | 15.3 | 91.5 | 8.7 | 11.0 | 59.6 |
| 495600 | 18.4 | 25.1 | 360.9 | 15.2 | 20.7 | 102.9 | 12.8 | 17.5 | 94.0 | 9.0 | 12.3 | 59.6 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22120622 | 10000 | 447 | 4.28 | 50 | 200 | 5815.0 | 9972.0 | 2.52 | 4.81 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 23.2 | 30.3 | 26.9 | 19.7 | 25.8 | 14.6 | 18.6 | 24.3 | 13.9 | 17.3 | 22.6 | 11.7 |
| 500 | 21.1 | 26.3 | 41.5 | 17.8 | 22.2 | 15.8 | 16.5 | 20.6 | 14.9 | 15.0 | 18.7 | 12.7 |
| 1000 | 22.5 | 30.6 | 55.8 | 19.0 | 25.9 | 17.3 | 17.5 | 23.8 | 16.0 | 15.7 | 21.4 | 13.7 |
| 5000 | 19.6 | 24.5 | 82.9 | 16.5 | 20.6 | 25.6 | 14.9 | 18.6 | 22.1 | 12.8 | 16.0 | 19.0 |
| 10000 | 20.2 | 26.6 | 107.4 | 16.9 | 22.3 | 31.4 | 15.2 | 20.0 | 27.0 | 12.8 | 16.8 | 23.4 |
| 33500 | 20.6 | 28.7 | 163.4 | 17.2 | 24.0 | 37.5 | 15.2 | 21.2 | 31.9 | 12.2 | 17.1 | 28.3 |
| 143000 | 18.8 | 25.0 | 240.7 | 15.6 | 20.7 | 42.9 | 13.5 | 17.9 | 35.7 | 10.1 | 13.5 | 30.7 |
| 328500 | 18.6 | 25.1 | 313.4 | 15.4 | 20.7 | 46.1 | 13.1 | 17.6 | 38.2 | 9.4 | 12.7 | 32.0 |
| 490000 | 16.3 | 19.5 | 313.7 | 13.5 | 16.1 | 48.5 | 11.4 | 13.6 | 39.4 | 8.0 | 9.6 | 32.5 |
| 687000 | 17.3 | 22.4 | 373.9 | 14.3 | 18.5 | 49.5 | 12.0 | 15.5 | 39.7 | 8.2 | 10.6 | 32.5 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22120632 | 10000 | 447 | 4.28 | 50 | 200 | 5808.0 | 9980.0 | 2.52 | 5.07 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 22.8 | 28.4 | 28.2 | 19.3 | 24.1 | 12.1 | 18.1 | 22.6 | 11.4 | 16.9 | 21.1 | 12.8 |
| 500 | 21.8 | 27.2 | 45.9 | 18.3 | 22.9 | 14.5 | 17.0 | 21.2 | 13.4 | 15.3 | 19.2 | 14.7 |
| 1000 | 22.8 | 30.7 | 60.5 | 19.2 | 25.8 | 16.5 | 17.6 | 23.7 | 15.0 | 15.7 | 21.1 | 15.9 |
| 5000 | 19.3 | 23.1 | 87.2 | 16.1 | 19.3 | 22.6 | 14.6 | 17.4 | 18.5 | 12.5 | 14.9 | 18.3 |
| 10800 | 21.1 | 28.3 | 123.2 | 17.6 | 23.6 | 29.0 | 15.7 | 21.1 | 22.9 | 13.1 | 17.6 | 21.7 |
| 147150 | 18.3 | 23.2 | 253.7 | 15.1 | 19.1 | 48.2 | 13.0 | 16.4 | 30.5 | 9.7 | 12.2 | 24.0 |
| 320100 | 17.3 | 21.2 | 309.9 | 14.2 | 17.4 | 54.2 | 12.1 | 14.7 | 32.0 | 8.6 | 10.5 | 23.5 |
| 505000 | 16.8 | 20.2 | 349.4 | 13.8 | 16.6 | 58.1 | 11.6 | 13.9 | 33.0 | 8.0 | 9.6 | 23.5 |

WA = TOTAL WEIGHT OF DRY AGGREGATES;
WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT;
SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR;
CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER;
AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22120615 | 10000 | 447 | 4.28 | 50 | 500 | 5780.0 | 9935.0 | 2.52 | 5.12 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 59.4 | 72.5 | 36.9 | 49.4 | 60.2 | 33.8 | 45.2 | 55.1 | 32.6 | 40.7 | 49.7 | 31.2 |
| 500 | 61.7 | 82.2 | 65.3 | 51.0 | 67.9 | 36.8 | 45.8 | 61.0 | 35.0 | 39.8 | 53.1 | 33.1 |
| 1000 | 62.6 | 86.7 | 83.4 | 51.7 | 71.5 | 38.5 | 46.0 | 63.6 | 36.6 | 39.3 | 54.3 | 34.1 |
| 5000 | 53.6 | 66.8 | 121.7 | 44.0 | 54.8 | 43.9 | 38.3 | 47.7 | 40.1 | 31.0 | 38.6 | 35.6 |
| 10000 | 57.4 | 78.2 | 163.8 | 46.9 | 64.0 | 46.8 | 40.4 | 55.1 | 42.1 | 31.8 | 43.4 | 36.2 |
| 36400 | 53.1 | 69.8 | 232.5 | 43.2 | 56.8 | 52.0 | 36.4 | 47.8 | 45.5 | 26.9 | 35.4 | 36.8 |
| 158700 | 50.1 | 65.0 | 356.7 | 40.5 | 52.5 | 58.3 | 33.1 | 43.0 | 50.8 | 22.4 | 29.0 | 37.0 |
| 332900 | 45.6 | 55.2 | 415.3 | 36.7 | 44.5 | 61.0 | 29.6 | 35.8 | 53.5 | 18.9 | 22.9 | 37.0 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22120625 | 10000 | 447 | 4.28 | 50 | 500 | 5815.0 | 9980.0 | 2.52 | 4.91 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 63.7 | 84.6 | 37.4 | 53.1 | 70.6 | 20.8 | 48.7 | 64.7 | 25.2 | 44.0 | 58.6 | 29.3 |
| 500 | 58.3 | 74.6 | 58.4 | 48.4 | 62.0 | 24.4 | 43.6 | 55.8 | 29.0 | 38.0 | 48.7 | 34.2 |
| 1100 | 55.0 | 68.1 | 71.5 | 45.5 | 56.4 | 26.3 | 40.6 | 50.3 | 29.4 | 34.7 | 43.0 | 36.6 |
| 5500 | 57.3 | 77.8 | 126.9 | 47.2 | 64.1 | 30.8 | 41.2 | 55.9 | 30.6 | 33.4 | 45.3 | 41.5 |
| 10900 | 56.3 | 76.8 | 156.4 | 46.3 | 63.1 | 32.8 | 39.9 | 54.5 | 32.3 | 31.5 | 42.9 | 43.9 |
| 22000 | 55.0 | 74.9 | 192.8 | 45.1 | 61.4 | 35.6 | 38.4 | 52.4 | 34.3 | 29.4 | 40.0 | 46.1 |
| 161700 | 45.7 | 55.0 | 309.7 | 37.1 | 44.7 | 42.9 | 30.5 | 36.7 | 40.4 | 20.8 | 25.0 | 52.2 |
| 353200 | 49.2 | 65.4 | 431.8 | 39.8 | 52.9 | 42.9 | 32.2 | 42.7 | 40.4 | 20.7 | 27.5 | 52.2 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 22120635 | 10000 | 447 | 4.28 | 50 | 500 | 5812.0 | 9993.0 | 2.52 | 5.15 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 67.1 | 91.5 | 41.9 | 55.7 | 76.0 | 17.1 | 50.9 | 69.4 | 16.7 | 45.9 | 62.6 | 17.7 |
| 500 | 63.3 | 85.8 | 67.4 | 52.3 | 70.8 | 22.4 | 47.0 | 63.6 | 22.5 | 40.8 | 55.3 | 23.1 |
| 1000 | 54.5 | 64.9 | 72.9 | 44.9 | 53.4 | 24.9 | 39.9 | 47.6 | 24.9 | 34.1 | 40.6 | 26.2 |
| 5500 | 57.1 | 75.3 | 134.3 | 46.8 | 61.6 | 35.6 | 40.6 | 53.5 | 36.1 | 32.7 | 43.1 | 38.4 |
| 10000 | 56.3 | 74.5 | 161.3 | 46.0 | 60.8 | 39.3 | 39.6 | 52.3 | 42.4 | 31.1 | 41.1 | 44.5 |
| 128000 | 47.9 | 58.6 | 319.5 | 38.7 | 47.3 | 56.4 | 31.8 | 38.9 | 66.8 | 21.8 | 26.6 | 72.6 |
| 337900 | 46.0 | 55.6 | 422.8 | 37.0 | 44.8 | 64.9 | 29.8 | 36.0 | 78.0 | 18.9 | 22.9 | 83.6 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32120611 | 10000 | 460 | 4.40 | 50 | 100 | 5826.0 | 9994.0 | 2.53 | 5.23 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 11.4 | 14.6 | 25.3 | 9.6 | 12.4 | 5.2 | 9.1 | 11.7 | 3.7 | - | - | - |
| 500 | 11.4 | 15.6 | 43.2 | 9.6 | 13.1 | 12.9 | 9.0 | 12.3 | 8.2 | - | - | - |
| 1000 | 10.9 | 14.4 | 51.6 | 9.2 | 12.1 | 21.0 | 8.5 | 11.2 | 12.8 | - | - | - |
| 5500 | 10.4 | 13.9 | 86.4 | 8.7 | 11.6 | 51.3 | 7.9 | 10.6 | 27.8 | - | - | - |
| 12000 | 9.7 | 12.4 | 104.5 | 8.1 | 10.4 | 85.2 | 7.3 | 9.4 | 43.8 | - | - | - |
| 37000 | 9.8 | 13.2 | 153.4 | 8.2 | 11.0 | 140.7 | 7.3 | 9.8 | 66.6 | - | - | - |
| 164500 | 8.9 | 11.2 | 225.5 | 7.3 | 9.3 | 480.9 | 6.3 | 8.0 | 189.8 | - | - | - |
| 365550 | 8.3 | 10.2 | 275.9 | - | - | - | - | - | - | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32120621 | 10000 | 460 | 4.40 | 50 | 100 | 5828.0 | 9997.0 | 2.53 | 5.22 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 11.8 | 15.7 | 26.1 | 10.0 | 13.3 | 5.2 | 9.4 | 12.6 | 3.7 | - | - | - |
| 500 | 10.6 | 13.5 | 40.1 | 9.0 | 11.4 | 12.9 | 8.4 | 10.6 | 8.2 | - | - | - |
| 1000 | 10.0 | 12.3 | 47.5 | 8.4 | 10.3 | 21.0 | 7.8 | 9.6 | 12.8 | - | - | - |
| 5000 | 10.6 | 14.5 | 85.4 | 8.9 | 12.1 | 51.3 | 8.1 | 11.0 | 27.8 | - | - | - |
| 10000 | 9.5 | 12.0 | 96.6 | 8.0 | 10.0 | 85.2 | 7.2 | 9.0 | 43.8 | - | - | - |
| 29500 | 9.9 | 13.2 | 142.5 | 8.2 | 11.0 | 140.7 | 7.3 | 9.8 | 66.6 | - | - | - |
| 154700 | 8.8 | 11.0 | 218.9 | 7.3 | 9.1 | 480.9 | 6.3 | 7.9 | 189.8 | - | - | - |
| 387450 | 9.1 | 12.2 | 306.5 | - | - | - | - | - | - | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32120631 | 10000 | 460 | 4.40 | 50 | 100 | 5825.0 | 9991.0 | 2.53 | 5.21 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 11.2 | 14.2 | 24.8 | 9.5 | 12.1 | 5.2 | 9.0 | 11.4 | 3.7 | - | - | - |
| 500 | 11.2 | 15.0 | 42.1 | 9.4 | 12.6 | 12.9 | 8.8 | 11.8 | 8.2 | - | - | - |
| 1000 | 11.0 | 14.7 | 51.9 | 9.2 | 12.4 | 21.0 | 8.6 | 11.5 | 12.8 | - | - | - |
| 5100 | 10.8 | 15.0 | 87.3 | 9.0 | 12.6 | 51.3 | 8.2 | 11.4 | 27.8 | - | - | - |
| 10500 | 9.7 | 12.3 | 99.3 | 8.1 | 10.3 | 85.2 | 7.3 | 9.3 | 43.8 | - | - | - |
| 28800 | 9.7 | 12.8 | 138.6 | 8.1 | 10.6 | 140.7 | 7.2 | 9.5 | 66.6 | - | - | - |
| 154700 | 8.6 | 10.6 | 213.8 | 7.1 | 8.8 | 480.9 | 6.2 | 7.6 | 189.8 | - | - | - |
| 412350 | 9.2 | 12.5 | 315.9 | - | - | - | - | - | - | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES;
WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT;
SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR;
CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER;
AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32120612 | 10000 | 460 | 4.40 | 50 | 100 | 5820.0 | 9980.0 | 2.53 | 5.18 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 11.8 | 16.0 | 26.0 | 10.0 | 13.5 | 5.2 | 9.5 | 12.8 | 3.7 | - | - | - |
| 500 | 11.1 | 14.8 | 41.4 | 9.4 | 12.5 | 12.9 | 8.7 | 11.6 | 8.2 | - | - | - |
| 2000 | 9.9 | 12.2 | 58.2 | 8.3 | 10.3 | 21.0 | 7.6 | 9.4 | 12.8 | - | - | - |
| 5100 | 9.4 | 11.4 | 75.3 | 7.9 | 9.5 | 51.3 | 7.2 | 8.7 | 27.8 | - | - | - |
| 14200 | 9.8 | 12.8 | 110.3 | 8.2 | 10.7 | 85.2 | 7.4 | 9.6 | 43.8 | - | - | - |
| 27150 | 9.0 | 11.0 | 124.9 | 7.5 | 9.1 | 140.7 | 6.7 | 8.1 | 66.6 | - | - | - |
| 194700 | 8.7 | 11.1 | 232.5 | 7.2 | 9.1 | 480.9 | 6.2 | 7.9 | 189.8 | - | - | - |
| 416600 | 9.2 | 12.5 | 313.8 | - | - | - | - | - | - | - | - | - |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32120622 | 10000 | 460 | 4.40 | 50 | 200 | 5795.0 | 9955.0 | 2.53 | 5.41 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 25.5 | 34.6 | 34.6 | 21.4 | 29.1 | 26.4 | 20.1 | 27.3 | 23.4 | 18.6 | 25.3 | 18.5 |
| 500 | 24.4 | 33.2 | 56.1 | 20.4 | 27.8 | 31.3 | 18.8 | 25.6 | 27.9 | 16.9 | 23.1 | 22.0 |
| 1000 | 20.9 | 25.0 | 60.5 | 17.4 | 20.9 | 34.3 | 16.0 | 19.1 | 30.3 | 14.2 | 17.0 | 23.9 |
| 5000 | 21.8 | 28.7 | 107.2 | 18.1 | 23.8 | 41.2 | 16.3 | 21.4 | 37.0 | 13.8 | 18.2 | 29.9 |
| 10000 | 20.4 | 25.6 | 125.9 | 16.9 | 21.2 | 44.6 | 15.0 | 18.8 | 39.5 | 12.5 | 15.7 | 32.8 |
| 153600 | 17.9 | 21.5 | 271.6 | 14.7 | 17.6 | 58.4 | 12.5 | 15.0 | 50.5 | 9.2 | 11.0 | 44.5 |
| 322400 | 19.3 | 25.5 | 373.4 | 15.7 | 20.8 | 62.3 | 13.2 | 17.5 | 53.5 | 9.3 | 12.3 | 47.5 |
| 471900 | 17.5 | 21.2 | 383.4 | 14.2 | 17.3 | 64.7 | 11.9 | 14.4 | 55.5 | 8.1 | 9.9 | 48.5 |
| 698000 | 19.1 | 25.7 | 476.7 | 15.5 | 20.9 | 66.5 | 12.9 | 17.3 | 57.3 | 8.5 | 11.5 | 50.9 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32120632 | 10000 | 460 | 4.40 | 50 | 200 | 5805.0 | 9945.0 | 2.53 | 5.05 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 24.7 | 33.7 | 30.5 | 20.9 | 28.5 | 19.0 | 19.6 | 26.8 | 15.2 | 18.3 | 24.9 | 11.7 |
| 500 | 20.5 | 24.4 | 43.0 | 17.3 | 20.6 | 22.0 | 16.0 | 19.0 | 17.1 | 14.5 | 17.2 | 12.7 |
| 1000 | 21.8 | 28.1 | 57.4 | 18.3 | 23.7 | 24.0 | 16.8 | 21.7 | 18.0 | 15.0 | 19.4 | 13.7 |
| 5000 | 20.1 | 25.3 | 90.1 | 16.8 | 21.2 | 30.1 | 15.2 | 19.1 | 21.5 | 13.0 | 16.3 | 15.6 |
| 10000 | 21.3 | 29.0 | 119.9 | 17.8 | 24.2 | 34.1 | 15.9 | 21.6 | 23.7 | 13.3 | 18.1 | 16.1 |
| 22700 | 20.1 | 26.5 | 148.2 | 16.7 | 22.0 | 38.9 | 14.8 | 19.5 | 26.1 | 12.0 | 15.9 | 16.8 |
| 147950 | 18.4 | 23.6 | 251.5 | 15.2 | 19.5 | 49.3 | 13.0 | 16.7 | 30.6 | 9.7 | 12.5 | 16.3 |
| 481600 | 18.7 | 25.3 | 376.8 | 15.4 | 20.7 | 56.1 | 12.9 | 17.4 | 33.9 | 9.0 | 12.1 | 15.6 |
| 1025500 | 16.1 | 19.2 | 416.4 | 13.2 | 15.7 | 60.1 | 10.9 | 13.0 | 35.6 | 7.2 | 8.5 | 15.5 |
| 1194900 | 18.3 | 25.0 | 498.0 | 15.0 | 20.4 | 59.6 | 12.4 | 16.8 | 35.0 | 8.0 | 10.9 | 14.4 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32120615 | 10000 | 460 | 4.40 | 50 | 100 | 5827.0 | 9989.0 | 2.53 | 5.14 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 11.2 | 14.2 | 24.3 | 9.5 | 12.1 | 5.2 | 9.0 | 11.4 | 3.7 | - | - | - |
| 500 | 10.7 | 13.9 | 39.7 | 9.1 | 11.7 | 12.9 | 8.5 | 10.9 | 8.2 | - | - | - |
| 1000 | 11.1 | 15.0 | 51.3 | 9.3 | 12.7 | 21.0 | 8.6 | 11.8 | 12.8 | - | - | - |
| 5000 | 10.5 | 14.4 | 83.2 | 8.9 | 12.1 | 51.3 | 8.1 | 11.0 | 27.8 | - | - | - |
| 12000 | 10.0 | 13.2 | 104.7 | 8.3 | 11.0 | 85.2 | 7.5 | 9.9 | 43.8 | - | - | - |
| 32500 | 10.0 | 13.8 | 146.2 | 8.3 | 11.5 | 140.7 | 7.4 | 10.2 | 66.6 | - | - | - |
| 174350 | 8.2 | 9.8 | 208.7 | 6.8 | 8.1 | 480.9 | 5.9 | 7.0 | 189.8 | - | - | - |
| 390500 | 8.5 | 10.8 | 282.1 | - | - | - | - | - | - | - | - | - |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

BEAM CYCLIC LOAD DATA

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32120625 | 10000 | 460 | 4.40 | 50 | 500 | 5800.0 | 9950.0 | 2.53 | 5.23 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 67.1 | 91.5 | 42.9 | 55.6 | 75.8 | 25.9 | 50.8 | 69.2 | 23.9 | 45.7 | 62.3 | 21.5 |
| 500 | 62.9 | 84.8 | 68.4 | 51.9 | 69.9 | 31.7 | 46.5 | 62.6 | 28.7 | 40.4 | 54.4 | 24.4 |
| 1000 | 61.9 | 83.9 | 84.6 | 50.9 | 68.9 | 35.5 | 45.2 | 61.3 | 31.1 | 38.5 | 52.2 | 25.8 |
| 5000 | 57.4 | 75.7 | 133.1 | 46.9 | 61.9 | 49.7 | 40.7 | 53.8 | 40.4 | 32.8 | 43.3 | 28.7 |
| 10000 | 53.4 | 66.9 | 155.5 | 43.5 | 54.6 | 57.9 | 37.4 | 46.9 | 45.7 | 29.3 | 36.7 | 30.2 |
| 29800 | 53.2 | 69.0 | 222.2 | 43.2 | 55.9 | 71.6 | 36.4 | 47.2 | 51.1 | 27.1 | 35.1 | 30.2 |
| 199500 | 52.6 | 71.4 | 410.5 | 42.3 | 57.5 | 92.6 | 34.3 | 46.6 | 61.1 | 22.7 | 30.8 | 28.7 |
| 490700 | 47.4 | 59.8 | 498.1 | 38.0 | 48.0 | 101.5 | 30.2 | 38.1 | 65.8 | 18.5 | 23.4 | 28.2 |
| 862500 | 47.3 | 60.5 | 597.8 | 37.8 | 48.4 | 106.2 | 29.6 | 37.9 | 67.5 | 17.2 | 22.1 | 27.7 |

| SAMPLE NUMBER | WA (gr) | WB (gr) | AC (%) | SL (lbs) | CL (lbs) | WBW (gr) | WBA (gr) | GMM | AV (%) |
|---|---|---|---|---|---|---|---|---|---|
| 32120635 | 10000 | 460 | 4.40 | 50 | 500 | 5760.0 | 9895.0 | 2.53 | 5.42 |

DEFORMATION (inches X 0.0001)

| CYCLE | LVDT #1(0.0 IN.) | | | LVDT #2(2.0 IN.) | | | LVDT #3(4.0 IN.) | | | LVDT #4(6.0625 IN.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. | ELA. | TOT. | PLA. |
| 100 | 69.1 | 95.8 | 46.6 | 57.0 | 79.1 | 25.4 | 52.0 | 72.1 | 22.2 | 46.7 | 64.8 | 19.0 |
| 500 | 63.1 | 84.0 | 72.2 | 51.8 | 68.9 | 28.3 | 46.3 | 61.7 | 24.3 | 40.1 | 53.4 | 21.0 |
| 1000 | 58.8 | 74.6 | 84.6 | 48.1 | 61.1 | 30.3 | 42.7 | 54.1 | 25.8 | 36.2 | 45.9 | 22.0 |
| 5000 | 53.3 | 64.5 | 130.3 | 43.4 | 52.4 | 35.7 | 37.6 | 45.4 | 30.2 | 30.1 | 36.5 | 25.5 |
| 10000 | 58.0 | 78.2 | 178.2 | 47.1 | 63.4 | 37.8 | 40.3 | 54.3 | 31.7 | 31.4 | 42.3 | 26.9 |
| 33300 | 50.3 | 60.9 | 229.4 | 40.6 | 49.2 | 40.9 | 34.0 | 41.2 | 33.9 | 25.0 | 30.3 | 27.9 |
| 150400 | 53.7 | 72.8 | 402.2 | 43.0 | 58.4 | 45.0 | 35.0 | 47.4 | 37.2 | 23.4 | 31.7 | 29.1 |
| 353200 | 52.4 | 71.4 | 520.6 | 41.9 | 57.0 | 48.0 | 33.4 | 45.5 | 39.3 | 20.9 | 28.4 | 30.1 |

WA = TOTAL WEIGHT OF DRY AGGREGATES; WB = WEIGHT OF BITUMEN;
AC = PERCENT ASPHALT CONTENT; SL = SUSTAINED LOAD;
WBA = WEIGHT OF SAMPLE IN AIR; CL = CYCLIC LOAD;
WBW = WEIGHT OF SAMPLE IN WATER; AV = PERCENT AIR VOIDS;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

# APPENDIX B

The values of the slope and intercept of equation 5.1 are presented in this Appendix.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11110511 | 1 | 0.6343 | -.5347 | 0.9991 | 0.02227 | 11110535 | 1 | 0.6278 | 0.3792 | 0.9988 | 0.02130 |
| | 2 | 0.5909 | -.7728 | 0.9989 | 0.02260 | | 2 | 0.5841 | 0.0945 | 0.9986 | 0.02115 |
| | 3 | 0.5325 | -.7683 | 0.9990 | 0.01914 | | 3 | 0.5164 | 0.0556 | 0.9982 | 0.02148 |
| | 4 | 0.4088 | -.6165 | 0.9967 | 0.02668 | | 4 | 0.3803 | 0.1407 | 0.9939 | 0.02886 |
| 11110521 | 1 | 0.6342 | -.5300 | 0.9989 | 0.02555 | 11210511 | 1 | 0.6567 | -.4973 | 0.9993 | 0.02348 |
| | 2 | 0.6034 | -.9043 | 0.9991 | 0.02310 | | 2 | 0.6127 | -.7491 | 0.9993 | 0.02270 |
| | 3 | 0.5459 | -.8977 | 0.9992 | 0.01960 | | 3 | 0.5475 | -.7350 | 0.9993 | 0.02027 |
| | 4 | 0.4183 | -.7152 | 0.9965 | 0.03110 | | 4 | 0.3990 | -.5244 | 0.9915 | 0.05144 |
| 11110531 | 1 | 0.6372 | -.5330 | 0.9987 | 0.02707 | 11210521 | 1 | 0.6516 | -.5043 | 0.9993 | 0.02128 |
| | 2 | 0.6212 | -.9425 | 0.9988 | 0.02605 | | 2 | 0.6071 | -.7458 | 0.9992 | 0.02109 |
| | 3 | 0.5612 | -.9297 | 0.9989 | 0.02309 | | 3 | 0.5468 | -.7451 | 0.9987 | 0.02427 |
| | 4 | 0.4311 | -.7454 | 0.9955 | 0.03503 | | 4 | 0.4133 | -.5752 | 0.9905 | 0.05046 |
| 11110512 | 1 | 0.6346 | -.1755 | 0.9993 | 0.01996 | 11210531 | 1 | 0.6582 | -.5240 | 0.9988 | 0.02669 |
| | 2 | 0.5909 | -.4255 | 0.9992 | 0.01932 | | 2 | 0.6153 | -.7729 | 0.9987 | 0.02549 |
| | 3 | 0.5288 | -.4272 | 0.9992 | 0.01680 | | 3 | 0.5544 | -.7692 | 0.9984 | 0.02511 |
| | 4 | 0.3944 | -.2656 | 0.9963 | 0.02786 | | 4 | 0.4252 | -.6087 | 0.9965 | 0.02884 |
| 11110522 | 1 | 0.6267 | -.1310 | 0.9991 | 0.02400 | 11210512 | 1 | 0.6520 | -.1419 | 0.9993 | 0.02033 |
| | 2 | 0.5824 | -.3851 | 0.9989 | 0.02425 | | 2 | 0.6086 | -.4012 | 0.9992 | 0.02032 |
| | 3 | 0.5183 | -.3828 | 0.9983 | 0.02716 | | 3 | 0.5440 | -.4016 | 0.9989 | 0.02086 |
| | 4 | 0.3869 | -.2435 | 0.9890 | 0.05110 | | 4 | - | - | - | - |
| 11110532 | 1 | 0.6331 | -.1667 | 0.9993 | 0.02098 | 11210522 | 1 | 0.6555 | -.1489 | 0.9992 | 0.02300 |
| | 2 | 0.5904 | -.4228 | 0.9992 | 0.02052 | | 2 | 0.6115 | -.4072 | 0.9991 | 0.02318 |
| | 3 | 0.5266 | -.4180 | 0.9991 | 0.01872 | | 3 | 0.5475 | -.4123 | 0.9991 | 0.02050 |
| | 4 | 0.3968 | -.2777 | 0.9961 | 0.03012 | | 4 | - | - | - | - |
| 11110515 | 1 | 0.6341 | 0.3624 | 0.9991 | 0.02278 | 11210532 | 1 | 0.6523 | -.1303 | 0.9992 | 0.02236 |
| | 2 | 0.5894 | 0.0811 | 0.9990 | 0.02253 | | 2 | 0.6090 | -.3939 | 0.9991 | 0.02239 |
| | 3 | 0.5171 | 0.0555 | 0.9989 | 0.02080 | | 3 | 0.5442 | -.3966 | 0.9987 | 0.02351 |
| | 4 | 0.3575 | 0.2085 | 0.9937 | 0.03399 | | 4 | 0.4060 | -.2420 | 0.9919 | 0.04382 |
| 11110525 | 1 | 0.6345 | 0.3555 | 0.9992 | 0.02130 | 11210515 | 1 | 0.6501 | 0.3777 | 0.9990 | 0.02233 |
| | 2 | 0.5898 | 0.0756 | 0.9991 | 0.02107 | | 2 | 0.6054 | 0.0938 | 0.9989 | 0.02233 |
| | 3 | 0.5180 | 0.0501 | 0.9989 | 0.02048 | | 3 | 0.5325 | 0.0634 | 0.9984 | 0.02341 |
| | 4 | 0.3592 | 0.2005 | 0.9926 | 0.03686 | | 4 | 0.3694 | 0.2198 | 0.9890 | 0.04331 |

S, I = regression coefficients (slope and intercept of equation 5.1);

$R^2$ = coefficient of determination; and

SE = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11210525 | 1 | 0.6570 | 0.3607 | 0.9989 | 0.02508 | 11310515 | 1 | 0.6619 | 0.3832 | 0.9989 | 0.02238 |
| | 2 | 0.6119 | 0.0764 | 0.9987 | 0.02489 | | 2 | 0.5418 | 0.2045 | 0.9980 | 0.02553 |
| | 3 | 0.5395 | 0.0433 | 0.9986 | 0.02265 | | 3 | 0.4830 | 0.1424 | 0.9977 | 0.02451 |
| | 4 | 0.3340 | 0.2616 | 0.9936 | 0.03073 | | 4 | 0.3665 | 0.1813 | 0.9962 | 0.02404 |
| 11210535 | 1 | 0.6515 | 0.3883 | 0.9991 | 0.02138 | 11310525 | 1 | 0.6624 | 0.4069 | 0.9990 | 0.02055 |
| | 2 | 0.6066 | 0.0999 | 0.9990 | 0.02139 | | 2 | 0.6176 | 0.1121 | 0.9989 | 0.02038 |
| | 3 | 0.5331 | 0.0681 | 0.9986 | 0.02239 | | 3 | 0.5465 | 0.0674 | 0.9985 | 0.02063 |
| | 4 | 0.3700 | 0.2190 | 0.9900 | 0.04104 | | 4 | 0.3998 | 0.1613 | 0.9950 | 0.02765 |
| 11310511 | 1 | 0.6695 | -.5209 | 0.9993 | 0.02205 | 11310535 | 1 | 0.6667 | 0.3519 | 0.9990 | 0.02212 |
| | 2 | 0.6260 | -.7678 | 0.9991 | 0.02235 | | 2 | 0.6224 | 0.0702 | 0.9989 | 0.02197 |
| | 3 | 0.5640 | -.7621 | 0.9992 | 0.01970 | | 3 | 0.5518 | 0.0328 | 0.9987 | 0.02142 |
| | 4 | 0.4393 | -.6284 | 0.9967 | 0.03093 | | 4 | 0.3813 | 0.1452 | 0.9941 | 0.03190 |
| 11310521 | 1 | 0.6602 | -.4859 | 0.9993 | 0.01991 | 11110611 | 1 | 0.6278 | -.3226 | 0.9987 | 0.02496 |
| | 2 | 0.6168 | -.7328 | 0.9992 | 0.02007 | | 2 | 0.5818 | -.6074 | 0.9985 | 0.02497 |
| | 3 | 0.5555 | -.7293 | 0.9989 | 0.02109 | | 3 | 0.5149 | -.6021 | 0.9978 | 0.02680 |
| | 4 | 0.4317 | -.5972 | 0.9942 | 0.03821 | | 4 | - | - | - | - |
| 11310531 | 1 | 0.6651 | -.5045 | 0.9993 | 0.02094 | 11110621 | 1 | 0.6331 | -.3567 | 0.9995 | 0.01897 |
| | 2 | 0.6220 | -.7533 | 0.9992 | 0.02144 | | 2 | 0.5878 | -.6400 | 0.9994 | 0.01871 |
| | 3 | 0.5600 | -.7476 | 0.9989 | 0.02240 | | 3 | 0.5169 | -.6187 | 0.9992 | 0.02024 |
| | 4 | 0.4377 | -.6239 | 0.9931 | 0.04391 | | 4 | 0.3657 | -.4225 | 0.9901 | 0.04921 |
| 11310512 | 1 | 0.6708 | -.1717 | 0.9991 | 0.02236 | 11110631 | 1 | 0.6341 | -.3724 | 0.9988 | 0.02614 |
| | 2 | 0.6281 | -.4327 | 0.9991 | 0.02149 | | 2 | 0.5898 | -.6559 | 0.9988 | 0.02501 |
| | 3 | 0.5657 | -.4429 | 0.9989 | 0.02074 | | 3 | 0.5224 | -.6439 | 0.9988 | 0.02188 |
| | 4 | 0.4373 | -.3173 | 0.9972 | 0.02592 | | 4 | 0.3865 | -.4912 | 0.9950 | 0.03304 |
| 11310522 | 1 | 0.6702 | -.1621 | 0.9991 | 0.02224 | 11110612 | 1 | 0.6345 | -.2123 | 0.9995 | 0.02048 |
| | 2 | 0.6261 | -.4191 | 0.9989 | 0.02247 | | 2 | 0.5915 | -.4546 | 0.9994 | 0.01994 |
| | 3 | 0.5644 | -.4331 | 0.9989 | 0.02057 | | 3 | 0.5254 | -.4379 | 0.9993 | 0.01916 |
| | 4 | - | - | - | - | | 4 | 0.3745 | -.2236 | 0.9927 | 0.04564 |
| 11310532 | 1 | 0.6708 | -.1599 | 0.9992 | 0.01963 | 11110622 | 1 | 0.6318 | 0.2129 | 0.9993 | 0.02090 |
| | 2 | 0.6276 | -.4219 | 0.9991 | 0.01938 | | 2 | 0.5831 | -.1346 | 0.9991 | 0.02066 |
| | 3 | 0.5659 | -.4360 | 0.9991 | 0.01751 | | 3 | 0.5025 | -.1355 | 0.9989 | 0.02022 |
| | 4 | - | - | - | - | | 4 | 0.3279 | 0.0637 | 0.9865 | 0.04634 |

S,I = regression coefficients (slope and intercept of equation 5.1);

$R^2$ = coefficient of determination; and

SE = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11110632 | 1 | 0.6314 | 0.0495 | 0.9992 | 0.02122 | 11110712 | 1 | 0.6322 | 0.2723 | 0.9990 | 0.02366 |
| | 2 | 0.5852 | -.2566 | 0.9991 | 0.02108 | | 2 | 0.5831 | -.0919 | 0.9989 | 0.02337 |
| | 3 | 0.5133 | -.2607 | 0.9991 | 0.01926 | | 3 | 0.4997 | -.0927 | 0.9986 | 0.02257 |
| | 4 | 0.3565 | -.0796 | 0.9928 | 0.03692 | | 4 | 0.3194 | 0.1107 | 0.9851 | 0.04743 |
| 11110615 | 1 | 0.6313 | 0.7188 | 0.9990 | 0.02060 | 11110712 | 1 | 0.6332 | 0.3939 | 0.9987 | 0.02592 |
| | 2 | 0.5818 | 0.3383 | 0.9989 | 0.02038 | | 2 | 0.5826 | -.0020 | 0.9985 | 0.02584 |
| | 3 | 0.4921 | 0.2956 | 0.9985 | 0.01961 | | 3 | 0.4965 | -.0130 | 0.9982 | 0.02382 |
| | 4 | 0.1876 | 0.5409 | 0.9937 | 0.02027 | | 4 | 0.3155 | 0.1670 | 0.9911 | 0.03364 |
| 11110625 | 1 | 0.6303 | 0.3130 | 0.9993 | 0.01986 | 11110712 | 1 | 0.6338 | 0.1341 | 0.9991 | 0.02309 |
| | 2 | 0.5863 | 0.0496 | 0.9992 | 0.01975 | | 2 | 0.5860 | -.1940 | 0.9989 | 0 02314 |
| | 3 | 0.5170 | 0.0267 | 0.9988 | 0.02075 | | 3 | 0.5087 | -.1935 | 0.9988 | 0.02152 |
| | 4 | 0.3612 | 0.1868 | 0.9900 | 0.04271 | | 4 | 0.3414 | -.0001 | 0.9890 | 0.04363 |
| 11110635 | 1 | 0.6275 | 0.3990 | 0.9991 | 0.01980 | 11110722 | 1 | 0.6321 | 0.3058 | 0.9989 | 0.02536 |
| | 2 | 0.5829 | 0.1117 | 0.9990 | 0.01997 | | 2 | 0.5823 | -.0667 | 0.9987 | 0.02524 |
| | 3 | 0.5124 | 0.0771 | 0.9984 | 0.02170 | | 3 | 0.4971 | -.0673 | 0.9984 | 0.02430 |
| | 4 | - | - | - | - | | 4 | 0.3084 | 0.1581 | 0.9835 | 0.04847 |
| 11110711 | 1 | 0.6397 | 0.0344 | 0.9995 | 0.01798 | 11110732 | 1 | 0.6282 | 0.2082 | 0.9992 | 0.02108 |
| | 2 | 0.5886 | -.3489 | 0.9994 | 0.01799 | | 2 | 0.5802 | -.1362 | 0.9990 | 0.02110 |
| | 3 | 0.5040 | -.3432 | 0.9993 | 0.01610 | | 3 | 0.5012 | -.1389 | 0.9983 | 0.02394 |
| | 4 | 0.3212 | -.1276 | 0.9860 | 0.04644 | | 4 | 0.3305 | 0.0532 | 0.9812 | 0.05290 |
| 11110711 | 1 | 0.6335 | -.4118 | 0.9991 | 0.02315 | 11110715 | 1 | 0.6312 | 0.9924 | 0.9983 | 0.02380 |
| | 2 | 0.5883 | -.6793 | 0.9989 | 0.02348 | | 2 | 0.5783 | 0.5331 | 0.9980 | 0.02360 |
| | 3 | 0.5255 | -.6795 | 0.9990 | 0.02016 | | 3 | 0.4791 | 0.4658 | 0.9974 | 0.02231 |
| | 4 | 0.3947 | -.5357 | 0.9950 | 0.03359 | | 4 | 0.2684 | 0.6019 | 0.9882 | 0.02649 |
| 11110721 | 1 | 0.6371 | -.1901 | 0.9993 | 0.02127 | 11110715 | 1 | 0.6328 | 0.9853 | 0.9977 | 0.02617 |
| | 2 | 0.5903 | -.5209 | 0.9993 | 0.01991 | | 2 | 0.5798 | 0.5266 | 0.9973 | 0.02608 |
| | 3 | 0.5161 | -.5168 | 0.9991 | 0.01825 | | 3 | 0.4815 | 0.4573 | 0.9965 | 0.02474 |
| | 4 | 0.3573 | -.3315 | 0.9914 | 0.04121 | | 4 | 0.2740 | 0.5859 | 0.9866 | 0.02771 |
| 11110731 | 1 | 0.6360 | -.3583 | 0.9992 | 0.02230 | 11110725 | 1 | 0.6309 | 0.8206 | 0.9985 | 0.02361 |
| | 2 | 0.5925 | -.6512 | 0.9991 | 0.02094 | | 2 | 0.5803 | 0.4115 | 0.9983 | 0.02346 |
| | 3 | 0.5241 | -.6392 | 0.9990 | 0.01968 | | 3 | 0.4882 | 0.3574 | 0.9978 | 0.02257 |
| | 4 | 0.3860 | -.4832 | 0.9943 | 0.03528 | | 4 | 0.2909 | 0.5004 | 0.9885 | 0.03066 |

S,I = regression coefficients (slope and intercept of equation 5.1);

$R^2$ = coefficient of determination; and

SE = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11110725 | 1 | 0.6336 | 0.9768 | 0.9984 | 0.02370 | 21110532 | 1 | 0.6492 | -.1421 | 0.9991 | 0.02347 |
| | 2 | 0.5806 | 0.5201 | 0.9981 | 0.02351 | | 2 | 0.6062 | -.4014 | 0.9990 | 0.02279 |
| | 3 | 0.4812 | 0.4544 | 0.9977 | 0.02146 | | 3 | 0.5428 | -.4019 | 0.9990 | 0.02041 |
| | 4 | 0.2682 | 0.5988 | 0.9897 | 0.02545 | | 4 | 0.4090 | -.2511 | 0.9959 | 0.03188 |
| 11110735 | 1 | 0.6276 | 0.8275 | 0.9988 | 0.02107 | 21110515 | 1 | 0.6424 | 0.4059 | 0.9987 | 0.02332 |
| | 2 | 0.5772 | 0.4190 | 0.9986 | 0.02105 | | 2 | 0.5980 | 0.1204 | 0.9985 | 0.02347 |
| | 3 | 0.4865 | 0.3616 | 0.9979 | 0.02183 | | 3 | 0.5282 | 0.0850 | 0.9980 | 0.02379 |
| | 4 | 0.2952 | 0.4896 | 0.9856 | 0.03476 | | 4 | 0.3818 | 0.1982 | 0.9927 | 0.03317 |
| 11110735 | 1 | 0.6244 | 0.9995 | 0.9982 | 0.02564 | 21110525 | 1 | 0.6450 | 0.3778 | 0.9991 | 0.01915 |
| | 2 | 0.5714 | 0.5440 | 0.9979 | 0.02553 | | 2 | 0.6009 | 0.0990 | 0.9989 | 0.01913 |
| | 3 | 0.4723 | 0.4784 | 0.9969 | 0.02566 | | 3 | 0.5339 | 0.0597 | 0.9986 | 0.01938 |
| | 4 | 0.2593 | 0.6248 | 0.9783 | 0.03764 | | 4 | 0.3974 | 0.1489 | 0.9953 | 0.02680 |
| 21110511 | 1 | 0.6525 | -.5276 | 0.9991 | 0.02384 | 21110535 | 1 | 0.6522 | 0.3795 | 0.9992 | 0.02069 |
| | 2 | 0.6095 | -.7695 | 0.9990 | 0.02303 | | 2 | 0.6077 | 0.0915 | 0.9991 | 0.02017 |
| | 3 | 0.5502 | -.7644 | 0.9989 | 0.02204 | | 3 | 0.5358 | 0.0600 | 0.9991 | 0.01830 |
| | 4 | 0.4286 | -.8261 | 0.9967 | 0.02999 | | 4 | 0.3804 | 0.1950 | 0.9955 | 0.02842 |
| 21110521 | 1 | 0.6507 | -.5058 | 0.9992 | 0.02190 | 21110611 | 1 | 0.6530 | -.2488 | 0.9993 | 0.02073 |
| | 2 | 0.6084 | -.7546 | 0.9992 | 0.02111 | | 2 | 0.6063 | -.5593 | 0.9993 | 0.02002 |
| | 3 | 0.5472 | -.7429 | 0.9992 | 0.01858 | | 3 | 0.5339 | -.5502 | 0.9992 | 0.01845 |
| | 4 | 0.4253 | -.8055 | 0.9973 | 0.02692 | | 4 | 0.3820 | -.3704 | 0.9939 | 0.03614 |
| 21110531 | 1 | 0.6512 | -.5215 | 0.9991 | 0.02304 | 21110621 | 1 | 0.6539 | -.2253 | 0.9990 | 0.02540 |
| | 2 | 0.6101 | -.7721 | 0.9991 | 0.02233 | | 2 | 0.6073 | -.5446 | 0.9989 | 0.02466 |
| | 3 | 0.5503 | -.7647 | 0.9990 | 0.02061 | | 3 | 0.5345 | -.5391 | 0.9987 | 0.02334 |
| | 4 | 0.4313 | -.8363 | 0.9965 | 0.03106 | | 4 | 0.3812 | -.3628 | 0.9919 | 0.04198 |
| 21110512 | 1 | 0.6537 | -.1860 | 0.9992 | 0.02188 | 21110631 | 1 | 0.6521 | -.2112 | 0.9990 | 0.02419 |
| | 2 | 0.6107 | -.4357 | 0.9991 | 0.02143 | | 2 | 0.6051 | -.5308 | 0.9989 | 0.02411 |
| | 3 | 0.5497 | -.4405 | 0.9992 | 0.01876 | | 3 | 0.5317 | -.5224 | 0.9987 | 0.02287 |
| | 4 | 0.4202 | -.2950 | 0.9963 | 0.03024 | | 4 | 0.3808 | -.3539 | 0.9936 | 0.03635 |
| 21110522 | 1 | 0.6534 | -.1732 | 0.9989 | 0.02605 | 21110612 | 1 | 0.6522 | 0.1415 | 0.9992 | 0.02268 |
| | 2 | 0.6106 | -.4278 | 0.9988 | 0.02538 | | 2 | 0.6045 | -.1891 | 0.9991 | 0.02243 |
| | 3 | 0.5481 | -.4294 | 0.9987 | 0.02425 | | 3 | 0.5274 | -.1918 | 0.9991 | 0.01895 |
| | 4 | 0.4142 | -.2734 | 0.9954 | 0.03442 | | 4 | 0.3601 | -.0018 | 0.9917 | 0.03994 |

S,I = regression coefficients (slope and intercept of equation 5.1);

$R^2$ = coefficient of determination; and

SE = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21110622 | 1 | 0.6533 | 0.1552 | 0.9990 | 0.02481 | 21110712 | 1 | 0.6486 | 0.4863 | 0.9992 | 0.02096 |
| | 2 | 0.6057 | -.1814 | 0.9989 | 0.02474 | | 2 | 0.5969 | 0.0696 | 0.9990 | 0.02072 |
| | 3 | 0.5270 | -.1809 | 0.9986 | 0.02414 | | 3 | 0.5073 | 0.0565 | 0.9987 | 0.02002 |
| | 4 | 0.3588 | 0.0073 | 0.9886 | 0.04643 | | 4 | 0.3157 | 0.2513 | 0.9877 | 0.03919 |
| 21110632 | 1 | 0.6517 | 0.1627 | 0.9991 | 0.02422 | 21110722 | 1 | 0.6490 | 0.4775 | 0.9992 | 0.01989 |
| | 2 | 0.6038 | -.1729 | 0.9989 | 0.02384 | | 2 | 0.5369 | 0.1458 | 0.9991 | 0.01856 |
| | 3 | 0.5255 | -.1742 | 0.9988 | 0.02158 | | 3 | 0.4580 | 0.1172 | 0.9985 | 0.01979 |
| | 4 | 0.3568 | 0.0156 | 0.9906 | 0.04206 | | 4 | 0.2998 | 0.2433 | 0.9880 | 0.03719 |
| 21110615 | 1 | 0.6469 | 0.7033 | 0.9990 | 0.02181 | 21110732 | 1 | 0.6492 | 0.4772 | 0.9988 | 0.02476 |
| | 2 | 0.5980 | 0.3311 | 0.9988 | 0.02168 | | 2 | 0.5456 | 0.1219 | 0.9984 | 0.02453 |
| | 3 | 0.5111 | 0.2857 | 0.9983 | 0.02197 | | 3 | 0.4668 | 0.0913 | 0.9975 | 0.02608 |
| | 4 | 0.3223 | 0.4374 | 0.9891 | 0.03521 | | 4 | 0.3041 | 0.2323 | 0.9850 | 0.04157 |
| 21110625 | 1 | 0.6508 | 0.6766 | 0.9989 | 0.02250 | 21110715 | 1 | 0.6444 | 1.0165 | 0.9983 | 0.02454 |
| | 2 | 0.6019 | 0.3084 | 0.9987 | 0.02240 | | 2 | 0.5706 | 0.5225 | 0.9974 | 0.02758 |
| | 3 | 0.5158 | 0.2623 | 0.9984 | 0.02142 | | 3 | 0.4772 | 0.4527 | 0.9969 | 0.02550 |
| | 4 | 0.3274 | 0.4162 | 0.9910 | 0.03280 | | 4 | 0.2830 | 0.5734 | 0.9904 | 0.02660 |
| 21110635 | 1 | 0.6437 | 0.6908 | 0.9989 | 0.02184 | 21110725 | 1 | 0.6464 | 1.0149 | 0.9984 | 0.02443 |
| | 2 | 0.5951 | 0.3229 | 0.9987 | 0.02172 | | 2 | 0.5933 | 0.5529 | 0.9981 | 0.02439 |
| | 3 | 0.5108 | 0.2732 | 0.9982 | 0.02211 | | 3 | 0.4924 | 0.4878 | 0.9971 | 0.02481 |
| | 4 | 0.3298 | 0.4077 | 0.9890 | 0.03580 | | 4 | 0.2759 | 0.6367 | 0.9802 | 0.03652 |
| 21110711 | 1 | 0.6524 | 0.0744 | 0.9991 | 0.02351 | 21110735 | 1 | 0.6449 | 1.0235 | 0.9987 | 0.02245 |
| | 2 | 0.6022 | -.3179 | 0.9990 | 0.02275 | | 2 | 0.6115 | 0.4275 | 0.9987 | 0.02203 |
| | 3 | 0.5151 | -.3060 | 0.9990 | 0.01997 | | 3 | 0.5049 | 0.3905 | 0.9979 | 0.02279 |
| | 4 | 0.3266 | -.0743 | 0.9873 | 0.04517 | | 4 | 0.2729 | 0.6107 | 0.9759 | 0.04222 |
| 21110721 | 1 | 0.6507 | 0.0937 | 0.9992 | 0.02187 | 31110511 | 1 | 0.6467 | -.5136 | 0.9991 | 0.02306 |
| | 2 | 0.5998 | -.3000 | 0.9991 | 0.02177 | | 2 | 0.6042 | -.7587 | 0.9990 | 0.02251 |
| | 3 | 0.5138 | -.2952 | 0.9990 | 0.01987 | | 3 | 0.5463 | -.7610 | 0.9991 | 0.01952 |
| | 4 | 0.3254 | -.0678 | 0.9842 | 0.05002 | | 4 | 0.4222 | -.6128 | 0.9968 | 0.02848 |
| 21110731 | 1 | 0.6540 | 0.0882 | 0.9993 | 0.02135 | 31110521 | 1 | 0.6477 | -.5200 | 0.9993 | 0.02143 |
| | 2 | 0.6033 | -.3083 | 0.9992 | 0.02075 | | 2 | 0.6069 | -.7730 | 0.9992 | 0.02080 |
| | 3 | 0.5166 | -.3021 | 0.9992 | 0.01813 | | 3 | 0.5476 | -.7686 | 0.9993 | 0.01781 |
| | 4 | 0.3278 | -.0754 | 0.9858 | 0.04757 | | 4 | 0.4218 | -.6124 | 0.9870 | 0.02791 |

S,I = regression coefficients (slope and intercept of equation 5.1);

$R^2$ = coefficient of determination; and

SE = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 31110531 | 1 | 0.6485 | -.5026 | 0.9994 | 0.01949 | 31110721 | 1 | 0.6485 | 0.1055 | 0.9990 | 0.02400 |
| | 2 | 0.6072 | -.7577 | 0.9994 | 0.01800 | | 2 | 0.5977 | -.2926 | 0.9989 | 0.02353 |
| | 3 | 0.5474 | -.7542 | 0.9993 | 0.01699 | | 3 | 0.5088 | -.2785 | 0.9987 | 0.02144 |
| | 4 | 0.2236 | -.3304 | 0.9967 | 0.02018 | | 4 | 0.3164 | -.0395 | 0.9854 | 0.04512 |
| 31110512 | 1 | 0.6488 | -.1531 | 0.9992 | 0.02195 | 31110731 | 1 | 0.6496 | 0.1083 | 0.9989 | 0.02491 |
| | 2 | 0.6050 | -.4080 | 0.9991 | 0.02225 | | 2 | 0.5979 | -.2890 | 0.9987 | 0.02452 |
| | 3 | 0.5420 | -.4106 | 0.9991 | 0.02021 | | 3 | 0.5083 | -.2737 | 0.9986 | 0.02135 |
| | 4 | 0.4089 | -.2626 | 0.9951 | 0.03458 | | 4 | 0.3135 | -.0270 | 0.9859 | 0.04267 |
| 31110522 | 1 | 0.6479 | -.1536 | 0.9993 | 0.02071 | 31110712 | 1 | 0.6427 | 0.4759 | 0.9987 | 0.02323 |
| | 2 | 0.6037 | -.4055 | 0.9992 | 0.02081 | | 2 | 0.5922 | 0.0596 | 0.9985 | 0.02283 |
| | 3 | 0.5419 | -.4120 | 0.9992 | 0.01908 | | 3 | 0.5072 | 0.0351 | 0.9981 | 0.02222 |
| | 4 | 0.4102 | -.2677 | 0.9952 | 0.03427 | | 4 | 0.3346 | 0.1777 | 0.9923 | 0.02930 |
| 31110532 | 1 | 0.6475 | -.1585 | 0.9993 | 0.02094 | 31110722 | 1 | 0.6452 | 0.4557 | 0.9987 | 0.02527 |
| | 2 | 0.6043 | -.4129 | 0.9992 | 0.02045 | | 2 | 0.5939 | 0.0473 | 0.9985 | 0.02501 |
| | 3 | 0.5405 | -.4100 | 0.9992 | 0.01847 | | 3 | 0.5058 | 0.0342 | 0.9982 | 0.02325 |
| | 4 | 0.4092 | -.2665 | 0.9959 | 0.03187 | | 4 | 0.3229 | 0.2079 | 0.9907 | 0.03385 |
| 31110515 | 1 | 0.6458 | 0.3963 | 0.9991 | 0.02194 | 31110732 | 1 | 0.6482 | 0.4647 | 0.9990 | 0.02221 |
| | 2 | 0.6009 | 0.1104 | 0.9989 | 0.02181 | | 2 | 0.5970 | 0.0508 | 0.9989 | 0.02179 |
| | 3 | 0.5293 | 0.0777 | 0.9988 | 0.02027 | | 3 | 0.5076 | 0.0390 | 0.9986 | 0.02063 |
| | 4 | 0.2149 | 0.4144 | 0.9927 | 0.02629 | | 4 | 0.3197 | 0.2252 | 0.9899 | 0.03543 |
| 31110525 | 1 | 0.6476 | 0.3583 | 0.9990 | 0.02371 | 31110715 | 1 | 0.6346 | 0.9849 | 0.9989 | 0.01957 |
| | 2 | 0.6032 | 0.0791 | 0.9989 | 0.02350 | | 2 | 0.5824 | 0.5373 | 0.9987 | 0.01940 |
| | 3 | 0.5321 | 0.0501 | 0.9986 | 0.02255 | | 3 | 0.4854 | 0.4705 | 0.9981 | 0.01916 |
| | 4 | 0.3748 | 0.1985 | 0.9930 | 0.03627 | | 4 | 0.2810 | 0.5990 | 0.9889 | 0.02724 |
| 31110535 | 1 | 0.6493 | 0.3498 | 0.9991 | 0.02312 | 31110725 | 1 | 0.6406 | 0.9968 | 0.9981 | 0.02546 |
| | 2 | 0.6050 | 0.0717 | 0.9989 | 0.02282 | | 2 | 0.5878 | 0.5425 | 0.9978 | 0.02539 |
| | 3 | 0.5337 | 0.0444 | 0.9987 | 0.02240 | | 3 | 0.4894 | 0.4749 | 0.9969 | 0.02518 |
| | 4 | 0.3762 | 0.1939 | 0.9923 | 0.03866 | | 4 | 0.2065 | 0.6680 | 0.9865 | 0.02799 |
| 31110711 | 1 | 0.6480 | 0.1026 | 0.9991 | 0.02331 | 31110735 | 1 | 0.6450 | 0.9943 | 0.9986 | 0.01998 |
| | 2 | 0.5970 | -.2936 | 0.9990 | 0.02280 | | 2 | 0.5922 | 0.5370 | 0.9984 | 0.01984 |
| | 3 | 0.5098 | -.2864 | 0.9990 | 0.02008 | | 3 | 0.4940 | 0.4672 | 0.9979 | 0.01889 |
| | 4 | 0.1785 | 0.1149 | 0.9902 | 0.02787 | | 4 | 0.2874 | 0.5940 | 0.9913 | 0.02234 |

S,I = regression coefficients (slope and intercept of equation 5.1);

$R^2$ = coefficient of determination; and

SE = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21210611 | 1 | 0.6741 | -.2008 | 0.9992 | 0.02256 | 21210635 | 1 | 0.6743 | 0.6692 | 0.9990 | 0.02154 |
| | 2 | 0.6271 | -.5262 | 0.9991 | 0.02171 | | 2 | 0.6255 | 0.2870 | 0.9989 | 0.02156 |
| | 3 | 0.5512 | -.5186 | 0.9990 | 0.02074 | | 3 | 0.5384 | 0.2463 | 0.9984 | 0.02168 |
| | 4 | - | - | - | - | | 4 | 0.3419 | 0.3603 | 0.9884 | 0.03856 |
| 21210621 | 1 | 0.6731 | -.1964 | 0.9993 | 0.02202 | 21310611 | 1 | 0.6895 | -.2069 | 0.9994 | 0.02122 |
| | 2 | 0.6258 | -.5210 | 0.9992 | 0.02136 | | 2 | 0.6426 | -.5354 | 0.9993 | 0.02049 |
| | 3 | 0.5503 | -.5147 | 0.9991 | 0.01927 | | 3 | 0.5675 | -.5360 | 0.9992 | 0.01921 |
| | 4 | 0.3896 | -.3252 | 0.9928 | 0.03976 | | 4 | 0.4040 | -.3426 | 0.9935 | 0.03953 |
| 21210631 | 1 | 0.6699 | -.1666 | 0.9992 | 0.02193 | 21310621 | 1 | 0.6899 | -.2181 | 0.9989 | 0.02705 |
| | 2 | 0.6221 | -.4954 | 0.9991 | 0.02199 | | 2 | 0.6425 | -.5433 | 0.9987 | 0.02675 |
| | 3 | 0.5471 | -.4944 | 0.9990 | 0.02028 | | 3 | 0.5660 | -.5361 | 0.9986 | 0.02462 |
| | 4 | 0.3854 | -.3056 | 0.9921 | 0.04079 | | 4 | 0.4001 | -.3308 | 0.9938 | 0.03658 |
| 21210612 | 1 | 0.6733 | 0.1808 | 0.9992 | 0.02036 | 21310631 | 1 | 0.6904 | -.2253 | 0.9992 | 0.02239 |
| | 2 | 0.6252 | -.1627 | 0.9991 | 0.02042 | | 2 | 0.6426 | -.5465 | 0.9992 | 0.02199 |
| | 3 | 0.5490 | -.1800 | 0.9989 | 0.01985 | | 3 | 0.5695 | -.5519 | 0.9992 | 0.01939 |
| | 4 | 0.3891 | -.0278 | 0.9948 | 0.03012 | | 4 | 0.4096 | -.3684 | 0.9929 | 0.04094 |
| 21210622 | 1 | 0.6781 | 0.1671 | 0.9994 | 0.01787 | 21310612 | 1 | 0.6897 | 0.1339 | 0.9991 | 0.02106 |
| | 2 | 0.6302 | -.1770 | 0.9994 | 0.01741 | | 2 | 0.6426 | -.2040 | 0.9990 | 0.02075 |
| | 3 | 0.5530 | -.1913 | 0.9993 | 0.01609 | | 3 | 0.5657 | -.2167 | 0.9989 | 0.01945 |
| | 4 | 0.3891 | -.0276 | 0.9948 | 0.03119 | | 4 | 0.3749 | -.0286 | 0.9952 | 0.02730 |
| 21210632 | 1 | 0.6780 | 0.1454 | 0.9990 | 0.02432 | 21310622 | 1 | 0.6903 | 0.1418 | 0.9992 | 0.02072 |
| | 2 | 0.6303 | -.1941 | 0.9988 | 0.02404 | | 2 | 0.6431 | -.1988 | 0.9991 | 0.02056 |
| | 3 | 0.5533 | -.2063 | 0.9987 | 0.02213 | | 3 | 0.5681 | -.2202 | 0.9988 | 0.02023 |
| | 4 | 0.3909 | -.0431 | 0.9949 | 0.03131 | | 4 | 0.3646 | -.0723 | 0.9974 | 0.02060 |
| 21210615 | 1 | 0.6679 | 0.6822 | 0.9989 | 0.02161 | 21310632 | 1 | 0.6896 | 0.1391 | 0.9991 | 0.02430 |
| | 2 | 0.6191 | 0.3176 | 0.9987 | 0.02161 | | 2 | 0.6421 | -.1993 | 0.9990 | 0.02380 |
| | 3 | 0.5338 | 0.2605 | 0.9982 | 0.02206 | | 3 | 0.5635 | -.2088 | 0.9989 | 0.02202 |
| | 4 | 0.3539 | 0.3766 | 0.9910 | 0.03278 | | 4 | 0.3941 | -.0289 | 0.9826 | 0.03981 |
| 21210625 | 1 | 0.6672 | 0.7017 | 0.9985 | 0.02450 | 21310615 | 1 | 0.6796 | 0.6930 | 0.9989 | 0.02131 |
| | 2 | 0.6184 | 0.3261 | 0.9983 | 0.02449 | | 2 | 0.6308 | 0.3177 | 0.9988 | 0.02117 |
| | 3 | 0.5337 | 0.2663 | 0.9978 | 0.02382 | | 3 | 0.5443 | 0.2606 | 0.9985 | 0.02056 |
| | 4 | 0.3554 | 0.3771 | 0.9924 | 0.02968 | | 4 | - | - | - | - |

S,I = regression coefficients (slope and intercept of equation 5.1);

$R^2$ = coefficient of determination; and

SE = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | SE | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21310625 | 1 | 0.6825 | 0.7200 | 0.9988 | 0.02348 | 12110515 | 1 | 0.6337 | 0.3542 | 0.9991 | 0.02207 |
| | 2 | 0.6334 | 0.3351 | 0.9986 | 0.02342 | | 2 | 0.5894 | 0.0750 | 0.9990 | 0.02187 |
| | 3 | 0.5455 | 0.2751 | 0.9980 | 0.02365 | | 3 | 0.5184 | 0.0463 | 0.9988 | 0.02117 |
| | 4 | 0.3594 | 0.3837 | 0.9906 | 0.03425 | | 4 | 0.3607 | 0.1967 | 0.9925 | 0.03629 |
| 21310635 | 1 | 0.6839 | 0.6954 | 0.9985 | 0.02457 | 12110525 | 1 | 0.6339 | 0.3779 | 0.9986 | 0.02517 |
| | 2 | 0.6350 | 0.3166 | 0.9983 | 0.02441 | | 2 | 0.5889 | 0.0935 | 0.9984 | 0.02520 |
| | 3 | 0.5516 | 0.2479 | 0.9981 | 0.02241 | | 3 | 0.5169 | 0.0638 | 0.9981 | 0.02391 |
| | 4 | - | - | - | - | | 4 | - | - | - | - |
| 12110511 | 1 | 0.6340 | -.5134 | 0.9990 | 0.02376 | 12110535 | 1 | 0.6318 | 0.3629 | 0.9988 | 0.02454 |
| | 2 | 0.5906 | -.7567 | 0.9989 | 0.02355 | | 2 | 0.5876 | 0.0839 | 0.9986 | 0.02432 |
| | 3 | 0.5324 | -.7585 | 0.9990 | 0.02057 | | 3 | 0.5174 | 0.0533 | 0.9984 | 0.02286 |
| | 4 | 0.4129 | -.6315 | 0.9969 | 0.02783 | | 4 | 0.1811 | 0.3874 | 1.0000 | 0.00000 |
| 12110521 | 1 | 0.6331 | -.5283 | 0.9990 | 0.02439 | 12110611 | 1 | 0.6356 | -.2075 | 0.9991 | 0.02275 |
| | 2 | 0.5891 | -.7652 | 0.9988 | 0.02448 | | 2 | 0.5882 | -.5292 | 0.9990 | 0.02245 |
| | 3 | 0.5326 | -.7714 | 0.9989 | 0.02158 | | 3 | 0.5184 | -.5306 | 0.9988 | 0.02180 |
| | 4 | 0.3177 | -.4828 | 0.9969 | 0.02275 | | 4 | 0.3607 | -.3481 | 0.9916 | 0.03963 |
| 12110531 | 1 | 0.6342 | -.5337 | 0.9991 | 0.02297 | 12110621 | 1 | 0.6326 | -.2103 | 0.9991 | 0.02361 |
| | 2 | 0.5904 | -.7698 | 0.9990 | 0.02256 | | 2 | 0.5848 | -.5255 | 0.9989 | 0.02387 |
| | 3 | 0.5335 | -.7742 | 0.9991 | 0.01925 | | 3 | 0.5132 | -.5264 | 0.9988 | 0.02185 |
| | 4 | 0.3127 | -.4775 | 0.9979 | 0.01834 | | 4 | 0.3550 | -.3323 | 0.9913 | 0.04081 |
| 12110512 | 1 | 0.6350 | -.1764 | 0.9990 | 0.02382 | 12110631 | 1 | 0.6333 | -.1739 | 0.9991 | 0.02321 |
| | 2 | 0.5932 | -.4334 | 0.9989 | 0.02311 | | 2 | 0.5862 | -.5043 | 0.9989 | 0.02274 |
| | 3 | 0.5298 | -.4292 | 0.9988 | 0.02193 | | 3 | 0.5114 | -.4969 | 0.9988 | 0.02147 |
| | 4 | 0.4013 | -.2906 | 0.9956 | 0.03155 | | 4 | 0.3566 | -.3233 | 0.9934 | 0.03451 |
| 12110522 | 1 | 0.6362 | -.1796 | 0.9992 | 0.02102 | 12110612 | 1 | 0.6334 | 0.1626 | 0.9990 | 0.02344 |
| | 2 | 0.5931 | -.4314 | 0.9992 | 0.02005 | | 2 | 0.5855 | -.1730 | 0.9989 | 0.02304 |
| | 3 | 0.5304 | -.4310 | 0.9991 | 0.01877 | | 3 | 0.5066 | -.1722 | 0.9987 | 0.02146 |
| | 4 | 0.3967 | -.2741 | 0.9956 | 0.03051 | | 4 | - | - | - | - |
| 12110532 | 1 | 0.6371 | -.1844 | 0.9991 | 0.02281 | 12110622 | 1 | 0.6350 | 0.1226 | 0.9993 | 0.02008 |
| | 2 | 0.5951 | -.4422 | 0.9990 | 0.02266 | | 2 | 0.5874 | -.2026 | 0.9992 | 0.01974 |
| | 3 | 0.5323 | -.4417 | 0.9988 | 0.02170 | | 3 | 0.5101 | -.2012 | 0.9992 | 0.01810 |
| | 4 | 0.3423 | -.1855 | 0.9948 | 0.02875 | | 4 | 0.3428 | -.0065 | 0.9888 | 0.04449 |

S,I = regression coefficients (slope and intercept of equation 5.1);

$R^2$ = coefficient of determination; and

SE = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12110632 | 1 | 0.6364 | 0.1317 | 0.9993 | 0.02010 | 12110722 | 1 | 0.6308 | 0.4838 | 0.9991 | 0.01850 |
| | 2 | 0.5887 | -.1983 | 0.9992 | 0.01991 | | 2 | 0.5792 | 0.0660 | 0.9990 | 0.01955 |
| | 3 | 0.5120 | -.2021 | 0.9993 | 0.01641 | | 3 | 0.4869 | 0.0622 | 0.9983 | 0.02111 |
| | 4 | 0.3436 | -.0072 | 0.9915 | 0.03853 | | 4 | 0.2521 | 0.2662 | 0.9921 | 0.02498 |
| 12110615 | 1 | 0.6350 | 0.6641 | 0.9992 | 0.01909 | 12110732 | 1 | 0.6357 | 0.4873 | 0.9993 | 0.02074 |
| | 2 | 0.5859 | 0.2968 | 0.9990 | 0.01893 | | 2 | 0.5840 | 0.0651 | 0.9991 | 0.02060 |
| | 3 | 0.4981 | 0.2571 | 0.9988 | 0.01763 | | 3 | 0.4908 | 0.0606 | 0.9986 | 0.02205 |
| | 4 | 0.2253 | 0.5162 | 0.9909 | 0.02511 | | 4 | 0.2886 | 0.2819 | 0.9794 | 0.04978 |
| 12110625 | 1 | 0.6319 | 0.6518 | 0.9991 | 0.02059 | 12110715 | 1 | 0.6260 | 1.0246 | 0.9988 | 0.02039 |
| | 2 | 0.5832 | 0.2922 | 0.9990 | 0.02040 | | 2 | 0.5729 | 0.5611 | 0.9985 | 0.02026 |
| | 3 | 0.4980 | 0.2488 | 0.9986 | 0.02036 | | 3 | 0.4735 | 0.4901 | 0.9981 | 0.01919 |
| | 4 | 0.3091 | 0.4113 | 0.9877 | 0.03741 | | 4 | - | - | - | - |
| 12110635 | 1 | 0.6332 | 0.6889 | 0.9991 | 0.01898 | 12110725 | 1 | 0.6286 | 0.9881 | 0.9989 | 0.01911 |
| | 2 | 0.5843 | 0.3167 | 0.9989 | 0.01875 | | 2 | 0.5759 | 0.5327 | 0.9987 | 0.01911 |
| | 3 | 0.4980 | 0.2691 | 0.9988 | 0.01688 | | 3 | 0.4776 | 0.4646 | 0.9981 | 0.01926 |
| | 4 | 0.2986 | 0.4107 | 0.9929 | 0.02515 | | 4 | 0.2708 | 0.5821 | 0.9858 | 0.03019 |
| 12110711 | 1 | 0.6327 | 0.1166 | 0.9990 | 0.02394 | 12110735 | 1 | 0.6234 | 1.0074 | 0.9976 | 0.02533 |
| | 2 | 0.5820 | -.2856 | 0.9989 | 0.02307 | | 2 | 0.5705 | 0.5513 | 0.9972 | 0.02533 |
| | 3 | 0.4939 | -.2761 | 0.9987 | 0.02104 | | 3 | 0.4722 | 0.4830 | 0.9960 | 0.02498 |
| | 4 | 0.3074 | -.0609 | 0.9834 | 0.04739 | | 4 | 0.2639 | 0.6183 | 0.9836 | 0.02844 |
| 12110721 | 1 | 0.6350 | 0.1041 | 0.9991 | 0.02217 | 11110715 | 1 | 0.6314 | 0.9973 | 0.9983 | 0.02344 |
| | 2 | 0.5841 | -.2963 | 0.9990 | 0.02169 | | 2 | 0.5785 | 0.5353 | 0.9981 | 0.02316 |
| | 3 | 0.4961 | -.2869 | 0.9989 | 0.01949 | | 3 | 0.4787 | 0.4679 | 0.9975 | 0.02165 |
| | 4 | 0.3031 | -.0446 | 0.9827 | 0.04668 | | 4 | 0.2659 | 0.6087 | 0.9891 | 0.02528 |
| 12110731 | 1 | 0.6329 | 0.1222 | 0.9992 | 0.02160 | 12210711 | 1 | 0.6573 | 0.1579 | 0.9992 | 0.02296 |
| | 2 | 0.5820 | -.2805 | 0.9991 | 0.02116 | | 2 | 0.6050 | -.2575 | 0.9990 | 0.02289 |
| | 3 | 0.4943 | -.2745 | 0.9989 | 0.02007 | | 3 | 0.5133 | -.2528 | 0.9988 | 0.02167 |
| | 4 | 0.3031 | -.0429 | 0.9833 | 0.04743 | | 4 | 0.3142 | -.0207 | 0.9813 | 0.05222 |
| 12110712 | 1 | 0.6320 | 0.4676 | 0.9992 | 0.02000 | 12210721 | 1 | 0.6584 | 0.0805 | 0.9996 | 0.01679 |
| | 2 | 0.5807 | 0.0532 | 0.9992 | 0.01943 | | 2 | 0.4995 | -.0983 | 0.9993 | 0.01613 |
| | 3 | 0.4900 | 0.0452 | 0.9989 | 0.01832 | | 3 | 0.5192 | -.3142 | 0.9994 | 0.01540 |
| | 4 | 0.1838 | 0.3527 | 0.9927 | 0.02329 | | 4 | 0.2428 | -.0248 | 0.9954 | 0.02242 |

S, I = regression coefficients;
$R^2$ = coefficient of determination; and
S.E. = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12210731 | 1 | 0.6555 | 0.1459 | 0.9992 | 0.02254 | 12310721 | 1 | 0.6695 | 0.1353 | 0.9993 | 0.02085 |
| | 2 | 0.6041 | -.2684 | 0.9991 | 0.02189 | | 2 | 0.6181 | -.2797 | 0.9993 | 0.02017 |
| | 3 | 0.5120 | -.2594 | 0.9988 | 0.02101 | | 3 | 0.5262 | -.2758 | 0.9991 | 0.01918 |
| | 4 | 0.1710 | 0.1632 | 0.9941 | 0.02053 | | 4 | 0.3287 | -.0517 | 0.9843 | 0.04953 |
| 12210712 | 1 | 0.6539 | 0.4833 | 0.9993 | 0.01943 | 12310731 | 1 | 0.6666 | 0.1388 | 0.9995 | 0.01804 |
| | 2 | 0.6024 | 0.0595 | 0.9992 | 0.01902 | | 2 | 0.6149 | -.2735 | 0.9995 | 0.01765 |
| | 3 | 0.5111 | 0.0423 | 0.9990 | 0.01784 | | 3 | 0.5224 | -.2674 | 0.9991 | 0.01898 |
| | 4 | 0.3182 | 0.2268 | 0.9901 | 0.03469 | | 4 | - | - | - | - |
| 12210722 | 1 | 0.6561 | 0.4743 | 0.9989 | 0.02410 | 12310712 | 1 | 0.6692 | 0.4744 | 0.9990 | 0.02376 |
| | 2 | 0.6046 | 0.0519 | 0.9988 | 0.02366 | | 2 | 0.6176 | 0.0476 | 0.9989 | 0.02338 |
| | 3 | 0.5181 | -.0582 | 0.9986 | 0.02212 | | 3 | 0.5249 | 0.0289 | 0.9986 | 0.02184 |
| | 4 | 0.2492 | 0.2596 | 0.9898 | 0.03140 | | 4 | 0.3271 | 0.2193 | 0.9918 | 0.03349 |
| 12210732 | 1 | 0.6561 | 0.4435 | 0.9990 | 0.02373 | 12310722 | 1 | 0.6686 | 0.4838 | 0.9992 | 0.02091 |
| | 2 | 0.6044 | 0.0296 | 0.9989 | 0.02352 | | 2 | 0.6167 | 0.0565 | 0.9990 | 0.02072 |
| | 3 | 0.5123 | 0.0190 | 0.9985 | 0.02339 | | 3 | 0.5244 | 0.0355 | 0.9988 | 0.02005 |
| | 4 | 0.3131 | 0.2282 | 0.9846 | 0.04564 | | 4 | 0.3273 | 0.2253 | 0.9885 | 0.03817 |
| 12210715 | 1 | 0.6577 | 0.9577 | 0.9990 | 0.01859 | 12310732 | 1 | 0.6673 | 0.4719 | 0.9995 | 0.01625 |
| | 2 | 0.6048 | 0.5009 | 0.9989 | 0.01841 | | 2 | 0.6158 | 0.0488 | 0.9994 | 0.01600 |
| | 3 | 0.5049 | 0.4281 | 0.9985 | 0.01747 | | 3 | 0.5239 | 0.0287 | 0.9993 | 0.01546 |
| | 4 | - | - | - | - | | 4 | 0.3274 | 0.2210 | 0.9902 | 0.03579 |
| 12210725 | 1 | 0.6532 | 0.9587 | 0.9984 | 0.02378 | 12310715 | 1 | 0.6728 | 0.9849 | 0.9983 | 0.02171 |
| | 2 | 0.6008 | 0.5034 | 0.9982 | 0.02360 | | 2 | 0.6195 | 0.5148 | 0.9980 | 0.02156 |
| | 3 | 0.5021 | 0.4295 | 0.9976 | 0.02271 | | 3 | 0.4993 | 0.4286 | 0.9972 | 0.02078 |
| | 4 | 0.2928 | 0.5547 | 0.9885 | 0.02900 | | 4 | 0.2259 | 0.5325 | 1.0000 | 0.00000 |
| 12210735 | 1 | 0.6497 | 1.0236 | 0.9982 | 0.02595 | 12310725 | 1 | 0.6705 | 0.9959 | 0.9979 | 0.02431 |
| | 2 | 0.5963 | 0.5531 | 0.9978 | 0.02582 | | 2 | 0.6170 | 0.5238 | 0.9975 | 0.02413 |
| | 3 | 0.4948 | 0.4763 | 0.9969 | 0.02551 | | 3 | 0.5160 | 0.4404 | 0.9968 | 0.02301 |
| | 4 | 0.2781 | 0.6070 | 0.9837 | 0.03319 | | 4 | 0.2126 | 0.5713 | 1.0000 | 0.00000 |
| 12310711 | 1 | 0.6716 | 0.1410 | 0.9992 | 0.02253 | 12310735 | 1 | 0.6658 | 0.9919 | 0.9984 | 0.02112 |
| | 2 | 0.6193 | -.2739 | 0.9991 | 0.02224 | | 2 | 0.6160 | 0.4476 | 0.9982 | 0.02118 |
| | 3 | 0.5276 | -.2738 | 0.9990 | 0.01988 | | 3 | 0.5161 | 0.3756 | 0.9974 | 0.02146 |
| | 4 | 0.3243 | -.0311 | 0.9834 | 0.05071 | | 4 | 0.3066 | 0.5088 | 0.9877 | 0.02786 |

S, I = regression coefficients;
$R^2$ = coefficient of determination; and
S.E. = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 22110611 | 1 | 0.6515 | -.2318 | 0.9991 | 0.02416 | 22110635 | 1 | 0.6522 | 0.6926 | 0.9991 | 0.02053 |
| | 2 | 0.6050 | -.5461 | 0.9990 | 0.02338 | | 2 | 0.6032 | 0.3185 | 0.9989 | 0.02040 |
| | 3 | 0.5330 | -.5411 | 0.9989 | 0.02156 | | 3 | 0.5164 | 0.2704 | 0.9986 | 0.02010 |
| | 4 | 0.3817 | -.3694 | 0.9922 | 0.04083 | | 4 | 0.3285 | 0.4155 | 0.9910 | 0.03195 |
| 22110621 | 1 | 0.6515 | -.2284 | 0.9990 | 0.02509 | 32110611 | 1 | 0.6482 | -.1628 | 0.9993 | 0.02053 |
| | 2 | 0.6042 | -.5406 | 0.9989 | 0.02488 | | 2 | 0.6013 | -.4957 | 0.9993 | 0.01937 |
| | 3 | 0.5335 | -.5422 | 0.9989 | 0.02162 | | 3 | 0.5240 | -.4819 | 0.9991 | 0.01908 |
| | 4 | 0.3246 | -.2600 | 0.9955 | 0.02731 | | 4 | - | - | - | - |
| 22110631 | 1 | 0.6515 | -.2085 | 0.9992 | 0.02230 | 32110621 | 1 | 0.6484 | -.1846 | 0.9991 | 0.02303 |
| | 2 | 0.6046 | -.5283 | 0.9991 | 0.02173 | | 2 | 0.6020 | -.5139 | 0.9991 | 0.02214 |
| | 3 | 0.5323 | -.5267 | 0.9991 | 0.01974 | | 3 | 0.5284 | -.5120 | 0.9987 | 0.02249 |
| | 4 | 0.3746 | -.3353 | 0.9919 | 0.04082 | | 4 | 0.3689 | -.3207 | 0.9909 | 0.04225 |
| 22110612 | 1 | 0.6514 | 0.1489 | 0.9994 | 0.01940 | 32110631 | 1 | 0.6490 | -.1672 | 0.9992 | 0.02218 |
| | 2 | 0.6041 | -.1839 | 0.9993 | 0.01910 | | 2 | 0.6014 | -.4965 | 0.9991 | 0.02171 |
| | 3 | 0.5259 | -.1832 | 0.9992 | 0.01830 | | 3 | 0.5265 | -.4918 | 0.9992 | 0.01849 |
| | 4 | 0.3575 | 0.0094 | 0.9901 | 0.04313 | | 4 | 0.3665 | -.3045 | 0.9927 | 0.03810 |
| 22110622 | 1 | 0.6510 | 0.1625 | 0.9992 | 0.02231 | 32110612 | 1 | 0.6460 | 0.1841 | 0.9993 | 0.02175 |
| | 2 | 0.6032 | -.1716 | 0.9991 | 0.02196 | | 2 | 0.5983 | -.1557 | 0.9992 | 0.02103 |
| | 3 | 0.5250 | -.1739 | 0.9989 | 0.02083 | | 3 | 0.5179 | -.1524 | 0.9991 | 0.01942 |
| | 4 | 0.3553 | 0.0200 | 0.9891 | 0.04485 | | 4 | 0.3440 | 0.0491 | 0.9879 | 0.04688 |
| 22110632 | 1 | 0.6476 | 0.1811 | 0.9990 | 0.02361 | 32110622 | 1 | 0.6472 | 0.1551 | 0.9991 | 0.02340 |
| | 2 | 0.5994 | -.1551 | 0.9988 | 0.02370 | | 2 | 0.6003 | -.1793 | 0.9990 | 0.02275 |
| | 3 | 0.5215 | -.1599 | 0.9982 | 0.02562 | | 3 | 0.5217 | -.1775 | 0.9990 | 0.02004 |
| | 4 | 0.3522 | 0.0316 | 0.9840 | 0.05125 | | 4 | 0.3083 | 0.0858 | 0.9929 | 0.03207 |
| 22110615 | 1 | 0.6479 | 0.6835 | 0.9991 | 0.01920 | 32110632 | 1 | 0.6493 | 0.1294 | 0.9993 | 0.02053 |
| | 2 | 0.5993 | 0.3146 | 0.9990 | 0.01890 | | 2 | 0.6016 | -.1964 | 0.9992 | 0.02053 |
| | 3 | 0.5141 | 0.2653 | 0.9987 | 0.01837 | | 3 | 0.5259 | -.2034 | 0.9991 | 0.01909 |
| | 4 | 0.3308 | 0.4025 | 0.9924 | 0.02902 | | 4 | 0.3161 | 0.0514 | 0.9939 | 0.03001 |
| 22110625 | 1 | 0.6501 | 0.6951 | 0.9986 | 0.02470 | 32110615 | 1 | 0.6448 | 0.6888 | 0.9992 | 0.01806 |
| | 2 | 0.6010 | 0.3226 | 0.9984 | 0.02455 | | 2 | 0.5961 | 0.3196 | 0.9991 | 0.01788 |
| | 3 | 0.5143 | 0.2745 | 0.9981 | 0.02329 | | 3 | 0.5100 | 0.2725 | 0.9988 | 0.01799 |
| | 4 | - | - | - | - | | 4 | - | - | - | - |

$S_2I$ = regression coefficients;

$R^2$ = coefficient of determination; and

S.E. = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 32110625 | 1 | 0.6451 | 0.8871 | 0.9991 | 0.02025 | 22210615 | 1 | 0.7067 | 0.4029 | 0.9993 | 0.01794 |
| | 2 | 0.5962 | 0.3204 | 0.9990 | 0.02012 | | 2 | 0.3265 | 0.8087 | 0.9999 | 0.00364 |
| | 3 | 0.5099 | 0.2742 | 0.9987 | 0.01923 | | 3 | 0.1604 | 1.1409 | 0.9811 | 0.02154 |
| | 4 | 0.3222 | 0.4233 | 0.9921 | 0.03042 | | 4 | 0.1470 | 0.1966 | 0.0645 | 0.54115 |
| 32110635 | 1 | 0.6462 | 0.6714 | 0.9989 | 0.02147 | 22210625 | 1 | 0.6796 | 0.6522 | 0.9993 | 0.01711 |
| | 2 | 0.5975 | 0.3057 | 0.9986 | 0.02119 | | 2 | 0.3284 | 0.8204 | 0.9946 | 0.02273 |
| | 3 | 0.5121 | 0.2587 | 0.9993 | 0.01953 | | 3 | 0.2531 | 0.7357 | 0.9941 | 0.01833 |
| | 4 | 0.3283 | 0.3993 | 0.9929 | 0.02818 | | 4 | - | - | - | - |
| 22210611 | 1 | 0.6762 | -.1236 | 0.9994 | 0.01669 | 22210635 | 1 | 0.6829 | 0.6057 | 0.9995 | 0 01471 |
| | 2 | 0.3082 | 0.1700 | 0.9996 | 0.00636 | | 2 | 0.3362 | 0.8000 | 0.9960 | 0.01952 |
| | 3 | 0.1692 | 0.1698 | 0.9957 | 0.01091 | | 3 | 0.2585 | 0.7223 | 0.9902 | 0 02362 |
| | 4 | 0 4374 | -1.1701 | 1.0000 | 0.00000 | | 4 | - | - | - | - |
| 22210621 | 1 | 0.6816 | -.1743 | 0.9994 | 0.01920 | 11120511 | 1 | 0.2835 | 0.4965 | 0.9985 | 0.01533 |
| | 2 | 0.2485 | 0.4367 | 0.9913 | 0.02765 | | 2 | 0.1149 | 1.2668 | 0.9870 | 0.01809 |
| | 3 | 0.1608 | 0.6325 | 0.9785 | 0.02832 | | 3 | 0.1063 | 1.3542 | 0.9809 | 0.02032 |
| | 4 | -.0114 | 0.9952 | 0.0274 | 0.07978 | | 4 | 0.0984 | 1.3969 | 0.9724 | 0.02273 |
| 22210631 | 1 | 0.6846 | -.1346 | 0.9999 | 0.00760 | 11120521 | 1 | 0.2860 | 0.4849 | 0.9970 | 0.02219 |
| | 2 | 0.2445 | 0.5108 | 0.9968 | 0.01629 | | 2 | 0.1333 | 1.3471 | 0.9882 | 0.02068 |
| | 3 | 0.1992 | 0.5729 | 0.9983 | 0.00959 | | 3 | 0.1139 | 1.3919 | 0.9909 | 0.01552 |
| | 4 | 0.0418 | 0.9923 | 0.2983 | 0.07541 | | 4 | 0.0872 | 1.4499 | 0.9966 | 0.00723 |
| 22210612 | 1 | 0.6852 | 0.1500 | 0.9996 | 0.01526 | 11120531 | 1 | 0.2927 | 0.4881 | 0.9903 | 0.01300 |
| | 2 | 0.2729 | 0.2676 | 0.9807 | 0.04213 | | 2 | 0.1876 | 1.0287 | 0.9937 | 0.02128 |
| | 3 | 0.1507 | 0.2206 | 0.9875 | 0.01865 | | 3 | 0.1640 | 1.1181 | 0.9928 | 0.01991 |
| | 4 | 0.3872 | -1.3177 | 0.9138 | 0.14327 | | 4 | 0.1445 | 1.1743 | 0.9960 | 0.01309 |
| 22210622 | 1 | 0.6647 | 0.2631 | 0.9991 | 0.02181 | 11120512 | 1 | 0.2890 | 0.5650 | 0.9984 | 0.01606 |
| | 2 | 0.2744 | 0.2651 | 0.9796 | 0.04332 | | 2 | 0.1240 | 1.2388 | 0.9891 | 0.01816 |
| | 3 | 0.1517 | 0.2185 | 0.9893 | 0.01726 | | 3 | 0.1246 | 1.2171 | 0.9924 | 0.01525 |
| | 4 | 0.3861 | -1.3103 | 0.8977 | 0.15612 | | 4 | 0.1345 | 1.1090 | 0.9837 | 0.02418 |
| 22210632 | 1 | 0.6653 | 0.2042 | 0.9995 | 0.01737 | 11120522 | 1 | 0.2989 | 0.5322 | 0.9980 | 0.01961 |
| | 2 | 0.2637 | 0.2930 | 0.9752 | 0.04769 | | 2 | 0.2675 | 0.6109 | 0.9909 | 0.03718 |
| | 3 | 0.1458 | 0.2339 | 0.9852 | 0.02032 | | 3 | 0.1907 | 0.7940 | 0.9936 | 0.02222 |
| | 4 | 0.3741 | -1.2816 | 0.9088 | 0.14739 | | 4 | -.1510 | 1.7258 | 0.5248 | 0.20834 |

$S_1$ I = regression coefficients;

$R^2$ = coefficient of determination; and

S.E. = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11120532 | 1 | 0.2938 | 0.5403 | 0.9979 | 0.01735 | 11320522 | 1 | 0.2993 | 0.6138 | 0.9981 | 0.01843 |
| | 2 | 0.1387 | 1.0080 | 0.9948 | 0.01298 | | 2 | 0.1824 | 0.9637 | 0.9836 | 0.03396 |
| | 3 | 0.0812 | 1.2122 | 0.9934 | 0.00858 | | 3 | 0.1420 | 1.0234 | 0.9772 | 0.03128 |
| | 4 | 0.0181 | 1.4111 | 0.2224 | 0.04394 | | 4 | 0.0753 | 1.0698 | 0.9179 | 0.03247 |
| 11120515 | 1 | 0.2996 | 0.6438 | 0.9978 | 0.01842 | 11320532 | 1 | 0.2940 | 0.6244 | 0.9984 | 0.01722 |
| | 2 | 0.1481 | 1.1612 | 0.9946 | 0.01444 | | 2 | 0.1837 | 0.9827 | 0.9876 | 0.03009 |
| | 3 | 0.0871 | 1.3571 | 0.9984 | 0.00459 | | 3 | 0.1483 | 1.0366 | 0.9836 | 0.02763 |
| | 4 | 0.0155 | 1.4885 | 0.1277 | 0.05345 | | 4 | 0.0862 | 1.0505 | 0.9806 | 0.01773 |
| 11120525 | 1 | 0.2926 | 0.6676 | 0.9976 | 0.01985 | 11320515 | 1 | 0.3058 | 0.5683 | 0.9980 | 0.01819 |
| | 2 | 0.2023 | 1.0545 | 0.9928 | 0.02370 | | 2 | 0.1086 | 1.4316 | 0.9952 | 0.01006 |
| | 3 | 0.1891 | 1.0615 | 0.9774 | 0.03942 | | 3 | 0.0596 | 1.5335 | 0.9937 | 0.00631 |
| | 4 | 0.1796 | 1.0114 | 0.9312 | 0.06688 | | 4 | -.0247 | 1.7195 | 0.6634 | 0.02345 |
| 11120535 | 1 | 0.2944 | 0.6800 | 0.9966 | 0.02357 | 11320525 | 1 | 0.3194 | 0.6069 | 0.9993 | 0.01158 |
| | 2 | 0.1026 | 1.3263 | 0.9909 | 0.01338 | | 2 | 0.0916 | 1.6182 | 0.9951 | 0.00854 |
| | 3 | 0.0754 | 1.3909 | 0.9889 | 0.01087 | | 3 | 0.0730 | 1.6504 | 0.9819 | 0.01321 |
| | 4 | 0.0388 | 1.5169 | 0.8973 | 0.01791 | | 4 | 0.0408 | 1.7667 | 0.8284 | 0.02477 |
| 11320511 | 1 | 0.3058 | 0.4853 | 0.9981 | 0.01910 | 11320535 | 1 | 0.2961 | 0.7991 | 0.9978 | 0.01935 |
| | 2 | 0.0775 | 1.1688 | 0.9710 | 0.01897 | | 2 | 0.1526 | 1.0441 | 0.9963 | 0.01302 |
| | 3 | 0.0588 | 1.5390 | 0.9787 | 0.01229 | | 3 | 0.1358 | 1.0502 | 0.9989 | 0.00640 |
| | 4 | 0.0818 | 1.3719 | 0.9121 | 0.03598 | | 4 | 0.1132 | 1.0757 | 0.9965 | 0.00939 |
| 11320521 | 1 | 0.3043 | 0.5098 | 0.9979 | 0.01895 | 22120611 | 1 | 0.3012 | 0.7479 | 0.9991 | 0.01283 |
| | 2 | 0.1508 | 0.5683 | 0.9950 | 0.01454 | | 2 | 0.1400 | 0.8117 | 0.9904 | 0.01924 |
| | 3 | 0.1677 | 0.4342 | 0.9925 | 0.01994 | | 3 | 0.1125 | 0.7015 | 0.9724 | 0.02648 |
| | 4 | 0.1674 | 0.4155 | 0.9829 | 0.03013 | | 4 | 0.0282 | 0.6348 | 0.1428 | 0.09634 |
| 11320531 | 1 | 0.3061 | 0.4587 | 0.9982 | 0.01919 | 22120621 | 1 | 0.3003 | 0.7650 | 0.9989 | 0.01440 |
| | 2 | 0.0944 | 1.0623 | 0.9959 | 0.00898 | | 2 | 0.2276 | 0.5183 | 0.9975 | 0.01668 |
| | 3 | 0.0989 | 0.9021 | 0.9872 | 0.01662 | | 3 | 0.2081 | 0.3898 | 0.9977 | 0.01468 |
| | 4 | 0.0832 | 0.7219 | 0.9512 | 0.02788 | | 4 | 0.2032 | 0.3175 | 0.9906 | 0.02893 |
| 11320512 | 1 | 0.3064 | 0.5853 | 0.9979 | 0.02061 | 22120631 | 1 | 0.2985 | 0.7970 | 0.9985 | 0.01657 |
| | 2 | 0.1376 | 0.8812 | 0.9890 | 0.02104 | | 2 | 0.1878 | 0.5253 | 0.9807 | 0.03806 |
| | 3 | 0.1129 | 0.9303 | 0.9894 | 0.01695 | | 3 | 0.1899 | 0.4894 | 0.9843 | 0.03464 |
| | 4 | 0.0667 | 0.9923 | 0.9292 | 0.02669 | | 4 | 0.1882 | 0.4855 | 0.9780 | 0.04078 |

$S_2I$ = regression coefficients;
$R^2$ = coefficient of determination; and
S.E. = standard error.

Table B. Parameters of the cumulative plastic deformation versus the number of load application curves.

| SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. | SAMPLE NUMBER | LVDT # | S | I | $R^2$ | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 22120612 | 1 | 0.3030 | 0.8184 | 0.9982 | 0.01777 | 32120631 | 1 | 0.2926 | 0.8295 | 0.9973 | 0.01828 |
| | 2 | 0.1034 | 1.4257 | 0.8650 | 0.05614 | | 2 | 0.6085 | -.5201 | 0.9980 | 0.03307 |
| | 3 | 0.0941 | 1.4392 | 0.8657 | 0.05092 | | 3 | 0.5305 | -.5036 | 0.9983 | 0.02658 |
| | 4 | 0.0414 | 1.5576 | 0.8448 | 0.02438 | | 4 | - | - | - | - |
| 22120622 | 1 | 0.2986 | 0.8325 | 0.9976 | 0.02115 | 32120612 | 1 | 0.2883 | 0.8292 | 0.9977 | 0.01686 |
| | 2 | 0.1527 | 0.8324 | 0.9685 | 0.03955 | | 2 | 0.6016 | -.5385 | 0.9918 | 0.06630 |
| | 3 | 0.1334 | 0.8512 | 0.9661 | 0.03583 | | 3 | 0.5246 | -.5206 | 0.9930 | 0.05342 |
| | 4 | 0.1307 | 0.7920 | 0.9503 | 0.04290 | | 4 | - | - | - | - |
| 22120632 | 1 | 0.2948 | 0.8732 | 0.9980 | 0.01974 | 32120622 | 1 | 0.2931 | 0.9384 | 0.9971 | 0.02413 |
| | 2 | 0.1956 | 0.6548 | 0.9928 | 0.02474 | | 2 | 0.1048 | 1.2190 | 0.9979 | 0.00741 |
| | 3 | 0.1311 | 0.7905 | 0.9880 | 0.02157 | | 3 | 0.1002 | 1.1809 | 0.9952 | 0.01070 |
| | 4 | 0.0741 | 0.9801 | 0.9292 | 0.03046 | | 4 | 0.1167 | 1.0350 | 0.9975 | 0.00895 |
| 22120615 | 1 | 0.2968 | 1.0042 | 0.9965 | 0.02332 | 32120632 | 1 | 0.3011 | 0.8554 | 0.9972 | 0.02130 |
| | 2 | 0.0762 | 1.3654 | 0.9956 | 0.00674 | | 2 | 0.1342 | 0.9923 | 0.9946 | 0.01326 |
| | 3 | 0.0620 | 1.3796 | 0.9946 | 0.00611 | | 3 | 0.0990 | 0.9724 | 0.9940 | 0.01038 |
| | 4 | 0.0206 | 1.4658 | 0.8861 | 0.00985 | | 4 | 0.0387 | 1.0194 | 0.7051 | 0.03367 |
| 22120625 | 1 | 0.2985 | 0.9706 | 0.9969 | 0.02203 | 32120615 | 1 | 0.2933 | 0.8170 | 0.9957 | 0.02360 |
| | 2 | 0.0926 | 1.1390 | 0.9922 | 0.01082 | | 2 | 0.5857 | -.4870 | 0.9978 | 0.03423 |
| | 3 | 0.0575 | 1.2894 | 0.9671 | 0.01397 | | 3 | 0.5192 | -.4748 | 0.9982 | 0.02740 |
| | 4 | 0.0722 | 1.3393 | 0.9796 | 0.01374 | | 4 | - | - | - | - |
| 22120635 | 1 | 0.2872 | 1.0416 | 0.9972 | 0.02141 | 32120635 | 1 | 0.2914 | 1.0470 | 0.9992 | 0.01221 |
| | 2 | 0.1661 | 0.9083 | 0.9949 | 0.01667 | | 2 | 0.1648 | 1.0793 | 0.9893 | 0.02535 |
| | 3 | 0.1937 | 0.8317 | 0.9977 | 0.01309 | | 3 | 0.1188 | 1.1518 | 0.9845 | 0.02202 |
| | 4 | 0.1977 | 0.8415 | 0.9973 | 0.01440 | | 4 | 0.0247 | 1.3323 | 0.4971 | 0.03665 |
| 32120611 | 1 | 0.2946 | 0.8275 | 0.9988 | 0.01252 | 32120635 | 1 | 0.2968 | 1.0508 | 0.9959 | 0.02524 |
| | 2 | 0.5836 | -.4858 | 0.9852 | 0.05048 | | 2 | 0.0797 | 1.2466 | 0.9926 | 0.00918 |
| | 3 | 0.5175 | -.4740 | 0.9858 | 0.04128 | | 3 | 0.0721 | 1.2013 | 0.9912 | 0.00902 |
| | 4 | - | - | - | - | | 4 | 0.0579 | 1.1741 | 0.9568 | 0.01636 |
| 32120621 | 1 | 0.2964 | 0.8115 | 0.9970 | 0.01947 | | | | | | |
| | 2 | 0.6086 | -.5184 | 0.9877 | 0.03486 | | | | | | |
| | 3 | 0.5304 | -.5021 | 0.9879 | 0.02904 | | | | | | |
| | 4 | - | - | - | - | | | | | | |

$S_2 I$ = regression coefficients;

$R^2$ = coefficient of determination; and

S.E. = standard error.

# APPENDIX C

The values of the parameters of the deflection basin of all beam specimens are presented in this Appendix.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| 11110511 | 2.909 | 150 | -0.545 | 0.488 | | | 5000 | -0.625 | 0.716 |
| | | 520 | -0.579 | 0.506 | | | 10000 | -0.632 | 0.743 |
| | | 1000 | -0.581 | 0.543 | | | 50000 | -0.648 | 0.805 |
| | | 5000 | -0.604 | 0.603 | | | 100000 | -0.654 | 0.832 |
| | | 10000 | -0.613 | 0.629 | 11110525 | 3.033 | 100 | -0.577 | 0.564 |
| | | 21940 | -0.622 | 0.658 | | | 500 | -0.595 | 0.630 |
| | | 164925 | -0.642 | 0.737 | | | 1000 | -0.603 | 0.657 |
| 11110521 | 2.951 | 100 | -0.533 | 0.487 | | | 5000 | -0.623 | 0.716 |
| | | 500 | -0.570 | 0.524 | | | 10000 | -0.630 | 0.742 |
| | | 1000 | -0.587 | 0.543 | | | 50000 | -0.646 | 0.805 |
| | | 5000 | -0.605 | 0.604 | | | 100000 | -0.652 | 0.832 |
| | | 10000 | -0.615 | 0.628 | 11110535 | 3.068 | 100 | -0.583 | 0.511 |
| | | 170420 | -0.645 | 0.738 | | | 500 | -0.598 | 0.630 |
| 11110531 | 3.001 | 100 | -0.533 | 0.487 | | | 1000 | -0.606 | 0.657 |
| | | 500 | -0.578 | 0.513 | | | 5027 | -0.626 | 0.716 |
| | | 1000 | -0.586 | 0.548 | | | 10400 | -0.633 | 0.745 |
| | | 5010 | -0.610 | 0.605 | | | 18000 | -0.638 | 0.765 |
| | | 10025 | -0.618 | 0.629 | 11210511 | 3.172 | 100 | -0.569 | 0.465 |
| | | 164725 | -0.647 | 0.738 | | | 500 | -0.590 | 0.526 |
| 11110512 | 2.982 | 155 | -0.561 | 0.508 | | | 1000 | -0.604 | 0.552 |
| | | 525 | -0.579 | 0.549 | | | 5000 | -0.624 | 0.612 |
| | | 1000 | -0.592 | 0.570 | | | 10000 | -0.630 | 0.641 |
| | | 5000 | -0.612 | 0.630 | | | 30500 | -0.643 | 0.682 |
| | | 10000 | -0.619 | 0.657 | | | 683000 | -0.671 | 0.805 |
| | | 26730 | -0.630 | 0.694 | 11210521 | 3.016 | 100 | -0.538 | 0.495 |
| | | 169100 | -0.648 | 0.766 | | | 500 | -0.575 | 0.534 |
| 11110522 | 3.116 | 100 | -0.568 | 0.472 | | | 1000 | -0.597 | 0.543 |
| | | 500 | -0.591 | 0.544 | | | 5000 | -0.611 | 0.612 |
| | | 1000 | -0.602 | 0.568 | | | 10000 | -0.620 | 0.639 |
| | | 5025 | -0.621 | 0.632 | | | 30550 | -0.633 | 0.681 |
| | | 10000 | -0.629 | 0.656 | | | 40000 | -0.635 | 0.692 |
| | | 158650 | -0.656 | 0.765 | | | 352030 | -0.656 | 0.777 |
| 11110532 | 3.015 | 100 | -0.576 | 0.456 | 11210531 | 3.032 | 150 | -0.573 | 0.470 |
| | | 500 | -0.587 | 0.540 | | | 550 | -0.572 | 0.548 |
| | | 1000 | -0.593 | 0.571 | | | 1000 | -0.598 | 0.546 |
| | | 5000 | -0.613 | 0.632 | | | 5000 | -0.613 | 0.613 |
| | | 10000 | -0.621 | 0.658 | | | 10000 | -0.619 | 0.642 |
| | | 30000 | -0.634 | 0.699 | | | 33100 | -0.634 | 0.686 |
| | | 163740 | -0.650 | 0.765 | | | 145000 | -0.649 | 0.742 |
| 11110515 | 3.061 | 100 | -0.578 | 0.566 | 11210512 | 3.083 | 100 | -0.574 | 0.477 |
| | | 500 | -0.598 | 0.628 | | | 500 | -0.592 | 0.550 |
| | | 1000 | -0.606 | 0.656 | | | 1000 | -0.599 | 0.581 |

SD# = beam designation number;
AV = percent air voids;
N = number of load applications; and
A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 5000 | -0.621 | 0.639 | | | 100900 | -0.660 | 0.844 |
| | | 10000 | -0.627 | 0.667 | 11310511 | 3.000 | 100 | -0.559 | 0.459 |
| | | 20000 | -0.635 | 0.694 | | | 500 | -0.586 | 0.523 |
| | | 34000 | -0.640 | 0.714 | | | 1000 | -0.589 | 0.561 |
| | | 164600 | -0.655 | 0.776 | | | 5000 | -0.611 | 0.618 |
| 11210522 | 3.111 | 100 | -0.565 | 0.496 | | | 10000 | -0.619 | 0.646 |
| | | 500 | -0.594 | 0.552 | | | 32142 | -0.632 | 0.690 |
| | | 1000 | -0.600 | 0.582 | | | 172900 | -0.649 | 0.755 |
| | | 5000 | -0.623 | 0.639 | 11310521 | 2.994 | 100 | -0.559 | 0.459 |
| | | 10000 | -0.629 | 0.668 | | | 500 | -0.579 | 0.534 |
| | | 44000 | -0.645 | 0.724 | | | 1000 | -0.592 | 0.556 |
| | | 165000 | -0.657 | 0.776 | | | 5000 | -0.613 | 0.617 |
| 11210532 | 3.154 | 100 | -0.578 | 0.490 | | | 10000 | -0.618 | 0.646 |
| | | 500 | -0.598 | 0.549 | | | 21000 | -0.627 | 0.674 |
| | | 1000 | -0.604 | 0.579 | | | 50535 | -0.636 | 0.707 |
| | | 5000 | -0.625 | 0.639 | | | 154500 | -0.648 | 0.750 |
| | | 10000 | -0.632 | 0.668 | 11310531 | 3.008 | 100 | -0.559 | 0.459 |
| | | 27100 | -0.643 | 0.706 | | | 200 | -0.584 | 0.468 |
| | | 49800 | -0.649 | 0.729 | | | 500 | -0.583 | 0.533 |
| | | 195000 | -0.661 | 0.783 | | | 1000 | -0.587 | 0.559 |
| 11210515 | 3.045 | 100 | -0.576 | 0.581 | | | 5000 | -0.611 | 0.619 |
| | | 500 | -0.598 | 0.639 | | | 10000 | -0.620 | 0.646 |
| | | 1000 | -0.607 | 0.664 | | | 30000 | -0.632 | 0.687 |
| | | 5000 | -0.625 | 0.726 | | | 164700 | -0.649 | 0.753 |
| | | 10000 | -0.632 | 0.753 | 11310512 | 3.014 | 100 | -0.573 | 0.487 |
| | | 21000 | -0.639 | 0.782 | | | 500 | -0.582 | 0.566 |
| | | 30400 | -0.643 | 0.796 | | | 1000 | -0.597 | 0.582 |
| | | 122877 | -0.655 | 0.851 | | | 5000 | -0.615 | 0.646 |
| 11210525 | 3.074 | 100 | -0.575 | 0.584 | | | 10000 | -0.623 | 0.673 |
| | | 500 | -0.600 | 0.640 | | | 30000 | -0.635 | 0.714 |
| | | 1000 | -0.609 | 0.665 | | | 75200 | -0.644 | 0.750 |
| | | 5200 | -0.627 | 0.729 | 11310522 | 3.060 | 100 | -0.560 | 0.503 |
| | | 10000 | -0.634 | 0.753 | | | 500 | -0.589 | 0.559 |
| | | 20000 | -0.641 | 0.780 | | | 1000 | -0.599 | 0.584 |
| | | 98850 | -0.655 | 0.842 | | | 5000 | -0.619 | 0.646 |
| 11210535 | 3.143 | 100 | -0.584 | 0.580 | | | 10000 | -0.626 | 0.674 |
| | | 500 | -0.606 | 0.639 | | | 30000 | -0.638 | 0.715 |
| | | 1000 | -0.613 | 0.666 | | | 56700 | -0.644 | 0.739 |
| | | 5000 | -0.631 | 0.727 | 11310532 | 3.081 | 120 | -0.571 | 0.510 |
| | | 10000 | -0.639 | 0.754 | | | 500 | -0.594 | 0.554 |
| | | 20000 | -0.645 | 0.780 | | | 1000 | -0.601 | 0.584 |
| | | 37500 | -0.651 | 0.805 | | | 5000 | -0.620 | 0.646 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 10000 | -0.628 | 0.672 | | | 30000 | -0.694 | 0.676 |
| | | 35340 | -0.641 | 0.721 | | | 165000 | -0.710 | 0.744 |
| | | 41700 | -0.643 | 0.727 | 11110612 | 2.752 | 100 | -0.551 | 0.470 |
| 11310515 | 3.039 | 100 | -0.577 | 0.584 | | | 500 | -0.564 | 0.543 |
| | | 500 | -0.599 | 0.645 | | | 1000 | -0.575 | 0.571 |
| | | 1000 | -0.607 | 0.671 | | | 5000 | -0.594 | 0.633 |
| | | 5000 | -0.625 | 0.733 | | | 10000 | -0.602 | 0.658 |
| | | 10000 | -0.632 | 0.759 | | | 42200 | -0.619 | 0.711 |
| 11310525 | 3.220 | 100 | -0.593 | 0.581 | | | 163500 | -0.633 | 0.762 |
| | | 500 | -0.611 | 0.647 | | | 216000 | -0.636 | 0.773 |
| | | 1000 | -0.620 | 0.671 | | | 337750 | -0.640 | 0.791 |
| | | 5000 | -0.637 | 0.734 | | | 510000 | -0.643 | 0.807 |
| | | 10000 | -0.644 | 0.761 | | | 855300 | -0.647 | 0.828 |
| | | 20300 | -0.651 | 0.788 | 11110622 | 5.421 | 100 | -0.740 | 0.471 |
| 11310535 | 2.932 | 100 | -0.571 | 0.582 | | | 500 | -0.757 | 0.543 |
| | | 500 | -0.590 | 0.647 | | | 1000 | -0.766 | 0.568 |
| | | 1000 | -0.598 | 0.671 | | | 5000 | -0.782 | 0.635 |
| | | 5300 | -0.618 | 0.734 | | | 10000 | -0.788 | 0.663 |
| | | 10000 | -0.624 | 0.758 | | | 30000 | -0.796 | 0.709 |
| | | 30000 | -0.635 | 0.801 | | | 166800 | -0.807 | 0.782 |
| | | 42100 | -0.638 | 0.813 | 11110632 | 4.358 | 100 | -0.657 | 0.483 |
| 11110611 | 4.141 | 100 | -0.635 | 0.447 | | | 500 | -0.682 | 0.543 |
| | | 500 | -0.653 | 0.524 | | | 1000 | -0.691 | 0.567 |
| | | 1000 | -0.673 | 0.537 | | | 5000 | -0.709 | 0.632 |
| | | 2170 | -0.683 | 0.568 | | | 10000 | -0.715 | 0.660 |
| | | 5870 | -0.690 | 0.611 | | | 36000 | -0.726 | 0.713 |
| | | 10350 | -0.698 | 0.632 | | | 161600 | -0.738 | 0.774 |
| | | 30000 | -0.706 | 0.676 | 11110615 | 5.303 | 100 | -0.748 | 0.565 |
| | | 150000 | -0.720 | 0.742 | | | 500 | -0.764 | 0.631 |
| 11110621 | 4.035 | 100 | -0.642 | 0.427 | | | 1000 | -0.770 | 0.660 |
| | | 500 | -0.653 | 0.514 | | | 5000 | -0.785 | 0.725 |
| | | 1000 | -0.668 | 0.533 | | | 10000 | -0.790 | 0.754 |
| | | 5000 | -0.683 | 0.603 | | | 20000 | -0.795 | 0.783 |
| | | 10000 | -0.689 | 0.632 | | | 40000 | -0.799 | 0.812 |
| | | 33000 | -0.700 | 0.681 | | | 44200 | -0.800 | 0.816 |
| | | 181000 | -0.715 | 0.748 | 11110625 | 2.676 | 100 | -0.546 | 0.571 |
| | | 351000 | -0.720 | 0.776 | | | 500 | -0.568 | 0.630 |
| 11110631 | 3.957 | 100 | -0.642 | 0.427 | | | 1000 | -0.579 | 0.655 |
| | | 500 | -0.651 | 0.505 | | | 5000 | -0.597 | 0.715 |
| | | 1170 | -0.656 | 0.554 | | | 10000 | -0.605 | 0.740 |
| | | 5000 | -0.676 | 0.605 | | | 26000 | -0.615 | 0.776 |
| | | 10000 | -0.684 | 0.631 | | | 51000 | -0.622 | 0.802 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 166770 | -0.632 | 0.848 | 11110712 | 6.586 | 100 | -0.827 | 0.471 |
| 11110635 | 3.178 | 100 | -0.586 | 0.567 | | | 500 | -0.846 | 0.536 |
| | | 600 | -0.609 | 0.635 | | | 1000 | -0.849 | 0.568 |
| | | 1000 | -0.615 | 0.655 | | | 5000 | -0.863 | 0.636 |
| | | 5050 | -0.634 | 0.717 | | | 18000 | -0.872 | 0.690 |
| | | 10150 | -0.640 | 0.744 | | | 30000 | -0.875 | 0.712 |
| | | 47000 | -0.655 | 0.803 | | | 61232 | -0.879 | 0.743 |
| 11110711 | 6.683 | 100 | -0.820 | 0.447 | 11110712 | 4.946 | 100 | -0.702 | 0.475 |
| | | 500 | -0.845 | 0.509 | | | 500 | -0.728 | 0.536 |
| | | 1050 | -0.850 | 0.541 | | | 1000 | -0.732 | 0.568 |
| | | 5000 | -0.865 | 0.606 | | | 5000 | -0.748 | 0.634 |
| | | 10200 | -0.871 | 0.636 | | | 10000 | -0.755 | 0.662 |
| | | 36700 | -0.878 | 0.691 | | | 30000 | -0.764 | 0.707 |
| | | 159340 | -0.886 | 0.756 | | | 173100 | -0.776 | 0.781 |
| 11110711 | 3.704 | 100 | -0.592 | 0.473 | 11110722 | 6.023 | 110 | -0.786 | 0.476 |
| | | 500 | -0.633 | 0.507 | | | 500 | -0.803 | 0.540 |
| | | 1000 | -0.640 | 0.539 | | | 1000 | -0.808 | 0.569 |
| | | 5000 | -0.657 | 0.606 | | | 5000 | -0.824 | 0.635 |
| | | 10000 | -0.666 | 0.631 | | | 10000 | -0.829 | 0.665 |
| | | 30000 | -0.677 | 0.675 | | | 38000 | -0.838 | 0.721 |
| | | 152000 | -0.693 | 0.739 | | | 164800 | -0.846 | 0.785 |
| 11110721 | 5.191 | 100 | -0.726 | 0.442 | 11110732 | 5.294 | 100 | -0.732 | 0.474 |
| | | 500 | -0.729 | 0.522 | | | 500 | -0.750 | 0.539 |
| | | 1000 | -0.745 | 0.538 | | | 1000 | -0.757 | 0.569 |
| | | 5400 | -0.761 | 0.609 | | | 5000 | -0.773 | 0.634 |
| | | 10400 | -0.768 | 0.636 | | | 10000 | -0.779 | 0.662 |
| | | 43000 | -0.780 | 0.694 | | | 30000 | -0.788 | 0.708 |
| | | 169500 | -0.790 | 0.752 | | | 33300 | -0.788 | 0.713 |
| 11110731 | 4.088 | 100 | -0.665 | 0.417 | | | 163200 | -0.799 | 0.781 |
| | | 500 | -0.657 | 0.512 | 11110715 | 7.048 | 100 | -0.880 | 0.566 |
| | | 1000 | -0.663 | 0.546 | | | 500 | -0.894 | 0.633 |
| | | 5000 | -0.685 | 0.605 | | | 1000 | -0.899 | 0.662 |
| | | 10000 | -0.693 | 0.631 | | | 5000 | -0.909 | 0.730 |
| | | 30000 | -0.703 | 0.677 | | | 11200 | -0.913 | 0.764 |
| | | 159800 | -0.718 | 0.744 | | | 12000 | -0.914 | 0.767 |
| 11110712 | 5.802 | 100 | -0.772 | 0.468 | | | 13100 | -0.914 | 0.771 |
| | | 500 | -0.787 | 0.538 | 11110715 | 7.042 | 100 | -0.878 | 0.566 |
| | | 1000 | -0.792 | 0.570 | | | 500 | -0.894 | 0.632 |
| | | 5000 | -0.808 | 0.634 | | | 1000 | -0.898 | 0.662 |
| | | 10600 | -0.814 | 0.666 | | | 5000 | -0.909 | 0.730 |
| | | 33400 | -0.823 | 0.715 | | | 8000 | -0.911 | 0.750 |
| | | 151100 | -0.831 | 0.780 | | | 10000 | -0.912 | 0.759 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 12100 | -0.913 | 0.768 | | | 500 | -0.584 | 0.508 |
| 11110725 | 5.924 | 100 | -0.796 | 0.565 | | | 1100 | -0.585 | 0.547 |
| | | 500 | -0.811 | 0.632 | | | 5000 | -0.605 | 0.607 |
| | | 1000 | -0.816 | 0.660 | | | 10200 | -0.615 | 0.633 |
| | | 5000 | -0.829 | 0.727 | | | 33500 | -0.628 | 0.679 |
| | | 10000 | -0.834 | 0.756 | | | 159300 | -0.645 | 0.737 |
| | | 20000 | -0.838 | 0.785 | 21110512 | 2.914 | 100 | -0.553 | 0.490 |
| | | 22544 | -0.839 | 0.790 | | | 500 | -0.578 | 0.542 |
| 11110725 | 7.005 | 100 | -0.875 | 0.568 | | | 1000 | -0.586 | 0.572 |
| | | 500 | -0.891 | 0.632 | | | 5000 | -0.607 | 0.633 |
| | | 1000 | -0.896 | 0.662 | | | 10600 | -0.615 | 0.661 |
| | | 5000 | -0.906 | 0.730 | | | 20900 | -0.623 | 0.686 |
| | | 10000 | -0.910 | 0.759 | | | 158700 | -0.643 | 0.764 |
| | | 15000 | -0.912 | 0.777 | 21110522 | 2.998 | 100 | -0.568 | 0.476 |
| | | 16000 | -0.912 | 0.780 | | | 500 | -0.581 | 0.549 |
| 11110735 | 5.899 | 100 | -0.794 | 0.565 | | | 1000 | -0.591 | 0.573 |
| | | 500 | -0.808 | 0.632 | | | 5000 | -0.612 | 0.633 |
| | | 1000 | -0.815 | 0.660 | | | 10000 | -0.621 | 0.658 |
| | | 5000 | -0.827 | 0.727 | | | 31300 | -0.633 | 0.702 |
| | | 10000 | -0.832 | 0.756 | | | 176600 | -0.650 | 0.769 |
| | | 20200 | -0.836 | 0.786 | 21110532 | 3.099 | 100 | -0.574 | 0.477 |
| 11110735 | 6.980 | 100 | -0.874 | 0.567 | | | 500 | -0.593 | 0.539 |
| | | 500 | -0.888 | 0.633 | | | 1000 | -0.600 | 0.571 |
| | | 1000 | -0.894 | 0.662 | | | 5000 | -0.621 | 0.632 |
| | | 5000 | -0.904 | 0.730 | | | 10400 | -0.628 | 0.660 |
| | | 10000 | -0.908 | 0.759 | | | 30000 | -0.639 | 0.701 |
| | | 20200 | -0.911 | 0.790 | | | 166000 | -0.656 | 0.768 |
| 21110511 | 2.952 | 100 | -0.557 | 0.447 | 21110515 | 3.118 | 120 | -0.585 | 0.575 |
| | | 500 | -0.565 | 0.532 | | | 500 | -0.604 | 0.628 |
| | | 1000 | -0.590 | 0.536 | | | 1000 | -0.610 | 0.658 |
| | | 5020 | -0.610 | 0.600 | | | 5000 | -0.629 | 0.718 |
| | | 10300 | -0.614 | 0.634 | | | 10000 | -0.636 | 0.745 |
| | | 31220 | -0.628 | 0.675 | | | 33200 | -0.648 | 0.791 |
| | | 176550 | -0.645 | 0.741 | 21110525 | 2.975 | 100 | -0.571 | 0.568 |
| 21110521 | 3.031 | 100 | -0.575 | 0.426 | | | 500 | -0.592 | 0.631 |
| | | 500 | -0.584 | 0.510 | | | 1000 | -0.600 | 0.657 |
| | | 1050 | -0.593 | 0.545 | | | 5000 | -0.618 | 0.718 |
| | | 5000 | -0.614 | 0.601 | | | 10000 | -0.626 | 0.744 |
| | | 10000 | -0.619 | 0.633 | | | 20600 | -0.634 | 0.771 |
| | | 35000 | -0.635 | 0.678 | 21110535 | 3.171 | 100 | -0.588 | 0.567 |
| | | 150600 | -0.649 | 0.735 | | | 500 | -0.606 | 0.630 |
| 21110531 | 2.958 | 100 | -0.572 | 0.439 | | | 1000 | -0.615 | 0.657 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 5000 | -0.633 | 0.718 | | | 5000 | -0.760 | 0.635 |
| | | 10000 | -0.640 | 0.745 | | | 10000 | -0.765 | 0.665 |
| | | 30000 | -0.651 | 0.788 | | | 30000 | -0.774 | 0.709 |
| | | 66000 | -0.658 | 0.818 | | | 164500 | -0.786 | 0.781 |
| 21110611 | 4.737 | 100 | -0.689 | 0.439 | 21110615 | 5.086 | 100 | -0.734 | 0.565 |
| | | 500 | -0.702 | 0.513 | | | 500 | -0.747 | 0.634 |
| | | 1000 | -0.715 | 0.540 | | | 1000 | -0.754 | 0.662 |
| | | 5000 | -0.730 | 0.606 | | | 5000 | -0.769 | 0.726 |
| | | 10000 | -0.736 | 0.636 | | | 10000 | -0.775 | 0.754 |
| | | 30300 | -0.747 | 0.680 | | | 30700 | -0.783 | 0.802 |
| | | 160300 | -0.760 | 0.749 | | | 31700 | -0.783 | 0.801 |
| 21110621 | 4.912 | 100 | -0.704 | 0.444 | 21110625 | 5.010 | 100 | -0.724 | 0.570 |
| | | 500 | -0.712 | 0.518 | | | 500 | -0.743 | 0.632 |
| | | 1000 | -0.725 | 0.539 | | | 1000 | -0.749 | 0.661 |
| | | 5400 | -0.745 | 0.608 | | | 5000 | -0.764 | 0.726 |
| | | 10900 | -0.749 | 0.639 | | | 10000 | -0.769 | 0.754 |
| | | 31050 | -0.759 | 0.681 | | | 30800 | -0.778 | 0.801 |
| | | 168930 | -0.772 | 0.752 | | | 35000 | -0.778 | 0.806 |
| 21110631 | 4.955 | 100 | -0.704 | 0.436 | 21110635 | 4.977 | 100 | -0.723 | 0.568 |
| | | 500 | -0.726 | 0.504 | | | 500 | -0.740 | 0.633 |
| | | 1000 | -0.729 | 0.541 | | | 1000 | -0.747 | 0.660 |
| | | 5000 | -0.745 | 0.607 | | | 5000 | -0.762 | 0.726 |
| | | 10000 | -0.752 | 0.635 | | | 10600 | -0.768 | 0.756 |
| | | 50000 | -0.766 | 0.701 | | | 30300 | -0.775 | 0.800 |
| | | 100000 | -0.771 | 0.730 | 21110711 | 6.778 | 100 | -0.844 | 0.433 |
| 21110612 | 4.973 | 100 | -0.704 | 0.480 | | | 500 | -0.854 | 0.507 |
| | | 500 | -0.728 | 0.540 | | | 1000 | -0.859 | 0.539 |
| | | 1000 | -0.734 | 0.571 | | | 5000 | -0.873 | 0.607 |
| | | 5000 | -0.751 | 0.635 | | | 10000 | -0.877 | 0.637 |
| | | 10000 | -0.757 | 0.664 | | | 31900 | -0.885 | 0.687 |
| | | 30000 | -0.766 | 0.709 | | | 175800 | -0.893 | 0.762 |
| | | 169200 | -0.778 | 0.782 | 21110721 | 6.867 | 100 | -0.836 | 0.450 |
| 21110622 | 5.090 | 100 | -0.720 | 0.469 | | | 500 | -0.862 | 0.507 |
| | | 500 | -0.737 | 0.541 | | | 1000 | -0.864 | 0.540 |
| | | 1000 | -0.743 | 0.569 | | | 5300 | -0.878 | 0.610 |
| | | 5000 | -0.759 | 0.635 | | | 10000 | -0.883 | 0.637 |
| | | 10000 | -0.765 | 0.664 | | | 31000 | -0.890 | 0.686 |
| | | 30000 | -0.774 | 0.709 | | | 171000 | -0.898 | 0.761 |
| | | 162310 | -0.785 | 0.781 | 21110731 | 6.917 | 100 | -0.844 | 0.447 |
| 21110632 | 5.094 | 100 | -0.716 | 0.475 | | | 500 | -0.864 | 0.507 |
| | | 500 | -0.735 | 0.542 | | | 1000 | -0.870 | 0.538 |
| | | 1000 | -0.744 | 0.568 | | | 5000 | -0.882 | 0.607 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 10000 | -0.886 | 0.638 | | | 10000 | -0.615 | 0.635 |
| | | 30000 | -0.893 | 0.684 | | | 30500 | -0.629 | 0.674 |
| | | 170000 | -0.901 | 0.761 | | | 162050 | -0.646 | 0.738 |
| 21110712 | 7.086 | 100 | -0.864 | 0.473 | 31110521 | 2.978 | 100 | -0.569 | 0.454 |
| | | 500 | -0.880 | 0.541 | | | 520 | -0.591 | 0.499 |
| | | 1000 | -0.885 | 0.570 | | | 1000 | -0.588 | 0.548 |
| | | 5000 | -0.898 | 0.638 | | | 5250 | -0.610 | 0.605 |
| | | 10000 | -0.903 | 0.667 | | | 10400 | -0.616 | 0.634 |
| | | 30900 | -0.909 | 0.716 | | | 30000 | -0.629 | 0.674 |
| | | 68500 | -0.913 | 0.752 | | | 165600 | -0.646 | 0.740 |
| 21110722 | 7.038 | 100 | -0.865 | 0.468 | 31110531 | 3.063 | 100 | -0.587 | 0.432 |
| | | 500 | -0.878 | 0.538 | | | 500 | -0.575 | 0.534 |
| | | 1000 | -0.884 | 0.568 | | | 1000 | -0.593 | 0.549 |
| | | 5200 | -0.895 | 0.639 | | | 5000 | -0.615 | 0.606 |
| | | 10000 | -0.899 | 0.667 | | | 10000 | -0.623 | 0.632 |
| | | 30000 | -0.906 | 0.715 | | | 30000 | -0.636 | 0.673 |
| 21110732 | 7.038 | 100 | -0.858 | 0.476 | | | 162900 | -0.651 | 0.740 |
| | | 500 | -0.877 | 0.541 | 31110512 | 3.080 | 100 | -0.560 | 0.490 |
| | | 1000 | -0.882 | 0.570 | | | 500 | -0.593 | 0.541 |
| | | 5000 | -0.895 | 0.637 | | | 1000 | -0.600 | 0.569 |
| | | 10000 | -0.899 | 0.667 | | | 5000 | -0.619 | 0.632 |
| | | 30000 | -0.906 | 0.715 | | | 10000 | -0.626 | 0.660 |
| 21110715 | 7.067 | 100 | -0.882 | 0.567 | | | 30600 | -0.638 | 0.703 |
| | | 550 | -0.896 | 0.638 | | | 167400 | -0.655 | 0.769 |
| | | 1000 | -0.900 | 0.663 | 31110522 | 3.051 | 100 | -0.552 | 0.501 |
| | | 5000 | -0.911 | 0.731 | | | 500 | -0.587 | 0.545 |
| | | 10000 | -0.914 | 0.761 | | | 1000 | -0.597 | 0.571 |
| 21110725 | 7.089 | 100 | -0.884 | 0.567 | | | 5000 | -0.616 | 0.634 |
| | | 500 | -0.897 | 0.634 | | | 10300 | -0.624 | 0.661 |
| | | 1000 | -0.902 | 0.663 | | | 30000 | -0.636 | 0.702 |
| | | 5000 | -0.912 | 0.731 | | | 164500 | -0.653 | 0.768 |
| | | 10000 | -0.916 | 0.761 | 31110532 | 3.015 | 100 | -0.569 | 0.469 |
| | | 11432 | -0.917 | 0.767 | | | 500 | -0.587 | 0.539 |
| 21110735 | 7.124 | 100 | -0.886 | 0.567 | | | 1000 | -0.593 | 0.572 |
| | | 500 | -0.899 | 0.635 | | | 5000 | -0.614 | 0.633 |
| | | 1000 | -0.905 | 0.663 | | | 10000 | -0.622 | 0.659 |
| | | 5000 | -0.915 | 0.732 | | | 30500 | -0.634 | 0.702 |
| | | 10000 | -0.918 | 0.761 | | | 168000 | -0.651 | 0.768 |
| 31110511 | 2.974 | 110 | -0.556 | 0.472 | 31110515 | 3.155 | 100 | -0.582 | 0.573 |
| | | 500 | -0.578 | 0.517 | | | 500 | -0.606 | 0.631 |
| | | 1000 | -0.580 | 0.556 | | | 1000 | -0.614 | 0.658 |
| | | 5000 | -0.606 | 0.609 | | | 5000 | -0.632 | 0.719 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 10000 | -0.639 | 0.746 | | | 10400 | -0.896 | 0.670 |
| | | 30000 | -0.650 | 0.788 | | | 23500 | -0.901 | 0.705 |
| | | 63188 | -0.656 | 0.818 | 31110722 | 6.878 | 100 | -0.850 | 0.471 |
| 31110525 | 2.989 | 100 | -0.572 | 0.572 | | | 500 | -0.865 | 0.541 |
| | | 500 | -0.593 | 0.631 | | | 1000 | -0.872 | 0.569 |
| | | 1000 | -0.601 | 0.658 | | | 5500 | -0.884 | 0.643 |
| | | 5200 | -0.620 | 0.720 | | | 10400 | -0.889 | 0.670 |
| | | 10000 | -0.627 | 0.745 | | | 27800 | -0.895 | 0.712 |
| | | 30200 | -0.638 | 0.787 | | | 52500 | -0.898 | 0.740 |
| | | 98000 | -0.649 | 0.833 | 31110732 | 6.983 | 100 | -0.862 | 0.488 |
| 31110535 | 2.958 | 100 | -0.570 | 0.570 | | | 500 | -0.872 | 0.542 |
| | | 500 | -0.591 | 0.631 | | | 1000 | -0.879 | 0.570 |
| | | 1000 | -0.600 | 0.657 | | | 5750 | -0.892 | 0.645 |
| | | 5000 | -0.618 | 0.718 | | | 10900 | -0.897 | 0.672 |
| | | 10000 | -0.625 | 0.744 | | | 26800 | -0.902 | 0.711 |
| | | 30000 | -0.636 | 0.787 | | | 62100 | -0.905 | 0.748 |
| | | 112800 | -0.648 | 0.838 | 31110715 | 6.750 | 110 | -0.860 | 0.571 |
| 31110711 | 6.921 | 100 | -0.846 | 0.441 | | | 500 | -0.871 | 0.636 |
| | | 500 | -0.862 | 0.513 | | | 1000 | -0.877 | 0.665 |
| | | 1000 | -0.869 | 0.541 | | | 5500 | -0.889 | 0.736 |
| | | 5000 | -0.882 | 0.608 | | | 10100 | -0.892 | 0.761 |
| | | 10000 | -0.887 | 0.637 | | | 12450 | -0.893 | 0.770 |
| | | 34800 | -0.895 | 0.692 | 31110725 | 6.919 | 110 | -0.871 | 0.572 |
| | | 165700 | -0.902 | 0.761 | | | 580 | -0.885 | 0.642 |
| 31110721 | 6.946 | 135 | -0.858 | 0.448 | | | 1000 | -0.890 | 0.664 |
| | | 500 | -0.866 | 0.508 | | | 5500 | -0.901 | 0.736 |
| | | 1150 | -0.870 | 0.548 | | | 10000 | -0.904 | 0.762 |
| | | 5000 | -0.883 | 0.609 | | | 13800 | -0.906 | 0.776 |
| | | 10000 | -0.889 | 0.638 | 31110735 | 6.976 | 110 | -0.876 | 0.572 |
| | | 32000 | -0.896 | 0.688 | | | 530 | -0.889 | 0.638 |
| | | 162650 | -0.903 | 0.761 | | | 1000 | -0.894 | 0.664 |
| 31110731 | 7.007 | 160 | -0.857 | 0.459 | | | 5400 | -0.905 | 0.735 |
| | | 500 | -0.869 | 0.509 | | | 6820 | -0.906 | 0.745 |
| | | 1000 | -0.875 | 0.540 | | | 8800 | -0.907 | 0.756 |
| | | 5100 | -0.888 | 0.609 | | | 10800 | -0.908 | 0.765 |
| | | 11000 | -0.893 | 0.642 | 21210611 | 4.991 | 130 | -0.717 | 0.458 |
| | | 20500 | -0.897 | 0.669 | | | 500 | -0.719 | 0.529 |
| | | 169500 | -0.907 | 0.763 | | | 1030 | -0.732 | 0.553 |
| 31110712 | 6.985 | 100 | -0.860 | 0.472 | | | 5000 | -0.748 | 0.618 |
| | | 500 | -0.873 | 0.541 | | | 10000 | -0.755 | 0.646 |
| | | 1000 | -0.880 | 0.569 | | | 24050 | -0.764 | 0.681 |
| | | 5200 | -0.891 | 0.640 | | | 177800 | -0.778 | 0.765 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| 21210621 | 4.994 | 110 | -0.707 | 0.459 | | | 500 | -0.748 | 0.643 |
| | | 500 | -0.724 | 0.522 | | | 1000 | -0.754 | 0.672 |
| | | 1020 | -0.736 | 0.548 | | | 5000 | -0.768 | 0.737 |
| | | 5600 | -0.750 | 0.622 | | | 10000 | -0.773 | 0.765 |
| | | 10600 | -0.757 | 0.647 | | | 16500 | -0.777 | 0.786 |
| | | 24500 | -0.764 | 0.682 | 21210635 | 4.983 | 100 | -0.726 | 0.578 |
| | | 177100 | -0.778 | 0.765 | | | 500 | -0.743 | 0.643 |
| 21210631 | 5.122 | 100 | -0.707 | 0.465 | | | 1000 | -0.748 | 0.672 |
| | | 500 | -0.738 | 0.517 | | | 5000 | -0.763 | 0.736 |
| | | 1000 | -0.743 | 0.551 | | | 10000 | -0.769 | 0.765 |
| | | 5000 | -0.759 | 0.616 | | | 27600 | -0.776 | 0.807 |
| | | 10620 | -0.766 | 0.647 | | | 27850 | -0.776 | 0.807 |
| | | 23600 | -0.772 | 0.681 | 21310611 | 4.986 | 100 | -0.707 | 0.465 |
| | | 154400 | -0.786 | 0.760 | | | 500 | -0.723 | 0.533 |
| 21210612 | 5.179 | 100 | -0.721 | 0.490 | | | 1000 | -0.736 | 0.554 |
| | | 520 | -0.744 | 0.553 | | | 5000 | -0.749 | 0.623 |
| | | 1000 | -0.751 | 0.579 | | | 10700 | -0.756 | 0.654 |
| | | 5120 | -0.767 | 0.647 | | | 29500 | -0.765 | 0.695 |
| | | 10700 | -0.773 | 0.677 | | | 163900 | -0.778 | 0.768 |
| | | 23650 | -0.779 | 0.710 | 21310621 | 4.930 | 150 | -0.709 | 0.476 |
| | | 51700 | -0.785 | 0.743 | | | 550 | -0.722 | 0.534 |
| 21210622 | 5.175 | 100 | -0.723 | 0.489 | | | 1040 | -0.729 | 0.558 |
| | | 500 | -0.742 | 0.552 | | | 5000 | -0.746 | 0.622 |
| | | 1000 | -0.751 | 0.580 | | | 10000 | -0.753 | 0.650 |
| | | 5000 | -0.767 | 0.645 | | | 32000 | -0.762 | 0.699 |
| | | 10000 | -0.772 | 0.675 | | | 167500 | -0.774 | 0.768 |
| | | 30500 | -0.781 | 0.721 | 21310631 | 4.906 | 100 | -0.689 | 0.480 |
| | | 67800 | -0.787 | 0.754 | | | 500 | -0.716 | 0.532 |
| 21210632 | 5.064 | 100 | -0.717 | 0.485 | | | 1000 | -0.727 | 0.557 |
| | | 500 | -0.735 | 0.552 | | | 5050 | -0.744 | 0.622 |
| | | 1000 | -0.743 | 0.579 | | | 10500 | -0.751 | 0.653 |
| | | 5000 | -0.758 | 0.646 | | | 18500 | -0.756 | 0.675 |
| | | 10000 | -0.764 | 0.674 | | | 161600 | -0.772 | 0.766 |
| | | 30000 | -0.773 | 0.720 | 21310612 | 4.935 | 150 | -0.716 | 0.506 |
| | | 71600 | -0.779 | 0.756 | | | 500 | -0.727 | 0.558 |
| 21210615 | 5.030 | 100 | -0.729 | 0.578 | | | 1000 | -0.735 | 0.586 |
| | | 500 | -0.746 | 0.643 | | | 5000 | -0.750 | 0.652 |
| | | 1000 | -0.753 | 0.671 | | | 10200 | -0.756 | 0.681 |
| | | 5000 | -0.767 | 0.737 | | | 28000 | -0.765 | 0.722 |
| | | 10000 | -0.772 | 0.765 | | | 48000 | -0.769 | 0.745 |
| | | 19500 | -0.777 | 0.793 | 21310622 | 4.990 | 100 | -0.713 | 0.494 |
| 21210625 | 5.051 | 100 | -0.730 | 0.580 | | | 500 | -0.730 | 0.560 |

SD# = beam designation number;
AV = percent air voids;
N = number of load applications; and
A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 1000 | -0.738 | 0.587 | | | 166200 | -0.643 | 0.739 |
| | | 5000 | -0.754 | 0.652 | 12110531 | 2.898 | 100 | -0.533 | 0.487 |
| | | 10000 | -0.760 | 0.680 | | | 500 | -0.564 | 0.528 |
| | | 30000 | -0.769 | 0.725 | | | 1000 | -0.581 | 0.543 |
| | | 33000 | -0.770 | 0.729 | | | 5150 | -0.604 | 0.607 |
| 21310632 | 4.971 | 100 | -0.713 | 0.490 | | | 10000 | -0.611 | 0.633 |
| | | 500 | -0.728 | 0.560 | | | 30000 | -0.624 | 0.673 |
| | | 1000 | -0.737 | 0.586 | | | 189900 | -0.642 | 0.744 |
| | | 5000 | -0.753 | 0.651 | 12110512 | 2.949 | 100 | -0.576 | 0.456 |
| | | 10000 | -0.759 | 0.680 | | | 500 | -0.586 | 0.538 |
| | | 29000 | -0.767 | 0.724 | | | 1000 | -0.590 | 0.571 |
| | | 123300 | -0.777 | 0.785 | | | 5000 | -0.608 | 0.634 |
| 21310615 | 4.984 | 120 | -0.729 | 0.593 | | | 10000 | -0.617 | 0.659 |
| | | 500 | -0.744 | 0.650 | | | 26600 | -0.628 | 0.696 |
| | | 1000 | -0.750 | 0.678 | | | 144000 | -0.645 | 0.761 |
| | | 5000 | -0.764 | 0.743 | 12110522 | 2.959 | 150 | -0.568 | 0.496 |
| | | 10100 | -0.770 | 0.771 | | | 500 | -0.575 | 0.554 |
| | | 22000 | -0.775 | 0.804 | | | 1100 | -0.593 | 0.571 |
| 21310625 | 5.189 | 100 | -0.743 | 0.583 | | | 5200 | -0.610 | 0.634 |
| | | 500 | -0.759 | 0.650 | | | 10100 | -0.619 | 0.658 |
| | | 1000 | -0.765 | 0.678 | | | 27400 | -0.629 | 0.697 |
| | | 5100 | -0.779 | 0.744 | | | 175550 | -0.647 | 0.769 |
| | | 10000 | -0.784 | 0.772 | 12110532 | 2.987 | 100 | -0.573 | 0.470 |
| | | 20756 | -0.789 | 0.803 | | | 500 | -0.588 | 0.540 |
| 21310635 | 5.063 | 100 | -0.730 | 0.588 | | | 1400 | -0.595 | 0.585 |
| | | 500 | -0.749 | 0.650 | | | 5000 | -0.612 | 0.633 |
| | | 1000 | -0.756 | 0.678 | | | 12300 | -0.622 | 0.667 |
| | | 5000 | -0.770 | 0.743 | | | 20100 | -0.627 | 0.686 |
| | | 9850 | -0.775 | 0.771 | | | 167500 | -0.649 | 0.767 |
| 12110511 | 3.017 | 100 | -0.553 | 0.462 | 12110515 | 2.982 | 100 | -0.571 | 0.572 |
| | | 500 | -0.575 | 0.529 | | | 500 | -0.593 | 0.630 |
| | | 1000 | -0.585 | 0.553 | | | 1000 | -0.601 | 0.657 |
| | | 5000 | -0.613 | 0.603 | | | 5000 | -0.619 | 0.718 |
| | | 10000 | -0.620 | 0.631 | | | 10000 | -0.627 | 0.744 |
| | | 30300 | -0.631 | 0.675 | | | 30000 | -0.637 | 0.787 |
| | | 157000 | -0.648 | 0.737 | | | 102631 | -0.649 | 0.835 |
| 12110521 | 2.931 | 100 | -0.533 | 0.487 | 12110525 | 3.129 | 150 | -0.585 | 0.590 |
| | | 500 | -0.570 | 0.524 | | | 500 | -0.604 | 0.632 |
| | | 1000 | -0.579 | 0.552 | | | 1000 | -0.612 | 0.656 |
| | | 5300 | -0.606 | 0.605 | | | 5000 | -0.630 | 0.718 |
| | | 10000 | -0.615 | 0.630 | | | 11500 | -0.639 | 0.751 |
| | | 30000 | -0.626 | 0.672 | | | 30000 | -0.648 | 0.788 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 65100 | -0.655 | 0.818 | | | 191500 | -0.771 | 0.787 |
| 12110535 | 2.977 | 100 | -0.573 | 0.567 | 12110632 | 4.958 | 100 | -0.702 | 0.483 |
| | | 500 | -0.592 | 0.632 | | | 500 | -0.728 | 0.538 |
| | | 1000 | -0.601 | 0.656 | | | 1000 | -0.732 | 0.571 |
| | | 5300 | -0.620 | 0.721 | | | 5100 | -0.750 | 0.636 |
| | | 10300 | -0.627 | 0.746 | | | 10800 | -0.757 | 0.667 |
| | | 30000 | -0.637 | 0.786 | | | 30000 | -0.765 | 0.709 |
| | | 62200 | -0.644 | 0.815 | | | 166100 | -0.777 | 0.781 |
| 12110611 | 5.025 | 100 | -0.696 | 0.463 | 12110615 | 4.994 | 150 | -0.727 | 0.588 |
| | | 500 | -0.722 | 0.519 | | | 500 | -0.742 | 0.632 |
| | | 1000 | -0.738 | 0.536 | | | 1000 | -0.749 | 0.661 |
| | | 5000 | -0.751 | 0.605 | | | 5400 | -0.763 | 0.730 |
| | | 10000 | -0.757 | 0.635 | | | 11100 | -0.769 | 0.759 |
| | | 30250 | -0.766 | 0.682 | | | 30100 | -0.776 | 0.800 |
| | | 143700 | -0.778 | 0.746 | | | 51000 | -0.780 | 0.822 |
| 12110621 | 4.927 | 100 | -0.680 | 0.470 | 12110625 | 4.818 | 100 | -0.708 | 0.572 |
| | | 500 | -0.717 | 0.518 | | | 500 | -0.728 | 0.635 |
| | | 1000 | -0.730 | 0.538 | | | 1000 | -0.736 | 0.660 |
| | | 5500 | -0.744 | 0.611 | | | 5000 | -0.750 | 0.726 |
| | | 10700 | -0.751 | 0.637 | | | 10000 | -0.756 | 0.754 |
| | | 30000 | -0.760 | 0.680 | | | 30000 | -0.764 | 0.799 |
| | | 192000 | -0.774 | 0.758 | | | 53800 | -0.768 | 0.824 |
| 12110631 | 5.178 | 100 | -0.726 | 0.435 | 12110635 | 5.087 | 125 | -0.733 | 0.579 |
| | | 500 | -0.738 | 0.510 | | | 500 | -0.749 | 0.633 |
| | | 1000 | -0.745 | 0.541 | | | 1000 | -0.755 | 0.661 |
| | | 5000 | -0.762 | 0.606 | | | 5100 | -0.769 | 0.728 |
| | | 10000 | -0.768 | 0.636 | | | 10200 | -0.775 | 0.756 |
| | | 50000 | -0.781 | 0.702 | | | 21600 | -0.781 | 0.787 |
| | | 100000 | -0.785 | 0.732 | | | 27700 | -0.782 | 0.797 |
| 12110612 | 5.084 | 130 | -0.719 | 0.488 | 12110711 | 7.026 | 100 | -0.864 | 0.431 |
| | | 500 | -0.734 | 0.543 | | | 500 | -0.867 | 0.513 |
| | | 1000 | -0.741 | 0.572 | | | 1000 | -0.878 | 0.538 |
| | | 6000 | -0.760 | 0.643 | | | 5300 | -0.890 | 0.610 |
| | | 10100 | -0.765 | 0.665 | | | 10000 | -0.894 | 0.638 |
| | | 30200 | -0.774 | 0.710 | | | 25500 | -0.900 | 0.678 |
| | | 186800 | -0.786 | 0.787 | | | 148700 | -0.908 | 0.756 |
| 12110622 | 4.846 | 100 | -0.699 | 0.472 | 12110721 | 7.006 | 120 | -0.856 | 0.451 |
| | | 500 | -0.717 | 0.543 | | | 510 | -0.871 | 0.509 |
| | | 1000 | -0.726 | 0.571 | | | 1000 | -0.876 | 0.538 |
| | | 5000 | -0.742 | 0.636 | | | 5420 | -0.889 | 0.612 |
| | | 10000 | -0.748 | 0.665 | | | 11580 | -0.893 | 0.644 |
| | | 27900 | -0.757 | 0.706 | | | 16800 | -0.896 | 0.660 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 167300 | -0.907 | 0.761 | 12110735 | 6.965 | 145 | -0.876 | 0.585 |
| 12110731 | 7.055 | 100 | -0.856 | 0.443 | | | 500 | -0.888 | 0.635 |
| | | 500 | -0.873 | 0.511 | | | 1000 | -0.893 | 0.664 |
| | | 1000 | -0.882 | 0.536 | | | 5100 | -0.904 | 0.732 |
| | | 5000 | -0.890 | 0.609 | | | 8700 | -0.907 | 0.755 |
| | | 11700 | -0.896 | 0.645 | | | 9700 | -0.907 | 0.760 |
| | | 26800 | -0.902 | 0.680 | 11110715 | 7.103 | 100 | -0.885 | 0.565 |
| | | 159000 | -0.910 | 0.759 | | | 500 | -0.897 | 0.633 |
| 12110712 | 7.006 | 100 | -0.863 | 0.470 | | | 1000 | -0.903 | 0.662 |
| | | 500 | -0.873 | 0.542 | | | 5000 | -0.913 | 0.730 |
| | | 1000 | -0.881 | 0.569 | | | 11200 | -0.917 | 0.765 |
| | | 5600 | -0.894 | 0.643 | | | 12000 | -0.917 | 0.768 |
| | | 10000 | -0.897 | 0.668 | | | 13100 | -0.918 | 0.771 |
| | | 27000 | -0.903 | 0.711 | 12210711 | 7.324 | 100 | -0.877 | 0.450 |
| | | 102200 | -0.909 | 0.770 | | | 500 | -0.894 | 0.521 |
| 12110722 | 7.099 | 130 | -0.870 | 0.484 | | | 1000 | -0.900 | 0.550 |
| | | 500 | -0.884 | 0.538 | | | 5000 | -0.913 | 0.618 |
| | | 1000 | -0.887 | 0.570 | | | 10000 | -0.917 | 0.648 |
| | | 5250 | -0.900 | 0.640 | | | 30000 | -0.922 | 0.696 |
| | | 7500 | -0.902 | 0.656 | | | 159200 | -0.929 | 0.771 |
| | | 10300 | -0.904 | 0.669 | 12210721 | 6.855 | 100 | -0.848 | 0.450 |
| | | 30000 | -0.910 | 0.716 | | | 500 | -0.860 | 0.521 |
| | | 110500 | -0.915 | 0.774 | | | 1000 | -0.865 | 0.551 |
| 12110732 | 7.194 | 100 | -0.878 | 0.467 | | | 5100 | -0.878 | 0.620 |
| | | 500 | -0.889 | 0.540 | | | 10000 | -0.884 | 0.648 |
| | | 1000 | -0.895 | 0.569 | | | 30000 | -0.890 | 0.696 |
| | | 5000 | -0.906 | 0.638 | 12210731 | 7.216 | 120 | -0.880 | 0.454 |
| | | 10000 | -0.910 | 0.668 | | | 500 | -0.885 | 0.522 |
| | | 50000 | -0.918 | 0.739 | | | 1000 | -0.891 | 0.552 |
| | | 100000 | -0.921 | 0.770 | | | 5200 | -0.905 | 0.620 |
| 12110715 | 7.123 | 100 | -0.886 | 0.568 | | | 10000 | -0.909 | 0.648 |
| | | 500 | -0.900 | 0.635 | | | 30000 | -0.915 | 0.696 |
| | | 1000 | -0.904 | 0.664 | | | 191300 | -0.922 | 0.779 |
| | | 5000 | -0.915 | 0.732 | 12210712 | 7.099 | 100 | -0.873 | 0.479 |
| | | 10800 | -0.919 | 0.765 | | | 500 | -0.884 | 0.551 |
| | | 11300 | -0.919 | 0.767 | | | 1000 | -0.889 | 0.581 |
| 12110725 | 6.938 | 100 | -0.873 | 0.567 | | | 6400 | -0.902 | 0.659 |
| | | 500 | -0.886 | 0.634 | | | 10000 | -0.905 | 0.679 |
| | | 1000 | -0.891 | 0.664 | | | 28500 | -0.911 | 0.724 |
| | | 5000 | -0.901 | 0.732 | | | 54000 | -0.914 | 0.753 |
| | | 10000 | -0.905 | 0.761 | 12210722 | 7.071 | 100 | -0.870 | 0.480 |
| | | 13300 | -0.907 | 0.774 | | | | | |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 1000 | -Q.887 | 0.581 | | | 30900 | -0.913 | 0.704 |
| | | 5500 | -0.900 | 0.653 | | | 144300 | -0.919 | 0.772 |
| | | 10000 | -0.903 | 0.679 | 12310731 | 7.133 | 100 | -0.868 | 0.457 |
| | | 70900 | -0.913 | 0.764 | | | 500 | -0.881 | 0.526 |
| 12210732 | 6.909 | 100 | -0.855 | 0.481 | | | 1000 | -0.889 | 0.554 |
| | | 500 | -0.870 | 0.551 | | | 5500 | -0.900 | 0.629 |
| | | 1000 | -0.876 | 0.580 | | | 10600 | -0.904 | 0.657 |
| | | 5000 | -0.887 | 0.649 | | | 30000 | -0.910 | 0.702 |
| | | 10000 | -0.892 | 0.678 | | | 129200 | -0.916 | 0.767 |
| | | 50000 | -0.901 | 0.748 | | | 130000 | -0.916 | 0.768 |
| | | 80000 | -0.903 | 0.769 | 12310712 | 7.089 | 100 | -0.873 | 0.487 |
| 12210715 | 6.861 | 100 | -0.868 | 0.579 | | | 500 | -0.885 | 0.556 |
| | | 500 | -0.881 | 0.647 | | | 1000 | -0.891 | 0.586 |
| | | 1030 | -0.887 | 0.676 | | | 5700 | -0.902 | 0.661 |
| | | 5000 | -0.898 | 0.742 | | | 22160 | -0.910 | 0.720 |
| | | 10000 | -0.901 | 0.772 | | | 31570 | -0.911 | 0.735 |
| | | 12500 | -0.903 | 0.782 | | | 52000 | -0.914 | 0.757 |
| | | 13000 | -0.903 | 0.784 | 12310722 | 7.132 | 100 | -0.873 | 0.489 |
| 12210725 | 6.801 | 100 | -0.865 | 0.578 | | | 500 | -0.887 | 0.557 |
| | | 500 | -0.878 | 0.646 | | | 1000 | -0.892 | 0.588 |
| | | 1000 | -0.882 | 0.675 | | | 5200 | -0.904 | 0.657 |
| | | 5000 | -0.893 | 0.742 | | | 10300 | -0.909 | 0.686 |
| | | 10000 | -0.897 | 0.772 | | | 27000 | -0.914 | 0.728 |
| | | 12100 | -0.898 | 0.780 | | | 55200 | -0.917 | 0.760 |
| 12210735 | 7.153 | 100 | -0.890 | 0.580 | 12310732 | 7.015 | 100 | -0.865 | 0.488 |
| | | 500 | -0.903 | 0.646 | | | 500 | -0.880 | 0.556 |
| | | 1000 | -0.909 | 0.675 | | | 1000 | -0.885 | 0.586 |
| | | 5000 | -0.918 | 0.743 | | | 5500 | -0.896 | 0.659 |
| | | 10000 | -0.922 | 0.773 | | | 10900 | -0.901 | 0.689 |
| | | 13000 | -0.923 | 0.785 | | | 30000 | -0.906 | 0.733 |
| 12310711 | 7.247 | 100 | -0.869 | 0.463 | | | 57000 | -0.909 | 0.761 |
| | | 500 | -0.889 | 0.528 | 12310715 | 7.078 | 100 | -0.885 | 0.587 |
| | | 1000 | -0.895 | 0.557 | | | 500 | -0.900 | 0.652 |
| | | 5000 | -0.907 | 0.625 | | | 1000 | -0.904 | 0.682 |
| | | 10000 | -0.912 | 0.655 | | | 2000 | -0.909 | 0.711 |
| | | 28000 | -0.918 | 0.699 | | | 5000 | -0.914 | 0.750 |
| | | 167440 | -0.925 | 0.779 | | | 7000 | -0.916 | 0.764 |
| 12310721 | 7.172 | 100 | -0.877 | 0.450 | 12310725 | 7.125 | 100 | -0.889 | 0.587 |
| | | 500 | -0.884 | 0.527 | | | 500 | -0.902 | 0.653 |
| | | 1000 | -0.890 | 0.556 | | | 1000 | -0.908 | 0.682 |
| | | 5000 | -0.902 | 0.626 | | | 2000 | -0.912 | 0.711 |
| | | 10300 | -0.907 | 0.656 | | | 5000 | -0.917 | 0.750 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 8000 | -0.920 | 0.770 | | | 169010 | -0.783 | 0.784 |
| | | 9000 | -0.920 | 0.775 | 22110632 | 5.111 | 100 | -0.713 | 0.484 |
| 12310735 | 6.991 | 100 | -0.878 | 0.588 | | | 550 | -0.738 | 0.548 |
| | | 500 | -0.892 | 0.653 | | | 1000 | -0.746 | 0.570 |
| | | 1000 | -0.897 | 0.682 | | | 5600 | -0.761 | 0.643 |
| | | 5000 | -0.908 | 0.750 | | | 10850 | -0.767 | 0.669 |
| | | 6000 | -0.909 | 0.757 | | | 20250 | -0.773 | 0.695 |
| | | 7000 | -0.910 | 0.764 | | | 36000 | -0.777 | 0.719 |
| 22110611 | 4.775 | 100 | -0.689 | 0.450 | | | 164600 | -0.787 | 0.784 |
| | | 500 | -0.707 | 0.514 | 22110615 | 4.983 | 100 | -0.725 | 0.570 |
| | | 1000 | -0.719 | 0.541 | | | 500 | -0.740 | 0.636 |
| | | 5000 | -0.733 | 0.608 | | | 1000 | -0.748 | 0.662 |
| | | 10000 | -0.740 | 0.637 | | | 5000 | -0.762 | 0.728 |
| | | 30000 | -0.750 | 0.681 | | | 10000 | -0.768 | 0.756 |
| | | 163000 | -0.763 | 0.752 | | | 20000 | -0.773 | 0.785 |
| 22110621 | 4.802 | 100 | -0.674 | 0.475 | | | 30000 | -0.776 | 0.802 |
| | | 500 | -0.707 | 0.517 | 22110625 | 5.084 | 100 | -0.731 | 0.571 |
| | | 1000 | -0.722 | 0.537 | | | 500 | -0.748 | 0.636 |
| | | 5500 | -0.737 | 0.611 | | | 1000 | -0.756 | 0.662 |
| | | 10200 | -0.741 | 0.638 | | | 5500 | -0.770 | 0.732 |
| | | 27800 | -0.751 | 0.678 | | | 10300 | -0.775 | 0.758 |
| | | 189865 | -0.765 | 0.758 | | | 27000 | -0.782 | 0.798 |
| 22110631 | 4.929 | 100 | -0.696 | 0.458 | | | 31000 | -0.783 | 0.804 |
| | | 500 | -0.717 | 0.518 | 22110635 | 5.107 | 100 | -0.734 | 0.569 |
| | | 1000 | -0.727 | 0.543 | | | 500 | -0.750 | 0.636 |
| | | 5000 | -0.744 | 0.608 | | | 1000 | -0.757 | 0.663 |
| | | 10300 | -0.751 | 0.638 | | | 5000 | -0.771 | 0.728 |
| | | 24100 | -0.758 | 0.673 | | | 10000 | -0.777 | 0.756 |
| | | 180000 | -0.773 | 0.757 | | | 23200 | -0.783 | 0.792 |
| 22110612 | 4.961 | 100 | -0.714 | 0.468 | | | 33000 | -0.785 | 0.806 |
| | | 500 | -0.727 | 0.544 | 32110611 | 5.195 | 100 | -0.737 | 0.426 |
| | | 1000 | -0.733 | 0.574 | | | 500 | -0.734 | 0.517 |
| | | 5000 | -0.751 | 0.637 | | | 1000 | -0.749 | 0.541 |
| | | 10000 | -0.756 | 0.666 | | | 5000 | -0.762 | 0.611 |
| | | 30000 | -0.766 | 0.711 | | | 10000 | -0.769 | 0.638 |
| | | 167200 | -0.777 | 0.783 | | | 27000 | -0.777 | 0.679 |
| 22110622 | 5.043 | 100 | -0.713 | 0.476 | | | 184700 | -0.791 | 0.761 |
| | | 500 | -0.730 | 0.546 | 32110621 | 5.078 | 100 | -0.717 | 0.448 |
| | | 1000 | -0.739 | 0.573 | | | 500 | -0.726 | 0.523 |
| | | 5000 | -0.756 | 0.637 | | | 1000 | -0.740 | 0.542 |
| | | 10000 | -0.762 | 0.666 | | | 5000 | -0.752 | 0.612 |
| | | 26800 | -0.770 | 0.706 | | | 10345 | -0.761 | 0.639 |

SD# = beam designation number;
AV = percent air voids;
N = number of load applications; and
A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 25000 | -0.769 | 0.675 | | | 30300 | -0.774 | 0.803 |
| | | 162000 | -0.782 | 0.754 | | | 32000 | -0.774 | 0.805 |
| 32110631 | 5.182 | 100 | -0.716 | 0.451 | 32110635 | 4.913 | 100 | -0.719 | 0.570 |
| | | 500 | -0.738 | 0.513 | | | 500 | -0.736 | 0.635 |
| | | 1000 | -0.747 | 0.543 | | | 1000 | -0.743 | 0.664 |
| | | 5000 | -0.762 | 0.609 | | | 5000 | -0.757 | 0.728 |
| | | 10850 | -0.768 | 0.642 | | | 10000 | -0.763 | 0.757 |
| | | 30000 | -0.778 | 0.683 | | | 20000 | -0.768 | 0.785 |
| | | 164300 | -0.789 | 0.755 | | | 35000 | -0.772 | 0.809 |
| 32110612 | 5.127 | 100 | -0.728 | 0.466 | 22210611 | 5.596 | 120 | -0.800 | -0.115 |
| | | 500 | -0.737 | 0.547 | | | 500 | -1.182 | 0.128 |
| | | 1000 | -0.747 | 0.572 | | | 1000 | -1.415 | 0.148 |
| | | 5100 | -0.761 | 0.640 | | | 5000 | -1.924 | 0.178 |
| | | 10000 | -0.768 | 0.667 | | | 10000 | -2.290 | 0.180 |
| | | 28000 | -0.776 | 0.710 | | | 30300 | -2.576 | 0.209 |
| | | 206700 | -0.789 | 0.794 | | | 167400 | -3.398 | 0.205 |
| 32110622 | 4.955 | 100 | -0.718 | 0.466 | 22210621 | 5.938 | 100 | -0.388 | 0.364 |
| | | 500 | -0.729 | 0.541 | | | 500 | -1.148 | 0.128 |
| | | 1000 | -0.733 | 0.574 | | | 1500 | -1.654 | 0.096 |
| | | 5000 | -0.749 | 0.639 | | | 5000 | -2.084 | 0.131 |
| | | 11300 | -0.757 | 0.672 | | | 10050 | -2.383 | 0.129 |
| | | 26000 | -0.764 | 0.706 | | | 21300 | -2.579 | 0.159 |
| | | 170200 | -0.777 | 0.785 | | | 170500 | -3.388 | 0.161 |
| 32110632 | 4.854 | 100 | -0.691 | 0.489 | 22210631 | 5.723 | 100 | -0.639 | 0.708 |
| | | 500 | -0.718 | 0.547 | | | 500 | -1.054 | 0.600 |
| | | 1000 | -0.726 | 0.574 | | | 1000 | -1.223 | 0.601 |
| | | 5000 | -0.742 | 0.639 | | | 6000 | -1.663 | 0.585 |
| | | 10000 | -0.749 | 0.666 | | | 10100 | -1.840 | 0.559 |
| | | 24000 | -0.756 | 0.702 | | | 20000 | -2.071 | 0.538 |
| | | 161500 | -0.770 | 0.782 | 22210612 | 5.502 | 100 | -1.198 | 0.481 |
| 32110615 | 4.987 | 100 | -0.725 | 0.570 | | | 500 | -1.743 | 0.433 |
| | | 500 | -0.742 | 0.635 | | | 1000 | -1.856 | 0.459 |
| | | 1000 | -0.749 | 0.663 | | | 6000 | -2.311 | 0.474 |
| | | 5000 | -0.763 | 0.729 | | | 10000 | -2.451 | 0.465 |
| | | 10000 | -0.768 | 0.757 | | | 52000 | -3.338 | 0.390 |
| | | 25000 | -0.775 | 0.795 | 22210622 | 5.776 | 100 | -1.362 | 0.441 |
| | | 30000 | -0.776 | 0.803 | | | 500 | -1.862 | 0.414 |
| 32110625 | 4.955 | 100 | -0.721 | 0.571 | | | 1000 | -1.905 | 0.451 |
| | | 500 | -0.739 | 0.636 | | | 5000 | -2.355 | 0.468 |
| | | 1000 | -0.745 | 0.664 | | | 11100 | -2.593 | 0.447 |
| | | 5000 | -0.760 | 0.729 | | | 49500 | -3.309 | 0.393 |
| | | 13900 | -0.768 | 0.771 | 22210632 | 5.316 | 100 | -1.226 | 0.474 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 500 | -1.701 | 0.440 | | | 500 | 0.575 | 0.105 |
| | | 1000 | -1.867 | 0.458 | | | 1000 | 0.412 | 0.143 |
| | | 5500 | -2.278 | 0.479 | | | 5000 | 0.292 | 0.080 |
| | | 12000 | -2.495 | 0.459 | | | 10000 | 0.269 | -0.028 |
| | | 63500 | -3.349 | 0.389 | | | 352725 | -0.029 | 1.393 |
| 22210615 | 4.128 | 110 | -0.912 | -0.085 | 11120512 | 3.116 | 100 | 0.938 | -0.134 |
| | | 500 | -1.118 | 0.293 | | | 510 | 0.562 | -0.175 |
| | | 1000 | -1.402 | 0.319 | | | 1020 | 0.394 | -0.125 |
| | | 5500 | -1.822 | 0.372 | | | 5000 | 0.195 | -0.230 |
| | | 10400 | -1.981 | 0.376 | | | 10000 | 0.087 | -0.740 |
| | | 20000 | -2.181 | 0.372 | | | 31000 | -0.203 | 0.098 |
| 22210625 | 5.171 | 100 | -0.927 | 0.441 | | | 161500 | -0.480 | 0.140 |
| | | 500 | -1.331 | 0.463 | | | 327700 | -0.401 | 0.158 |
| | | 1000 | -1.396 | 0.499 | | | 501370 | -0.523 | 0.144 |
| | | 5450 | -1.915 | 0.436 | 11120522 | 3.165 | 100 | 0.202 | -0.046 |
| | | 10050 | -2.098 | 0.399 | | | 500 | -0.026 | 0.758 |
| | | 15000 | -2.356 | 0.358 | | | 1000 | -0.114 | 0.476 |
| | | 18400 | -2.458 | 0.361 | | | 5100 | -0.047 | 1.381 |
| 22210635 | 4.993 | 100 | -0.835 | 0.474 | | | 10400 | -0.078 | 1.293 |
| | | 500 | -1.225 | 0.490 | | | 20300 | -0.047 | 1.719 |
| | | 1000 | -1.341 | 0.512 | | | 176900 | -0.003 | 3.681 |
| | | 5450 | -1.885 | 0.440 | | | 516800 | -0.055 | 1.936 |
| | | 10050 | -2.066 | 0.403 | | | 691600 | -0.087 | 1.693 |
| | | 12000 | -2.136 | 0.385 | 11120532 | 3.125 | 130 | 0.246 | 0.423 |
| | | 17000 | -2.271 | 0.382 | | | 500 | 0.043 | 1.154 |
| 11120511 | 3.060 | 120 | 0.790 | 0.227 | | | 1000 | 0.010 | 1.920 |
| | | 560 | 0.545 | 0.274 | | | 5000 | -0.330 | -0.159 |
| | | 1000 | 0.491 | 0.280 | | | 10200 | -0.343 | 0.106 |
| | | 5000 | 0.288 | 0.454 | | | 20000 | -0.343 | 0.252 |
| | | 13600 | 0.072 | 1.009 | | | 177600 | -0.629 | 0.392 |
| | | 20000 | 0.093 | 0.758 | | | 341000 | -0.657 | 0.421 |
| | | 27900 | 0.092 | 0.771 | 11120515 | 3.154 | 100 | 0.458 | 0.280 |
| | | 172800 | -0.406 | -0.919 | | | 500 | 0.180 | 0.365 |
| | | 338300 | -0.505 | -0.437 | | | 1000 | 0.145 | 0.315 |
| | | 715700 | -0.637 | -0.208 | | | 5600 | -0.149 | 0.291 |
| | | 861900 | -0.694 | -0.187 | | | 10000 | -0.206 | 0.362 |
| 11120521 | 3.029 | 100 | 1.330 | -0.002 | | | 19500 | -0.259 | 0.408 |
| | | 500 | 1.092 | -0.033 | | | 170900 | -0.451 | 0.547 |
| | | 1000 | 0.922 | -0.053 | | | 346100 | -0.401 | 0.667 |
| | | 5000 | 0.721 | -0.088 | 11120525 | 3.137 | 100 | 0.599 | -0.373 |
| | | 10500 | 0.555 | -0.164 | | | 500 | 0.342 | -0.514 |
| 11120531 | 3.166 | 100 | 0.725 | 0.159 | | | 1100 | 0.305 | -0.254 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 5400 | 0.281 | -0.998 | | | 843950 | -1.484 | 0.173 |
| | | 10400 | 0.320 | -1.465 | 11320522 | 3.297 | 100 | 0.363 | -0.343 |
| | | 23200 | 0.401 | -1.791 | | | 500 | 0.621 | -1.984 |
| | | 123900 | -0.085 | 0.889 | | | 5000 | -0.005 | 2.858 |
| | | 339200 | -0.174 | 0.702 | | | 10000 | -0.054 | 1.480 |
| | | 470000 | -0.255 | 0.595 | | | 27600 | -0.071 | 1.400 |
| 11120535 | | 500 | 0.286 | -0.112 | | | 501150 | -0.379 | 0.739 |
| | | 1000 | 0.121 | -0.258 | 11320532 | 3.202 | 100 | 0.386 | -0.313 |
| | | 5100 | -0.163 | 0.436 | | | 5000 | -0.006 | 2.796 |
| | | 10500 | -0.171 | 0.510 | | | 11100 | -0.017 | 2.165 |
| | | 27000 | -0.350 | 0.366 | | | 31800 | -0.025 | 2.000 |
| | | 184100 | -0.680 | 0.284 | | | 171600 | -0.319 | 0.686 |
| | | 510000 | -0.843 | 0.279 | | | 349400 | -0.397 | 0.648 |
| | | 1061500 | -0.990 | 0.263 | | | 627900 | -0.416 | 0.681 |
| 11320511 | 3.182 | 100 | 0.166 | 1.471 | | | 720000 | -0.429 | 0.687 |
| | | 550 | 0.040 | 2.232 | 11320515 | 2.431 | 100 | 1.079 | -0.003 |
| | | 1000 | 0.001 | 4.900 | | | 500 | 0.792 | -0.113 |
| | | 30975 | -3.722 | -2.271 | | | 1000 | 0.732 | -0.206 |
| | | 327866 | -2.641 | -0.976 | | | 5000 | 1.014 | -1.960 |
| | | 511050 | -2.395 | -0.736 | | | 10150 | 3.089 | -3.630 |
| 11320521 | 3.302 | 100 | -0.368 | 0.549 | | | 35900 | -0.008 | 2.692 |
| | | 500 | -0.665 | 0.305 | | | 157900 | -0.167 | 1.020 |
| | | 1000 | -0.797 | 0.281 | | | 334600 | -0.360 | 0.713 |
| | | 5500 | -1.127 | 0.156 | 11320525 | 2.961 | 100 | 1.275 | -0.025 |
| | | 10000 | -1.109 | 0.157 | | | 500 | 0.983 | -0.085 |
| | | 30140 | -1.278 | 0.117 | | | 1000 | 0.837 | -0.093 |
| | | 167820 | -1.664 | 0.073 | | | 5000 | 0.474 | -0.348 |
| | | 497250 | -1.753 | 0.092 | | | 10700 | 0.367 | -0.569 |
| 11320531 | | 1000 | -0.040 | 1.835 | | | 191200 | -0.328 | 0.440 |
| | | 5000 | -0.199 | 0.851 | | | 351450 | -0.441 | 0.390 |
| | | 11500 | -0.335 | 0.677 | 11320535 | 3.642 | 100 | -0.052 | 0.642 |
| | | 36300 | -0.619 | 0.444 | | | 500 | -0.323 | 0.235 |
| | | 362000 | -1.124 | 0.287 | | | 1000 | -0.296 | 0.326 |
| | | 682000 | -1.172 | 0.291 | | | 5300 | -0.549 | 0.301 |
| | | 699350 | -1.195 | 0.293 | | | 10225 | -0.646 | 0.301 |
| 11320512 | | 500 | -0.415 | 0.075 | | | 30000 | -0.741 | 0.284 |
| | | 1000 | -0.402 | 0.162 | | | 153100 | -0.971 | 0.207 |
| | | 5000 | -0.552 | 0.237 | | | 325300 | -1.090 | 0.196 |
| | | 10200 | -0.714 | 0.201 | | | 501200 | -1.179 | 0.185 |
| | | 21900 | -0.867 | 0.192 | 22120611 | 4.886 | 100 | -0.309 | 0.815 |
| | | 135600 | -1.097 | 0.200 | | | 500 | -0.599 | 0.577 |
| | | 493400 | -1.429 | 0.171 | | | 1000 | -0.714 | 0.507 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A | SD# | AV | N | B | A |
|---|---|---|---|---|---|---|---|---|---|
| | | 7700 | -0.916 | 0.449 | | | 328500 | -1.745 | 0.135 |
| | | 10500 | -1.011 | 0.434 | | | 490000 | -1.680 | 0.152 |
| | | 134600 | -1.311 | 0.407 | | | 687000 | -1.823 | 0.149 |
| | | 309300 | -1.412 | 0.427 | 22120632 | 5.074 | 100 | -0.790 | 0.098 |
| | | 1011900 | -1.611 | 0.423 | | | 500 | -1.078 | 0.096 |
| 22120621 | 4.944 | 100 | -0.545 | 0.626 | | | 1000 | -1.210 | 0.102 |
| | | 500 | -0.789 | 0.464 | | | 5000 | -1.176 | 0.199 |
| | | 1000 | -0.772 | 0.457 | | | 10800 | -1.243 | 0.218 |
| | | 5000 | -0.885 | 0.445 | | | 147150 | -1.302 | 0.351 |
| | | 10000 | -0.915 | 0.439 | | | 320100 | -1.339 | 0.381 |
| | | 30500 | -0.986 | 0.441 | | | 505000 | -1.364 | 0.395 |
| | | 185800 | -1.054 | 0.438 | 22120615 | 5.115 | 100 | -0.062 | 0.498 |
| | | 330538 | -1.065 | 0.460 | | | 500 | -0.527 | 0.121 |
| | | 515900 | -1.084 | 0.474 | | | 1000 | -0.725 | 0.091 |
| | | 676900 | -1.119 | 0.459 | | | 5000 | -0.936 | 0.123 |
| | | 695700 | -1.152 | 0.451 | | | 10000 | -1.155 | 0.117 |
| 22120631 | 5.076 | 100 | -0.946 | 0.092 | | | 36400 | -1.375 | 0.123 |
| | | 500 | -1.193 | 0.115 | | | 158700 | -1.683 | 0.106 |
| | | 1240 | -1.327 | 0.087 | | | 332900 | -1.795 | 0.095 |
| | | 5000 | -1.708 | 0.017 | 22120625 | 4.914 | 100 | -0.872 | -0.571 |
| | | 10000 | -1.776 | 0.024 | | | 500 | -1.088 | -0.318 |
| | | 49400 | -1.734 | 0.056 | | | 1100 | -1.126 | -0.170 |
| | | 171600 | -1.843 | 0.044 | | | 5500 | -1.409 | 0.007 |
| | | 359000 | -1.935 | 0.046 | | | 10900 | -1.547 | 0.014 |
| | | 511400 | -1.997 | 0.044 | | | 22000 | -1.653 | 0.031 |
| | | 706000 | -2.033 | 0.041 | | | 161700 | -1.918 | 0.043 |
| 22120612 | 4.831 | 100 | 0.529 | -0.055 | | | 353200 | -2.251 | 0.037 |
| | | 500 | 0.051 | -0.495 | 22120635 | 5.155 | 100 | -0.873 | 0.038 |
| | | 1000 | -0.023 | 0.895 | | | 500 | -1.106 | -0.006 |
| | | 5000 | -0.234 | 0.209 | | | 5500 | -1.342 | -0.015 |
| | | 10000 | -0.378 | 0.158 | | | 10000 | -1.492 | -0.080 |
| | | 136200 | -1.080 | 0.076 | | | 128000 | -1.922 | -0.148 |
| | | 11111 | -0.150 | 0.472 | | | 337900 | -2.078 | -0.149 |
| | | 322900 | -0.979 | 0.125 | 32120611 | 5.226 | 100 | -1.302 | 0.281 |
| | | 495600 | -1.170 | 0.100 | | | 500 | -0.879 | 0.459 |
| 22120622 | 4.808 | 100 | -0.566 | 0.112 | | | 1000 | -0.580 | 0.633 |
| | | 500 | -0.910 | 0.085 | | | 5500 | -0.240 | 1.121 |
| | | 1000 | -1.098 | 0.093 | | | 12000 | -0.048 | 2.090 |
| | | 5000 | -1.044 | 0.170 | | | 37000 | -0.009 | 3.271 |
| | | 10000 | -1.095 | 0.167 | 32120621 | 5.220 | 100 | -1.332 | 0.276 |
| | | 33500 | -1.326 | 0.150 | | | 500 | -0.810 | 0.485 |
| | | 143000 | -1.559 | 0.146 | | | 1000 | -0.508 | 0.684 |

SD# = beam designation number;

AV = percent air voids;

N = number of load applications; and

A,B = regression coefficients.

Table C. Parameters of the deflection basin of the beam specimens.

| SD# | AV | N | B | A |
|---|---|---|---|---|
| | | 5000 | -0.231 | 1.139 |
| | | 10000 | -0.020 | 2.655 |
| | | 29500 | -0.000 | 5.903 |
| 32120631 | 5.209 | 100 | -1.283 | 0.284 |
| | | 500 | -0.855 | 0.468 |
| | | 1000 | -0.585 | 0.630 |
| | | 5100 | -0.247 | 1.106 |
| | | 10500 | -0.029 | 2.418 |
| 32120612 | 5.176 | 100 | -1.329 | 0.277 |
| | | 500 | -0.840 | 0.474 |
| | | 2000 | -0.686 | 0.571 |
| | | 5100 | -0.148 | 1.376 |
| | | 14200 | -0.072 | 1.839 |
| 32120622 | 5.414 | 100 | -0.187 | 0.532 |
| | | 500 | -0.487 | 0.260 |
| | | 1000 | -0.466 | 0.285 |
| | | 5000 | -0.860 | 0.154 |
| | | 10000 | -0.929 | 0.160 |
| | | 153600 | -1.404 | 0.130 |
| | | 322400 | -1.650 | 0.118 |
| | | 471900 | -1.638 | 0.119 |
| | | 698000 | -1.831 | 0.105 |
| 32120632 | 5.052 | 100 | -0.322 | 0.557 |
| | | 500 | -0.487 | 0.460 |
| | | 1000 | -0.656 | 0.411 |
| | | 5000 | -0.839 | 0.386 |
| | | 10000 | -0.975 | 0.367 |
| | | 22700 | -1.030 | 0.377 |
| | | 147950 | -1.261 | 0.370 |
| | | 481600 | -1.506 | 0.339 |
| | | 1025500 | -1.523 | 0.345 |
| | | 1194900 | -1.697 | 0.323 |
| 32120615 | 5.136 | 100 | -1.263 | 0.288 |
| | | 500 | -0.801 | 0.489 |
| | | 1000 | -0.575 | 0.636 |
| | | 5000 | -0.213 | 1.181 |
| | | 12000 | -0.049 | 2.080 |
| | | 32500 | -0.002 | 4.358 |
| 32120625 | 5.234 | 100 | -0.435 | 0.213 |
| | | 500 | -0.681 | 0.175 |
| | | 1000 | -0.754 | 0.205 |
| | | 5000 | -0.814 | 0.275 |
| | | 10000 | -0.797 | 0.310 |
| | | 29800 | -0.873 | 0.376 |
| | | 199500 | -1.164 | 0.355 |
| | | 490700 | -1.250 | 0.348 |
| | | 862500 | -1.369 | 0.336 |
| 32120635 | 5.416 | 100 | -0.497 | 0.289 |
| | | 500 | -0.806 | 0.217 |
| | | 1000 | -0.888 | 0.210 |
| | | 5000 | -1.147 | 0.175 |
| | | 10000 | -1.393 | 0.155 |
| | | 33300 | -1.555 | 0.149 |
| | | 150400 | -2.015 | 0.120 |
| | | 353200 | -2.199 | 0.116 |

SD# = beam designation number;
AV = percent air voids;
N = number of load applications; and
A,B = regression coefficients.

# APPENDIX D

The calculated fatigue lives of the beam specimens based on a maximum allowable cumlative plastic deformation under the loaded area of 0.45-in. are presented in this Appendix.

Table D. Fatigue life of beam specimens based on a maximum allowable cumulative plastic deformation of 0.45 and 0.1-in for the 77 and 40 °F tests, respectively.

| SD# | AV | KV | ANG | CS | TT | CD2/CD1 | $N_{FL}$ | CD1 |
|---|---|---|---|---|---|---|---|---|
| 11110511 | 2.909 | 270 | 4 | 50 | 77 | 0.300 | 3512081 | 4500.0 |
| 11110521 | 2.951 | 270 | 4 | 50 | 77 | 0.299 | 3431208 | 4500.0 |
| 11110531 | 3.001 | 270 | 4 | 50 | 77 | 0.297 | 3335606 | 4500.0 |
| 11110512 | 2.982 | 270 | 4 | 100 | 77 | 0.309 | 885929 | 4500.0 |
| 11110522 | 3.116 | 270 | 4 | 100 | 77 | 0.305 | 822165 | 4500.0 |
| 11110532 | 3.015 | 270 | 4 | 100 | 77 | 0.308 | 869683 | 4500.0 |
| 11110515 | 3.061 | 270 | 4 | 250 | 77 | 0.304 | 144914 | 4500.0 |
| 11110525 | 3.033 | 270 | 4 | 250 | 77 | 0.305 | 147197 | 4500.0 |
| 11110535 | 3.068 | 270 | 4 | 250 | 77 | 0.304 | 144341 | 4500.0 |
| 11210511 | 3.172 | 212 | 4 | 50 | 77 | 0.293 | 2407828 | 4500.0 |
| 11210521 | 3.016 | 212 | 4 | 50 | 77 | 0.298 | 2627008 | 4500.0 |
| 11210531 | 3.032 | 212 | 4 | 50 | 77 | 0.297 | 2603976 | 4500.0 |
| 11210512 | 3.083 | 212 | 4 | 100 | 77 | 0.306 | 665019 | 4500.0 |
| 11210522 | 3.111 | 212 | 4 | 100 | 77 | 0.306 | 654459 | 4500.0 |
| 11210532 | 3.154 | 212 | 4 | 100 | 77 | 0.304 | 639050 | 4500.0 |
| 11210515 | 3.045 | 212 | 4 | 250 | 77 | 0.306 | 116064 | 4500.0 |
| 11210525 | 3.074 | 212 | 4 | 250 | 77 | 0.305 | 114182 | 4500.0 |
| 11210535 | 3.143 | 212 | 4 | 250 | 77 | 0.303 | 109872 | 4500.0 |
| 11310511 | 3.000 | 159 | 4 | 50 | 77 | 0.299 | 2147055 | 4500.0 |
| 11310521 | 2.994 | 159 | 4 | 50 | 77 | 0.299 | 2153660 | 4500.0 |
| 11310531 | 3.008 | 159 | 4 | 50 | 77 | 0.298 | 2136748 | 4500.0 |
| 11310512 | 3.014 | 159 | 4 | 100 | 77 | 0.309 | 559781 | 4500.0 |
| 11310522 | 3.060 | 159 | 4 | 100 | 77 | 0.308 | 545320 | 4500.0 |
| 11310532 | 3.081 | 159 | 4 | 100 | 77 | 0.307 | 539053 | 4500.0 |
| 11310515 | 3.039 | 159 | 4 | 250 | 77 | 0.307 | 94294 | 4500.0 |
| 11310525 | 3.220 | 159 | 4 | 250 | 77 | 0.301 | 85270 | 4500.0 |
| 11310535 | 2.932 | 159 | 4 | 250 | 77 | 0.310 | 100145 | 4500.0 |
| 11110611 | 4.141 | 270 | 4 | 50 | 77 | 0.266 | 1765305 | 4500.0 |
| 11110621 | 4.035 | 270 | 4 | 50 | 77 | 0.268 | 1872924 | 4500.0 |
| 11110631 | 3.957 | 270 | 4 | 50 | 77 | 0.270 | 1956109 | 4500.0 |
| 11110612 | 2.752 | 270 | 4 | 100 | 77 | 0.316 | 1007701 | 4500.0 |

SD# = sample designation number;
AV = percent air voids (AV = 3 to 7);
KV = kinematic viscosity (centistokes);
ANG = angularity;
CS = cyclic stress (psi) = cyclic load/loaded area;
TT = test temperature (°F);
$N_{FL}$ = number of load applications to fatigue failure;
CD1 = cumulative plastic deformation at the center of the loaded area (x $10^{-4}$ in.); and
CD2 = cumulative plastic deformation at a radial distance of 2.25-in from the center of the loaded area (x $10^{-4}$ in.).

Table D. Fatigue life of beam specimens based on a maximum allowable cumulative plastic deformation of 0.45 and 0.1-in for the 77 and 40 °F tests, respectively.

| SD# | AV | KV | ANG | CS | TT | CD2/CD1 | $N_{FL}$ | CD1 |
|---|---|---|---|---|---|---|---|---|
| 11110622 | 5.421 | 270 | 4 | 100 | 77 | 0.245 | 226967 | 4500.0 |
| 11110632 | 4.358 | 270 | 4 | 100 | 77 | 0.270 | 411053 | 4500.0 |
| 11110615 | 5.303 | 270 | 4 | 250 | 77 | 0.245 | 41437 | 4500.0 |
| 11110625 | 2.676 | 270 | 4 | 250 | 77 | 0.317 | 179669 | 4500.0 |
| 11110635 | 3.178 | 270 | 4 | 250 | 77 | 0.301 | 135760 | 4500.0 |
| 11110711 | 6.683 | 270 | 4 | 50 | 77 | 0.210 | 427105 | 4500.0 |
| 11110711 | 3.704 | 270 | 4 | 50 | 77 | 0.277 | 2253501 | 4500.0 |
| 11110721 | 5.191 | 270 | 4 | 50 | 77 | 0.240 | 982105 | 4500.0 |
| 11110731 | 4.088 | 270 | 4 | 50 | 77 | 0.267 | 1818846 | 4500.0 |
| 11110712 | 5.802 | 270 | 4 | 100 | 77 | 0.236 | 183495 | 4500.0 |
| 11110712 | 6.586 | 270 | 4 | 100 | 77 | 0.221 | 118498 | 4500.0 |
| 11110712 | 4.946 | 270 | 4 | 100 | 77 | 0.256 | 295935 | 4500.0 |
| 11110722 | 6.023 | 270 | 4 | 100 | 77 | 0.232 | 162222 | 4500.0 |
| 11110732 | 5.294 | 270 | 4 | 100 | 77 | 0.248 | 243682 | 4500.0 |
| 11110715 | 7.048 | 270 | 4 | 250 | 77 | 0.210 | 15647 | 4500.0 |
| 11110715 | 7.042 | 270 | 4 | 250 | 77 | 0.210 | 15700 | 4500.0 |
| 11110725 | 5.924 | 270 | 4 | 250 | 77 | 0.232 | 29293 | 4500.0 |
| 11110725 | 7.005 | 270 | 4 | 250 | 77 | 0.210 | 16024 | 4500.0 |
| 11110735 | 5.899 | 270 | 4 | 250 | 77 | 0.232 | 29708 | 4500.0 |
| 11110735 | 6.980 | 270 | 4 | 250 | 77 | 0.211 | 16250 | 4500.0 |
| 21110511 | 2.952 | 270 | 2 | 50 | 77 | 0.302 | 2673333 | 4500.0 |
| 21110521 | 3.031 | 270 | 2 | 50 | 77 | 0.300 | 2558497 | 4500.0 |
| 21110531 | 2.958 | 270 | 2 | 50 | 77 | 0.302 | 2664829 | 4500.0 |
| 21110512 | 2.914 | 270 | 2 | 100 | 77 | 0.314 | 717529 | 4500.0 |
| 21110522 | 2.998 | 270 | 2 | 100 | 77 | 0.312 | 684672 | 4500.0 |
| 21110532 | 3.099 | 270 | 2 | 100 | 77 | 0.309 | 647067 | 4500.0 |
| 21110515 | 3.118 | 270 | 2 | 250 | 77 | 0.306 | 109430 | 4500.0 |
| 21110525 | 2.975 | 270 | 2 | 250 | 77 | 0.311 | 118533 | 4500.0 |
| 21110535 | 3.171 | 270 | 2 | 250 | 77 | 0.305 | 106250 | 4500.0 |
| 21110611 | 4.737 | 270 | 2 | 50 | 77 | 0.254 | 986743 | 4500.0 |
| 21110621 | 4.912 | 270 | 2 | 50 | 77 | 0.250 | 894907 | 4500.0 |
| 21110631 | 4.955 | 270 | 2 | 50 | 77 | 0.249 | 873914 | 4500.0 |

SD# = sample designation number;
AV = percent air voids (AV = 3 to 7);
KV = kinematic viscosity (centistokes);
ANG = angularity;
CS = cyclic stress (psi) = cyclic load/loaded area;
TT = test temperature (°F);
$N_{FL}$ = number of load applications to fatigue failure;
CD1 = cumulative plastic deformation at the center of the loaded area (x $10^{-4}$ in.); and
CD2 = cumulative plastic deformation at a radial distance of 2.25-in from the center of the loaded area (x $10^{-4}$ in.).

Table D. Fatigue life of beam specimens based on a maximum allowable cumulative plastic deformation of 0.45 and 0.1-in for the 77 and 40 °F tests, respectively.

| SD# | AV | KV | ANG | CS | TT | CD2/CD1 | $N_{FL}$ | CD1 |
|---|---|---|---|---|---|---|---|---|
| 21110612 | 4.973 | 270 | 2 | 100 | 77 | 0.258 | 227319 | 4500.0 |
| 21110622 | 5.090 | 270 | 2 | 100 | 77 | 0.255 | 212982 | 4500.0 |
| 21110632 | 5.094 | 270 | 2 | 100 | 77 | 0.255 | 212524 | 4500.0 |
| 21110615 | 5.086 | 270 | 2 | 250 | 77 | 0.253 | 36477 | 4500.0 |
| 21110625 | 5.010 | 270 | 2 | 250 | 77 | 0.255 | 38051 | 4500.0 |
| 21110635 | 4.977 | 270 | 2 | 250 | 77 | 0.256 | 38765 | 4500.0 |
| 21110711 | 6.778 | 270 | 2 | 50 | 77 | 0.211 | 315720 | 4500.0 |
| 21110721 | 6.867 | 270 | 2 | 50 | 77 | 0.209 | 300400 | 4500.0 |
| 21110731 | 6.917 | 270 | 2 | 50 | 77 | 0.208 | 292191 | 4500.0 |
| 21110712 | 7.086 | 270 | 2 | 100 | 77 | 0.214 | 69868 | 4500.0 |
| 21110722 | 7.038 | 270 | 2 | 100 | 77 | 0.215 | 71754 | 4500.0 |
| 21110732 | 7.038 | 270 | 2 | 100 | 77 | 0.215 | 71784 | 4500.0 |
| 21110715 | 7.067 | 270 | 2 | 250 | 77 | 0.212 | 12071 | 4500.0 |
| 21110725 | 7.089 | 270 | 2 | 250 | 77 | 0.212 | 11918 | 4500.0 |
| 21110735 | 7.124 | 270 | 2 | 250 | 77 | 0.211 | 11693 | 4500.0 |
| 31110511 | 2.974 | 270 | 3 | 50 | 77 | 0.300 | 2991184 | 4500.0 |
| 31110521 | 2.978 | 270 | 3 | 50 | 77 | 0.300 | 2983881 | 4500.0 |
| 31110531 | 3.063 | 270 | 3 | 50 | 77 | 0.297 | 2845763 | 4500.0 |
| 31110512 | 3.080 | 270 | 3 | 100 | 77 | 0.307 | 740589 | 4500.0 |
| 31110522 | 3.051 | 270 | 3 | 100 | 77 | 0.308 | 752983 | 4500.0 |
| 31110532 | 3.015 | 270 | 3 | 100 | 77 | 0.309 | 768081 | 4500.0 |
| 31110515 | 3.155 | 270 | 3 | 250 | 77 | 0.303 | 121377 | 4500.0 |
| 31110525 | 2.989 | 270 | 3 | 250 | 77 | 0.308 | 133153 | 4500.0 |
| 31110535 | 2.958 | 270 | 3 | 250 | 77 | 0.309 | 135515 | 4500.0 |
| 31110711 | 6.921 | 270 | 3 | 50 | 77 | 0.207 | 330200 | 4500.0 |
| 31110721 | 6.946 | 270 | 3 | 50 | 77 | 0.207 | 325631 | 4500.0 |
| 31110731 | 7.007 | 270 | 3 | 50 | 77 | 0.205 | 314629 | 4500.0 |
| 31110712 | 6.985 | 270 | 3 | 100 | 77 | 0.214 | 83709 | 4500.0 |
| 31110722 | 6.878 | 270 | 3 | 100 | 77 | 0.216 | 88880 | 4500.0 |
| 31110732 | 6.983 | 270 | 3 | 100 | 77 | 0.214 | 83790 | 4500.0 |
| 31110715 | 6.750 | 270 | 3 | 250 | 77 | 0.217 | 16313 | 4500.0 |

SD# = sample designation number;
AV = percent air voids (AV = 3 to 7);
KV = kinematic viscosity (centistokes);
ANG = angularity;
CS = cyclic stress (psi) = cyclic load/loaded area;
TT = test temperature (°F);
$N_{FL}$ = number of load applications to fatigue failure;
CD1 = cumulative plastic deformation at the center of the loaded area (x $10^{-4}$ in.); and
CD2 = cumulative plastic deformation at a radial distance of 2.25-in from the center of the loaded area (x $10^{-4}$ in.).

Table D. Fatigue life of beam specimens based on a maximum allowable cumulative plastic deformation of 0.45 and 0.1-in for the 77 and 40 °F tests, respectively.

| SD# | AV | KV | ANG | CS | TT | CD2/CD1 | $N_{FL}$ | CD1 |
|---|---|---|---|---|---|---|---|---|
| 31110725 | 6.919 | 270 | 3 | 250 | 77 | 0.213 | 14841 | 4500.0 |
| 31110735 | 6.976 | 270 | 3 | 250 | 77 | 0.212 | 14381 | 4500.0 |
| 21210611 | 4.991 | 212 | 2 | 50 | 77 | 0.249 | 680131 | 4500.0 |
| 21210621 | 4.994 | 212 | 2 | 50 | 77 | 0.249 | 678850 | 4500.0 |
| 21210631 | 5.122 | 212 | 2 | 50 | 77 | 0.246 | 631863 | 4500.0 |
| 21210612 | 5.179 | 212 | 2 | 100 | 77 | 0.254 | 160903 | 4500.0 |
| 21210622 | 5.175 | 212 | 2 | 100 | 77 | 0.254 | 161222 | 4500.0 |
| 21210632 | 5.064 | 212 | 2 | 100 | 77 | 0.257 | 171545 | 4500.0 |
| 21210615 | 5.030 | 212 | 2 | 250 | 77 | 0.255 | 29874 | 4500.0 |
| 21210625 | 5.051 | 212 | 2 | 250 | 77 | 0.255 | 29527 | 4500.0 |
| 21210635 | 4.983 | 212 | 2 | 250 | 77 | 0.257 | 30676 | 4500.0 |
| 21310611 | 4.986 | 159 | 2 | 50 | 77 | 0.249 | 552183 | 4500.0 |
| 21310621 | 4.930 | 159 | 2 | 50 | 77 | 0.251 | 569681 | 4500.0 |
| 21310631 | 4.906 | 159 | 2 | 50 | 77 | 0.251 | 577318 | 4500.0 |
| 21310612 | 4.935 | 159 | 2 | 100 | 77 | 0.260 | 149285 | 4500.0 |
| 21310622 | 4.990 | 159 | 2 | 100 | 77 | 0.259 | 144789 | 4500.0 |
| 21310632 | 4.971 | 159 | 2 | 100 | 77 | 0.260 | 146318 | 4500.0 |
| 21310615 | 4.984 | 159 | 2 | 250 | 77 | 0.257 | 24821 | 4500.0 |
| 21310625 | 5.189 | 159 | 2 | 250 | 77 | 0.252 | 22148 | 4500.0 |
| 21310635 | 5.063 | 159 | 2 | 250 | 77 | 0.255 | 23755 | 4500.0 |
| 12110511 | 3.017 | 270 | 4 | 50 | 77 | 0.297 | 3307200 | 4500.0 |
| 12110521 | 2.931 | 270 | 4 | 50 | 77 | 0.299 | 3469943 | 4500.0 |
| 12110531 | 2.898 | 270 | 4 | 50 | 77 | 0.300 | 3534547 | 4500.0 |
| 12110512 | 2.949 | 270 | 4 | 100 | 77 | 0.310 | 902350 | 4500.0 |
| 12110522 | 2.959 | 270 | 4 | 100 | 77 | 0.309 | 897649 | 4500.0 |
| 12110532 | 2.987 | 270 | 4 | 100 | 77 | 0.308 | 883695 | 4500.0 |
| 12110515 | 2.982 | 270 | 4 | 250 | 77 | 0.307 | 151443 | 4500.0 |
| 12110535 | 2.977 | 270 | 4 | 250 | 77 | 0.307 | 151865 | 4500.0 |
| 12110611 | 5.025 | 270 | 4 | 50 | 77 | 0.244 | 1077415 | 4500.0 |
| 12110621 | 4.927 | 270 | 4 | 50 | 77 | 0.246 | 1138239 | 4500.0 |
| 12110631 | 5.178 | 270 | 4 | 50 | 77 | 0.241 | 989374 | 4500.0 |

SD# = sample designation number;
AV = percent air voids (AV = 3 to 7);
KV = kinematic viscosity (centistokes);
ANG = angularity;
CS = cyclic stress (psi) = cyclic load/loaded area;
TT = test temperature (°F);
$N_{FL}$ = number of load applications to fatigue failure;
CD1 = cumulative plastic deformation at the center of the loaded area (x $10^{-4}$ in.); and
CD2 = cumulative plastic deformation at a radial distance of 2.25-in from the center of the loaded area (x $10^{-4}$ in.).

Table D. Fatigue life of beam specimens based on a maximum allowable cumulative plastic deformation of 0.45 and 0.1-in for the 77 and 40 °F tests, respectively.

| SD# | AV | KV | ANG | CS | TT | CD2/CD1 | $N_{FL}$ | CD1 |
|---|---|---|---|---|---|---|---|---|
| 12110612 | 5.084 | 270 | 4 | 100 | 77 | 0.252 | 274055 | 4500.0 |
| 12110622 | 4.846 | 270 | 4 | 100 | 77 | 0.258 | 312932 | 4500.0 |
| 12110632 | 4.958 | 270 | 4 | 100 | 77 | 0.255 | 294032 | 4500.0 |
| 12110615 | 4.994 | 270 | 4 | 250 | 77 | 0.252 | 49255 | 4500.0 |
| 12110625 | 4.818 | 270 | 4 | 250 | 77 | 0.257 | 54325 | 4500.0 |
| 12110635 | 5.087 | 270 | 4 | 250 | 77 | 0.250 | 46743 | 4500.0 |
| 12110711 | 7.026 | 270 | 4 | 50 | 77 | 0.204 | 352629 | 4500.0 |
| 12110721 | 7.006 | 270 | 4 | 50 | 77 | 0.204 | 356506 | 4500.0 |
| 12110731 | 7.055 | 270 | 4 | 50 | 77 | 0.203 | 346984 | 4500.0 |
| 12110712 | 7.006 | 270 | 4 | 100 | 77 | 0.213 | 93689 | 4500.0 |
| 12110722 | 7.099 | 270 | 4 | 100 | 77 | 0.211 | 88960 | 4500.0 |
| 12110732 | 7.194 | 270 | 4 | 100 | 77 | 0.209 | 84369 | 4500.0 |
| 12110715 | 7.123 | 270 | 4 | 250 | 77 | 0.208 | 15002 | 4500.0 |
| 12110725 | 6.938 | 270 | 4 | 250 | 77 | 0.212 | 16638 | 4500.0 |
| 12110735 | 6.965 | 270 | 4 | 250 | 77 | 0.211 | 16382 | 4500.0 |
| 11110715 | 7.103 | 270 | 4 | 250 | 77 | 0.209 | 15174 | 4500.0 |
| 12210711 | 7.324 | 212 | 4 | 50 | 77 | 0.199 | 237040 | 4500.0 |
| 12210721 | 6.855 | 212 | 4 | 50 | 77 | 0.207 | 307938 | 4500.0 |
| 12210731 | 7.216 | 212 | 4 | 50 | 77 | 0.201 | 251850 | 4500.0 |
| 12210712 | 7.099 | 212 | 4 | 100 | 77 | 0.212 | 70638 | 4500.0 |
| 12210722 | 7.071 | 212 | 4 | 100 | 77 | 0.212 | 71751 | 4500.0 |
| 12210732 | 6.909 | 212 | 4 | 100 | 77 | 0.215 | 78557 | 4500.0 |
| 12210715 | 6.861 | 212 | 4 | 250 | 77 | 0.214 | 13786 | 4500.0 |
| 12210725 | 6.801 | 212 | 4 | 250 | 77 | 0.215 | 14259 | 4500.0 |
| 12210735 | 7.153 | 212 | 4 | 250 | 77 | 0.208 | 11714 | 4500.0 |
| 12310711 | 7.247 | 159 | 4 | 50 | 77 | 0.201 | 200381 | 4500.0 |
| 12310721 | 7.172 | 159 | 4 | 50 | 77 | 0.202 | 208996 | 4500.0 |
| 12310731 | 7.133 | 159 | 4 | 50 | 77 | 0.203 | 213616 | 4500.0 |
| 12310712 | 7.089 | 159 | 4 | 100 | 77 | 0.212 | 57520 | 4500.0 |
| 12310722 | 7.132 | 159 | 4 | 100 | 77 | 0.211 | 56163 | 4500.0 |
| 12310732 | 7.015 | 159 | 4 | 100 | 77 | 0.214 | 59951 | 4500.0 |

SD# = sample designation number;
AV = percent air voids (AV = 3 to 7);
KV = kinematic viscosity (centistokes);
ANG = angularity;
CS = cyclic stress (psi) = cyclic load/loaded area;
TT = test temperature (°F);
$N_{FL}$ = number of load applications to fatigue failure;
CD1 = cumulative plastic deformation at the center of the loaded area ($\times 10^{-4}$ in.); and
CD2 = cumulative plastic deformation at a radial distance of 2.25-in from the center of the loaded area ($\times 10^{-4}$ in.).

Table D. Fatigue life of beam specimens based on a maximum allowable cumulative plastic deformation of 0.45 and 0.1-in for the 77 and 40 °F tests, respectively.

| SD# | AV | KV | ANG | CS | TT | CD2/CD1 | $N_{FL}$ | CD1 |
|---|---|---|---|---|---|---|---|---|
| 12310715 | 7.078 | 159 | 4 | 250 | 77 | 0.210 | 9890 | 4500.0 |
| 12310725 | 7.125 | 159 | 4 | 250 | 77 | 0.209 | 9635 | 4500.0 |
| 12310735 | 6.991 | 159 | 4 | 250 | 77 | 0.212 | 10387 | 4500.0 |
| 22110611 | 4.775 | 270 | 2 | 50 | 77 | 0.253 | 966062 | 4500.0 |
| 22110621 | 4.802 | 270 | 2 | 50 | 77 | 0.252 | 951783 | 4500.0 |
| 22110631 | 4.929 | 270 | 2 | 50 | 77 | 0.249 | 886445 | 4500.0 |
| 22110612 | 4.961 | 270 | 2 | 100 | 77 | 0.259 | 228840 | 4500.0 |
| 22110622 | 5.043 | 270 | 2 | 100 | 77 | 0.257 | 218606 | 4500.0 |
| 22110632 | 5.111 | 270 | 2 | 100 | 77 | 0.255 | 210497 | 4500.0 |
| 22110615 | 4.983 | 270 | 2 | 250 | 77 | 0.256 | 38631 | 4500.0 |
| 22110625 | 5.084 | 270 | 2 | 250 | 77 | 0.253 | 36508 | 4500.0 |
| 22110635 | 5.107 | 270 | 2 | 250 | 77 | 0.253 | 36048 | 4500.0 |
| 32110611 | 5.195 | 270 | 3 | 50 | 77 | 0.242 | 865322 | 4500.0 |
| 32110621 | 5.078 | 270 | 3 | 50 | 77 | 0.244 | 923905 | 4500.0 |
| 32110631 | 5.182 | 270 | 3 | 50 | 77 | 0.242 | 871810 | 4500.0 |
| 32110612 | 5.127 | 270 | 3 | 100 | 77 | 0.253 | 236227 | 4500.0 |
| 32110622 | 4.955 | 270 | 3 | 100 | 77 | 0.257 | 260055 | 4500.0 |
| 32110632 | 4.854 | 270 | 3 | 100 | 77 | 0.259 | 275119 | 4500.0 |
| 32110615 | 4.987 | 270 | 3 | 250 | 77 | 0.254 | 43656 | 4500.0 |
| 32110625 | 4.955 | 270 | 3 | 250 | 77 | 0.255 | 44443 | 4500.0 |
| 32110635 | 4.913 | 270 | 3 | 250 | 77 | 0.256 | 45482 | 4500.0 |
| 11120511 | 1.276 | 270 | 4 | 50 | 40 | - | 4178193000 | 1000.0 |
| 11120521 | 1.244 | 270 | 4 | 50 | 40 | - | 4353370000 | 1000.0 |
| 11120531 | 1.384 | 270 | 4 | 50 | 40 | - | 3631464000 | 1000.0 |
| 11120512 | 1.333 | 270 | 4 | 100 | 40 | - | 1992056000 | 1000.0 |
| 11120522 | 1.383 | 270 | 4 | 100 | 40 | - | 1867469000 | 1000.0 |
| 11120532 | 1.342 | 270 | 4 | 100 | 40 | - | 1969142000 | 1000.0 |
| 11120515 | 1.372 | 270 | 4 | 250 | 40 | - | 785514600 | 1000.0 |
| 11120525 | 1.355 | 270 | 4 | 250 | 40 | - | 802680100 | 1000.0 |
| 11120535 | 1.412 | 270 | 4 | 250 | 40 | - | 745664500 | 1000.0 |
| 11320511 | 4.932 | 159 | 4 | 50 | 40 | - | 22625860 | 1000.0 |

SD# = sample designation number;
AV = percent air voids (AV = 3 to 7);
KV = kinematic viscosity (centistokes);
ANG = angularity;
CS = cyclic stress (psi) = cyclic load/loaded area;
TT = test temperature (°F);
$N_{FL}$ = number of load applications to fatigue failure;
CD1 = cumulative plastic deformation at the center of the loaded area (x $10^{-4}$ in.); and
CD2 = cumulative plastic deformation at a radial distance of 2.25-in from the center of the loaded area (x $10^{-4}$ in.).

Table D. Fatigue life of beam specimens based on a maximum allowable cumulative plastic deformation of 0.45 and 0.1-in for the 77 and 40 °F tests, respectively.

| SD# | AV | KV | ANG | CS | TT | CD2/CD1 | $N_{FL}$ | CD1 |
|---|---|---|---|---|---|---|---|---|
| 11320521 | 5.050 | 159 | 4 | 50 | 40 | - | 19397270 | 1000.0 |
| 11320531 | 4.738 | 159 | 4 | 50 | 40 | - | 29087340 | 1000.0 |
| 11320512 | 5.026 | 159 | 4 | 100 | 40 | - | 10285220 | 1000.0 |
| 11320522 | 5.045 | 159 | 4 | 100 | 40 | - | 10029730 | 1000.0 |
| 11320532 | 4.952 | 159 | 4 | 100 | 40 | - | 11320480 | 1000.0 |
| 11320515 | 1.143 | 159 | 4 | 250 | 40 | - | 657489600 | 1000.0 |
| 11320525 | 4.715 | 159 | 4 | 250 | 40 | - | 6379867 | 1000.0 |
| 11320535 | 5.384 | 159 | 4 | 250 | 40 | - | 2677309 | 1000.0 |
| 22120611 | 4.125 | 270 | 2 | 50 | 40 | - | 89680980 | 1000.0 |
| 22120621 | 4.184 | 270 | 2 | 50 | 40 | - | 83142020 | 1000.0 |
| 22120631 | 4.317 | 270 | 2 | 50 | 40 | - | 69985780 | 1000.0 |
| 22120612 | 4.070 | 270 | 2 | 100 | 40 | - | 49512020 | 1000.0 |
| 22120622 | 4.046 | 270 | 2 | 100 | 40 | - | 51050680 | 1000.0 |
| 22120632 | 4.314 | 270 | 2 | 100 | 40 | - | 36041680 | 1000.0 |
| 22120615 | 4.356 | 270 | 2 | 250 | 40 | - | 14150430 | 1000.0 |
| 22120625 | 4.154 | 270 | 2 | 250 | 40 | - | 18403690 | 1000.0 |
| 22120635 | 4.396 | 270 | 2 | 250 | 40 | - | 13436780 | 1000.0 |
| 32120611 | 4.088 | 270 | 3 | 50 | 40 | - | 101133300 | 1000.0 |
| 32120621 | 4.083 | 270 | 3 | 50 | 40 | - | 101893400 | 1000.0 |
| 32120631 | 4.071 | 270 | 3 | 50 | 40 | - | 103420200 | 1000.0 |
| 32120612 | 4.038 | 270 | 3 | 100 | 40 | - | 107888500 | 1000.0 |
| 32120622 | 4.279 | 270 | 3 | 100 | 40 | - | 40563260 | 1000.0 |
| 32120632 | 3.913 | 270 | 3 | 100 | 40 | - | 65205160 | 1000.0 |
| 32120615 | 3.998 | 270 | 3 | 250 | 40 | - | 113692000 | 1000.0 |
| 32120625 | 4.096 | 270 | 3 | 250 | 40 | - | 21302600 | 1000.0 |
| 32120635 | 4.281 | 270 | 3 | 250 | 40 | - | 16774870 | 1000.0 |

SD# = sample designation number;
AV = percent air voids (AV = 3 to 7);
KV = kinematic viscosity (centistokes);
ANG = angularity;
CS = cyclic stress (psi) = cyclic load/loaded area;
TT = test temperature (°F);
$N_{FL}$ = number of load applications to fatigue failure;
CD1 = cumulative plastic deformation at the center of the loaded area (x $10^{-4}$ in.); and
CD2 = cumulative plastic deformation at a radial distance of 2.25-in from the center of the loaded area (x $10^{-4}$ in.).

# APPENDIX E

The values of the resilient and total moduli obtained using the FEM for all beam specimens are presented in this Appendix.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| 11110511 | 2.909 | 150 | 526623 | 434498 | | | 500 | 585882 | 498634 |
| | | 520 | 585823 | 478781 | | | 1000 | 622538 | 509501 |
| | | 1000 | 620356 | 512222 | | | 5000 | 690695 | 566732 |
| | | 5000 | 688681 | 570415 | | | 10000 | 711694 | 595076 |
| | | 10000 | 712213 | 599541 | | | 50000 | 739362 | 617333 |
| | | 21940 | 734586 | 619087 | | | 100000 | 739362 | 630672 |
| | | 164925 | 747578 | 619087 | 11110525 | 3.033 | 100 | 508940 | 419599 |
| 11110521 | 2.951 | 100 | 516390 | 443227 | | | 500 | 589177 | 499399 |
| | | 500 | 603675 | 491784 | | | 1000 | 626355 | 526965 |
| | | 1000 | 637107 | 527201 | | | 5000 | 694267 | 577992 |
| | | 5000 | 712368 | 565757 | | | 10000 | 715683 | 588836 |
| | | 10000 | 727912 | 610990 | | | 50000 | 744436 | 637974 |
| | | 36235 | 754663 | 610990 | | | 100000 | 744436 | 637974 |
| | | 170420 | 754663 | 628037 | 11110535 | 3.068 | 100 | 505049 | 431695 |
| 11110531 | 3.001 | 100 | 513427 | 432202 | | | 500 | 582662 | 477842 |
| | | 500 | 592683 | 490732 | | | 1000 | 619913 | 523344 |
| | | 1000 | 630174 | 522527 | | | 5027 | 688323 | 564985 |
| | | 5010 | 703014 | 571225 | | | 10400 | 709430 | 598643 |
| | | 10025 | 725495 | 603773 | | | 18000 | 725222 | 598643 |
| | | 21200 | 740155 | 624105 | 11210511 | 3.172 | 100 | 516390 | 437721 |
| | | 164725 | 750375 | 624105 | | | 500 | 598148 | 507154 |
| 11110512 | 2.982 | 155 | 513628 | 442037 | | | 1000 | 636750 | 537827 |
| | | 525 | 574807 | 485282 | | | 5000 | 712346 | 598073 |
| | | 1000 | 608803 | 513615 | | | 10000 | 727906 | 610110 |
| | | 5000 | 677620 | 565900 | | | 30500 | 752299 | 623472 |
| | | 10000 | 700210 | 585383 | | | 683000 | 682177 | 583309 |
| | | 26730 | 721178 | 601921 | 11210521 | 3.016 | 100 | 536159 | 435011 |
| | | 169100 | 721178 | 609380 | | | 500 | 621668 | 529660 |
| 11110522 | 3.116 | 100 | 500000 | 415461 | | | 1000 | 657557 | 559041 |
| | | 500 | 578750 | 483305 | | | 5000 | 731447 | 620353 |
| | | 1000 | 614378 | 517479 | | | 10000 | 748938 | 627926 |
| | | 5025 | 680535 | 570629 | | | 30550 | 777309 | 664867 |
| | | 10000 | 700908 | 603953 | | | 40000 | 786925 | 657909 |
| | | 158650 | 721827 | 611425 | 11210531 | 3.032 | 150 | 538911 | 443359 |
| 11110532 | 3.015 | 100 | 510630 | 418178 | | | 550 | 604997 | 508877 |
| | | 500 | 592455 | 500622 | | | 1000 | 628211 | 524276 |
| | | 1000 | 630277 | 511404 | | | 5000 | 706610 | 584375 |
| | | 5000 | 698772 | 586309 | | | 10000 | 724619 | 603160 |
| | | 10000 | 720719 | 601193 | | | 33100 | 756014 | 645370 |
| | | 30000 | 742628 | 636948 | | | 145000 | 756014 | 645370 |
| | | 163740 | 742628 | 625004 | 11210512 | 3.083 | 100 | 530367 | 444688 |
| 11110515 | 3.061 | 100 | 506713 | 421830 | | | 500 | 612907 | 499765 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 1000 | 650460 | 544374 | | | 1000 | 678782 | 553762 |
| | | 5000 | 722005 | 615698 | | | 5000 | 751632 | 634151 |
| | | 10000 | 742413 | 632965 | | | 10000 | 770757 | 657261 |
| | | 20000 | 763683 | 632965 | | | 32142 | 798398 | 657261 |
| | | 34000 | 774645 | 632965 | | | 172900 | 798398 | 678249 |
| 11210522 | 3.111 | 100 | 528400 | 434947 | 11310521 | 2.994 | 100 | 556132 | 463876 |
| | | 500 | 610026 | 500888 | | | 500 | 640645 | 526403 |
| | | 1000 | 647045 | 528025 | | | 1000 | 685825 | 569100 |
| | | 5000 | 717363 | 587627 | | | 5000 | 752027 | 642814 |
| | | 10000 | 737159 | 604456 | | | 10000 | 779956 | 642814 |
| | | 44000 | 767487 | 656721 | | | 21000 | 802465 | 655916 |
| | | 165000 | 767487 | 642818 | | | 50535 | 812023 | 702576 |
| 11210532 | 3.154 | 100 | 524680 | 430872 | 11310531 | 3.008 | 100 | 556132 | 457794 |
| | | 500 | 604229 | 492521 | | | 200 | 592698 | 493112 |
| | | 1000 | 643470 | 529582 | | | 500 | 643208 | 528914 |
| | | 5000 | 712612 | 581327 | | | 1000 | 678952 | 574565 |
| | | 10000 | 732054 | 615805 | | | 5000 | 751642 | 621446 |
| | | 27100 | 755480 | 638533 | | | 10000 | 779869 | 640754 |
| | | 49800 | 768889 | 638533 | | | 30000 | 808059 | 688018 |
| 11210515 | 3.045 | 100 | 535356 | 457794 | 11310512 | 3.014 | 100 | 554098 | 463805 |
| | | 500 | 618305 | 512359 | | | 500 | 640617 | 524265 |
| | | 1000 | 657298 | 556777 | | | 1000 | 682295 | 571562 |
| | | 5000 | 727860 | 618662 | | | 5000 | 751830 | 631835 |
| | | 10000 | 749732 | 637538 | | | 10000 | 775329 | 646632 |
| | | 21000 | 769298 | 645904 | | | 30000 | 801451 | 667900 |
| | | 30400 | 778263 | 645904 | | | 75200 | 813305 | 678858 |
| 11210525 | 3.074 | 100 | 532273 | 441589 | 11310522 | 3.060 | 100 | 547975 | 459266 |
| | | 500 | 614703 | 484010 | | | 500 | 634201 | 530380 |
| | | 1000 | 653129 | 549470 | | | 1000 | 675079 | 572028 |
| | | 5200 | 725629 | 613448 | | | 5000 | 746681 | 624652 |
| | | 10000 | 745807 | 633647 | | | 10000 | 769785 | 638420 |
| | | 20000 | 765441 | 616209 | | | 30000 | 794705 | 654119 |
| | | 98850 | 776376 | 659920 | | | 56700 | 802703 | 663730 |
| 11210535 | 3.143 | 100 | 516905 | 438266 | 11310532 | 3.081 | 120 | 545332 | 453698 |
| | | 500 | 601452 | 505629 | | | 500 | 618187 | 519123 |
| | | 1000 | 639531 | 533914 | | | 1000 | 656960 | 544494 |
| | | 5000 | 708866 | 592613 | | | 5000 | 730198 | 603193 |
| | | 10000 | 730315 | 611052 | | | 10000 | 752823 | 639376 |
| | | 20000 | 748734 | 626573 | | | 35340 | 781394 | 664405 |
| | | 37500 | 761963 | 648262 | | | 41700 | 781394 | 664405 |
| 11310511 | 3.000 | 100 | 552076 | 463876 | 11310515 | 3.039 | 100 | 549628 | 485023 |
| | | 500 | 640344 | 526403 | | | 500 | 635485 | 533574 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 1000 | 675821 | 589641 | | | 500 | 358815 | 298255 |
| | | 5000 | 747667 | 636847 | | | 1000 | 382314 | 303681 |
| | | 10000 | 769924 | 636847 | | | 5000 | 426438 | 359371 |
| | | 30000 | 794735 | 675425 | | | 10000 | 446640 | 367596 |
| 11310525 | 3.220 | 100 | 528436 | 447851 | | | 30000 | 459228 | 374490 |
| | | 500 | 609983 | 507347 | 11110632 | 4.358 | 100 | 389399 | 324315 |
| | | 1000 | 647686 | 539718 | | | 500 | 446795 | 369963 |
| | | 5000 | 718226 | 590432 | | | 1000 | 476729 | 381237 |
| | | 10000 | 739051 | 627803 | | | 5000 | 529956 | 444786 |
| | | 20300 | 758681 | 635046 | | | 10000 | 548570 | 458111 |
| 11310535 | 2.932 | 100 | 562887 | 465656 | | | 36000 | 576220 | 458111 |
| | | 500 | 650876 | 541721 | 11110615 | 5.303 | 100 | 316330 | 254685 |
| | | 1000 | 692142 | 569195 | | | 500 | 368816 | 294576 |
| | | 5300 | 768173 | 654365 | | | 1000 | 391866 | 321729 |
| | | 10000 | 789133 | 654365 | | | 5000 | 437738 | 356153 |
| | | 30000 | 814515 | 690744 | | | 10000 | 457246 | 375015 |
| | | 42100 | 823741 | 690744 | | | 20000 | 467380 | 375015 |
| 11110611 | 4.141 | 100 | 406044 | 333345 | 11110625 | 2.676 | 100 | 552076 | 471857 |
| | | 500 | 465761 | 388259 | | | 500 | 638047 | 533311 |
| | | 1000 | 498648 | 399186 | | | 1000 | 677361 | 562411 |
| | | 2170 | 530438 | 428469 | | | 5000 | 749649 | 624747 |
| | | 5870 | 559490 | 458169 | | | 10000 | 772173 | 641625 |
| | | 10350 | 574967 | 487918 | | | 26000 | 797547 | 675816 |
| 11110621 | 4.035 | 100 | 416816 | 347398 | 11110635 | 3.178 | 100 | 500000 | 420148 |
| | | 500 | 477808 | 385632 | | | 600 | 587064 | 495327 |
| | | 1000 | 508262 | 417784 | | | 1000 | 610613 | 505180 |
| | | 5000 | 564276 | 463162 | | | 5050 | 682320 | 576714 |
| | | 10000 | 584023 | 485852 | | | 10150 | 703835 | 593076 |
| | | 33000 | 603245 | 511625 | | | 47000 | 731875 | 603295 |
| 11110631 | 3.957 | 100 | 422437 | 353719 | 11110711 | 6.683 | 100 | 252007 | 197162 |
| | | 500 | 485970 | 394342 | | | 500 | 293696 | 230398 |
| | | 1170 | 526187 | 420296 | | | 1050 | 313066 | 246409 |
| | | 5000 | 577850 | 467798 | | | 5000 | 351599 | 287579 |
| | | 10000 | 593238 | 501931 | | | 10200 | 366640 | 293061 |
| | | 30000 | 613398 | 517215 | | | 36700 | 382962 | 316694 |
| 11110612 | 2.752 | 100 | 544019 | 454802 | 11110711 | 3.704 | 100 | 473037 | 398217 |
| | | 500 | 628039 | 514980 | | | 500 | 545016 | 454570 |
| | | 1000 | 667862 | 560462 | | | 1000 | 581124 | 485410 |
| | | 5000 | 736786 | 620339 | | | 5000 | 643655 | 522613 |
| | | 10000 | 758673 | 630966 | | | 10000 | 659623 | 541602 |
| | | 42200 | 788076 | 668432 | | | 30000 | 683434 | 582124 |
| 11110622 | 5.421 | 100 | 307584 | 248733 | 11110721 | 5.191 | 100 | 349551 | 279291 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 500 | 403554 | 323466 | | | 500 | 270189 | 221091 |
| | | 1000 | 426112 | 345042 | | | 1000 | 288128 | 236941 |
| | | 5400 | 477057 | 388745 | | | 5000 | 326911 | 265945 |
| | | 10400 | 499774 | 398212 | | | 11200 | 341690 | 280975 |
| | | 43000 | 517003 | 434579 | | | 12000 | 341690 | 277277 |
| 11110731 | 4.088 | 100 | 440459 | 369146 | 11110715 | 7.042 | 100 | 231785 | 183029 |
| | | 500 | 503406 | 413175 | | | 500 | 270532 | 213280 |
| | | 1000 | 537530 | 443939 | | | 1000 | 288176 | 237628 |
| | | 5000 | 598050 | 483824 | | | 5000 | 327459 | 259988 |
| | | 10000 | 616115 | 508763 | | | 8000 | 334649 | 266300 |
| | | 30000 | 633553 | 524244 | | | 10000 | 339439 | 270489 |
| 11110712 | 5.802 | 100 | 303140 | 241084 | 11110725 | 5.924 | 100 | 296092 | 236786 |
| | | 500 | 353599 | 281212 | | | 500 | 345711 | 273851 |
| | | 1000 | 376295 | 300474 | | | 1000 | 367470 | 291499 |
| | | 5000 | 420051 | 345293 | | | 5000 | 410525 | 330404 |
| | | 10600 | 439846 | 365424 | | | 10000 | 429088 | 344101 |
| | | 33400 | 452566 | 369795 | | | 20000 | 438776 | 358959 |
| 11110712 | 6.586 | 100 | 256719 | 208496 | 11110725 | 7.005 | 100 | 233914 | 186807 |
| | | 500 | 299662 | 231165 | | | 500 | 273009 | 219537 |
| | | 1000 | 318846 | 262122 | | | 1000 | 291033 | 230023 |
| | | 5000 | 358130 | 275002 | | | 5000 | 330382 | 265130 |
| | | 18000 | 382290 | 318561 | | | 10000 | 340145 | 280319 |
| | | 30000 | 388398 | 318561 | | | 15000 | 347268 | 287256 |
| 11110712 | 4.946 | 100 | 365799 | 302279 | 11110735 | 5.899 | 100 | 297445 | 243460 |
| | | 500 | 422956 | 353560 | | | 500 | 347222 | 281511 |
| | | 1000 | 448429 | 368362 | | | 1000 | 368690 | 303790 |
| | | 5000 | 501346 | 415400 | | | 5000 | 412857 | 347256 |
| | | 10000 | 517048 | 420542 | | | 10000 | 430981 | 347256 |
| | | 30000 | 534649 | 447376 | | | 20200 | 441002 | 355305 |
| 11110722 | 6.023 | 110 | 289907 | 229761 | 11110735 | 6.980 | 100 | 234865 | 186112 |
| | | 500 | 335245 | 266671 | | | 500 | 274085 | 216582 |
| | | 1000 | 356686 | 288435 | | | 1000 | 292262 | 230555 |
| | | 5000 | 399929 | 314010 | | | 5000 | 331568 | 270498 |
| | | 10000 | 417292 | 333032 | | | 10000 | 341444 | 277576 |
| | | 38000 | 435561 | 354421 | | | 20200 | 351283 | 289243 |
| 11110732 | 5.294 | 100 | 340306 | 280824 | 21110511 | 2.952 | 100 | 500000 | 408664 |
| | | 500 | 394251 | 322428 | | | 500 | 581150 | 473325 |
| | | 1000 | 417147 | 335754 | | | 1000 | 617510 | 516718 |
| | | 5000 | 465282 | 378700 | | | 5020 | 684939 | 583148 |
| | | 10000 | 481334 | 388392 | | | 10300 | 711083 | 592561 |
| | | 30000 | 503818 | 410443 | 21110521 | 3.031 | 100 | 500000 | 414114 |
| 11110715 | 7.048 | 100 | 231554 | 181347 | | | 500 | 571243 | 477532 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 1050 | 613183 | 513989 | | | 10000 | 510256 | 424847 |
| | | 5000 | 676832 | 570758 | 21110621 | 4.912 | 100 | 347398 | 277698 |
| | | 10000 | 696125 | 591357 | | | 500 | 400496 | 329927 |
| 21110531 | 2.958 | 100 | 500000 | 414114 | | | 1000 | 425805 | 345823 |
| | | 500 | 581150 | 481379 | | | 5400 | 477027 | 388838 |
| | | 1100 | 622593 | 525092 | | | 10900 | 491913 | 405999 |
| | | 5000 | 685534 | 577765 | 21110631 | 4.955 | 100 | 345362 | 280824 |
| | | 10200 | 711937 | 597547 | | | 500 | 397354 | 327882 |
| 21110512 | 2.914 | 100 | 509243 | 436298 | | | 1000 | 422220 | 337623 |
| | | 500 | 589759 | 498965 | | | 5000 | 472596 | 393183 |
| | | 1000 | 627029 | 527872 | | | 10000 | 487515 | 404401 |
| | | 5000 | 694365 | 584338 | 21110612 | 4.973 | 100 | 344351 | 283965 |
| | | 10600 | 718712 | 605286 | | | 500 | 397376 | 323654 |
| 21110522 | 2.998 | 100 | 500000 | 415461 | | | 1000 | 422285 | 351065 |
| | | 500 | 578750 | 475841 | | | 5000 | 470289 | 378940 |
| | | 1000 | 617233 | 486208 | | | 10000 | 486769 | 397028 |
| | | 5000 | 685331 | 565427 | 21110622 | 5.090 | 100 | 334352 | 273916 |
| | | 10000 | 705764 | 599963 | | | 500 | 386832 | 317807 |
| 21110532 | 3.099 | 100 | 494220 | 406044 | | | 1000 | 410162 | 332944 |
| | | 500 | 565813 | 469382 | | | 5000 | 458009 | 376770 |
| | | 1000 | 601855 | 507542 | | | 10000 | 473291 | 394941 |
| | | 5000 | 668159 | 558108 | 21110632 | 5.094 | 100 | 334352 | 273916 |
| | | 10400 | 690866 | 571600 | | | 500 | 386832 | 304472 |
| 21110515 | 3.118 | 120 | 493576 | 406019 | | | 1000 | 410162 | 338002 |
| | | 500 | 555677 | 450509 | | | 5000 | 458009 | 378976 |
| | | 1000 | 591166 | 482813 | | | 10000 | 473291 | 387113 |
| | | 5000 | 656097 | 526348 | 21110615 | 5.086 | 100 | 334940 | 264408 |
| | | 10000 | 677442 | 568653 | | | 500 | 387149 | 308811 |
| 21110525 | 2.975 | 100 | 500000 | 418477 | | | 1000 | 410481 | 337202 |
| | | 500 | 582241 | 480989 | | | 5000 | 458056 | 368218 |
| | | 1000 | 619885 | 520877 | | | 10000 | 473690 | 388955 |
| | | 5000 | 687168 | 577520 | 21110625 | 5.010 | 100 | 340099 | 280194 |
| | | 10000 | 707792 | 597726 | | | 500 | 393689 | 310757 |
| 21110535 | 3.171 | 100 | 490062 | 403400 | | | 1000 | 417396 | 336100 |
| | | 500 | 559682 | 465542 | | | 5000 | 465776 | 367481 |
| | | 1000 | 595232 | 499508 | | | 10000 | 481457 | 391033 |
| | | 5000 | 659790 | 555122 | 21110635 | 4.977 | 100 | 343747 | 275590 |
| | | 10000 | 680351 | 561475 | | | 500 | 397340 | 326742 |
| 21110611 | 4.737 | 100 | 360220 | 297110 | | | 1000 | 421596 | 335166 |
| | | 500 | 416337 | 347167 | | | 5000 | 470682 | 397465 |
| | | 1000 | 440755 | 353081 | | | 10600 | 486776 | 405365 |
| | | 5000 | 493151 | 401007 | 21110711 | 6.778 | 100 | 239226 | 187168 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 500 | 278434 | 223291 | | | 5000 | 314004 | 245616 |
| | | 1000 | 297253 | 238643 | | | 10000 | 323024 | 265424 |
| | | 5000 | 336301 | 271797 | 31110511 | 2.974 | 110 | 506166 | 419677 |
| | | 10000 | 350254 | 286995 | | | 500 | 576878 | 473997 |
| 21110721 | 6.867 | 100 | 234394 | 182016 | | | 1000 | 617909 | 516776 |
| | | 500 | 273066 | 220401 | | | 5000 | 680086 | 572604 |
| | | 1000 | 291041 | 238182 | | | 10000 | 700340 | 594089 |
| | | 5300 | 332999 | 262473 | | | 30500 | 722667 | 608906 |
| | | 10000 | 341069 | 272767 | | | 162050 | 732734 | 608906 |
| 21110731 | 6.917 | 100 | 232005 | 184565 | 31110521 | 2.978 | 100 | 500000 | 422437 |
| | | 500 | 271192 | 212233 | | | 520 | 583883 | 487703 |
| | | 1000 | 288972 | 239637 | | | 1000 | 617693 | 522277 |
| | | 5000 | 327461 | 259558 | | | 5250 | 689062 | 580034 |
| | | 10000 | 336949 | 274445 | | | 10400 | 711118 | 580034 |
| 21110712 | 7.086 | 100 | 223455 | 176675 | | | 30000 | 730838 | 617664 |
| | | 500 | 260928 | 213392 | | | 165600 | 730838 | 617664 |
| | | 1000 | 277992 | 218684 | 31110531 | 3.063 | 100 | 500000 | 408664 |
| | | 5000 | 316192 | 250848 | | | 500 | 571243 | 473325 |
| | | 10000 | 328919 | 268009 | | | 1000 | 605103 | 512267 |
| 21110722 | 7.038 | 100 | 226270 | 174693 | | | 5000 | 676308 | 558485 |
| | | 500 | 263494 | 213237 | | | 10000 | 696000 | 576986 |
| | | 1000 | 280886 | 231138 | | | 30000 | 718254 | 595774 |
| | | 5200 | 319646 | 264488 | | | 162900 | 718254 | 577431 |
| | | 10000 | 328911 | 268475 | 31110512 | 3.080 | 100 | 500000 | 402101 |
| 21110732 | 7.038 | 100 | 226270 | 183284 | | | 500 | 568710 | 460113 |
| | | 500 | 264287 | 216255 | | | 1000 | 604929 | 506725 |
| | | 1000 | 281861 | 227869 | | | 5000 | 672308 | 564053 |
| | | 5000 | 320354 | 263001 | | | 10000 | 691417 | 575859 |
| | | 10000 | 329161 | 266443 | | | 30600 | 715128 | 611123 |
| 21110715 | 7.067 | 100 | 224685 | 181011 | | | 167400 | 715128 | 611123 |
| | | 550 | 264426 | 210633 | 31110522 | 3.051 | 100 | 500000 | 414114 |
| | | 1000 | 280009 | 220589 | | | 500 | 573693 | 464905 |
| | | 5000 | 317871 | 256265 | | | 1000 | 611089 | 513663 |
| | | 10000 | 330510 | 269410 | | | 5000 | 676698 | 570732 |
| 21110725 | 7.089 | 100 | 223345 | 177397 | | | 10300 | 697463 | 580990 |
| | | 500 | 260616 | 205369 | | | 30000 | 718477 | 613506 |
| | | 1000 | 277778 | 229442 | | | 164500 | 718477 | 605581 |
| | | 5000 | 315646 | 256436 | 31110532 | 3.015 | 100 | 500000 | 420988 |
| | | 10000 | 328582 | 259554 | | | 500 | 578750 | 474580 |
| 21110735 | 7.124 | 100 | 222018 | 178373 | | | 1000 | 614378 | 510174 |
| | | 500 | 258957 | 209475 | | | 5000 | 681074 | 561360 |
| | | 1000 | 276192 | 224700 | | | 10000 | 704748 | 596086 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 30500 | 727869 | 586458 | | | 20500 | 326872 | 273031 |
| | | 168000 | 727869 | 596517 | | | 169500 | 332652 | 257289 |
| 31110515 | 3.155 | 100 | 490062 | 407089 | 31110712 | 6.985 | 100 | 228544 | 183703 |
| | | 500 | 559682 | 465928 | | | 500 | 266864 | 213344 |
| | | 1000 | 596358 | 487965 | | | 1000 | 284842 | 228649 |
| | | 5000 | 661407 | 542630 | | | 5200 | 323876 | 263345 |
| | | 10000 | 680744 | 572733 | | | 10400 | 333085 | 268295 |
| | | 30000 | 703831 | 581863 | | | 23500 | 346836 | 282793 |
| | | 63188 | 714380 | 581863 | 31110722 | 6.878 | 100 | 235574 | 188927 |
| 31110525 | 2.989 | 100 | 505049 | 433322 | | | 500 | 274814 | 217259 |
| | | 500 | 582662 | 486255 | | | 1000 | 293075 | 236980 |
| | | 1000 | 619913 | 524054 | | | 5500 | 333938 | 272735 |
| | | 5200 | 688543 | 584779 | | | 10400 | 343146 | 272735 |
| | | 10000 | 708118 | 584779 | | | 27800 | 358377 | 272735 |
| | | 30200 | 731483 | 606619 | | | 52500 | 358377 | 288601 |
| | | 98000 | 739126 | 606619 | 31110732 | 6.983 | 100 | 228544 | 178710 |
| 31110535 | 2.958 | 100 | 506166 | 419599 | | | 500 | 266059 | 214128 |
| | | 500 | 584821 | 496885 | | | 1000 | 283852 | 230671 |
| | | 1000 | 622467 | 509689 | | | 5750 | 325490 | 245159 |
| | | 5000 | 688980 | 579114 | | | 10900 | 333910 | 279103 |
| | | 10000 | 709775 | 596997 | | | 26800 | 343917 | 286161 |
| | | 30000 | 734369 | 606286 | | | 62100 | 351061 | 286161 |
| | | 112800 | 734369 | 624187 | 31110715 | 6.750 | 110 | 241329 | 196923 |
| 31110711 | 6.921 | 100 | 233223 | 187168 | | | 500 | 278917 | 221153 |
| | | 500 | 271266 | 213572 | | | 1000 | 296930 | 233499 |
| | | 1000 | 288982 | 236780 | | | 5500 | 338686 | 276239 |
| | | 5000 | 330302 | 260943 | | | 10100 | 347748 | 282184 |
| | | 10000 | 340130 | 281015 | | | 12450 | 352895 | 293366 |
| | | 34800 | 356255 | 287170 | 31110725 | 6.919 | 110 | 231763 | 179735 |
| | | 165700 | 356255 | 287170 | | | 580 | 271259 | 217489 |
| 31110721 | 6.946 | 135 | 231181 | 183963 | | | 1000 | 285696 | 226120 |
| | | 500 | 261049 | 211096 | | | 5500 | 326087 | 257934 |
| | | 1150 | 281562 | 230981 | | | 10000 | 334468 | 264552 |
| | | 5000 | 317931 | 257504 | | | 13800 | 340760 | 275574 |
| | | 10000 | 330653 | 264521 | 31110735 | 6.976 | 110 | 229165 | 182103 |
| | | 32000 | 345272 | 279746 | | | 530 | 265931 | 210261 |
| | | 162650 | 345272 | 274420 | | | 1000 | 282154 | 224229 |
| 31110731 | 7.007 | 160 | 228086 | 179828 | | | 5400 | 321881 | 250128 |
| | | 500 | 250600 | 204643 | | | 6820 | 326190 | 261646 |
| | | 1000 | 268558 | 217818 | | | 8800 | 330618 | 261646 |
| | | 5100 | 306013 | 253601 | | | 10800 | 334292 | 267690 |
| | | 11000 | 319740 | 260326 | 21210611 | 4.991 | 130 | 357863 | 294969 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 500 | 399145 | 321716 | | | 5000 | 491161 | 405719 |
| | | 1030 | 427317 | 352045 | | | 10000 | 507091 | 414415 |
| | | 5000 | 476566 | 392016 | 21310611 | 4.986 | 100 | 369146 | 304005 |
| | | 10000 | 492901 | 414907 | | | 500 | 422187 | 339495 |
| 21210621 | 4.994 | 110 | 357353 | 292383 | | | 1000 | 451946 | 369363 |
| | | 500 | 412338 | 343586 | | | 5000 | 504151 | 410067 |
| | | 1020 | 435605 | 350738 | | | 10700 | 522650 | 433945 |
| | | 5600 | 490743 | 409655 | 21310621 | 4.930 | 150 | 372705 | 287159 |
| | | 10600 | 503011 | 409655 | | | 550 | 414667 | 347985 |
| 21210631 | 5.122 | 100 | 349551 | 285575 | | | 1040 | 440059 | 368133 |
| | | 500 | 403554 | 328117 | | | 5000 | 491327 | 403201 |
| | | 1000 | 426112 | 352835 | | | 10000 | 515476 | 412415 |
| | | 5000 | 477514 | 397413 | 21310631 | 4.906 | 100 | 376097 | 298792 |
| | | 10620 | 493556 | 402916 | | | 500 | 436696 | 354628 |
| 21210612 | 5.179 | 100 | 345362 | 280056 | | | 1000 | 460649 | 379084 |
| | | 520 | 399925 | 319693 | | | 5050 | 514568 | 410536 |
| | | 1000 | 422543 | 346953 | | | 10500 | 531515 | 443948 |
| | | 5120 | 473303 | 385307 | 21310612 | 4.935 | 150 | 373903 | 305122 |
| | | 10700 | 489882 | 397224 | | | 500 | 411711 | 330061 |
| 21210622 | 5.175 | 100 | 344351 | 265126 | | | 1000 | 440102 | 352270 |
| | | 500 | 398842 | 324883 | | | 5000 | 491331 | 405345 |
| | | 1000 | 422434 | 344081 | | | 10200 | 508932 | 424650 |
| | | 5000 | 472542 | 389568 | 21310622 | 4.990 | 100 | 369200 | 305787 |
| | | 10000 | 487438 | 396061 | | | 500 | 428009 | 350017 |
| 21210632 | 5.064 | 100 | 352670 | 280056 | | | 1000 | 452501 | 369273 |
| | | 500 | 408264 | 330093 | | | 5000 | 504202 | 408208 |
| | | 1000 | 433247 | 360514 | | | 10000 | 520115 | 429693 |
| | | 5000 | 482895 | 400083 | 21310632 | 4.971 | 100 | 370327 | 304915 |
| | | 10000 | 498741 | 409591 | | | 500 | 429759 | 351238 |
| 21210615 | 5.030 | 100 | 355045 | 291095 | | | 1000 | 454481 | 377384 |
| | | 500 | 411148 | 331087 | | | 5000 | 506886 | 423994 |
| | | 1000 | 435514 | 350271 | | | 10000 | 523085 | 431147 |
| | | 5000 | 485933 | 410200 | 21310615 | 4.984 | 120 | 369639 | 305762 |
| | | 10000 | 502132 | 410200 | | | 500 | 416403 | 343056 |
| 21210625 | 5.051 | 100 | 353319 | 288788 | | | 1000 | 444769 | 370985 |
| | | 500 | 408606 | 339682 | | | 5000 | 496885 | 403866 |
| | | 1000 | 433255 | 348702 | | | 10100 | 513740 | 415987 |
| | | 5000 | 482880 | 405525 | 21310625 | 5.189 | 100 | 353319 | 291095 |
| | | 10000 | 499568 | 418040 | | | 500 | 408580 | 332890 |
| 21210635 | 4.983 | 100 | 358926 | 286524 | | | 1000 | 433252 | 358318 |
| | | 500 | 415038 | 340498 | | | 5100 | 483438 | 404726 |
| | | 1000 | 439989 | 363263 | | | 10000 | 498888 | 415925 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| 21310635 | 5.063 | 100 | 364672 | 289125 | | | 1400 | 643192 | 533689 |
| | | 500 | 422287 | 351712 | | | 5000 | 699561 | 591263 |
| | | 1000 | 447680 | 361330 | | | 12300 | 723338 | 611335 |
| | | 5000 | 498752 | 417688 | | | 20100 | 740299 | 623595 |
| | | 9850 | 514546 | 421972 | | | 167500 | 740299 | 623595 |
| 12110511 | 3.017 | 100 | 507864 | 414114 | 12110515 | 2.982 | 100 | 511187 | 418477 |
| | | 500 | 587082 | 481379 | | | 500 | 592501 | 474329 |
| | | 1000 | 623922 | 521749 | | | 1000 | 630257 | 512320 |
| | | 5000 | 694169 | 565340 | | | 5000 | 697926 | 574333 |
| | | 10000 | 715660 | 584308 | | | 10000 | 719721 | 614532 |
| | | 30300 | 740439 | 617034 | | | 30000 | 744346 | 624512 |
| | | 157000 | 740439 | 617034 | | | 102631 | 744346 | 633270 |
| 12110521 | 2.931 | 100 | 516390 | 425225 | 12110525 | 3.129 | 150 | 500000 | 415500 |
| | | 500 | 598148 | 507223 | | | 500 | 553886 | 428970 |
| | | 1000 | 636750 | 542637 | | | 1000 | 588695 | 479413 |
| | | 5300 | 706566 | 580742 | | | 5000 | 653700 | 538777 |
| | | 10000 | 726570 | 593996 | | | 11500 | 678421 | 554531 |
| | | 30000 | 753828 | 627425 | | | 30000 | 701002 | 599916 |
| | | 166200 | 753828 | 616656 | | | 65100 | 711170 | 587786 |
| 12110531 | 2.898 | 100 | 516390 | 435011 | 12110535 | 2.977 | 100 | 511187 | 437695 |
| | | 500 | 603675 | 502879 | | | 500 | 592501 | 489735 |
| | | 1000 | 643435 | 518984 | | | 1000 | 630257 | 531725 |
| | | 5150 | 709854 | 581234 | | | 5300 | 701031 | 574982 |
| | | 10000 | 727332 | 599864 | | | 10300 | 721128 | 611899 |
| | | 30000 | 754003 | 622154 | | | 30000 | 744671 | 625278 |
| | | 189900 | 754003 | 622154 | | | 62200 | 754663 | 625278 |
| 12110512 | 2.949 | 100 | 513494 | 423827 | 12110611 | 5.025 | 100 | 345362 | 273211 |
| | | 500 | 595291 | 500785 | | | 500 | 400418 | 329695 |
| | | 1000 | 633561 | 525712 | | | 1000 | 422530 | 350588 |
| | | 5000 | 703225 | 597249 | | | 5000 | 472627 | 393749 |
| | | 10000 | 725790 | 609899 | | | 10000 | 487524 | 411949 |
| | | 26600 | 746230 | 627758 | | | 30250 | 513119 | 420891 |
| | | 144000 | 746230 | 618837 | | | 143700 | 513119 | 425107 |
| 12110522 | 2.959 | 150 | 513093 | 421382 | 12110621 | 4.927 | 100 | 355933 | 290446 |
| | | 500 | 574354 | 466434 | | | 500 | 409977 | 344475 |
| | | 1100 | 612830 | 509975 | | | 1000 | 436818 | 354012 |
| | | 5200 | 680300 | 561049 | | | 5500 | 491178 | 395619 |
| | | 10100 | 701545 | 590797 | | | 10700 | 505603 | 407885 |
| | | 27400 | 725150 | 612760 | | | 30000 | 523343 | 428701 |
| | | 175550 | 725150 | 612760 | | | 192000 | 523343 | 434586 |
| 12110532 | 2.987 | 100 | 510630 | 437721 | 12110631 | 5.178 | 100 | 333345 | 273211 |
| | | 500 | 592455 | 485501 | | | 500 | 385333 | 318819 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 1000 | 408461 | 333068 | | | 1000 | 410610 | 335983 |
| | | 5000 | 457907 | 385788 | | | 5100 | 459585 | 388977 |
| | | 10000 | 471343 | 385788 | | | 10200 | 480511 | 394828 |
| | | 50000 | 498641 | 411367 | | | 21600 | 491515 | 414443 |
| | | 100000 | 498641 | 411367 | | | 27700 | 497230 | 414443 |
| 12110612 | 5.084 | 130 | 341536 | 270383 | 12110711 | 7.026 | 100 | 232005 | 188906 |
| | | 500 | 380786 | 317537 | | | 500 | 269547 | 217258 |
| | | 1000 | 407509 | 339547 | | | 1000 | 288741 | 227431 |
| | | 6000 | 460173 | 383712 | | | 5300 | 327177 | 264426 |
| | | 10100 | 473357 | 395751 | | | 10000 | 336849 | 281515 |
| | | 30200 | 495982 | 413896 | | | 25500 | 350783 | 281515 |
| | | 186800 | 495982 | 413896 | | | 148700 | 350783 | 288214 |
| 12110622 | 4.846 | 100 | 359141 | 283965 | 12110721 | 7.006 | 120 | 232779 | 184888 |
| | | 500 | 414733 | 337135 | | | 510 | 267023 | 204153 |
| | | 1000 | 440665 | 365163 | | | 1000 | 283484 | 222563 |
| | | 5000 | 490747 | 409532 | | | 5420 | 322960 | 266654 |
| | | 10000 | 507378 | 400853 | | | 11580 | 338444 | 269848 |
| | | 27900 | 523780 | 443371 | | | 16800 | 342804 | 272956 |
| | | 191500 | 523780 | 443371 | | | 167300 | 346797 | 284713 |
| 12110632 | 4.958 | 100 | 350586 | 280824 | 12110731 | 7.055 | 100 | 229707 | 182847 |
| | | 500 | 405094 | 327882 | | | 500 | 267778 | 214464 |
| | | 1000 | 429576 | 353988 | | | 1000 | 286705 | 228229 |
| | | 5100 | 478844 | 389635 | | | 5000 | 324639 | 267080 |
| | | 10800 | 502458 | 410572 | | | 11700 | 340240 | 267080 |
| | | 30000 | 514798 | 422753 | | | 26800 | 348685 | 288390 |
| | | 166100 | 514798 | 417385 | | | 159000 | 348685 | 284905 |
| 12110615 | 4.994 | 150 | 347515 | 274581 | 12110712 | 7.006 | 100 | 233780 | 187600 |
| | | 500 | 383374 | 315037 | | | 500 | 272994 | 219580 |
| | | 1000 | 409442 | 327802 | | | 1000 | 291030 | 236694 |
| | | 5400 | 460443 | 377435 | | | 5600 | 332905 | 264622 |
| | | 11100 | 476264 | 396643 | | | 10000 | 341036 | 270020 |
| | | 30100 | 492711 | 401160 | | | 27000 | 356408 | 287123 |
| | | 51000 | 500772 | 420194 | | | 102200 | 356408 | 287123 |
| 12110625 | 4.818 | 100 | 360674 | 295411 | 12110722 | 7.099 | 130 | 227791 | 172089 |
| | | 500 | 417008 | 336291 | | | 500 | 258682 | 204735 |
| | | 1000 | 442265 | 368958 | | | 1000 | 275888 | 222175 |
| | | 5000 | 493326 | 408518 | | | 5250 | 315009 | 254879 |
| | | 10000 | 509432 | 414073 | | | 7500 | 320606 | 254879 |
| | | 30000 | 527650 | 442141 | | | 10300 | 325870 | 260320 |
| | | 53800 | 535959 | 447754 | | | 30000 | 340967 | 272085 |
| 12110635 | 5.087 | 125 | 342982 | 271600 | | | 500 | 260116 | 212277 |
| | | 500 | 384497 | 314386 | | | 1000 | 277875 | 222996 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| 12210731 | 7.216 | 120 | 233947 | 185779 | | | 500 | 278419 | 224768 |
| | | 500 | 267766 | 217525 | | | 1000 | 296531 | 243175 |
| | | 1000 | 285342 | 232278 | | | 5000 | 336305 | 277183 |
| | | 5200 | 325203 | 262876 | | | 10000 | 346221 | 288625 |
| | | 10000 | 334457 | 276972 | | | 13000 | 352619 | 288625 |
| | | 30000 | 352842 | 282740 | 12310711 | 7.247 | 100 | 240443 | 193443 |
| | | 191300 | 348758 | 285897 | | | 500 | 282048 | 226246 |
| 12210712 | 7.099 | 100 | 240472 | 192518 | | | 1000 | 299636 | 237773 |
| | | 500 | 280270 | 226812 | | | 5000 | 339367 | 276002 |
| | | 1000 | 298483 | 236538 | | | 10000 | 353605 | 292148 |
| | | 6400 | 343726 | 283389 | | | 28000 | 368267 | 292148 |
| | | 10000 | 350366 | 287991 | | | 167440 | 368267 | 292148 |
| | | 28500 | 364862 | 293733 | 12310721 | 7.172 | 100 | 244208 | 194352 |
| | | 54000 | 368545 | 293733 | | | 500 | 285881 | 223809 |
| 12210722 | 7.071 | 100 | 241698 | 189365 | | | 1000 | 303996 | 245526 |
| | | 500 | 282122 | 222193 | | | 5000 | 345502 | 283003 |
| | | 1000 | 300598 | 238443 | | | 10300 | 355582 | 286043 |
| | | 5500 | 343090 | 279321 | | | 30900 | 373467 | 293751 |
| | | 10000 | 351306 | 290261 | | | 144300 | 373467 | 293751 |
| | | 29000 | 367607 | 296855 | 12310731 | 7.133 | 100 | 246787 | 196234 |
| | | 70900 | 367607 | 300663 | | | 500 | 287826 | 226443 |
| 12210732 | 6.909 | 100 | 250671 | 196697 | | | 1000 | 308187 | 241793 |
| | | 500 | 292654 | 233668 | | | 5500 | 346025 | 278442 |
| | | 1000 | 311798 | 255727 | | | 10600 | 363825 | 299142 |
| | | 5000 | 349978 | 291554 | | | 30000 | 373237 | 314091 |
| | | 10000 | 366009 | 296927 | | | 129200 | 373237 | 314091 |
| | | 50000 | 383965 | 311040 | 12310712 | 7.089 | 100 | 250023 | 199558 |
| | | 80000 | 383965 | 311040 | | | 500 | 291695 | 238636 |
| 12210715 | 6.861 | 100 | 252007 | 196596 | | | 1000 | 310663 | 252801 |
| | | 500 | 294053 | 231932 | | | 5700 | 355425 | 289829 |
| | | 1030 | 313850 | 252138 | | | 22160 | 376137 | 304186 |
| | | 5000 | 351682 | 288808 | | | 31570 | 380651 | 304186 |
| | | 10000 | 368493 | 302853 | | | 52000 | 380651 | 304186 |
| | | 12500 | 372253 | 307141 | 12310722 | 7.132 | 100 | 247423 | 198590 |
| | | 13000 | 372253 | 307141 | | | 500 | 288767 | 216467 |
| 12210725 | 6.801 | 100 | 255231 | 199454 | | | 1000 | 307284 | 251380 |
| | | 500 | 298029 | 238920 | | | 5200 | 349531 | 274748 |
| | | 1000 | 317175 | 260755 | | | 10300 | 359353 | 294022 |
| | | 5000 | 356148 | 283768 | | | 27000 | 375123 | 299050 |
| | | 10000 | 372996 | 306100 | | | 55200 | 375123 | 313178 |
| | | 12100 | 376762 | 306100 | 12310732 | 7.015 | 100 | 252663 | 203454 |
| 12210735 | 7.153 | 100 | 238489 | 193987 | | | 500 | 295602 | 236841 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 1000 | 314180 | 258453 | | | 5000 | 488035 | 384136 |
| | | 5500 | 357595 | 291856 | | | 10300 | 502744 | 425238 |
| | | 10900 | 368291 | 298426 | | | 24100 | 517312 | 430738 |
| | | 30000 | 384803 | 313998 | | | 180000 | 517312 | 0 |
| | | 57000 | 384803 | 313998 | 22110612 | 4.961 | 100 | 352670 | 293711 |
| 12310715 | 7.078 | 100 | 250418 | 194726 | | | 500 | 408264 | 344631 |
| | | 500 | 292078 | 238855 | | | 1000 | 433247 | 354066 |
| | | 1000 | 311108 | 244736 | | | 5000 | 482895 | 384136 |
| | | 2000 | 329977 | 264552 | | | 10000 | 498741 | 425238 |
| | | 5000 | 351407 | 282278 | | | 30000 | 516231 | 430738 |
| | | 7000 | 358138 | 288211 | | | 167200 | 516231 | 430738 |
| | | 9000 | 363625 | 295221 | 22110622 | 5.043 | 100 | 347447 | 278493 |
| 12310725 | 7.125 | 100 | 248074 | 194918 | | | 500 | 401981 | 336859 |
| | | 500 | 289350 | 231551 | | | 1000 | 425954 | 356302 |
| | | 1000 | 308360 | 251865 | | | 5000 | 475221 | 394417 |
| | | 2000 | 326851 | 264609 | | | 10000 | 497268 | 420056 |
| | | 5000 | 348204 | 285966 | | | 26800 | 511044 | 420056 |
| | | 8000 | 356678 | 285966 | | | 169010 | 511044 | 420056 |
| | | 9000 | 360733 | 293032 | 22110632 | 5.111 | 100 | 342296 | 280824 |
| 12310735 | 6.991 | 100 | 253876 | 199256 | | | 550 | 400052 | 325702 |
| | | 500 | 296423 | 242264 | | | 1000 | 420938 | 351318 |
| | | 1000 | 315740 | 248098 | | | 5600 | 471721 | 399009 |
| | | 5000 | 354221 | 291347 | | | 10850 | 486583 | 406313 |
| | | 6000 | 360279 | 294615 | | | 20250 | 498032 | 415346 |
| | | 7000 | 364350 | 300659 | | | 36000 | 505805 | 420810 |
| 22110611 | 4.775 | 100 | 364693 | 302279 | 22110615 | 4.983 | 100 | 353759 | 270938 |
| | | 500 | 422984 | 334943 | | | 500 | 409233 | 327876 |
| | | 1000 | 448432 | 368815 | | | 1000 | 433993 | 332551 |
| | | 5000 | 498887 | 410005 | | | 5000 | 483914 | 382525 |
| | | 10000 | 516341 | 418857 | | | 10000 | 499870 | 391402 |
| | | 30000 | 542975 | 444628 | | | 20000 | 514356 | 402359 |
| | | 163000 | 542975 | 444628 | | | 30000 | 521700 | 428790 |
| 22110621 | 4.802 | 100 | 364693 | 292072 | 22110625 | 5.084 | 100 | 344553 | 287493 |
| | | 500 | 422984 | 349428 | | | 500 | 398568 | 336368 |
| | | 1000 | 448432 | 375766 | | | 1000 | 422369 | 359237 |
| | | 5500 | 502171 | 412458 | | | 5500 | 473542 | 396133 |
| | | 10200 | 516064 | 424897 | | | 10300 | 488483 | 416178 |
| | | 27800 | 531795 | 451095 | | | 27000 | 504587 | 425504 |
| | | 189865 | 531795 | 451095 | | | 31000 | 504587 | 436750 |
| 22110631 | 4.929 | 100 | 355933 | 293711 | 22110635 | 5.107 | 100 | 342925 | 283021 |
| | | 500 | 413060 | 344631 | | | 500 | 396724 | 325793 |
| | | 1000 | 437120 | 354066 | | | 1000 | 420267 | 340699 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 5000 | 468740 | 380568 | | | 5000 | 495999 | 402455 |
| | | 10000 | 484734 | 401008 | | | 10000 | 511079 | 433381 |
| | | 23200 | 500238 | 427302 | | | 24000 | 527626 | 433381 |
| | | 33000 | 507015 | 417782 | | | 161500 | 527626 | 433381 |
| 32110611 | 5.195 | 100 | 339271 | 279291 | 32110615 | 4.987 | 100 | 352043 | 284615 |
| | | 500 | 391336 | 327805 | | | 500 | 407315 | 328967 |
| | | 1000 | 415323 | 345569 | | | 1000 | 431779 | 354377 |
| | | 5000 | 462916 | 379938 | | | 5000 | 481809 | 388809 |
| | | 10000 | 485831 | 399064 | | | 10000 | 497570 | 408325 |
| | | 27000 | 499917 | 405838 | | | 25000 | 514394 | 419822 |
| | | 184700 | 499917 | 415849 | | | 30000 | 520697 | 424547 |
| 32110621 | 5.078 | 100 | 345362 | 271669 | 32110625 | 4.955 | 100 | 353759 | 292414 |
| | | 500 | 397354 | 323075 | | | 500 | 409233 | 340783 |
| | | 1000 | 422220 | 342643 | | | 1000 | 433993 | 359756 |
| | | 5000 | 472596 | 393380 | | | 5000 | 483914 | 390748 |
| | | 10345 | 494553 | 386068 | | | 13900 | 511262 | 426373 |
| | | 25000 | 507624 | 421172 | | | 30300 | 521166 | 437977 |
| | | 162000 | 507624 | 421172 | | | 32000 | 521166 | 437977 |
| 32110631 | 5.182 | 100 | 339271 | 276190 | 32110635 | 4.913 | 100 | 355893 | 291745 |
| | | 500 | 391336 | 321085 | | | 500 | 411795 | 343594 |
| | | 1000 | 415323 | 340163 | | | 1000 | 436943 | 352219 |
| | | 5000 | 462916 | 376030 | | | 5000 | 487041 | 391903 |
| | | 10850 | 484898 | 401055 | | | 10000 | 503309 | 411785 |
| | | 30000 | 497481 | 410905 | | | 20000 | 517255 | 422062 |
| | | 164300 | 497481 | 416883 | | | 35000 | 526238 | 441010 |
| 32110612 | 5.127 | 100 | 343345 | 277734 | 11120511 | 3.060 | 120 | 1586414 | 1106042 |
| | | 500 | 397337 | 321208 | | | 560 | 1660332 | 1163740 |
| | | 1000 | 420664 | 336739 | | | 1000 | 1744691 | 1279887 |
| | | 5100 | 471096 | 381002 | | | 5000 | 2004423 | 1586665 |
| | | 10000 | 484996 | 399119 | | | 13600 | 1887682 | 1313810 |
| | | 28000 | 502117 | 410652 | | | 20000 | 1969677 | 1452254 |
| | | 206700 | 502117 | 410652 | | | 27900 | 2110580 | 1687641 |
| 32110622 | 4.955 | 100 | 353769 | 281595 | 11120521 | 3.029 | 100 | 1557572 | 1057588 |
| | | 500 | 409833 | 327921 | | | 500 | 1827537 | 1393265 |
| | | 1000 | 433402 | 352811 | | | 1000 | 1770323 | 1268598 |
| | | 5000 | 482909 | 385613 | | | 5000 | 2008279 | 1540365 |
| | | 11300 | 507600 | 417290 | | | 10500 | 1915148 | 1348219 |
| | | 26000 | 518553 | 427587 | | | 155600 | 2106109 | 1542132 |
| | | 170200 | 518553 | 427587 | | | 187200 | 2073048 | 1473129 |
| 32110632 | 4.854 | 100 | 361357 | 292889 | 11120531 | 3.166 | 100 | 1557572 | 1075930 |
| | | 500 | 418018 | 341028 | | | 500 | 1804090 | 1378284 |
| | | 1000 | 444479 | 365624 | | | 1000 | 1728766 | 1221443 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 5000 | 1819515 | 1302571 | | | 5100 | 1559890 | 1083018 |
| | | 10000 | 1873856 | 1338586 | | | 10500 | 1845528 | 1482800 |
| | | 166500 | 2097324 | 1541928 | | | 27000 | 1845528 | 1416962 |
| | | 352725 | 2072195 | 1473104 | | | 184100 | 1845528 | 1370600 |
| 11120512 | 3.116 | 100 | 1622894 | 1241783 | 11320511 | 3.182 | 100 | 1672388 | 1167284 |
| | | 510 | 1595263 | 1123573 | | | 550 | 1953756 | 1521555 |
| | | 1020 | 1624874 | 1147101 | | | 1000 | 1909700 | 1429508 |
| | | 5000 | 1864080 | 1432608 | | | 5000 | 2190744 | 1780301 |
| | | 10000 | 1935219 | 1508635 | | | 10200 | 2223903 | 1780301 |
| | | 31000 | 1935219 | 1435033 | | | 30975 | 2196498 | 1654307 |
| | | 161500 | 1966454 | 1418924 | | | 327866 | 2422467 | 1901272 |
| 11120522 | 3.165 | 100 | 1662151 | 1304541 | 11320521 | 3.302 | 100 | 1713132 | 1272697 |
| | | 500 | 1760384 | 1393584 | | | 500 | 1927911 | 1507226 |
| | | 1000 | 1724571 | 1299740 | | | 1000 | 1907024 | 1427760 |
| | | 5100 | 1884285 | 1491186 | | | 5500 | 1907024 | 1344000 |
| | | 10400 | 1766289 | 1229172 | | | 10000 | 2126596 | 1672711 |
| | | 20300 | 1793275 | 1250142 | | | 30140 | 2246863 | 1772398 |
| | | 176900 | 2189290 | 1732055 | | | 167820 | 2198604 | 1584760 |
| 11120532 | 3.125 | 130 | 1539036 | 1123250 | 11320531 | 2.984 | 160 | 1663424 | 1171433 |
| | | 500 | 1644047 | 1251033 | | | 500 | 1953622 | 1544488 |
| | | 1000 | 1822254 | 1488006 | | | 1000 | 1819010 | 1279669 |
| | | 5000 | 1793149 | 1335909 | | | 5000 | 2102360 | 1662435 |
| | | 10200 | 1854182 | 1408573 | | | 11500 | 2102360 | 1633600 |
| | | 20000 | 2004243 | 1635577 | | | 36300 | 2077756 | 1531418 |
| | | 177600 | 1957632 | 1416695 | | | 362000 | 2224096 | 1599177 |
| 11120515 | 3.154 | 100 | 1579639 | 1265063 | 11320512 | 3.277 | 100 | 1585242 | 1125190 |
| | | 500 | 1579639 | 1221059 | | | 500 | 1675390 | 1188565 |
| | | 1000 | 1734320 | 1406167 | | | 1000 | 1927369 | 1547708 |
| | | 5600 | 1684770 | 1235751 | | | 5000 | 2054373 | 1661326 |
| | | 10000 | 1684770 | 1235751 | | | 10200 | 1978585 | 1489857 |
| | | 19500 | 1745771 | 1280647 | | | 21900 | 1935604 | 1387641 |
| | | 170900 | 1800820 | 1266033 | | | 135600 | 2223398 | 1724401 |
| 11120525 | 3.137 | 100 | 1594421 | 1290330 | 11320522 | 3.297 | 100 | 1566701 | 1105099 |
| | | 500 | 1490203 | 1035320 | | | 500 | 1851697 | 1462304 |
| | | 1100 | 1602291 | 1210754 | | | 1000 | 1772886 | 1288152 |
| | | 5400 | 1672280 | 1232831 | | | 5000 | 1924448 | 1475106 |
| | | 10400 | 1748154 | 1309001 | | | 10000 | 1841297 | 1276225 |
| | | 23200 | 1959860 | 1602450 | | | 27600 | 2017991 | 1532382 |
| | | 123900 | 1959860 | 1499815 | | | 344800 | 2292853 | 1804389 |
| 11120535 | 3.193 | 110 | 1533827 | 1205987 | 11320532 | 3.202 | 100 | 1566701 | 1090503 |
| | | 500 | 1457970 | 1012811 | | | 500 | 1655509 | 1154701 |
| | | 1000 | 1479042 | 1026948 | | | 1000 | 1702798 | 1188738 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) | SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | 5000 | 1859015 | 1375283 | | | 5000 | 1490973 | 1032943 |
| | | 11100 | 1922812 | 1410661 | | | 10000 | 1490973 | 1006848 |
| | | 31800 | 2174536 | 1735628 | | | 49400 | 1655522 | 1200726 |
| | | 171600 | 2206978 | 1649504 | | | 171600 | 1789352 | 1341503 |
| 11320515 | 2.431 | 100 | 1726380 | 1306044 | 22120612 | 4.831 | 100 | 1410274 | 1100093 |
| | | 500 | 1806835 | 1352966 | | | 500 | 1347322 | 928756 |
| | | 1000 | 1907729 | 1485960 | | | 1000 | 1419396 | 1036463 |
| | | 5000 | 1865440 | 1320446 | | | 5000 | 1625519 | 1266044 |
| | | 10150 | 2177106 | 1763950 | | | 10000 | 1603326 | 1200924 |
| | | 35900 | 2151127 | 1663126 | | | 136200 | 1677748 | 1200924 |
| | | 157900 | 2354756 | 1911962 | | | 322900 | 1853417 | 1419253 |
| 11320525 | 2.961 | 100 | 1696626 | 1343729 | 22120622 | 4.808 | 100 | 1311243 | 952124 |
| | | 500 | 1766813 | 1378208 | | | 500 | 1467570 | 1130467 |
| | | 1000 | 1807463 | 1405759 | | | 1000 | 1378638 | 951216 |
| | | 5000 | 1775662 | 1271296 | | | 5000 | 1596340 | 1227222 |
| | | 10700 | 1908640 | 1461984 | | | 10000 | 1552515 | 1123247 |
| | | 20750 | 1831399 | 1282089 | | | 33500 | 1517082 | 1025476 |
| | | 191200 | 1996902 | 1446656 | | | 143000 | 1675404 | 1201338 |
| 11320535 | 3.642 | 100 | 1440709 | 1030432 | 22120632 | 5.074 | 100 | 1338219 | 1030488 |
| | | 500 | 1499385 | 1057239 | | | 500 | 1405230 | 1080634 |
| | | 1000 | 1732970 | 1378516 | | | 1000 | 1352657 | 946214 |
| | | 5300 | 1699072 | 1239810 | | | 5000 | 1624172 | 1313379 |
| | | 10225 | 1662999 | 1168603 | | | 10800 | 1473133 | 1046749 |
| | | 30000 | 1790578 | 1326965 | | | 147150 | 1726053 | 1310303 |
| | | 153100 | 2089451 | 1688184 | | | 320100 | 1829860 | 1459579 |
| 22120611 | 4.886 | 100 | 1409797 | 1048327 | 22120615 | 5.115 | 100 | 1275099 | 1004536 |
| | | 500 | 1483301 | 1099758 | | | 500 | 1232428 | 870151 |
| | | 1000 | 1537544 | 1151777 | | | 1000 | 1208493 | 811935 |
| | | 7700 | 1696892 | 1313383 | | | 5000 | 1438869 | 1103853 |
| | | 10500 | 1579399 | 1096456 | | | 10000 | 1347640 | 926130 |
| | | 134600 | 1782958 | 1298768 | | | 36400 | 1443531 | 1053101 |
| | | 309300 | 1890778 | 1428689 | | | 158700 | 1544612 | 1148882 |
| 22120621 | 4.944 | 100 | 1366169 | 988184 | 22120625 | 4.914 | 100 | 1173795 | 830443 |
| | | 500 | 1408937 | 1005992 | | | 500 | 1306258 | 969855 |
| | | 1000 | 1615163 | 1283869 | | | 1100 | 1387499 | 1085578 |
| | | 5000 | 1615163 | 1186539 | | | 5500 | 1343335 | 931292 |
| | | 10000 | 1615163 | 1156870 | | | 10900 | 1360908 | 931292 |
| | | 30500 | 1615163 | 1101702 | | | 22000 | 1395663 | 963235 |
| | | 185800 | 1852475 | 1380064 | | | 161700 | 1726975 | 1389601 |
| 22120631 | 5.076 | 100 | 1272697 | 876578 | 22120635 | 5.155 | 100 | 1103029 | 752229 |
| | | 500 | 1428105 | 1047690 | | | 500 | 1186246 | 817144 |
| | | 1240 | 1579457 | 1248046 | | | 1000 | 1411256 | 1141951 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.

Table E. Calculated resilient and total moduli using FEM program

| SAMPLE NUMBER | AV | N | MR (psi) | E (psi) |
|---|---|---|---|---|
| | | 5500 | 1351119 | 969408 |
| | | 10000 | 1351119 | 969408 |
| | | 128000 | 1637326 | 1292336 |
| | | 337900 | 1709560 | 1370465 |
| 32120611 | 5.226 | 100 | 1338655 | 996040 |
| | | 500 | 1338655 | 926034 |
| | | 1000 | 1404886 | 1015432 |
| | | 5500 | 1482591 | 1054720 |
| | | 12000 | 1600795 | 1213656 |
| | | 37000 | 1600795 | 1143635 |
| | | 164500 | 1783299 | 1366968 |
| 32120621 | 5.220 | 100 | 1285598 | 911346 |
| | | 500 | 1459528 | 1094893 |
| | | 1000 | 1549836 | 1226444 |
| | | 5000 | 1474063 | 1015553 |
| | | 10000 | 1655221 | 1259186 |
| | | 29500 | 1590882 | 1133997 |
| | | 154700 | 1804632 | 1395560 |
| 32120631 | 5.209 | 100 | 1366169 | 1030209 |
| | | 500 | 1366169 | 979564 |
| | | 1000 | 1396742 | 990961 |
| | | 5100 | 1426570 | 972863 |
| | | 10500 | 1615503 | 1222520 |
| | | 28800 | 1615503 | 1180675 |
| | | 154700 | 1852480 | 1456965 |
| 32120612 | 5.176 | 100 | 1285598 | 890392 |
| | | 500 | 1371918 | 981809 |
| | | 2000 | 1578353 | 1234617 |
| | | 5100 | 1666000 | 1342329 |
| | | 14200 | 1608620 | 1176850 |
| | | 27150 | 1744123 | 1396726 |
| | | 194700 | 1821376 | 1396726 |
| 32120622 | 5.414 | 100 | 1172822 | 807863 |
| | | 500 | 1230737 | 845126 |
| | | 1000 | 1481881 | 1194379 |
| | | 5000 | 1425014 | 1027211 |
| | | 10000 | 1514583 | 1169000 |
| | | 153600 | 1769900 | 1433206 |
| | | 322400 | 1645053 | 1183929 |
| | | 471900 | 1817126 | 1456555 |
| 32120632 | 5.052 | 100 | 1218042 | 834827 |
| | | 500 | 1514354 | 1228219 |
| | | 1000 | 1429049 | 1053822 |
| | | 5000 | 1538128 | 1185835 |
| | | 10000 | 1465620 | 1014638 |
| | | 22700 | 1543350 | 1122505 |
| | | 147850 | 1717295 | 1287078 |
| | | 481600 | 1691634 | 1191765 |
| 32120615 | 5.136 | 100 | 1366169 | 1030209 |
| | | 500 | 1435679 | 1057393 |
| | | 1000 | 1393454 | 971627 |
| | | 5000 | 1466606 | 1009997 |
| | | 12000 | 1550833 | 1127386 |
| | | 32500 | 1550833 | 1080982 |
| | | 174350 | 1951825 | 1589339 |
| 32120625 | 5.234 | 100 | 1103029 | 752229 |
| | | 500 | 1194978 | 828742 |
| | | 1000 | 1216451 | 840545 |
| | | 5000 | 1330863 | 953627 |
| | | 10000 | 1447721 | 1107781 |
| | | 29800 | 1447721 | 1078075 |
| | | 199500 | 1471764 | 1037143 |
| | | 490700 | 1659156 | 1264827 |
| 32120635 | 5.416 | 100 | 1064743 | 709441 |
| | | 500 | 1189553 | 836029 |
| | | 1000 | 1293887 | 970099 |
| | | 5000 | 1450051 | 1156540 |
| | | 10000 | 1319834 | 927424 |
| | | 33300 | 1548994 | 1234522 |
| | | 150400 | 1454452 | 1010850 |
| | | 353200 | 1478386 | 1025685 |

N = number of load applications;

AV = percent air voids;

MR = calculated resilient modulus using FEM program;

E = calculated total modulus using FEM program.