CHARACTERISTICS OF ASPHALT PAVING MIXTURES UNDER CYCLIC LOAD USING FLEXURAL TESTS

Dissertation for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

KISE LEE

1988

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CHARACTERISTICS OF ASPHALT PAVING MIXTURES UNDER CYCLIC LOAD USING FLEXURAL TESTS

BY

KISE LEE

A DISSERTATION

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

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1988

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

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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.

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Special appreciation, admiration, and love are due his parents who make it all worth while.

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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.

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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;

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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;

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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 tem pavemen

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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

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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.

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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.

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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.


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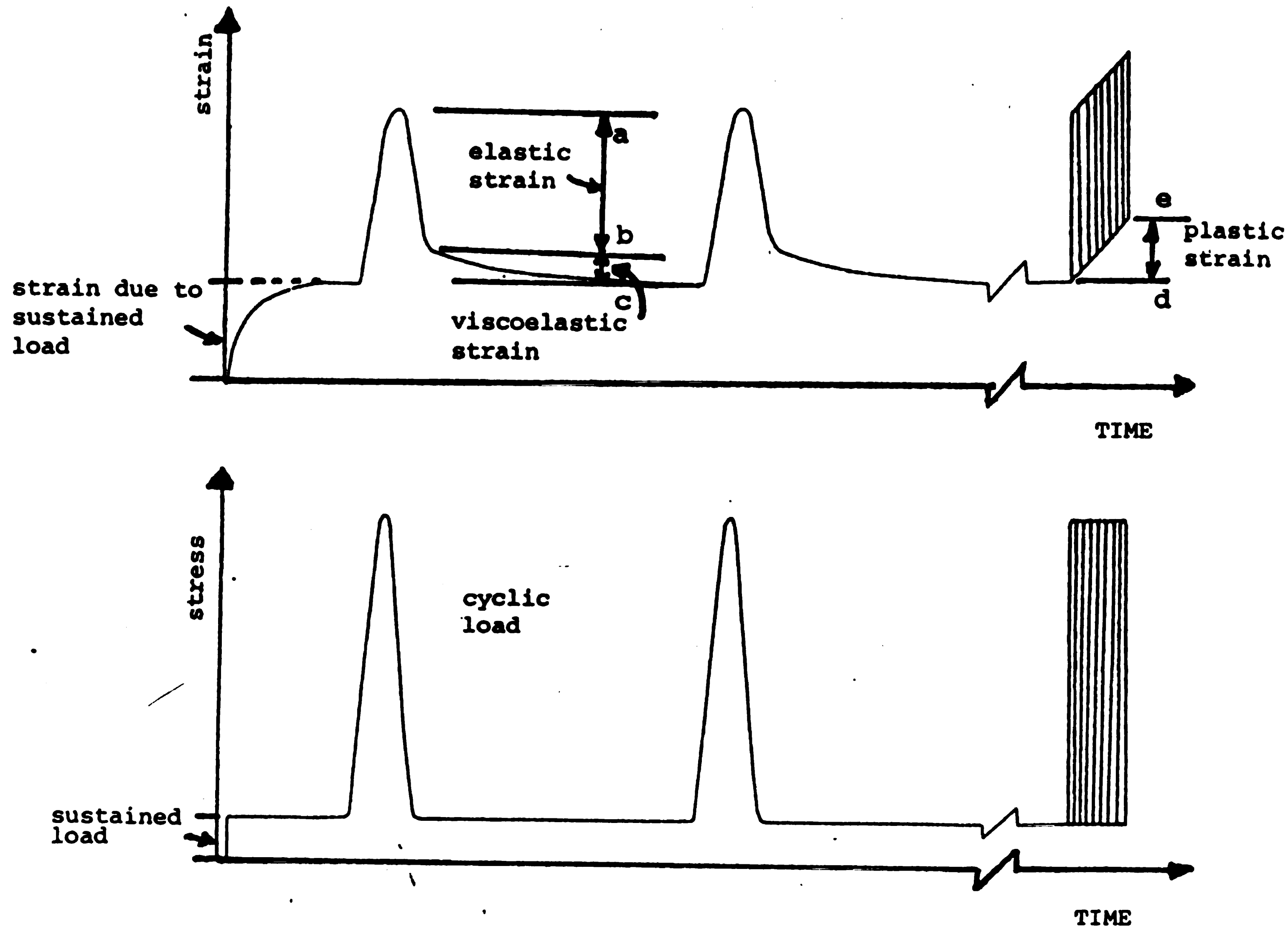

Figure 2.1 Features of the cyclic stress-strain curve of asphalt mixes.

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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

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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

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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.

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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

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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.

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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

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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:

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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 modu

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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 $425^{o}F$. 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.

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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:

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

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

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

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

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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 ^oF (10^6 poises);

X4 = percent asphalt by total weight of mix;

X5 = test temperature (^oF);

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 agreem

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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 conc

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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 dist

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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

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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).

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

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 agr

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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.

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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

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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 de

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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

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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 s

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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).

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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.

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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

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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

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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.

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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.

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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

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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 desig

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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,

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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.

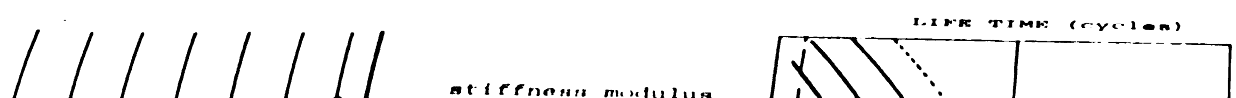
1) Although the slopes of the fatigue lines are dependent on the asphalt type, the test temperature, the asphalt content, and the test type a constant value of 0.2 is assumed to represents all of the 146 fatigue lines.
2) The slope of the line representing the initial strain

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


LIFE TIME (cycles)
stiffness modulus

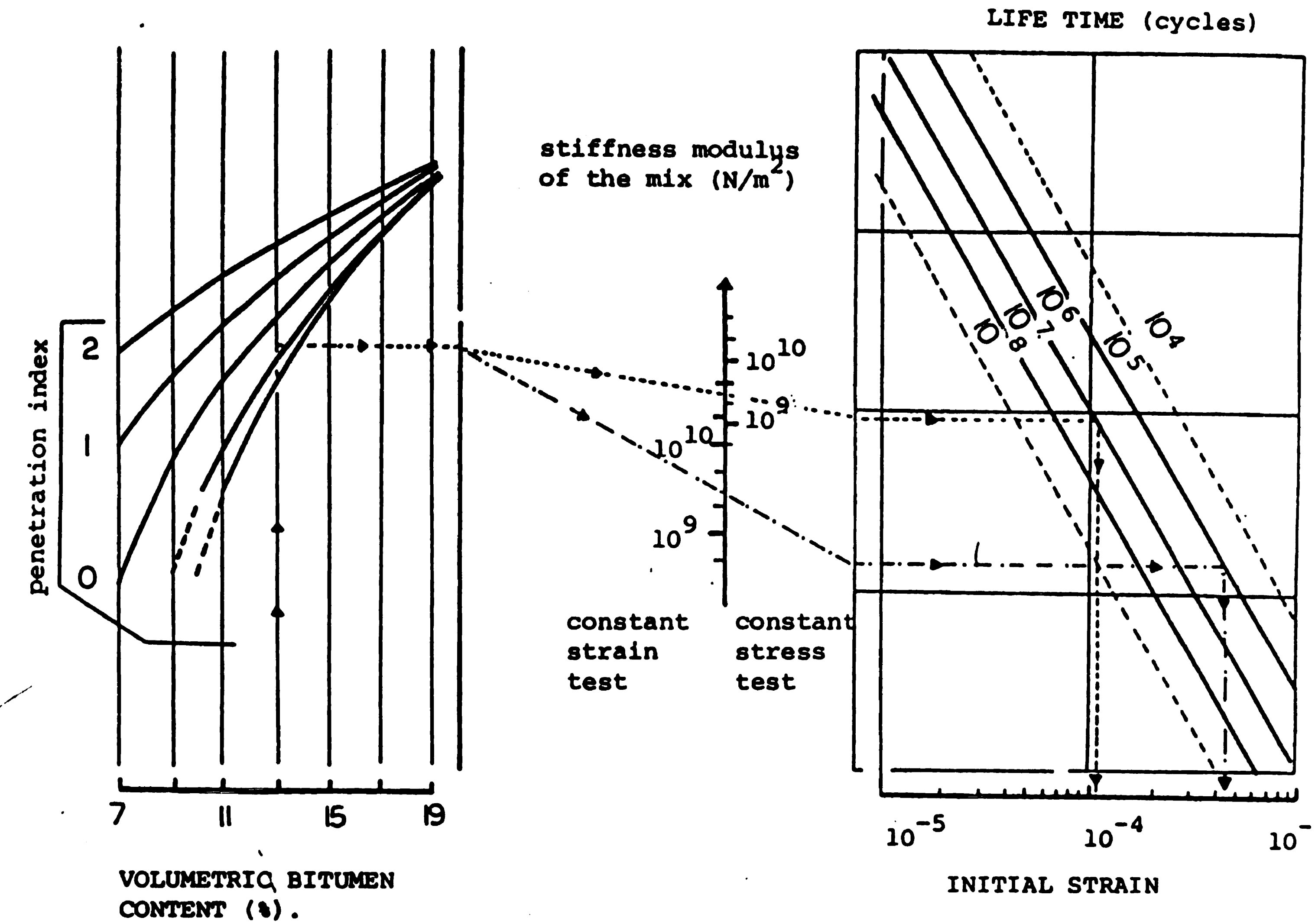


Figure 2.2 Nomograph for predicting the fatigue life of bituminous materials (after bonnaure et al.).

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

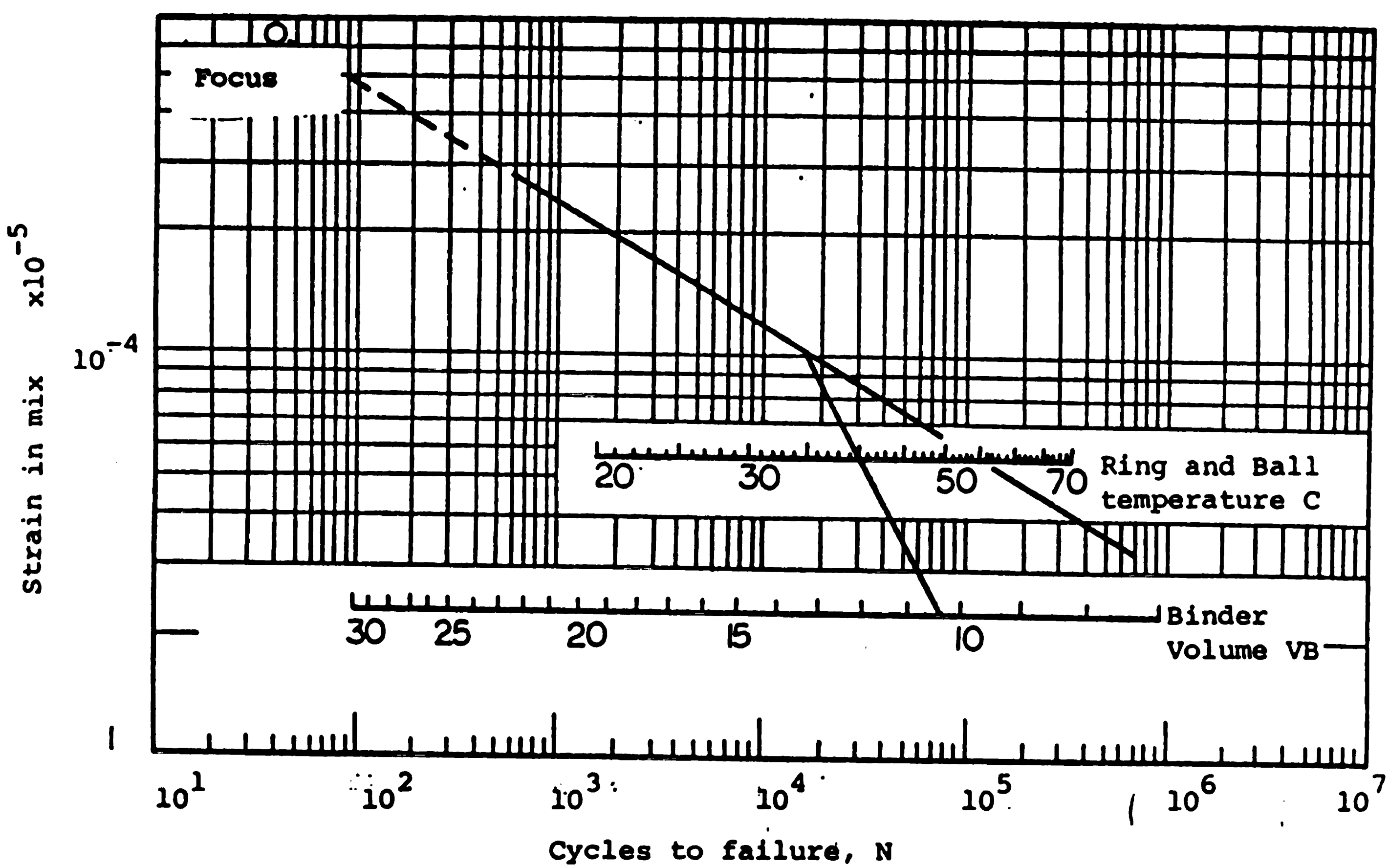


Figure 2.3 Nomograph for prediction on the fatigue life of bituminous materials (after pell and cooper).

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.
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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	61.42
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	11.59
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
	Gs (BK)	2.665	2.676	2.671	2.757	2.699	2.728
limestone	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
	Gs (BK)	2.683	2.704	2.694	2.623	2.703	2.663
natural gravel	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
	Gs (BK)	2.663	2.726	2.695	2.697	2.726	2.712
50/50 mix	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.

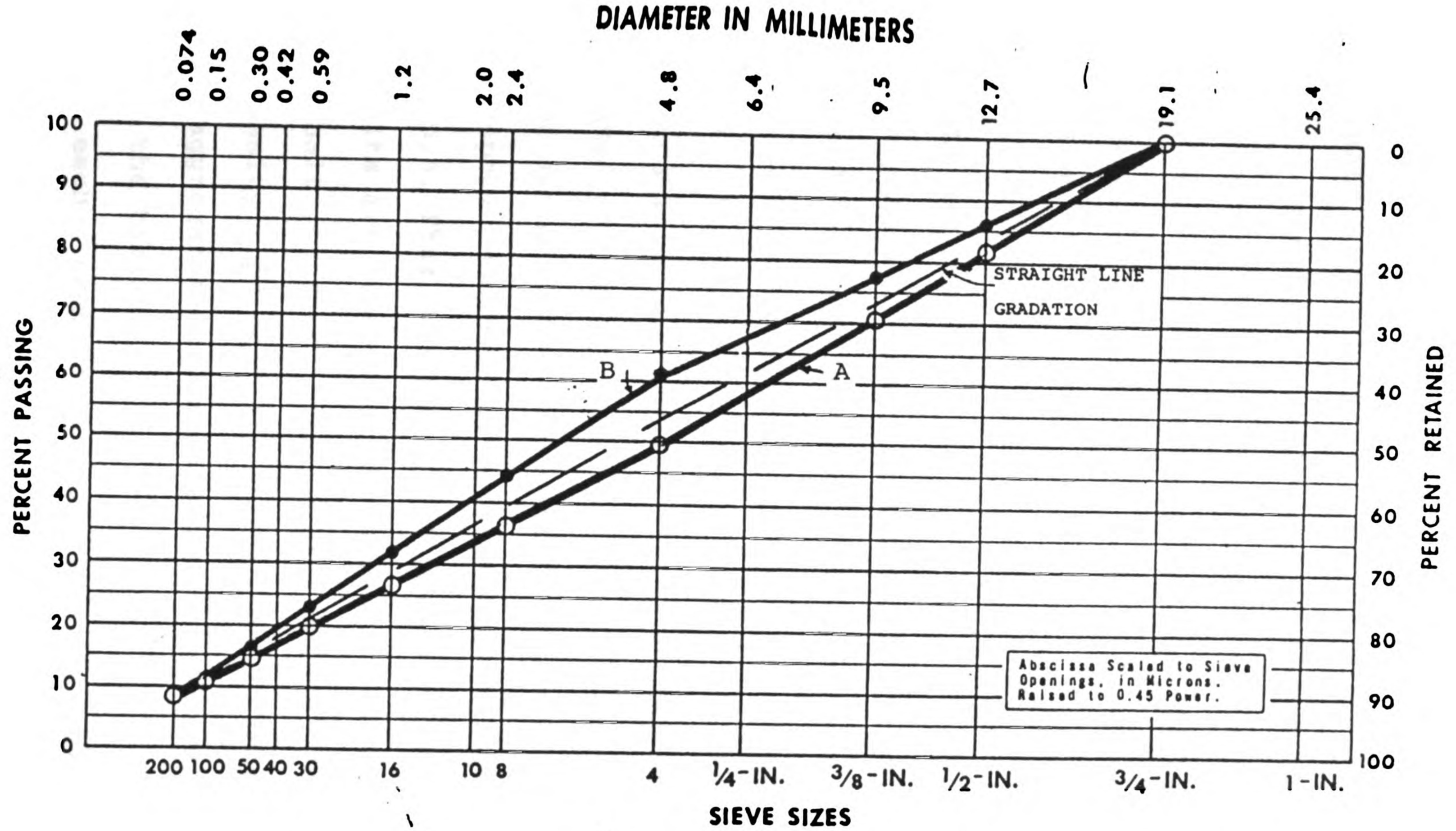

Figure 3.1 Straight line and A and B gradations.

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	2850	2795	2780	1920	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 content	S	1450	1450	1530	1670	2070	2040	1070	1000	1050	1480	1530	1850	1210	1360	1200	1459	1470	1650
	AS	1577	1579	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	_.45	2.46
	AV	1.65	1.65	1.93	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			1706			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 3.5	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
	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	
4.2	S	2210	2380	2250	2600	2530	2510	1480	1450	1450	1950	2040	1990	2205	2030	2170	3030	2880	2690
	AS	2374	2562	2419	2766	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
	GS	2.47	2.47	2.47	2.45	2.45	2.46	2.46	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	920	1000	1020	1190	1230	1300	1240	1180	1260	1680	1770	1830
	AS	1656	1564	1681	1961	1808	1950	986	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	1260	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			796			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 content	S	2610	2450	2600	2920	2950	3200	2070	2150	1660	2560	2590	2500	2200	2010	2300	2190	2360	2300
	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	4.93	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	1460	2080	2200	2270	1480	1500	1780	1920	1850	1780
	AS	2077	2009	2169	2620	2676	2873	1306	1228	1594	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	3.85	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		1927			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 content	S	1180	1400	1390	1650	1560	1660	960	900	1000	1050	1140	1200	890	860	980	1300	1230	1380
	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	920	820	910	800	830	720	900	970	930
	AS	1024	981	1042	1103	1300	1288	660	800	920	980	889	965	864	910	778	962	1055	994
	F	25	24	21	18	19	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	14.80	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	LIMESTONE		ROUNDED GRAVEL		50/50 MIX	
GRADATION	A	B	A	B	A	B
ASPHALT TYPE (PENETRATION)						
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	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

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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

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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.

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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.

AGGREGATE			LIMESTONE									ROUNDED GRAVEL									50/50 MIX BY WEIGHT								
ASPHALT PEN			75-100			125-150			200-250			75-100			125-150			200-250			75-100			125-150			200-250		
AIR VOIDS (%)			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
TEMPERATURE (°F)	**GRADATION**	**LOAD**																											
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, bu

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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°F = 1, 40°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:

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(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.

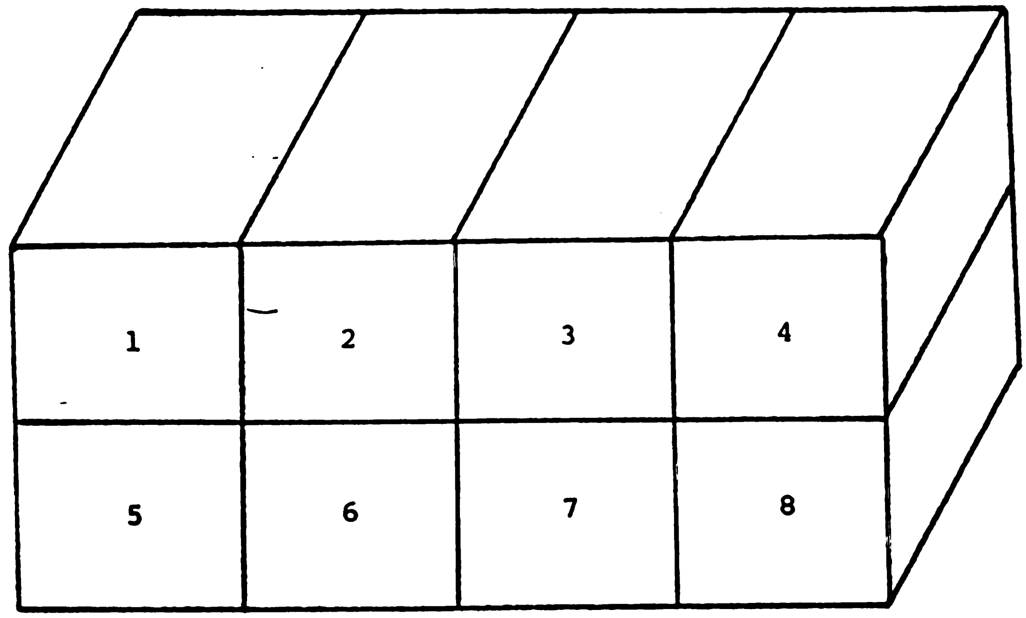

Figure 3.4 Beam specimen sawed to eight equal parts for density analysis.

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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)

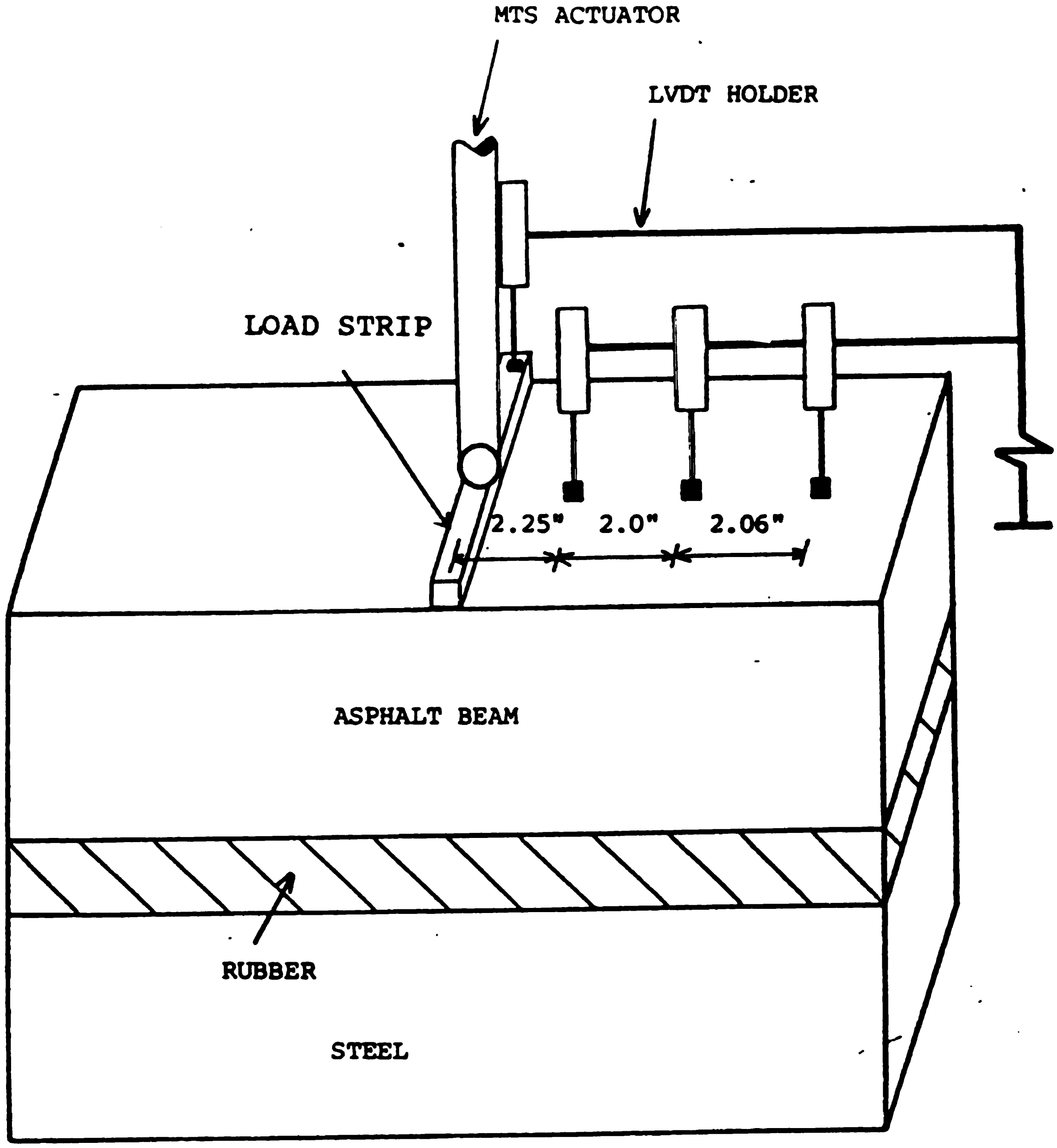

Figure 3.5 Schematic diagram of the beam test set-up.

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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

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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.

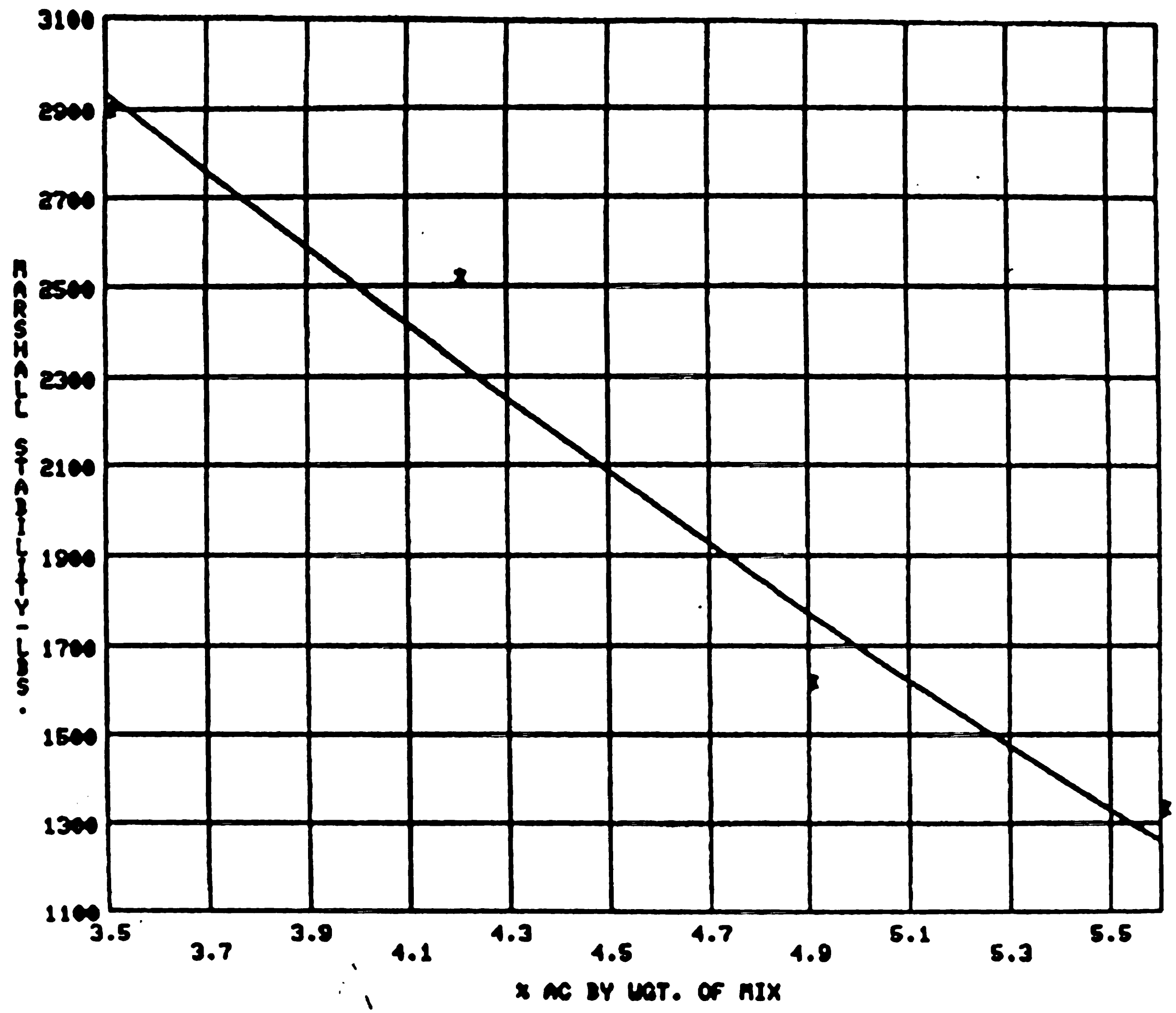


Figure 4.1 Marshall stability versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

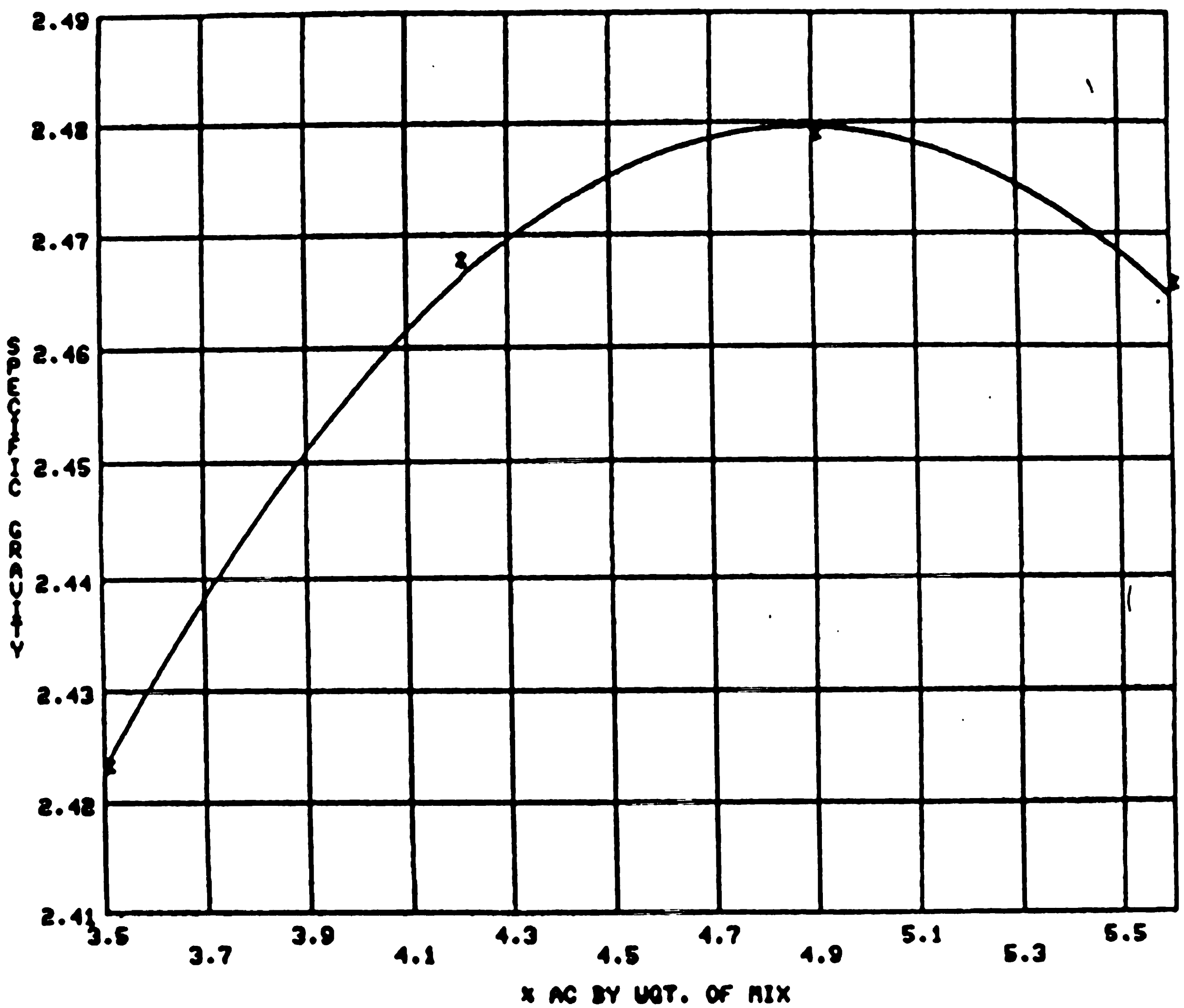


Figure 4.2 bulk specific gravity of the mix versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

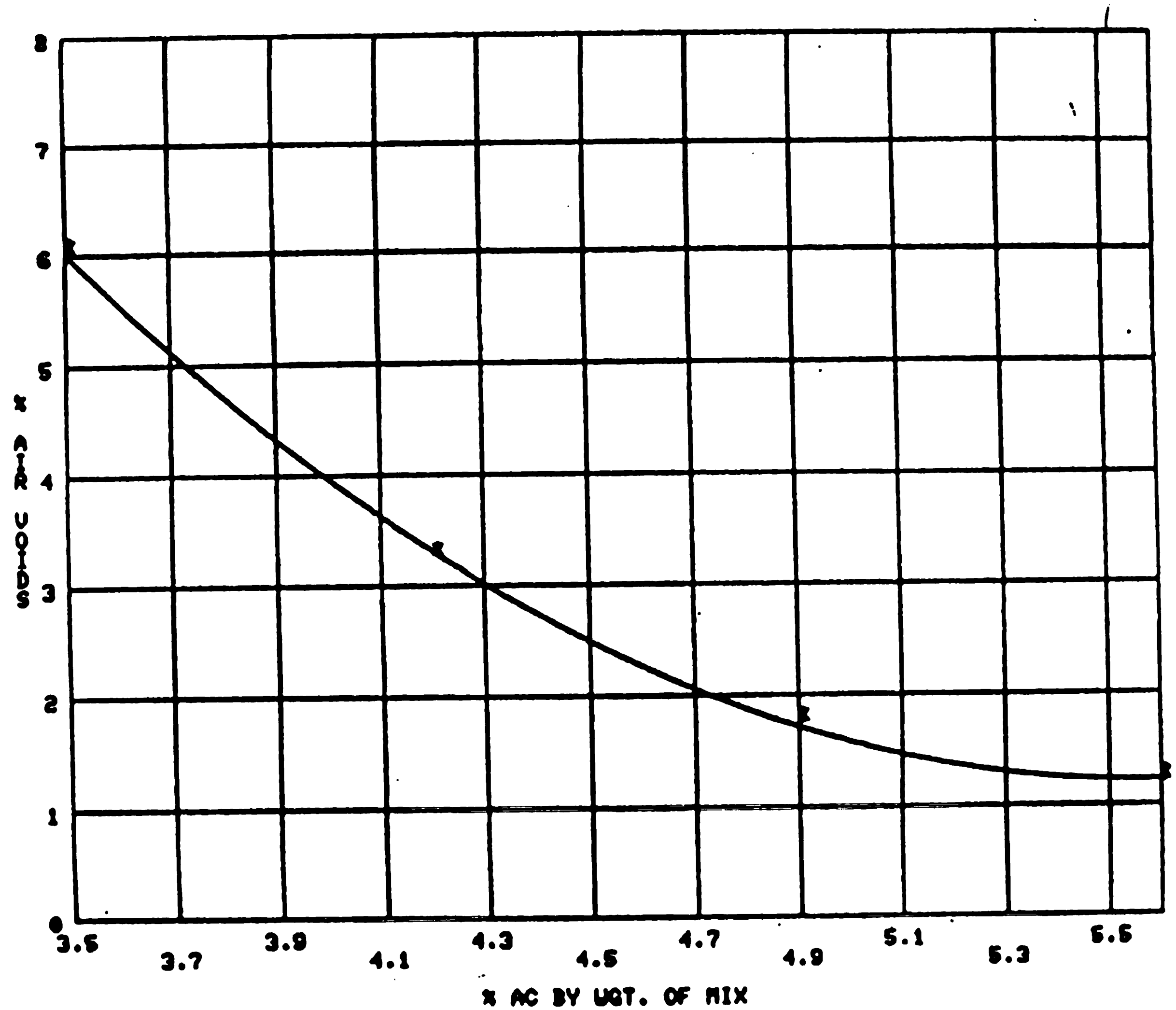


Figure 4.3 Percent air voids versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

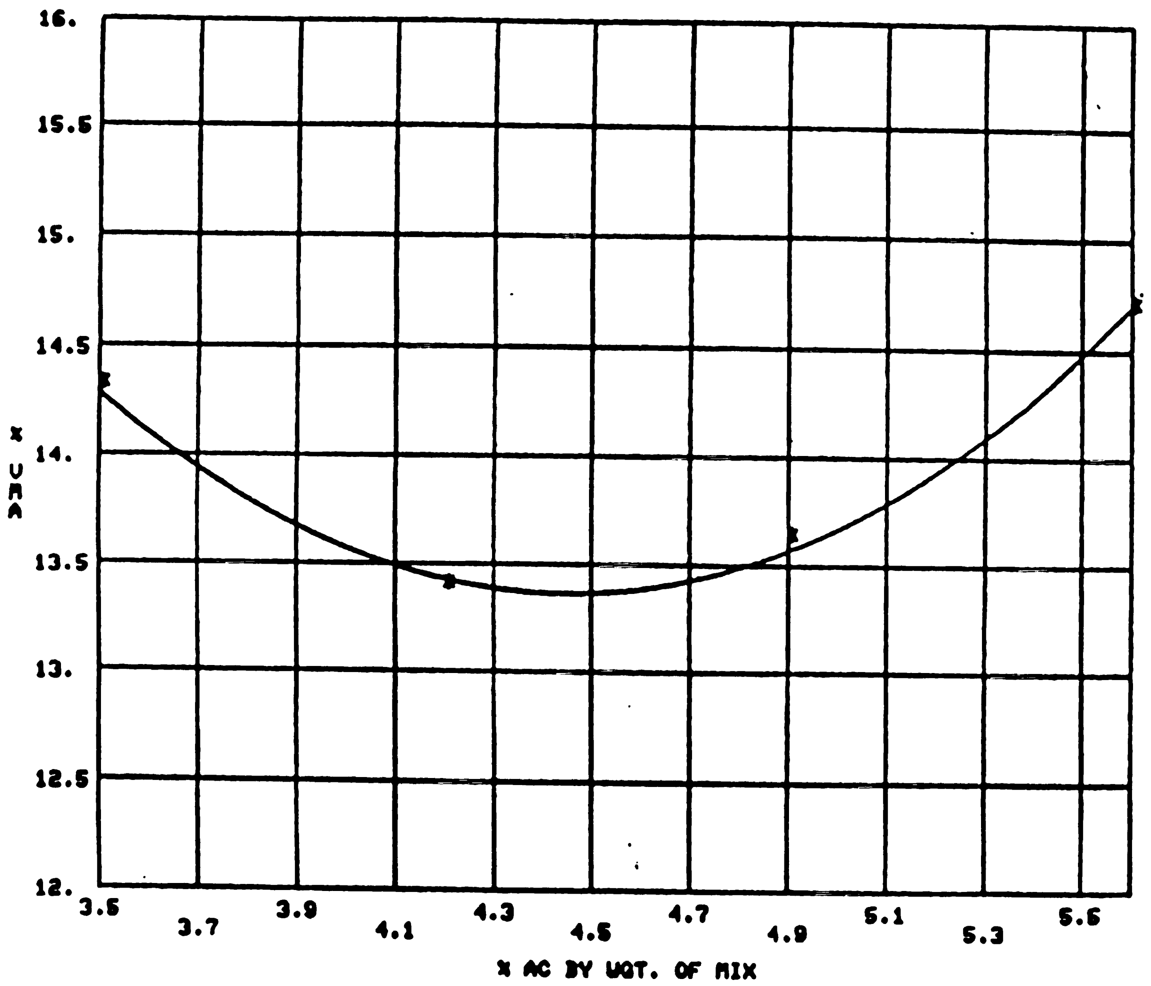


Figure 4.4 Percent voids in mineral aggregate versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

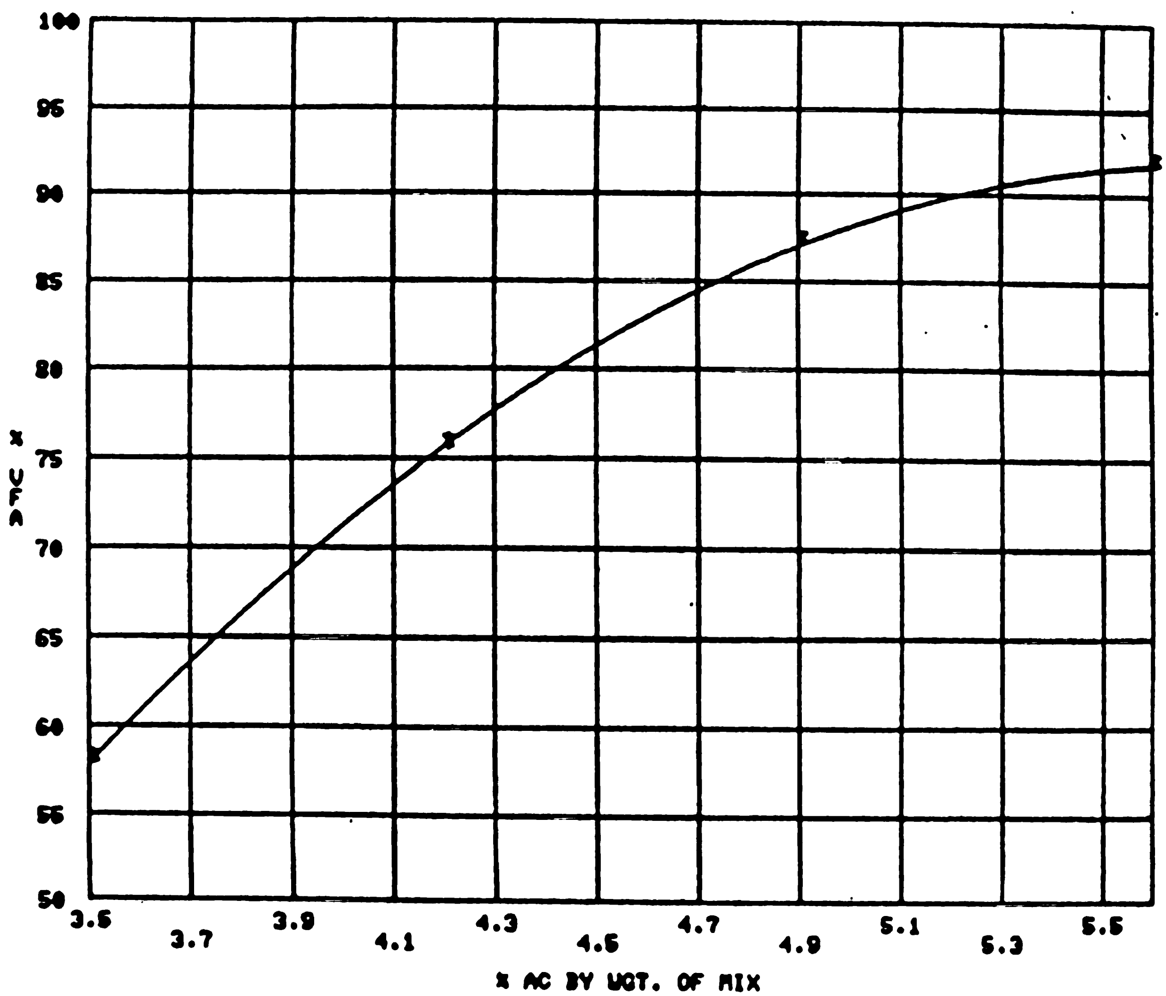


Figure 4.5 Percent voids filled with asphalt versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

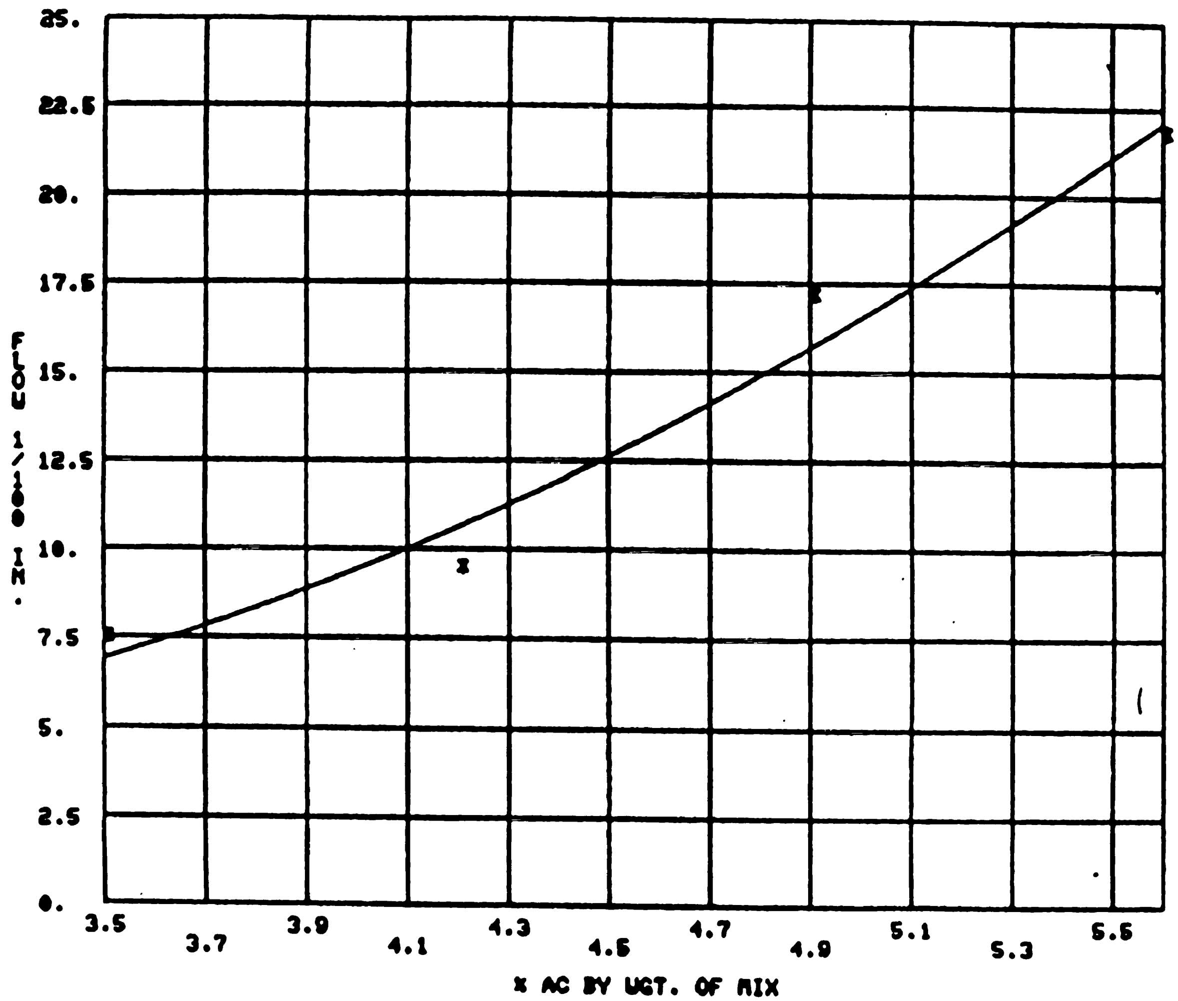


Figure 4.6 Flow versus percent asphalt content for limestone gradation A and viscosity graded asphalt AC-10.

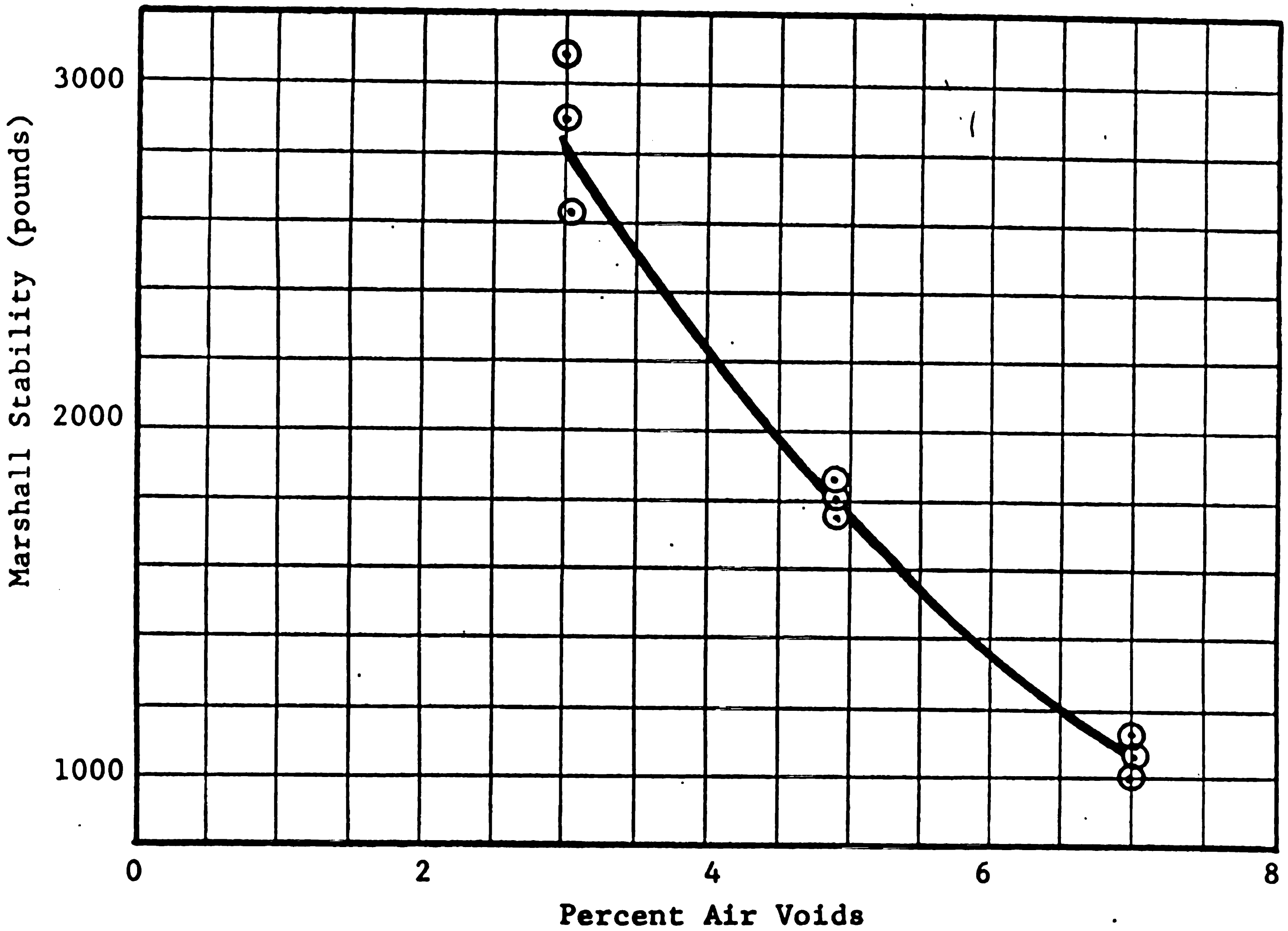


Figure 4.7 Marshall stability versus the percent air voids of the specimen.

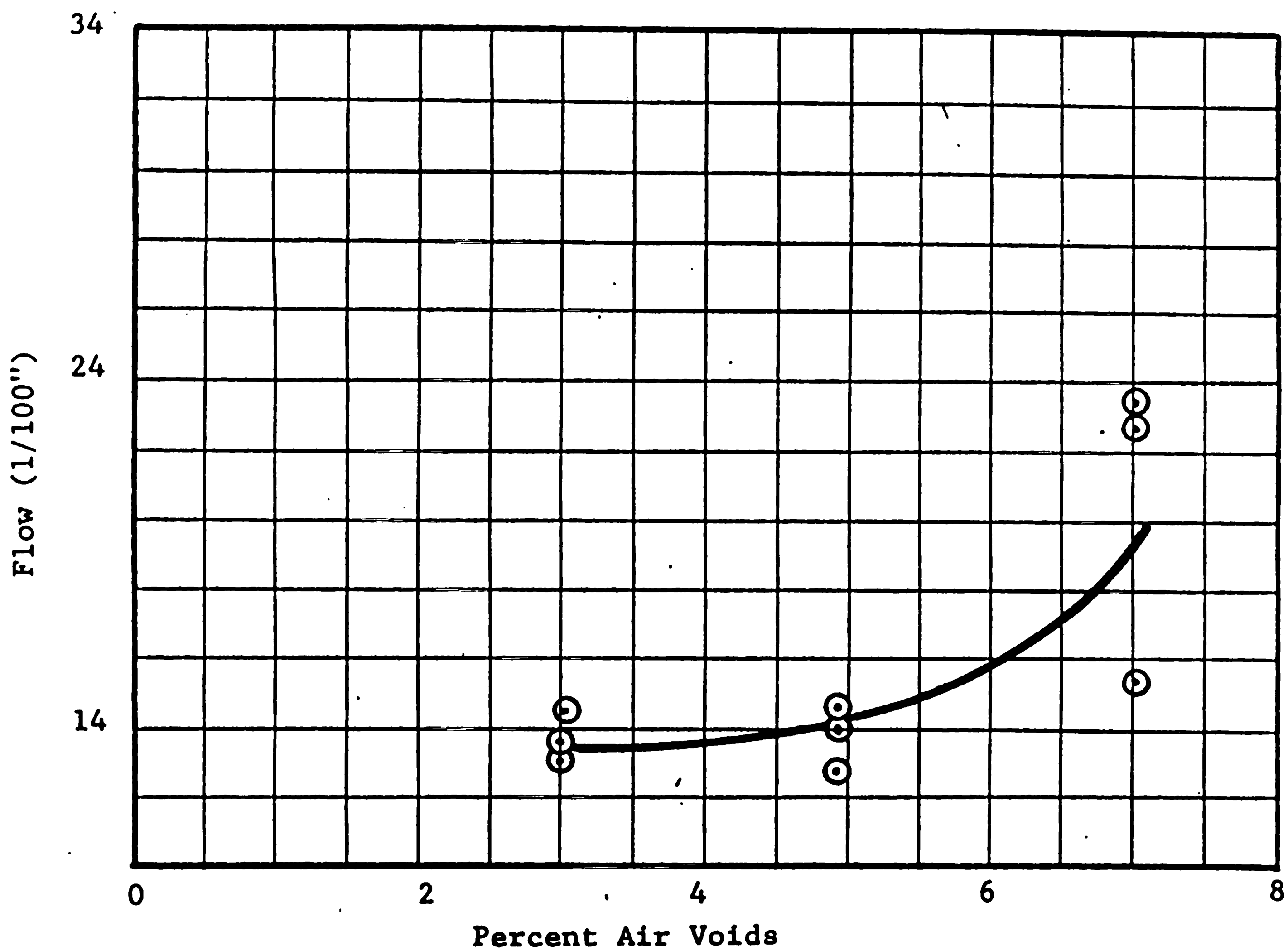


Figure 1.8 Flow values versus the percent air voids of the specimens.

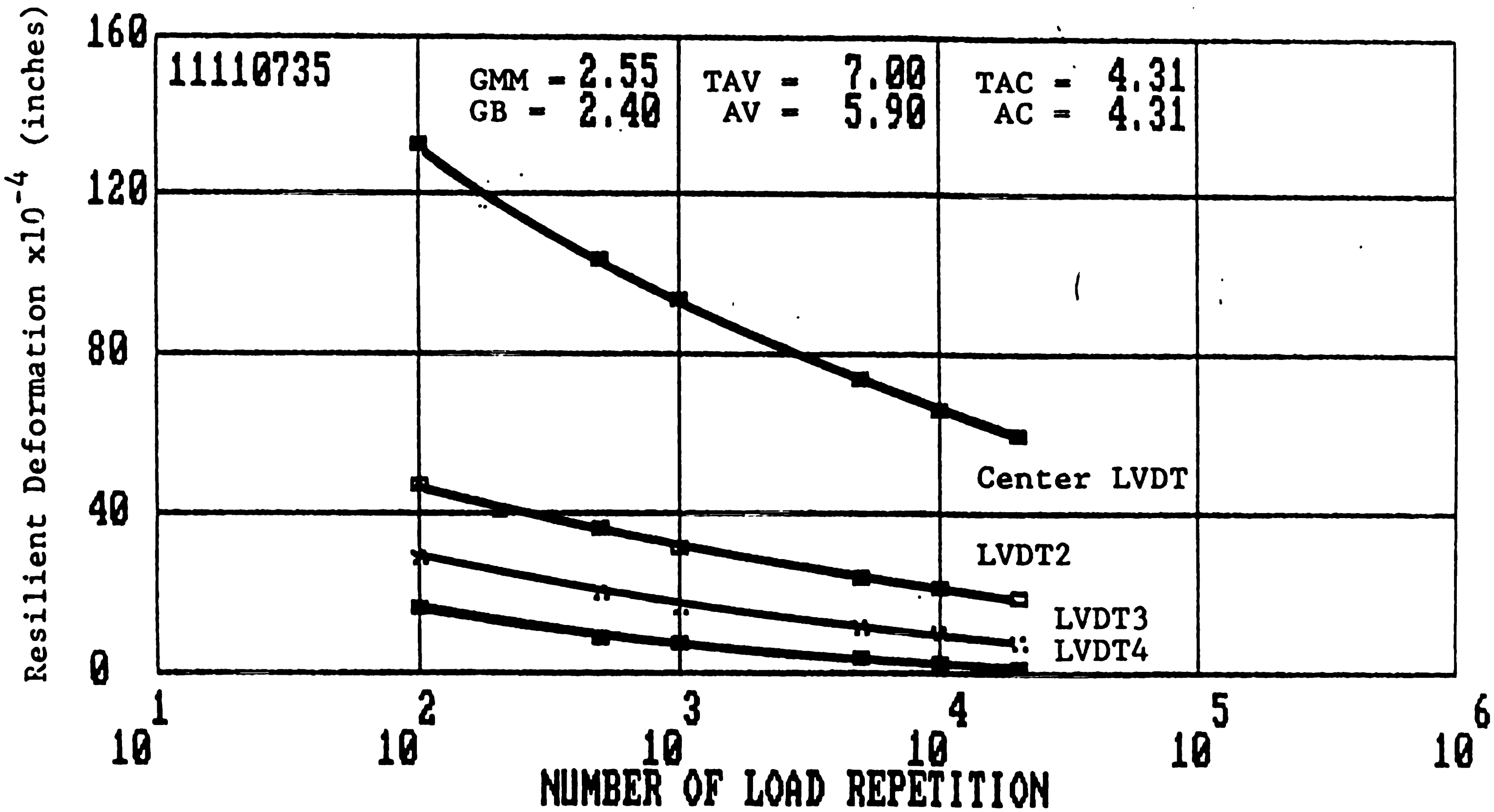


Figure 4.9 Resilient deformations at four points on the surface of the beam specimen versus the number of load applications.

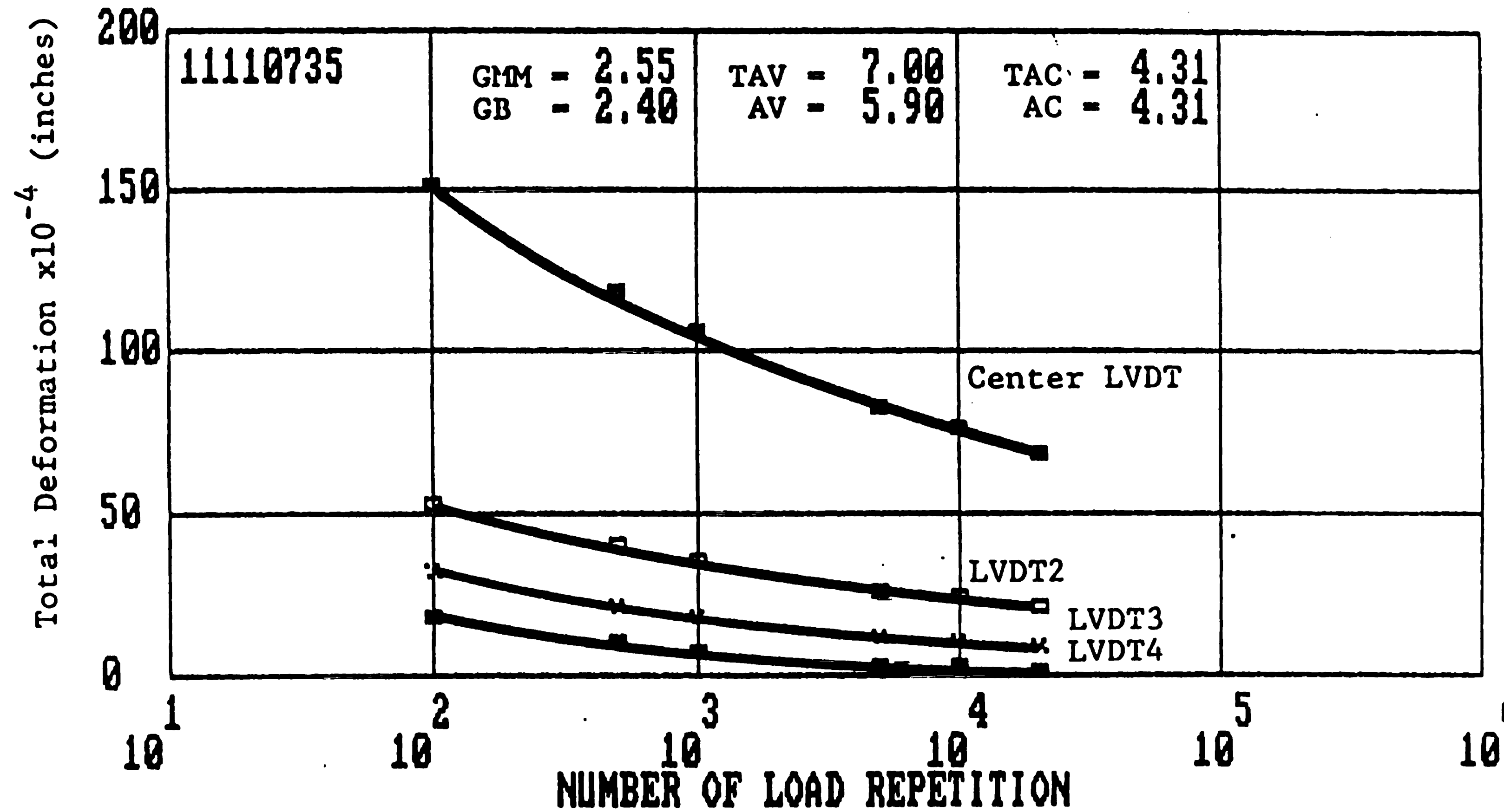


Figure 4.10 Total deformations at four points on the surface of the beam specimen versus the number of load applications.

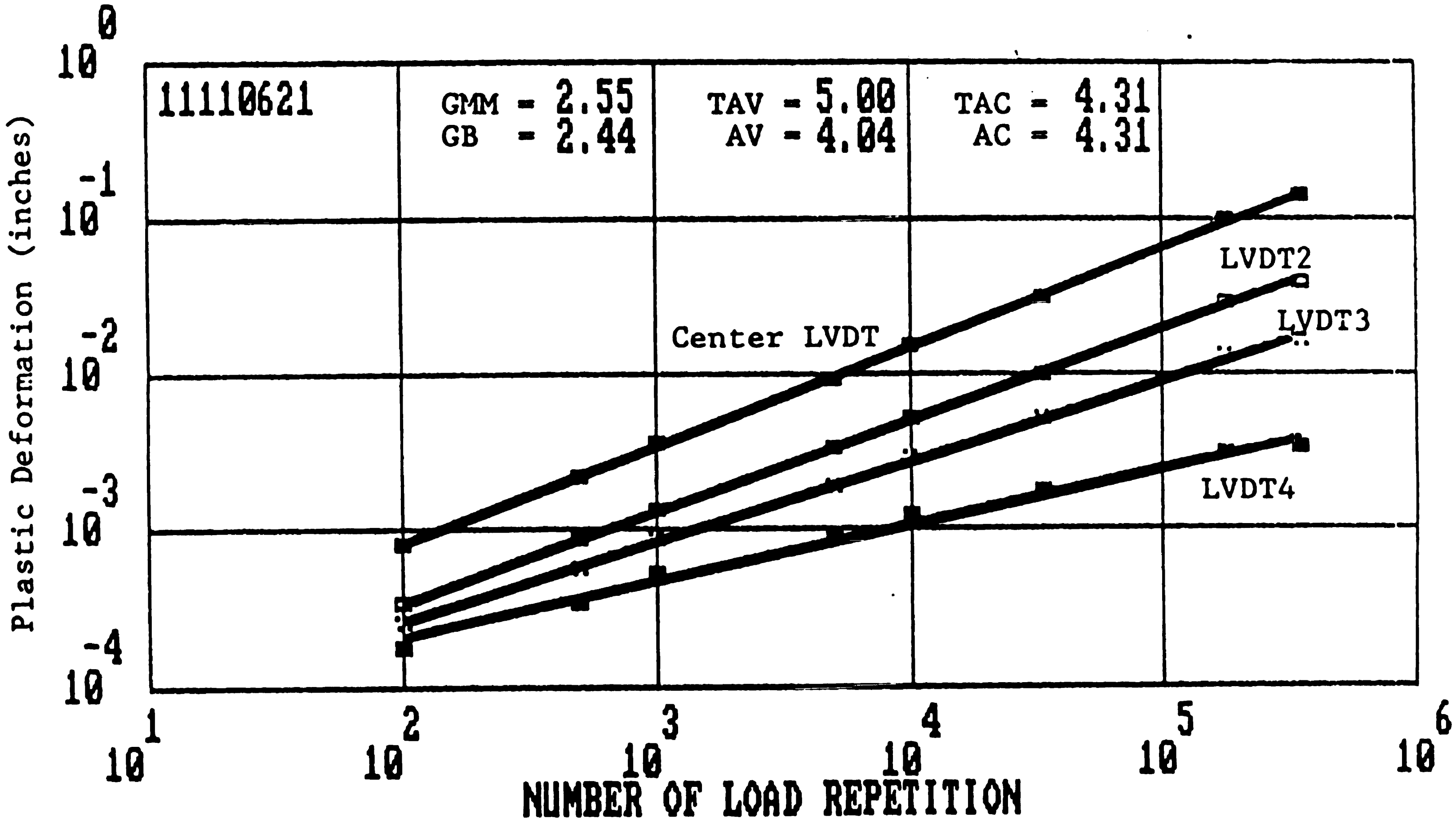


Figure 4.11 Cumulative plastic deformations at four points on the surface of the beam specimen versus the number of load applications.

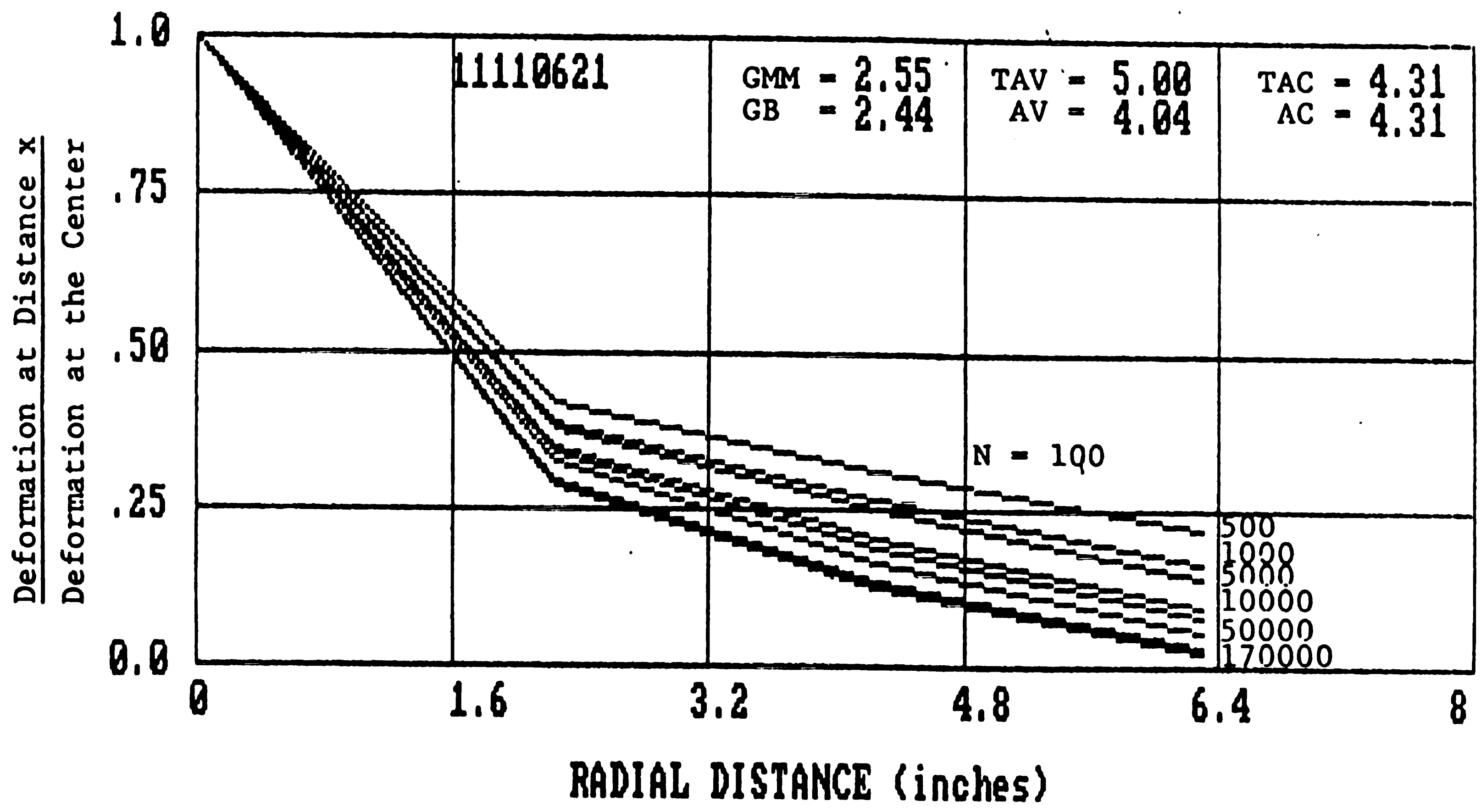


Figure 4.12 Normalized plastic deformation basin of the beam specimen at different number of load applications.

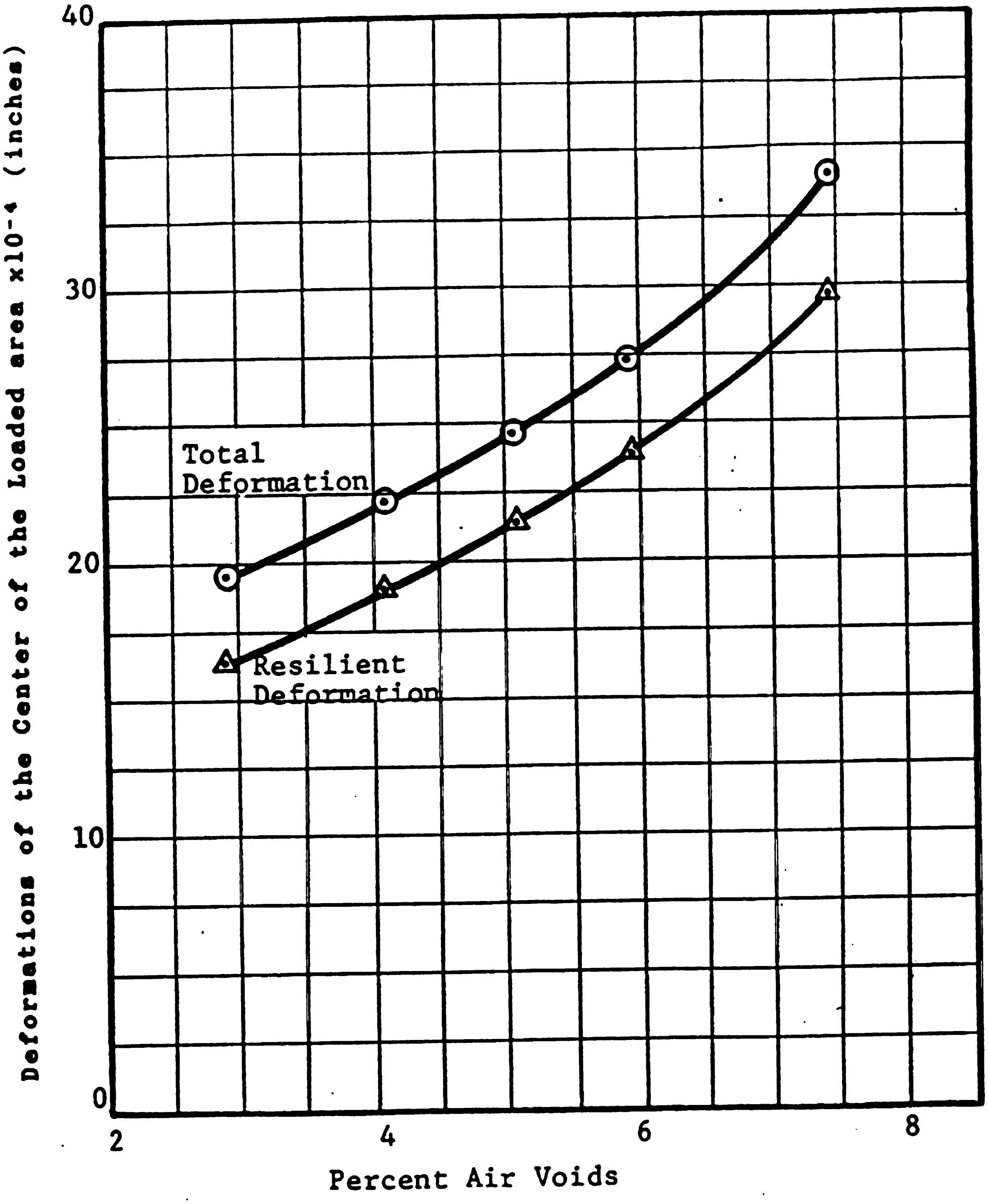


Figure 4.13 Resilient and total deformations at the center of the loaded area at cycle number 100 versus the percent air voids of the beam specimen.

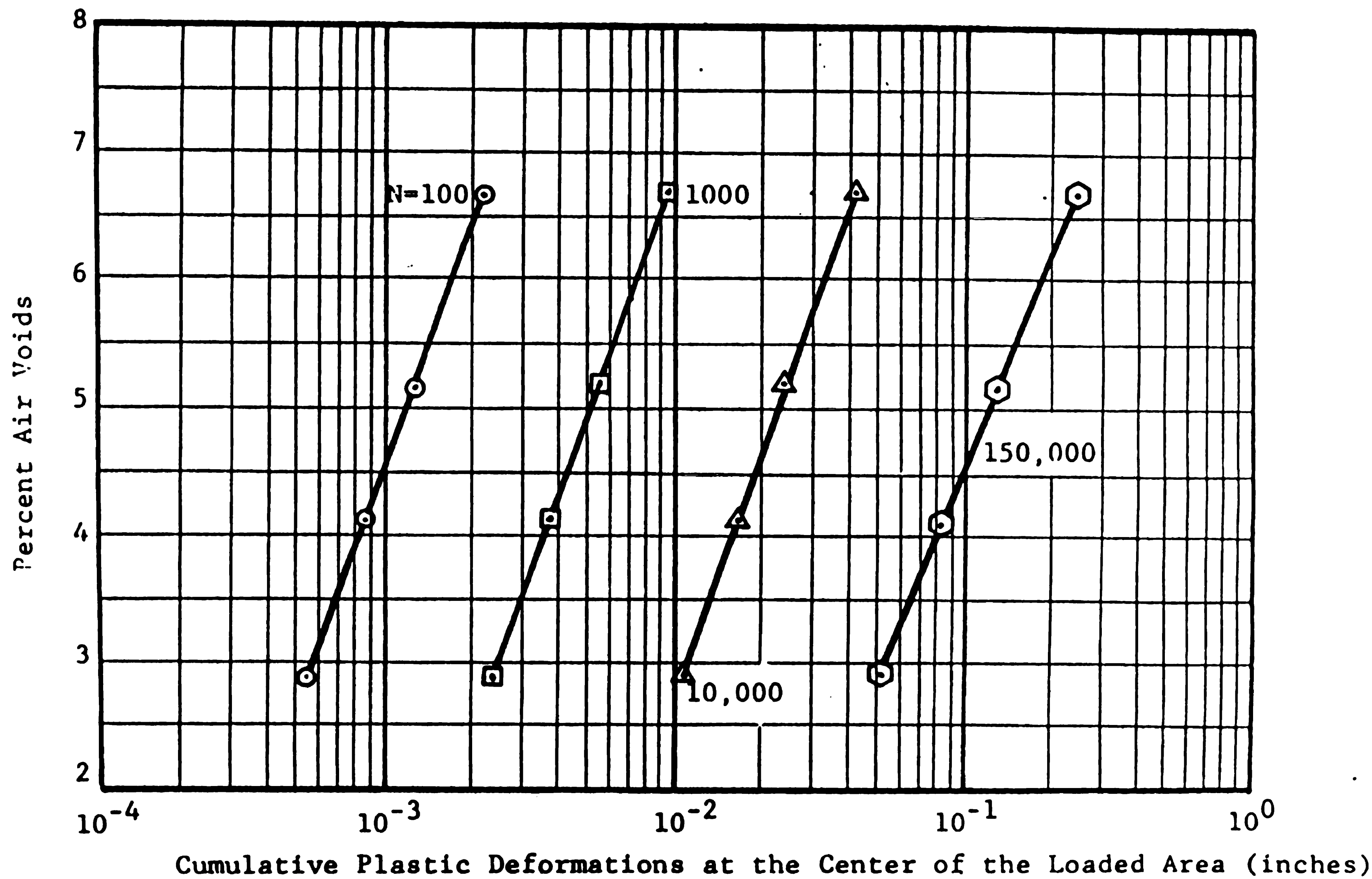


Figure 4.14 Cumulative plastic deformations at the center of the loaded area at different number of load applications versus the percent air voids of the beam specimen.

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

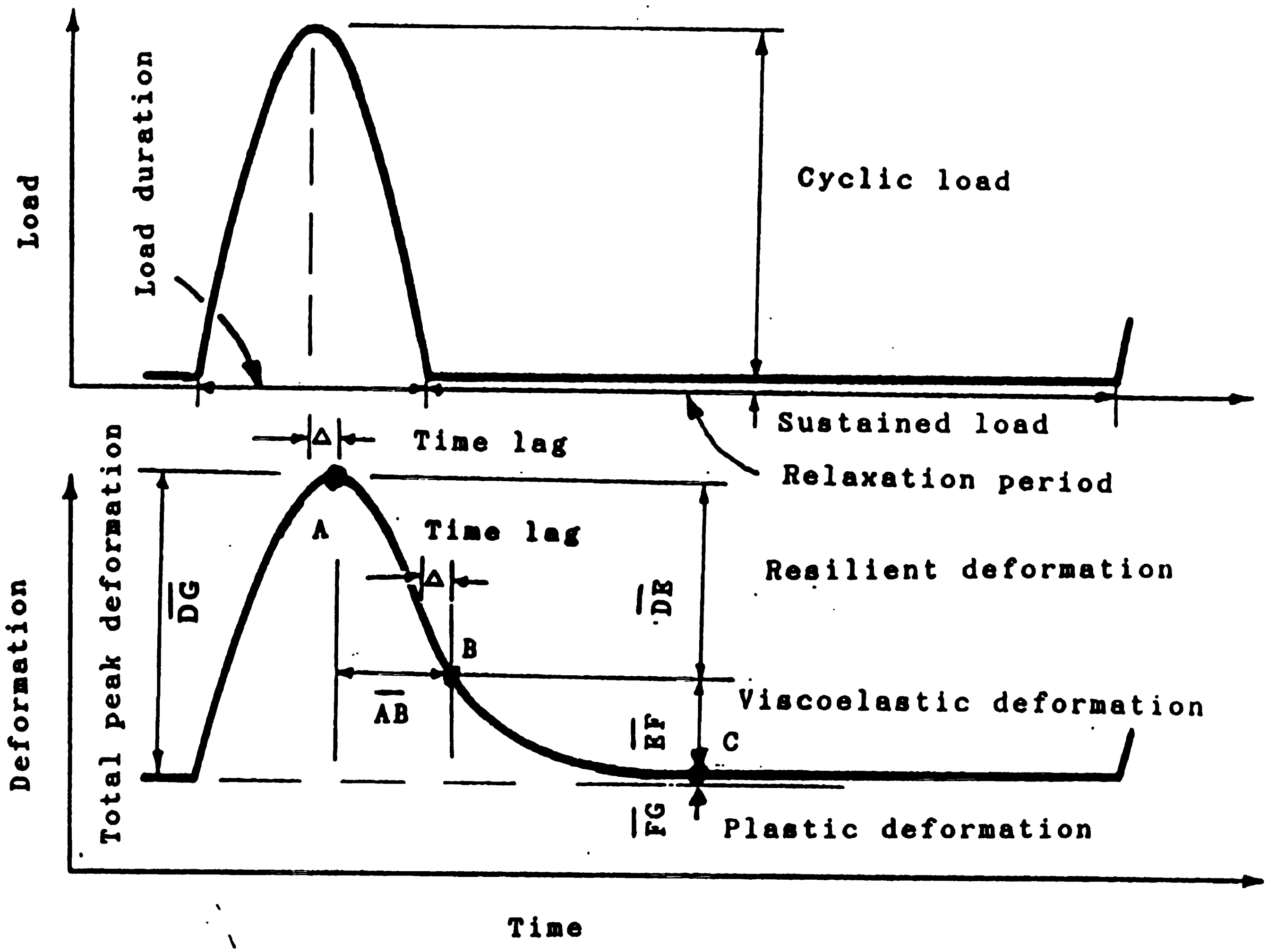


Figure 5.1 Typical load and deformation records versus time.

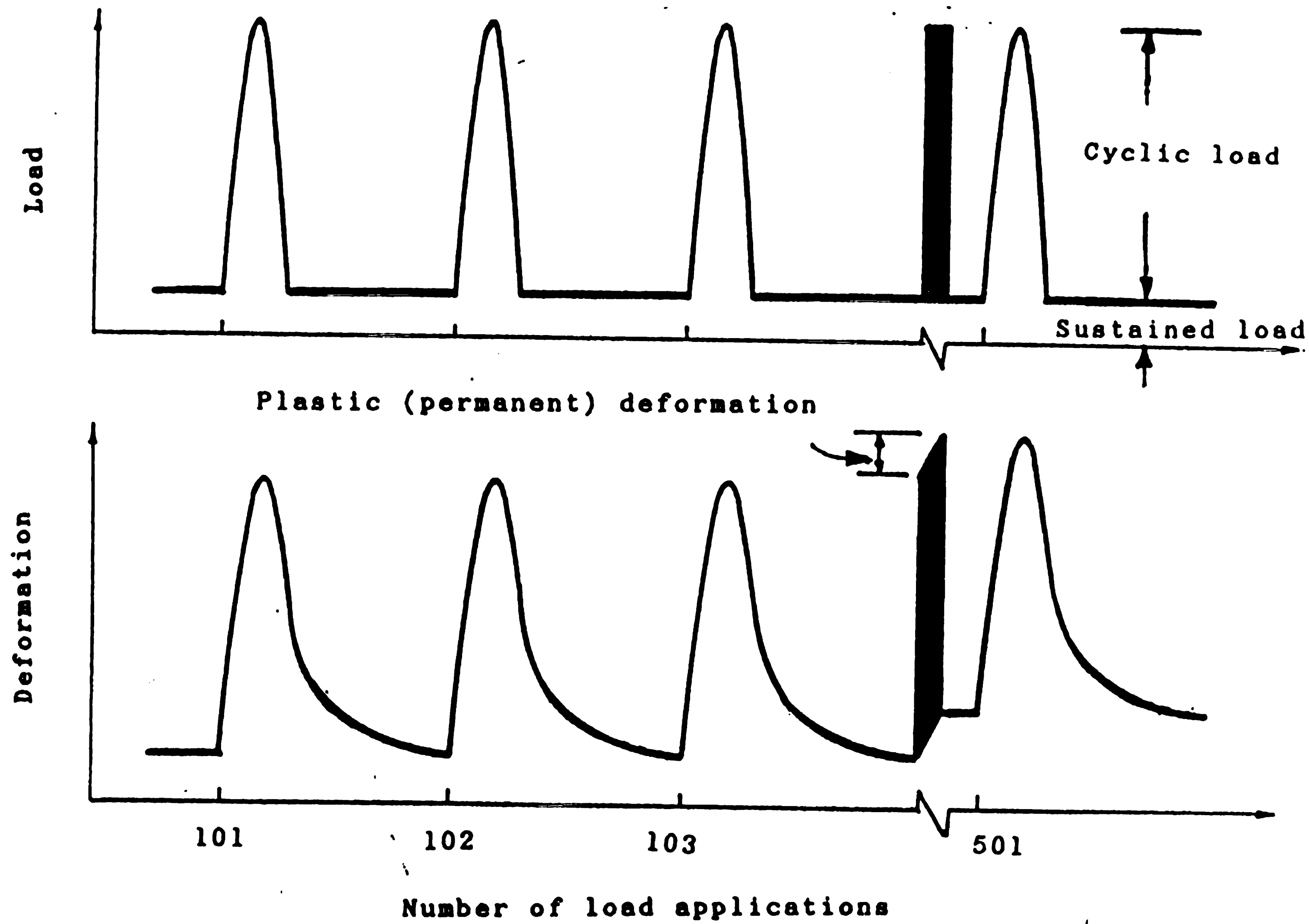


Figure 5.2 Typical load and deformation records versus the number of load application.

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:

$$CD_i = I_i N^{S_i} \qquad (5.1)$$

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

$$\ln(CD)_i = \ln I_i + S_i \ln N \qquad (5.2)$$

where: ln = natural logarithm;

all other variables are as before.

Each cell designates a triplicate.

TEMPERATURE (°F)	GRADATION	LOAD	LIMESTONE									ROUNDED GRAVEL									50/50 MIX BY WEIGHT								
ASPHALT PEN			75-100			125-150			200-250			75-100			125-150			200-250			75-100			125-150			200-250		
AIR VOIDS (%)			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.

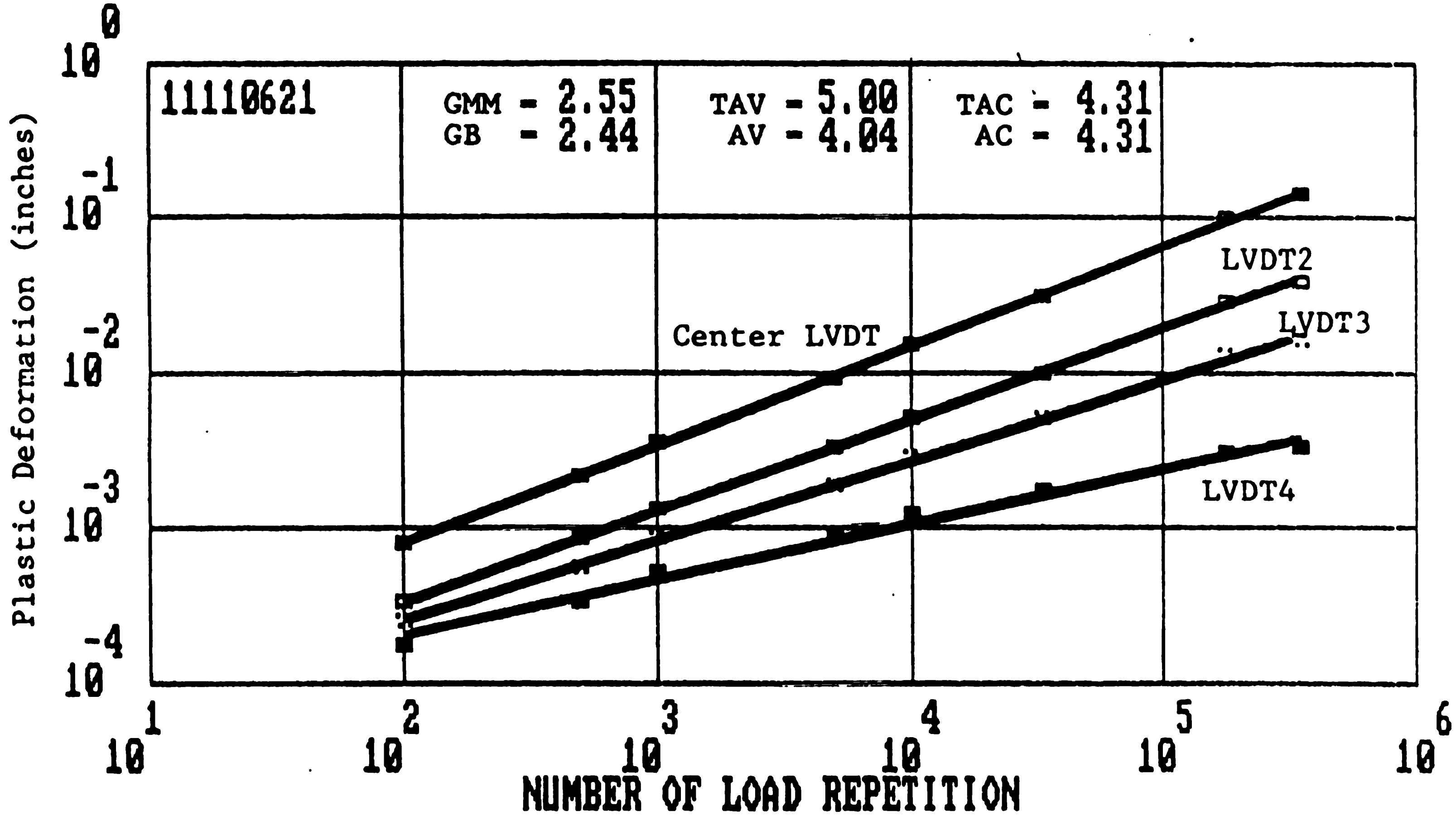


Figure 5.4 Cumulative plastic defromations at four points on the surface of the beam specimen versus the number of load applications.

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^{o}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).

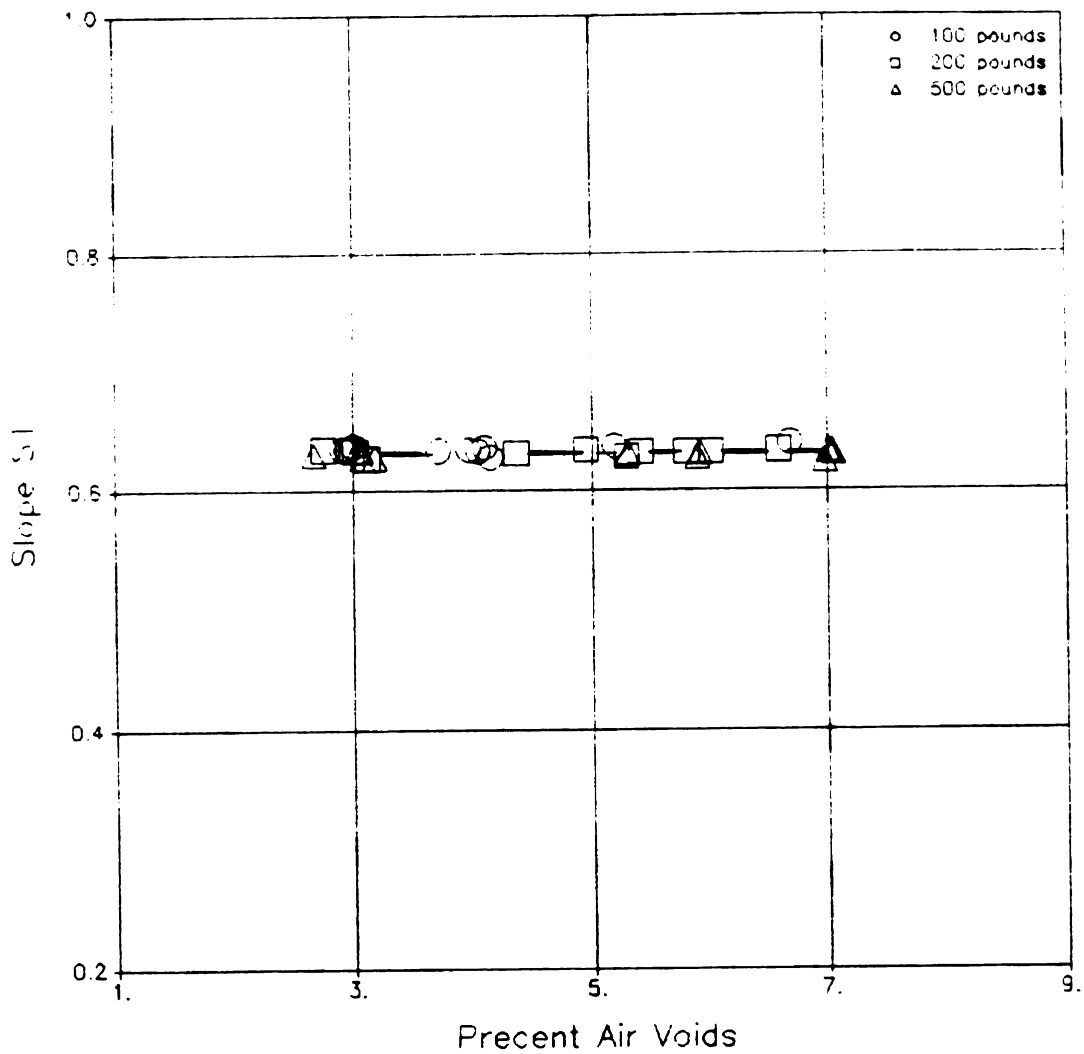


Figure 5.5 Slope of equation 5.1 versus the percent air voids for three levels of the cyclic load and a kinematic viscosity value of 270 centistoke.

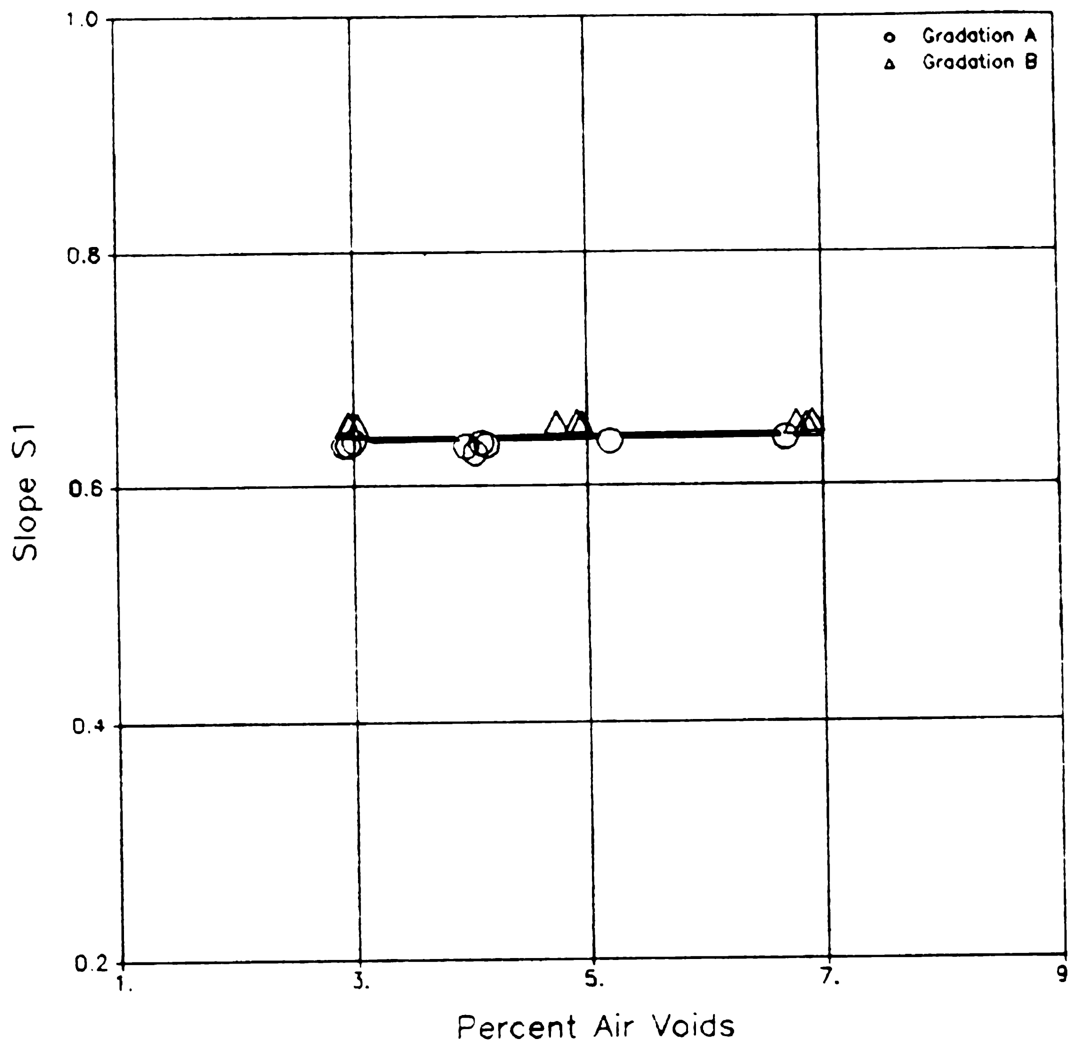


Figure 5.6 Slope of equation 5.1 versus the percent air voids for aggregate gradations A and B.

Figur

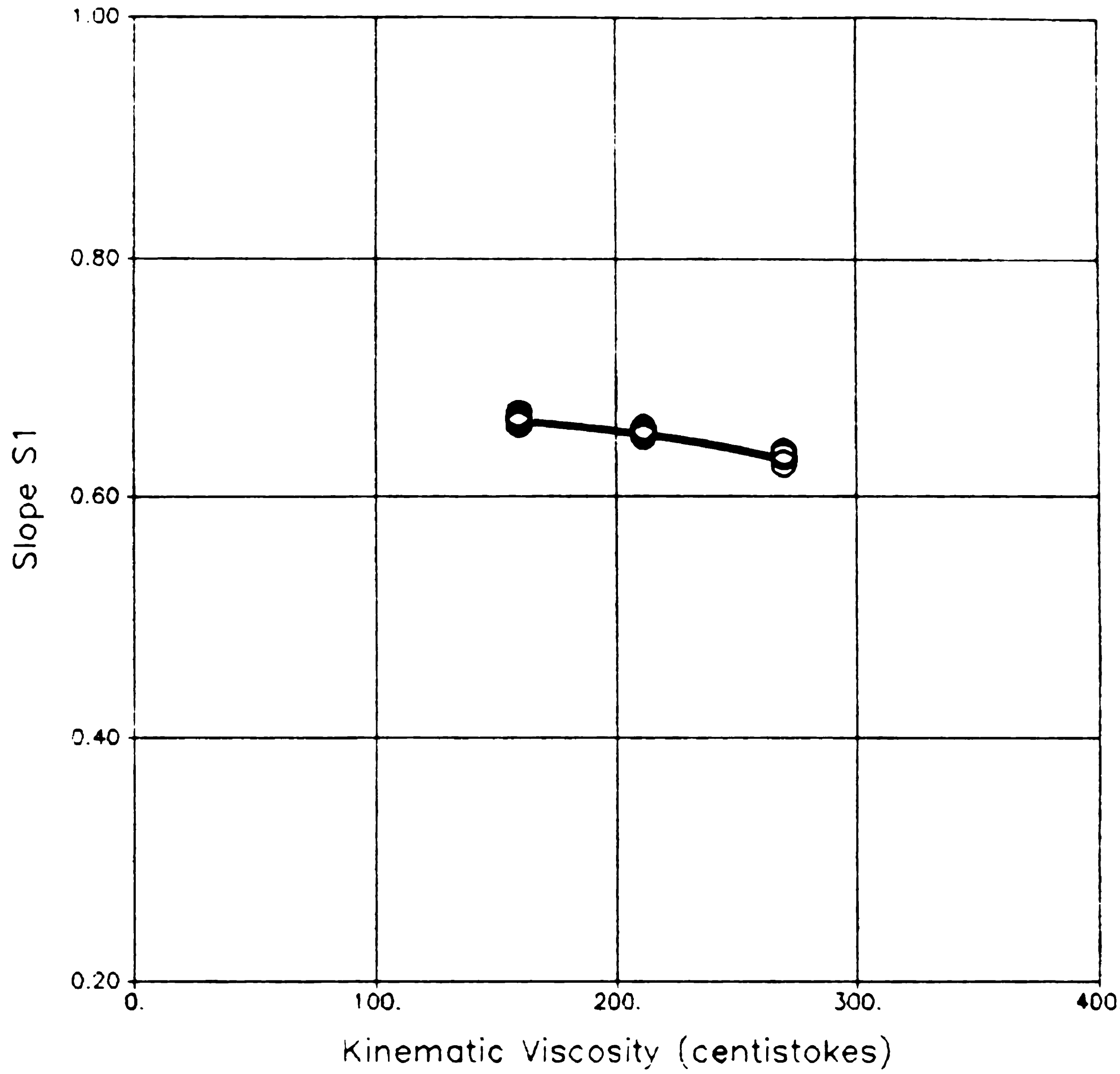


Figure 5.7 Slope of equation 5.1 versus the kinematic viscosity of the asphalt.

Figur

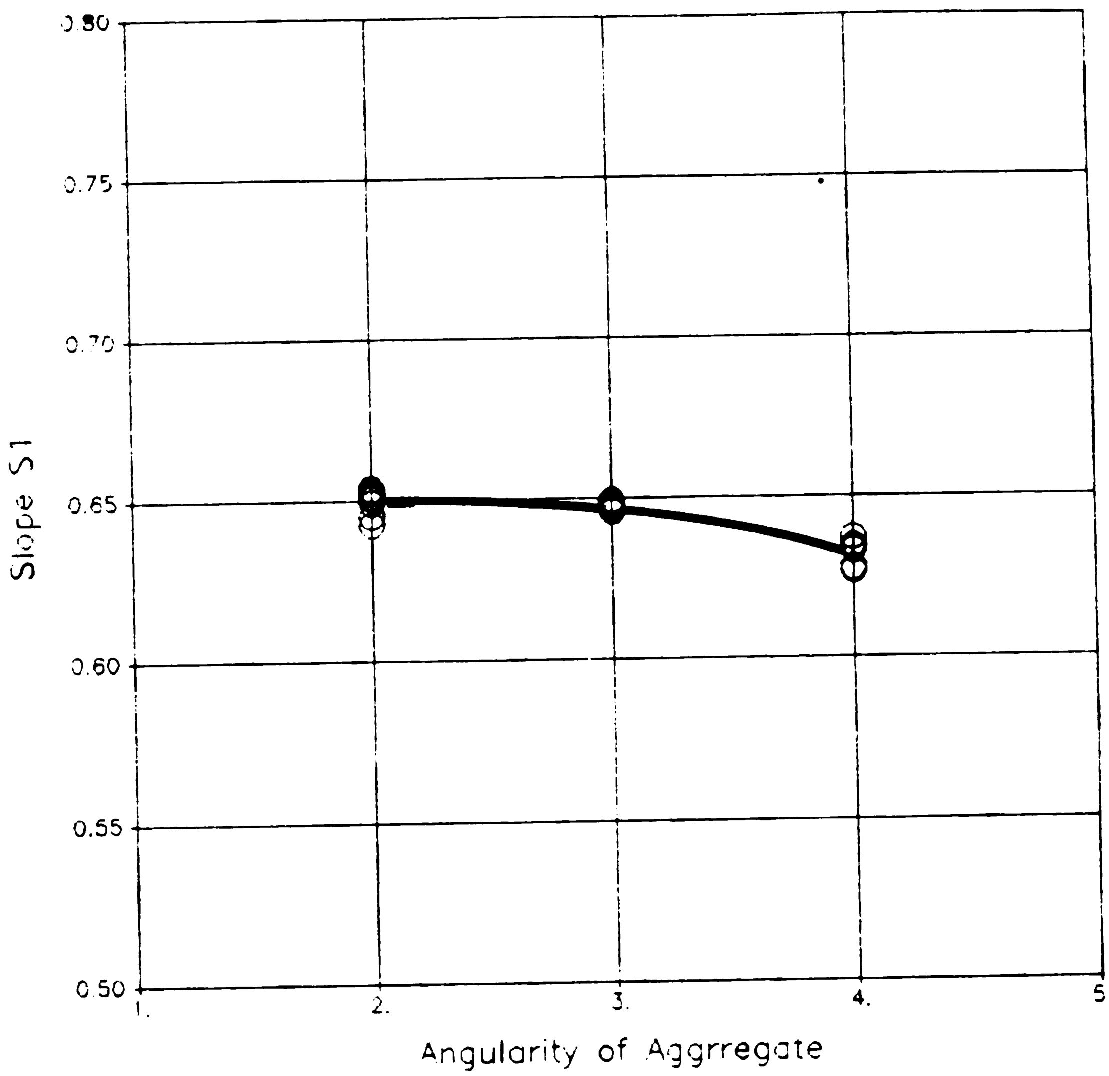


Figure 5.8 Slope of equation 5.1 versus the angularity of aggregate.

Figure

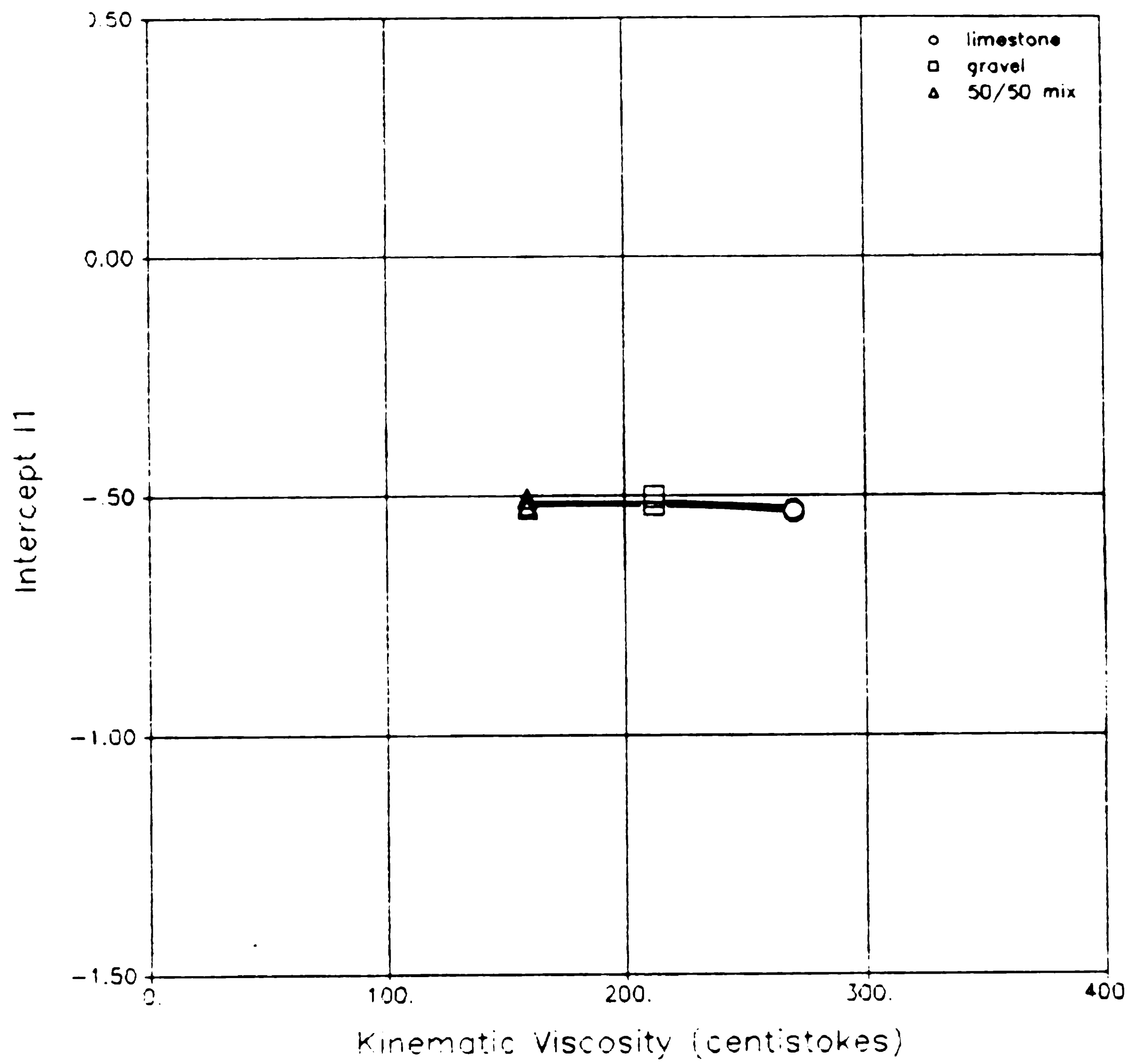


Figure 5.9 Intercept of equation 5.1 versus the kinematic viscosity for three values of the aggregate angularity.

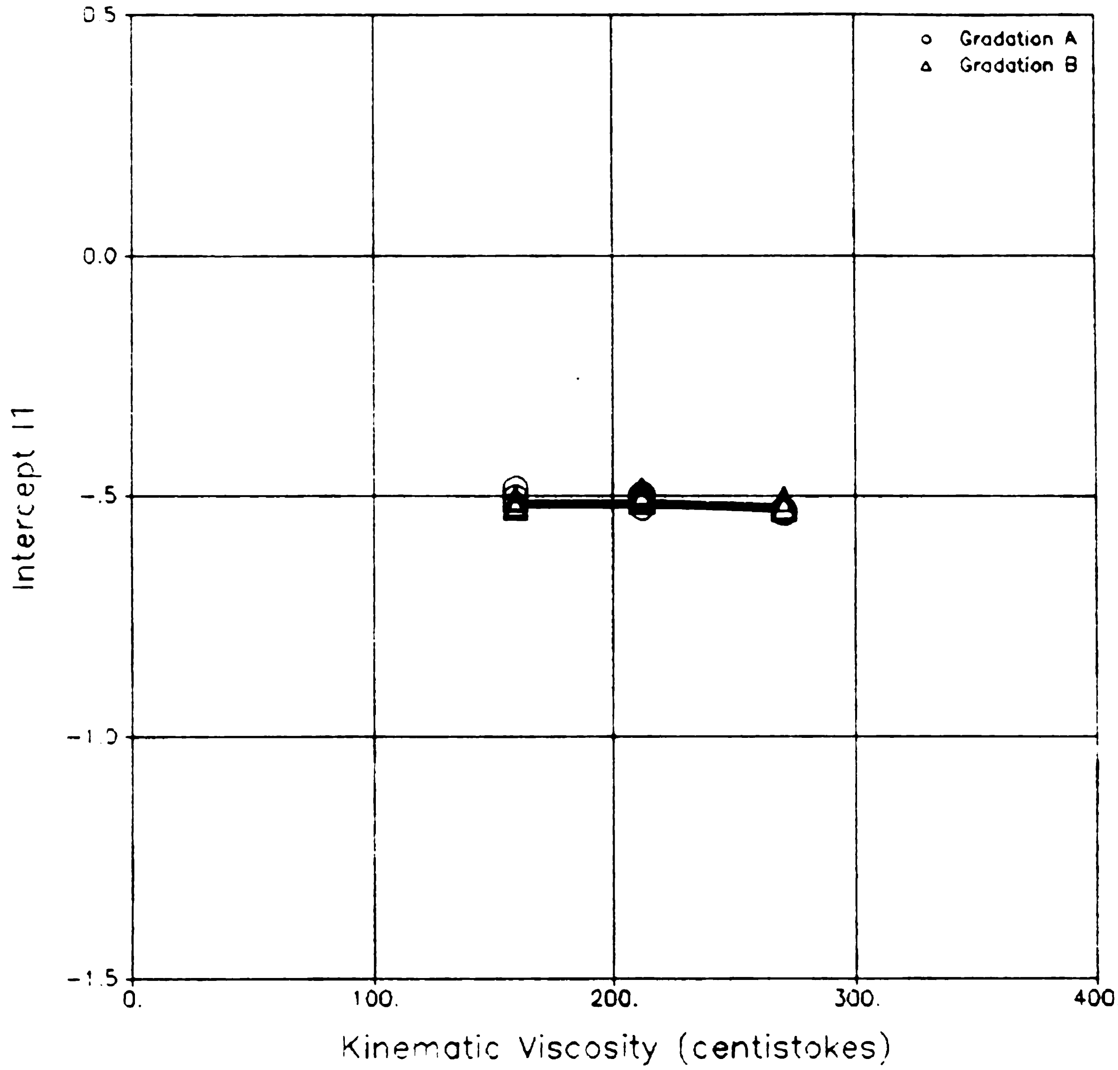


Figure 5.10 Intercept of equation 5.1 versus the kinematic viscosity for aggregate gradations A and B.

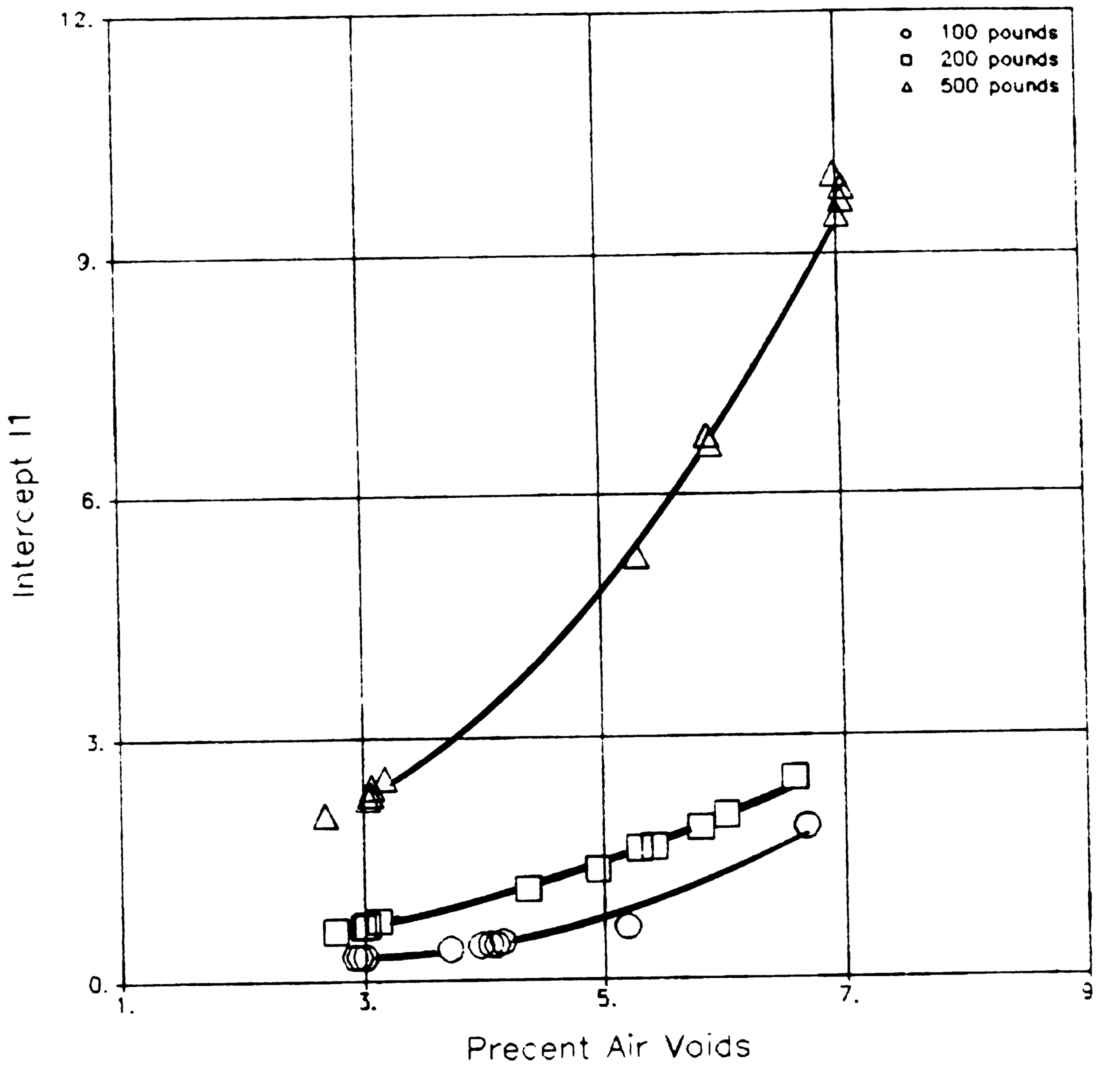


Figure 5.11 Intercept of equation 5.1 versus the percent air voids for three levels of the cyclic load and a kinematic viscosity of 270 centistoke.

$$\ln(I_i) = \ln(A1) + B1(AV) \tag{5.4}$$

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.

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

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

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

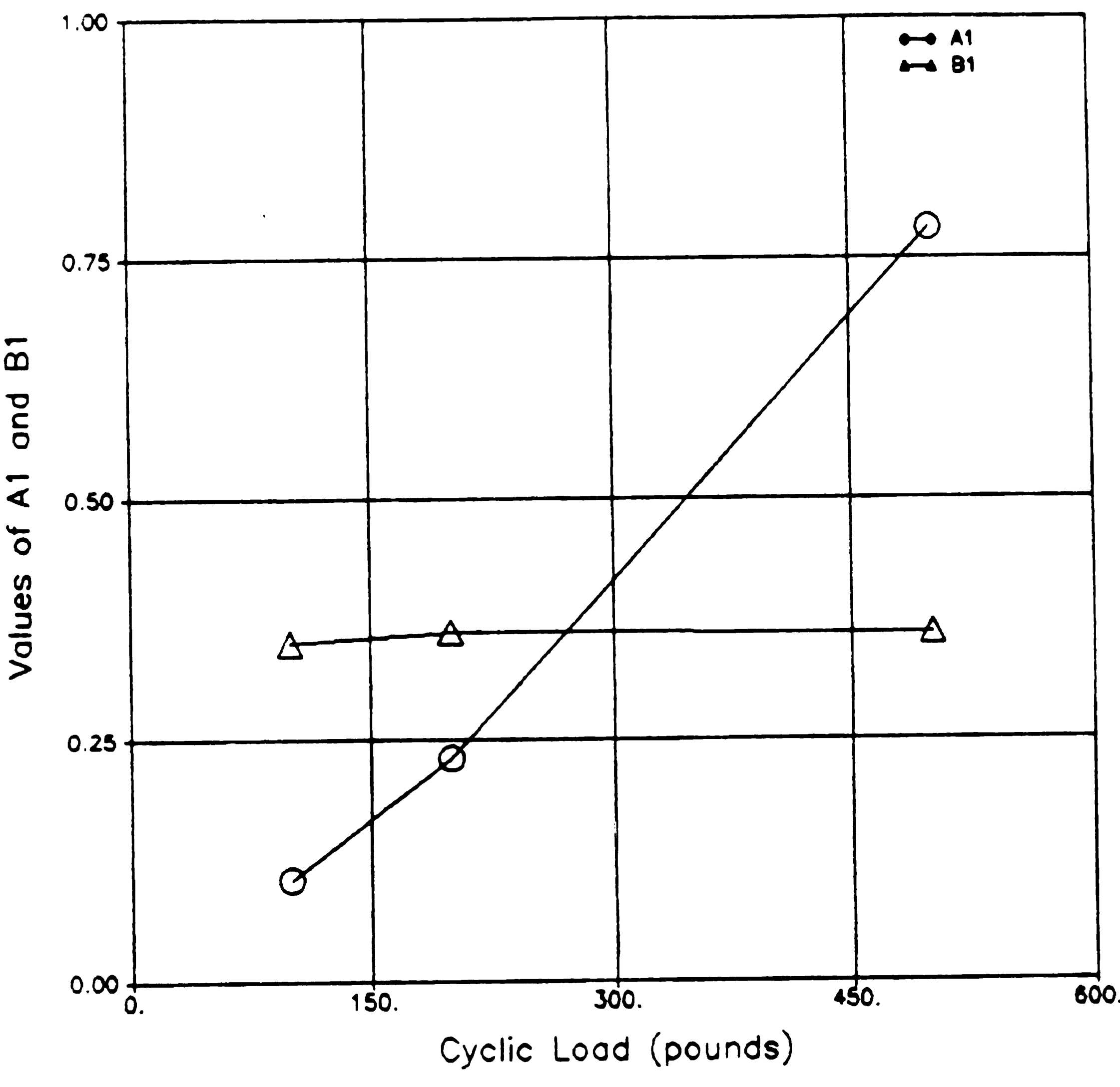


Figure 5.12 Slope and intercept (A1 and B1) of equation 5.4 versus the applied cyclic load.

$R^2 = 0.98$ 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°F and those at 40°F are listed in tables 5.1 and 5.2, respectively. Equations 5.6 and 5.7 are the corresponding regression equations.

For 77°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°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 defor- mation, CD1	Inter- cept	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 x10^{-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) (10^{-1})	(AV) (10^{-1})	ln(CL) (10^{-1})	(KV) (10^{-3})	(ANG) (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 x10^{-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^{o}F, respectively.

e) The effects of aggregate angularity on CD_1 at 77^{o}F is also higher than that at 40^{o}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^{o}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°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°) 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) (10^{-1})	TT (10^{-2})	ln(CL)	(AV) (10^{-1})	(KV) (10^{-3})	(ANG) (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 x10^{-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:

$$CD(X) = (CD_1)(EXP(A \times X^B)) \tag{5.9}$$

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:

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

R^2 = 0.99, and SE = 0.06

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

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 (10^{-1})	Regression coefficients of the independent variables: AV (10^{-2})	ln(N) (10^{-3})	CL (10^{-5})	ln(KV) (10^{-3})	ANG	R^2	SE
	-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 (10^{-1})	Regression coefficients of the independent variables: ln(N) (10^{-2})	CL (10^{-4})	KV (10^{-4})	AV (10^{-3})	ANG (10^{-4})	R^2	SE
	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 x10^{-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 x10^{-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°F:

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

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

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

$R^2 = 0.09$, 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°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^{o}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^{o}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^{o}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^{o}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,

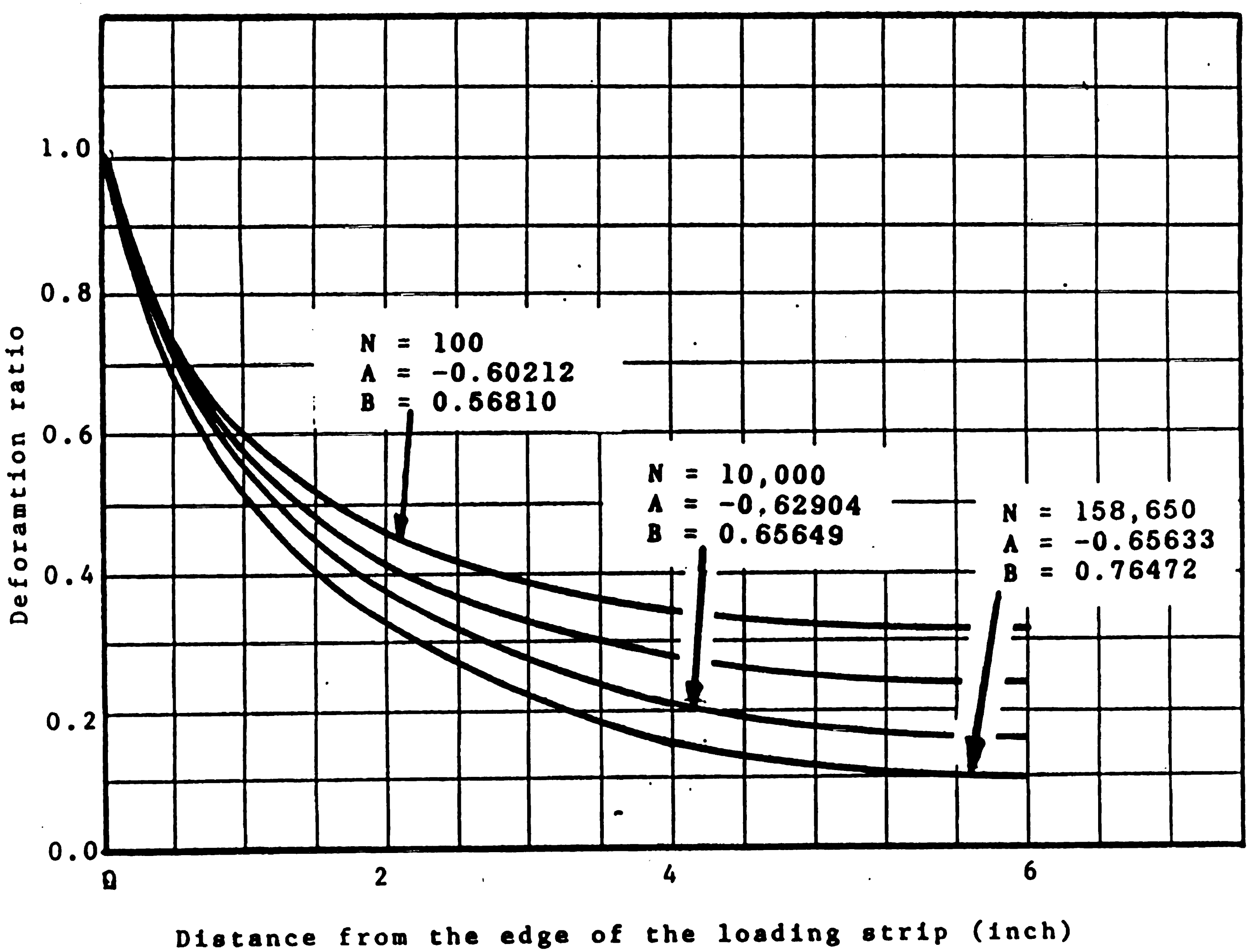


Figure 5.13 Schematic representation of the plastic deflection basin of the beam specimen at 77°F and for different number of load applications.

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^{o}F and 77^{o}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

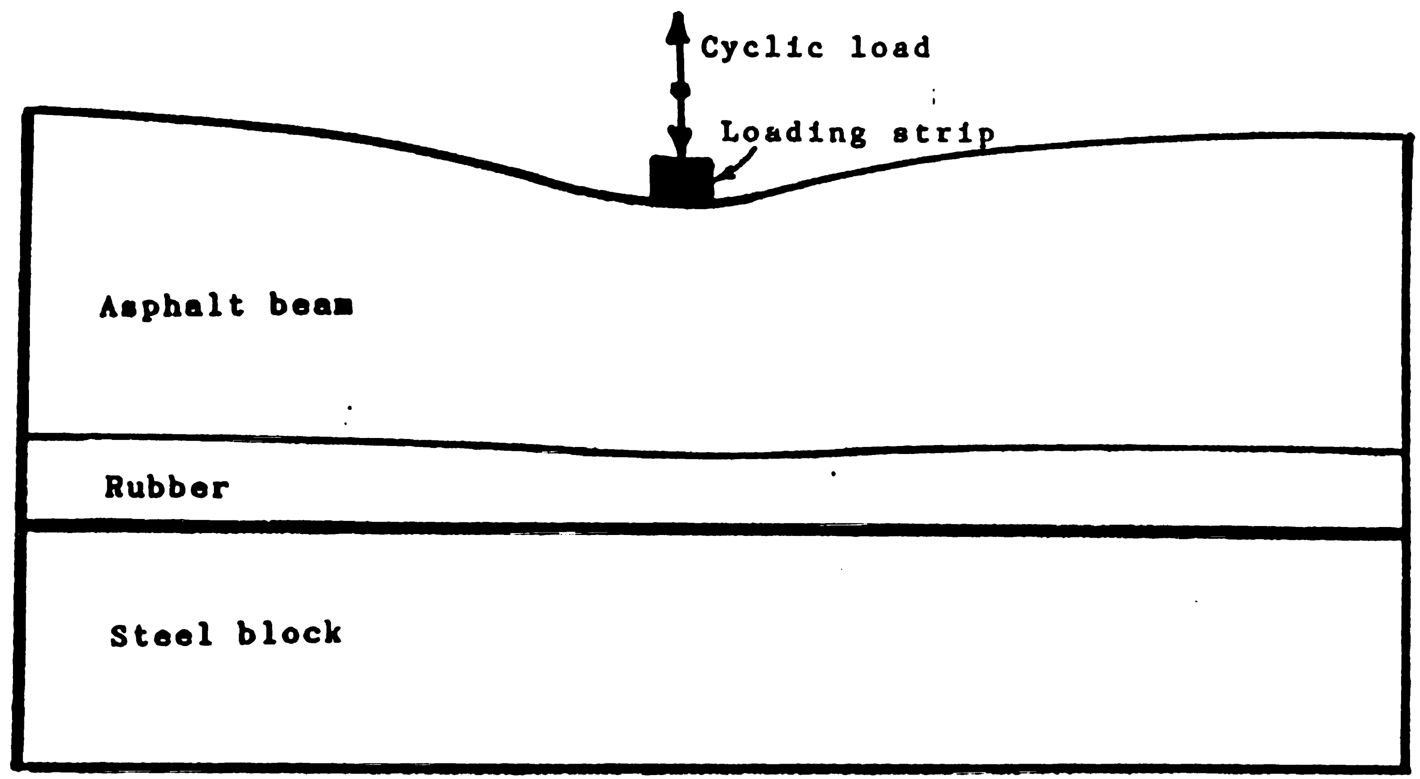


Figure 5.14 Schematic representation of the deflected shape of the beam specimen.

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°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^{o}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^{o}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^{o}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^{o}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 ^oF (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

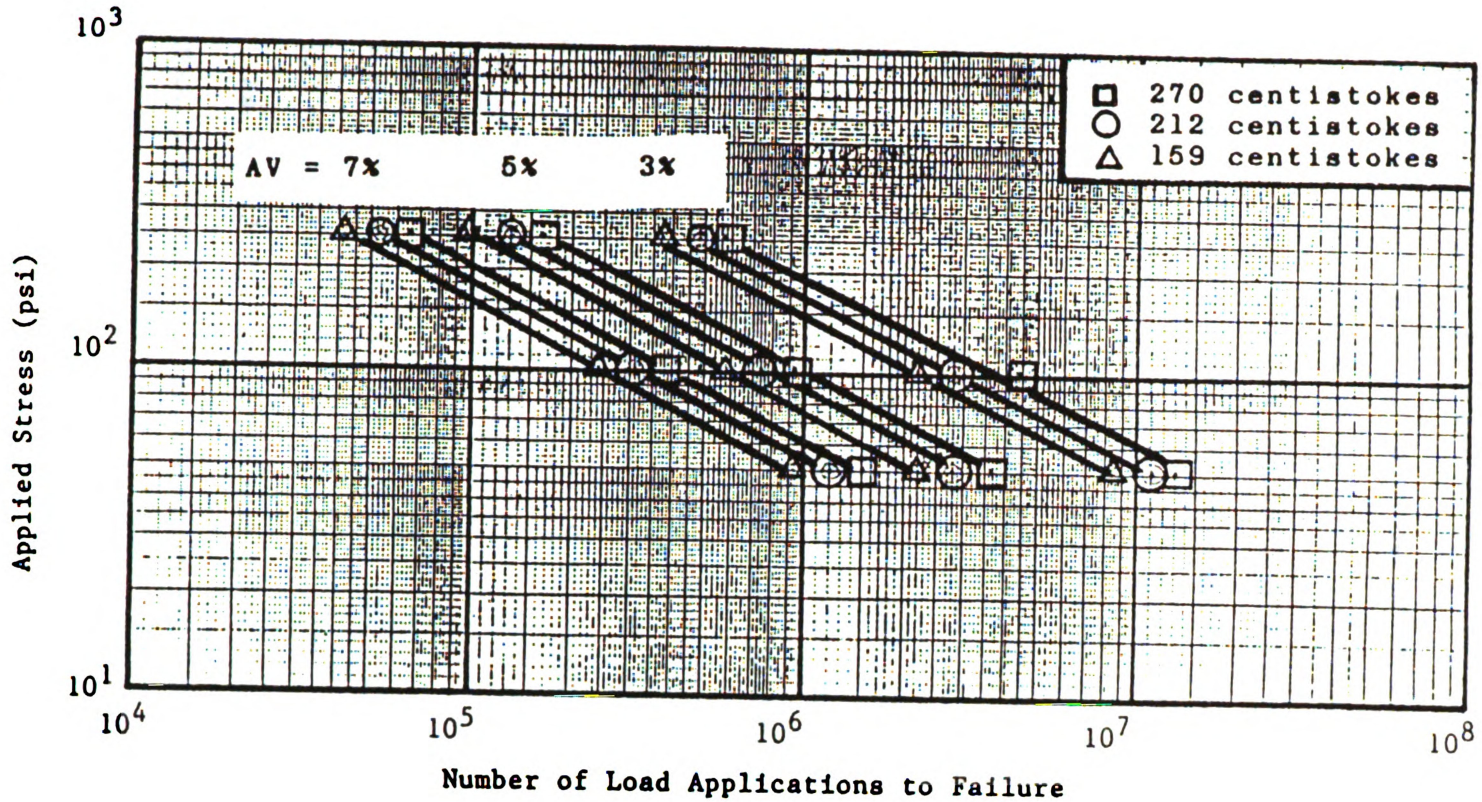


Figure 5.15 Stress-fatigue life curves for the beam specimens for 3 viscosity graded asphalts and 3 values of the percent air voids.

(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^{o}F and 0.07 for the 40^{o}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^{o}F) and 0.07 (at 40^{o}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

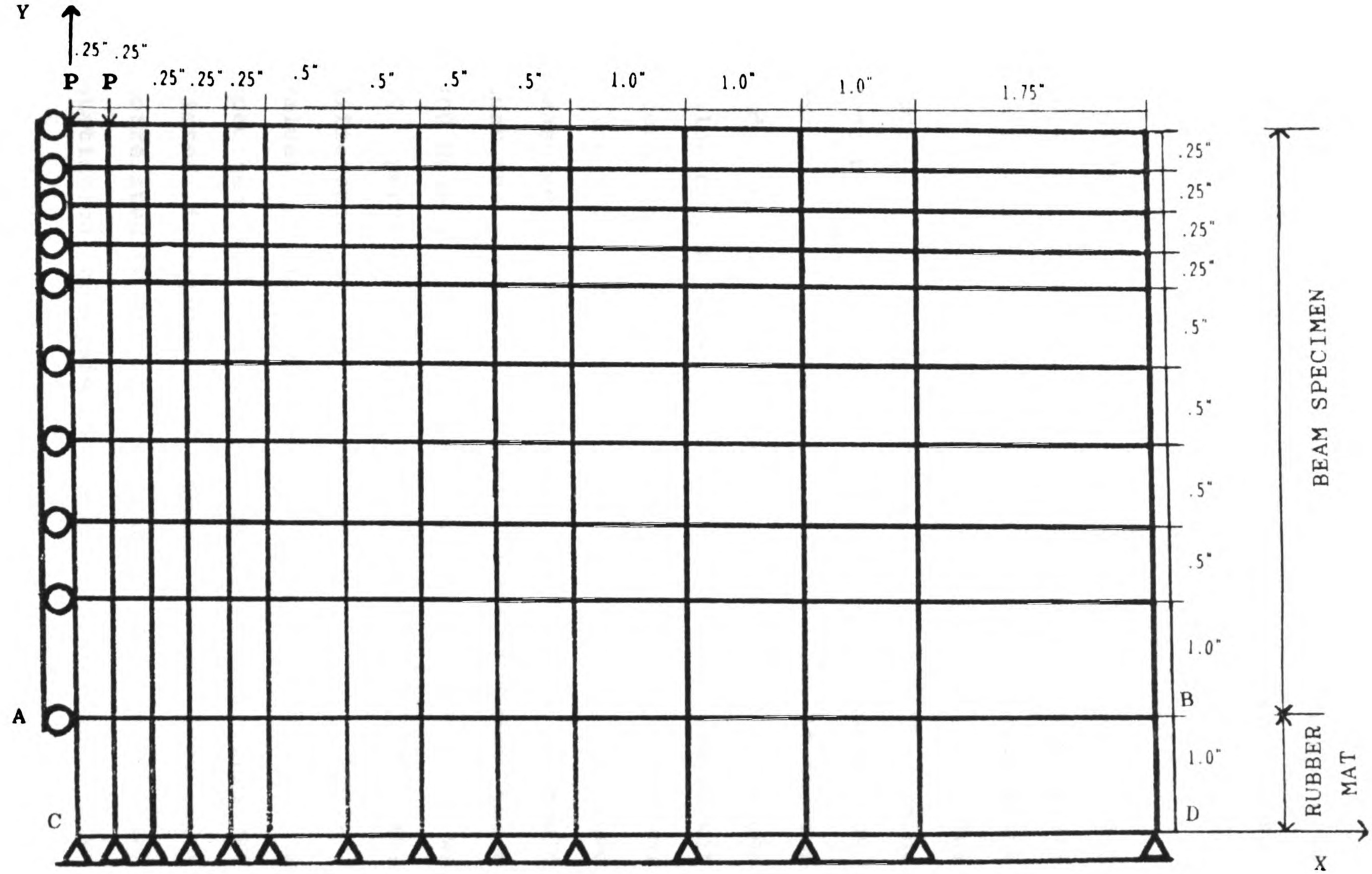
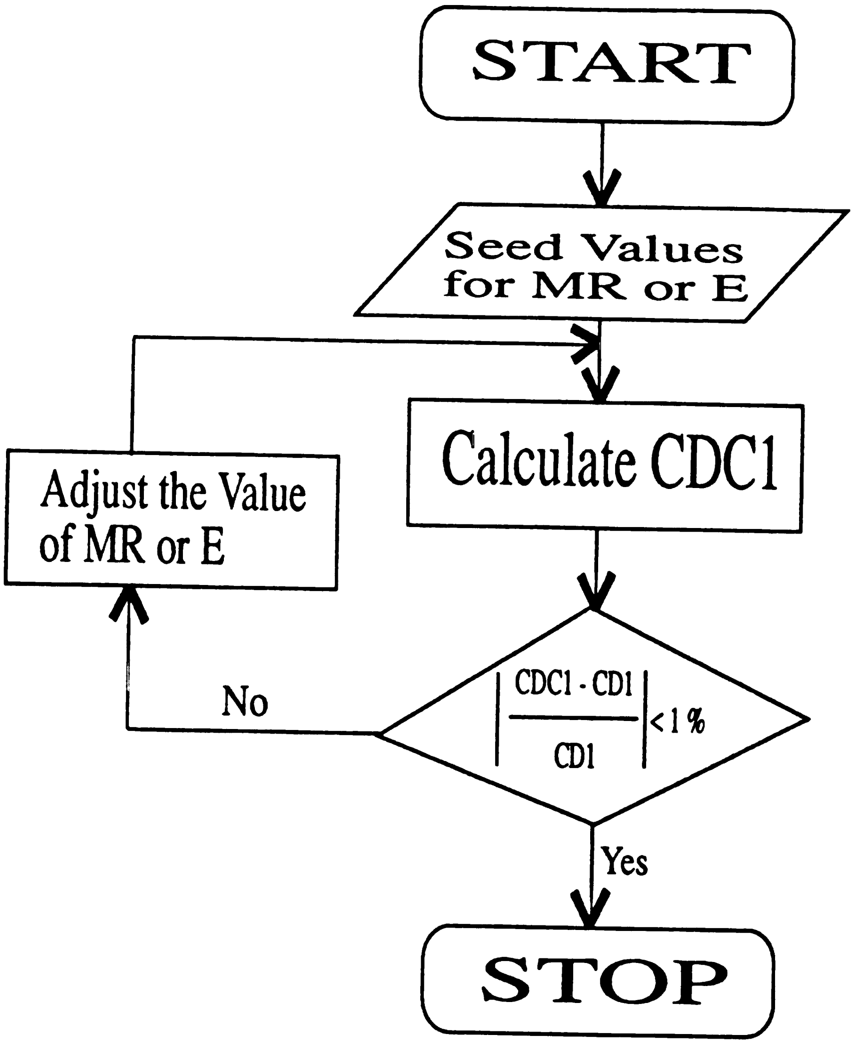


Figure 5.16 Boundary conditions and the finite element mesh.

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

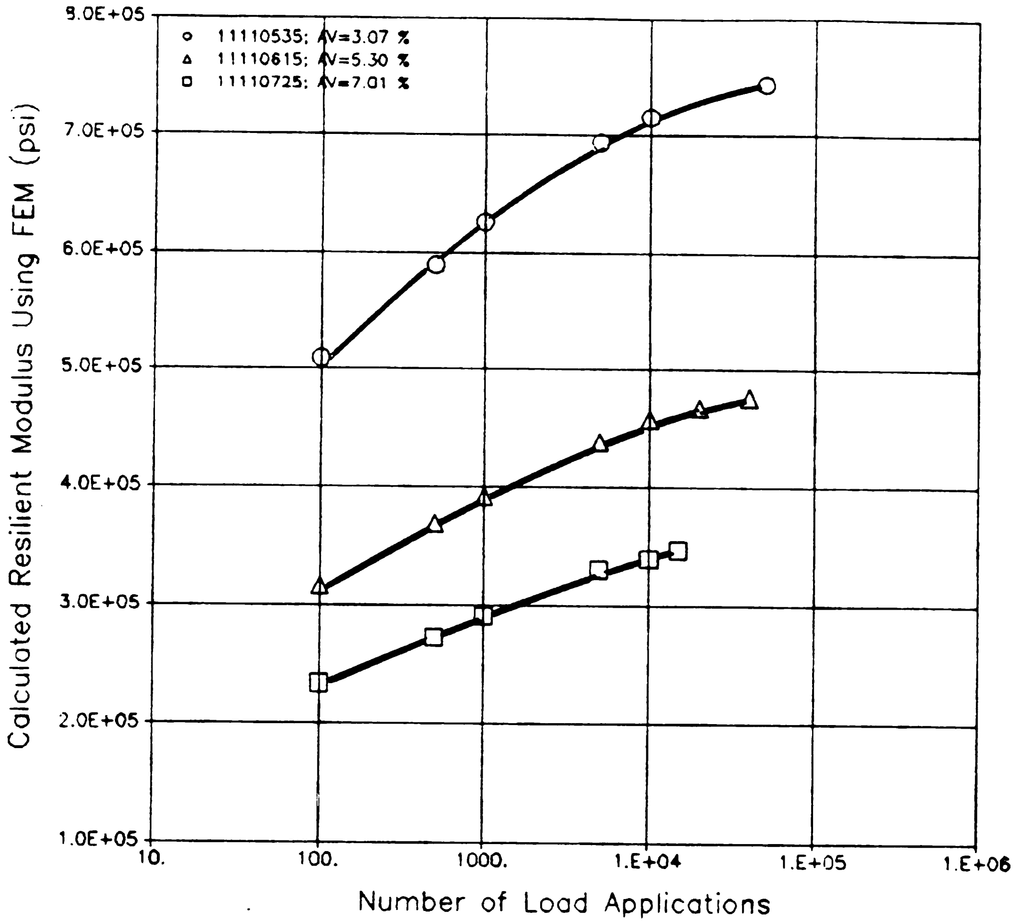


Figure 5.18 Calculated resilient modulus using FEM program versus the number of load application at different percent air voids.

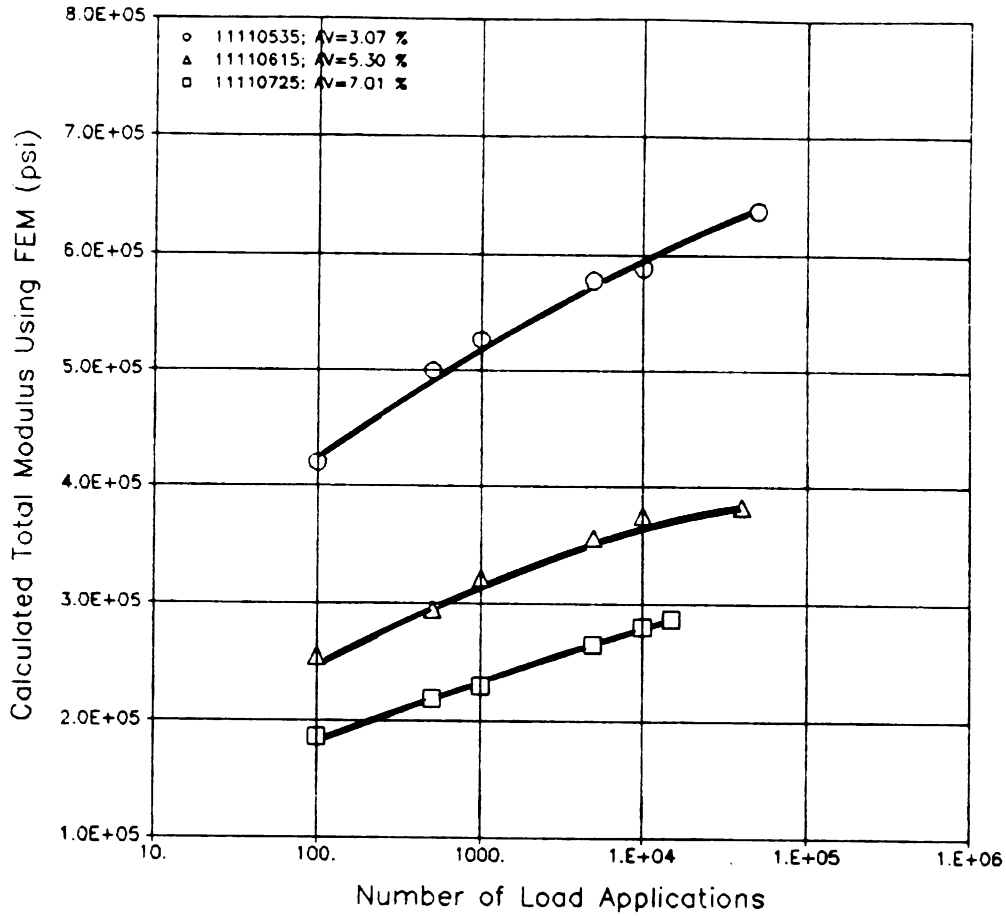


Figure 5.19 Calculated total modulus using FEM program versus the number of load application at different percent air voids.

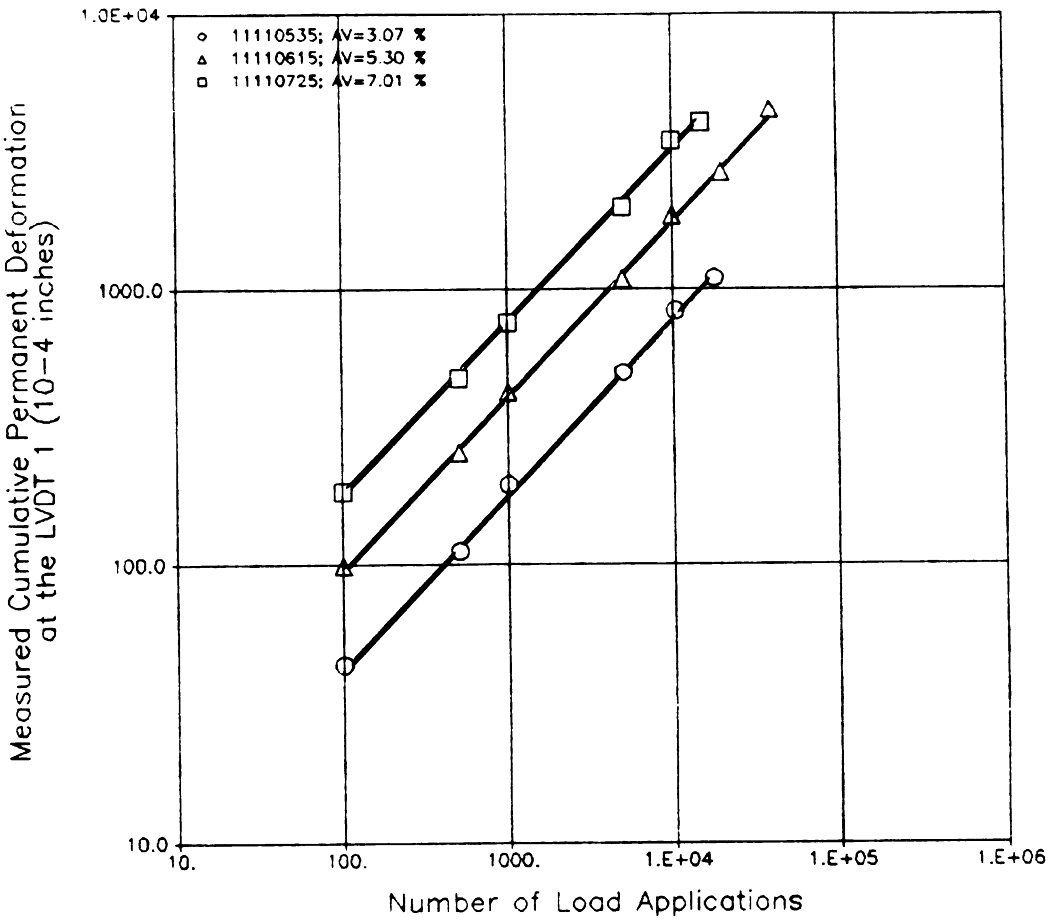


Figure 5.20 Measured cumulative permanent deformation versus the number of load application at differnt percent air voids.

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

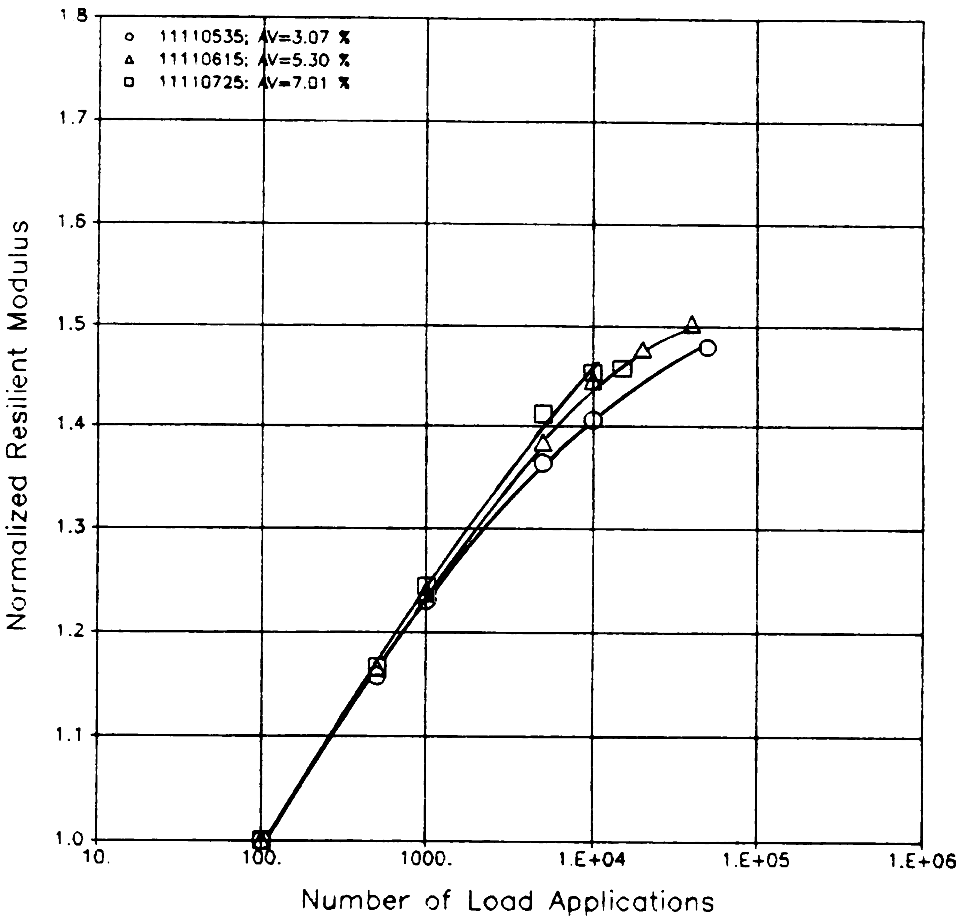


Figure 5.21 Normalized resilient modulus versus the number of load application at different percent air voids.

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°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.

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

$R^2 = 0.998$ and SE = 0.014

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

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

MR	Intercept	Regression coefficients of the independent variables				R^2	SE
		AV (10^{-1})	KV (10^{-4})	ANG (10^{-3})	GRAD (10^{-3})		
ln(MR)	14.750	-1.959	-	-	-	0.988	0.034
	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.

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

E	Intercept	Regression coefficients of the independent variables			R^2	SE
		AV (10^{-1})	KV (10^{-4})	ANG (10^{-2})		
ln(E)	13.604	-2.084	-	-	0.987	0.039
	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.

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

$R^2 = 0.998$ 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.

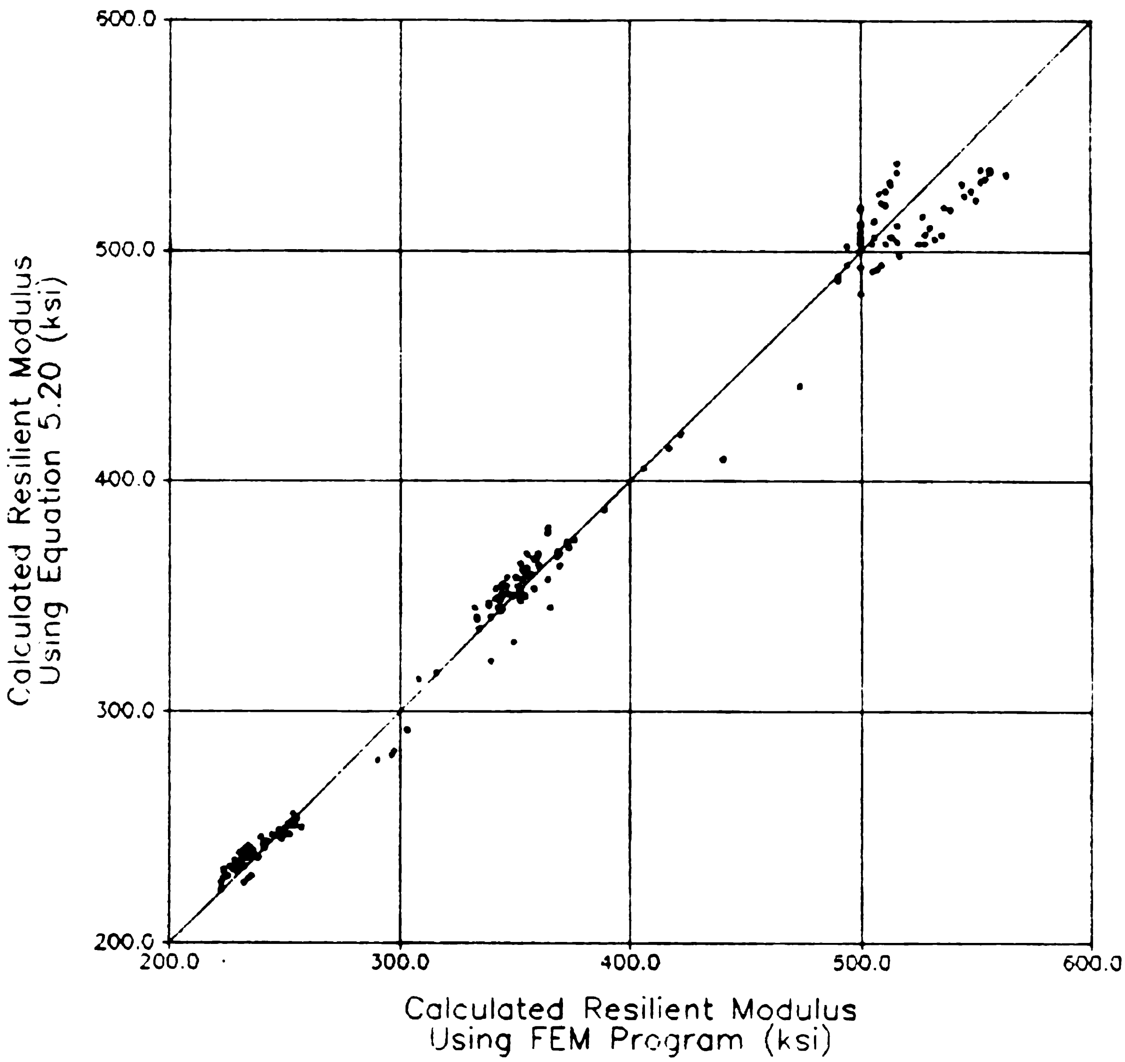


Figure 5.22 Calculated resilient modulus using equation 5.20 versus calculated resilient modulus using FEM program.

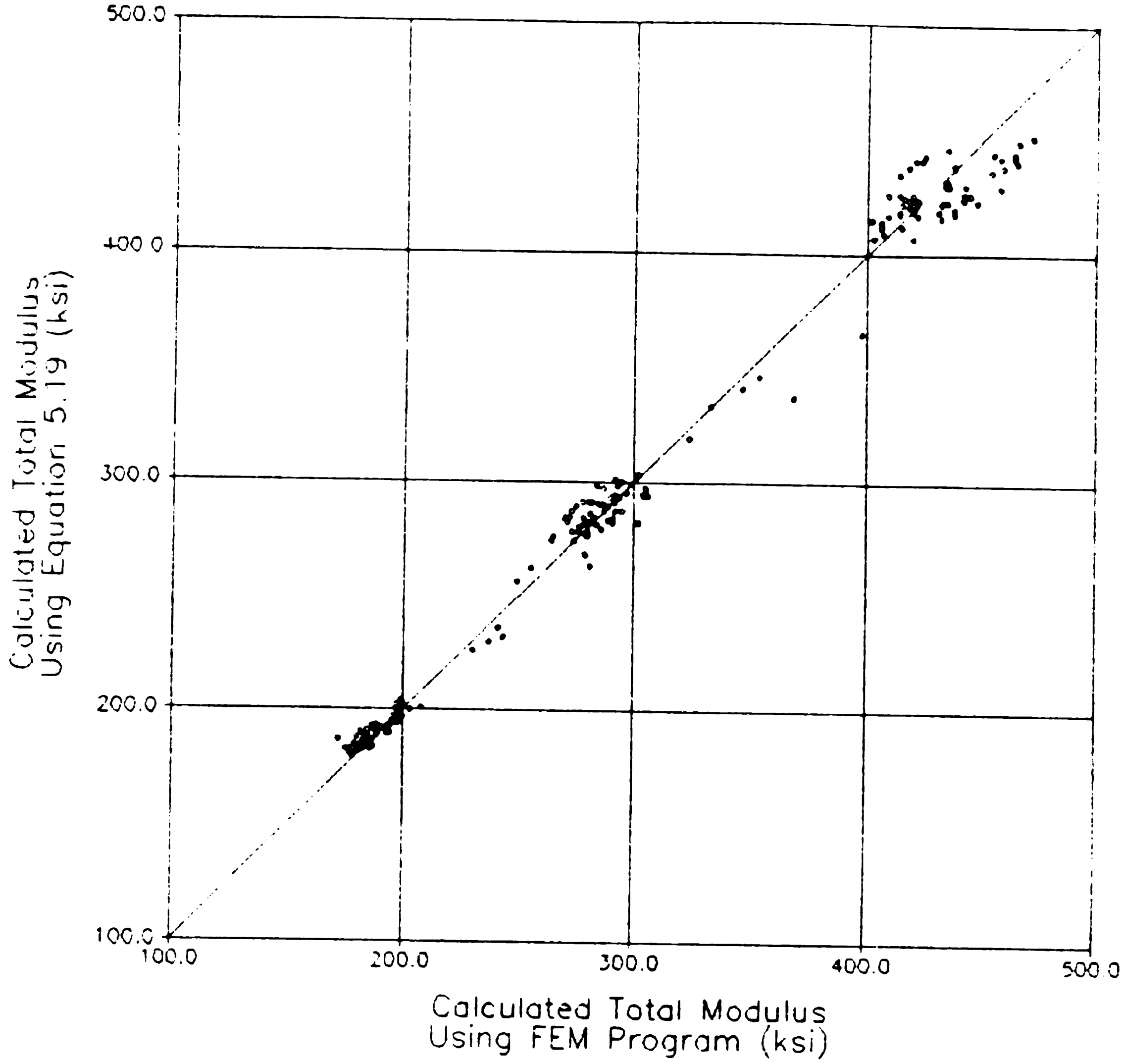


Figure 5.23 Calculated total modulus using equation 5.19 versus calculated total modulus using FEM program.

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

$R^2 = .679$ 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°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: AV (10^-1)	CL (10^-4)	R^2	SE
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: AV (10^-1)	R^2	SE
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

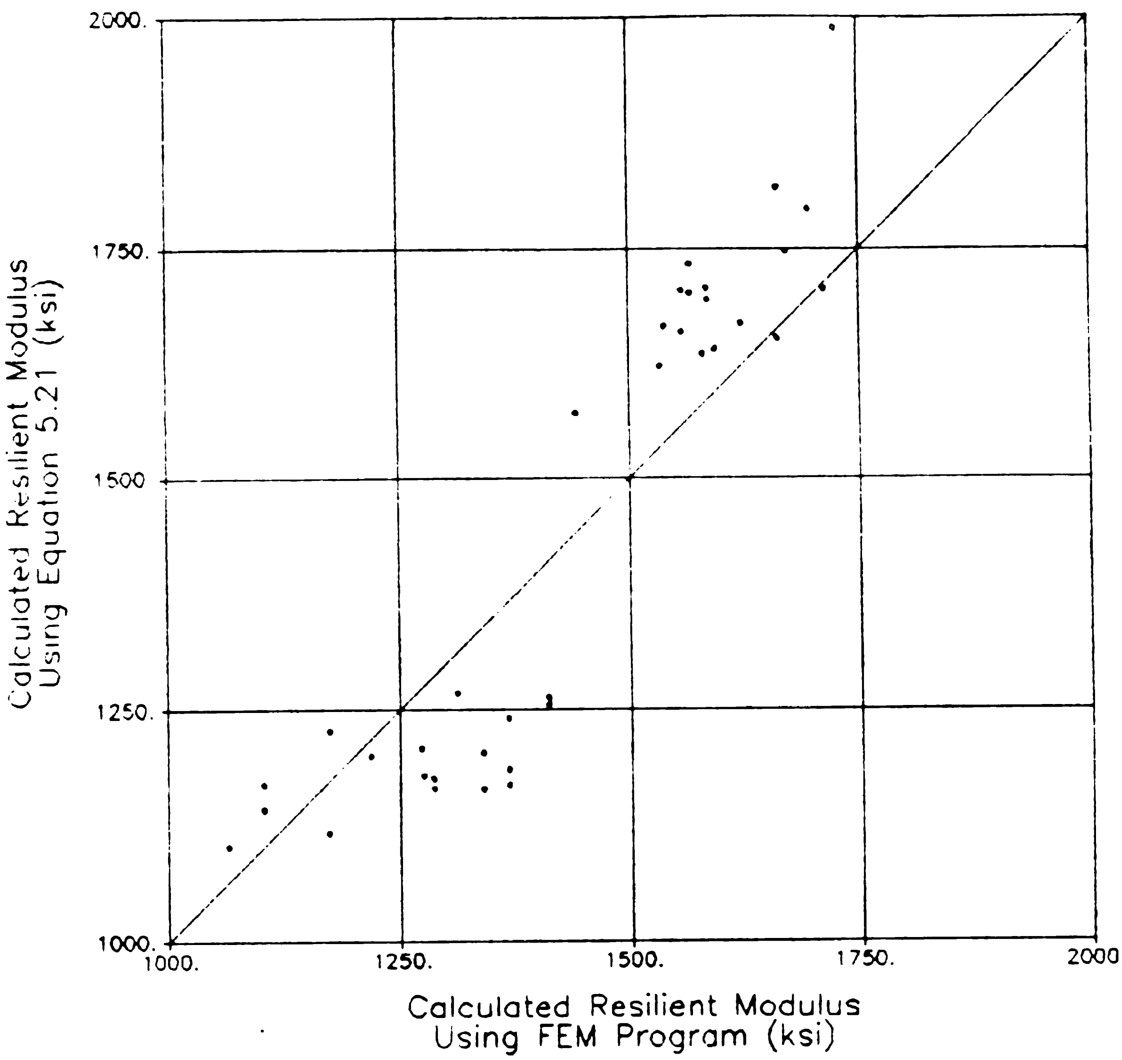


Figure 5.24 Calculated resilient modulus using equation 5.21 versus calculated resilient modulus using FEM program.

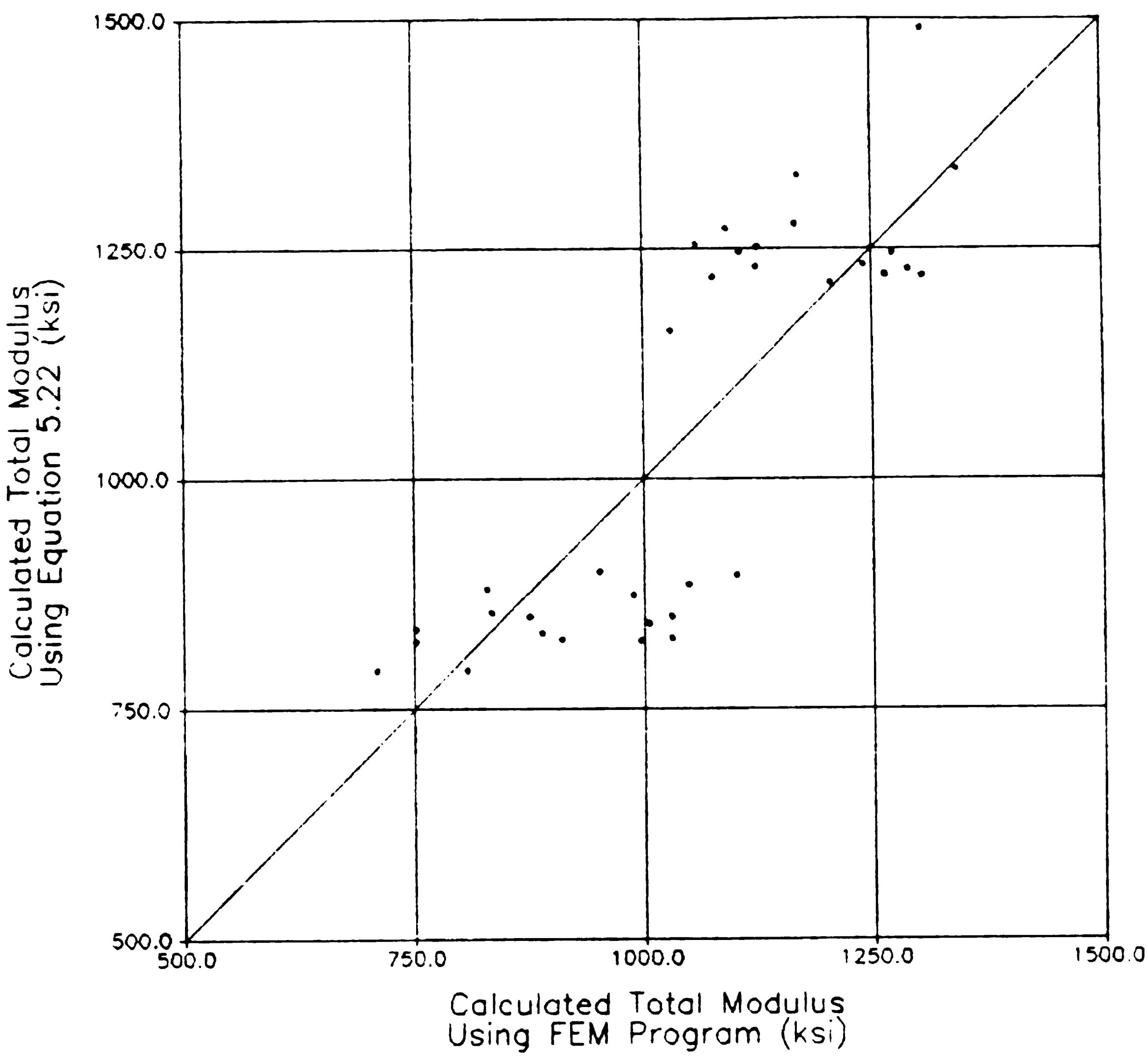


Figure 5.25 Calculated total modulus using equation 5.22 versus calculated total modulus using FEM program.

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 TT (10^{-2})	AV (10^{-1})	KV (10^{-4})	R^2	SE
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 TT (10^{-2})	AV (10^{-1})	KV (10^{-4})	R^2	SE
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.

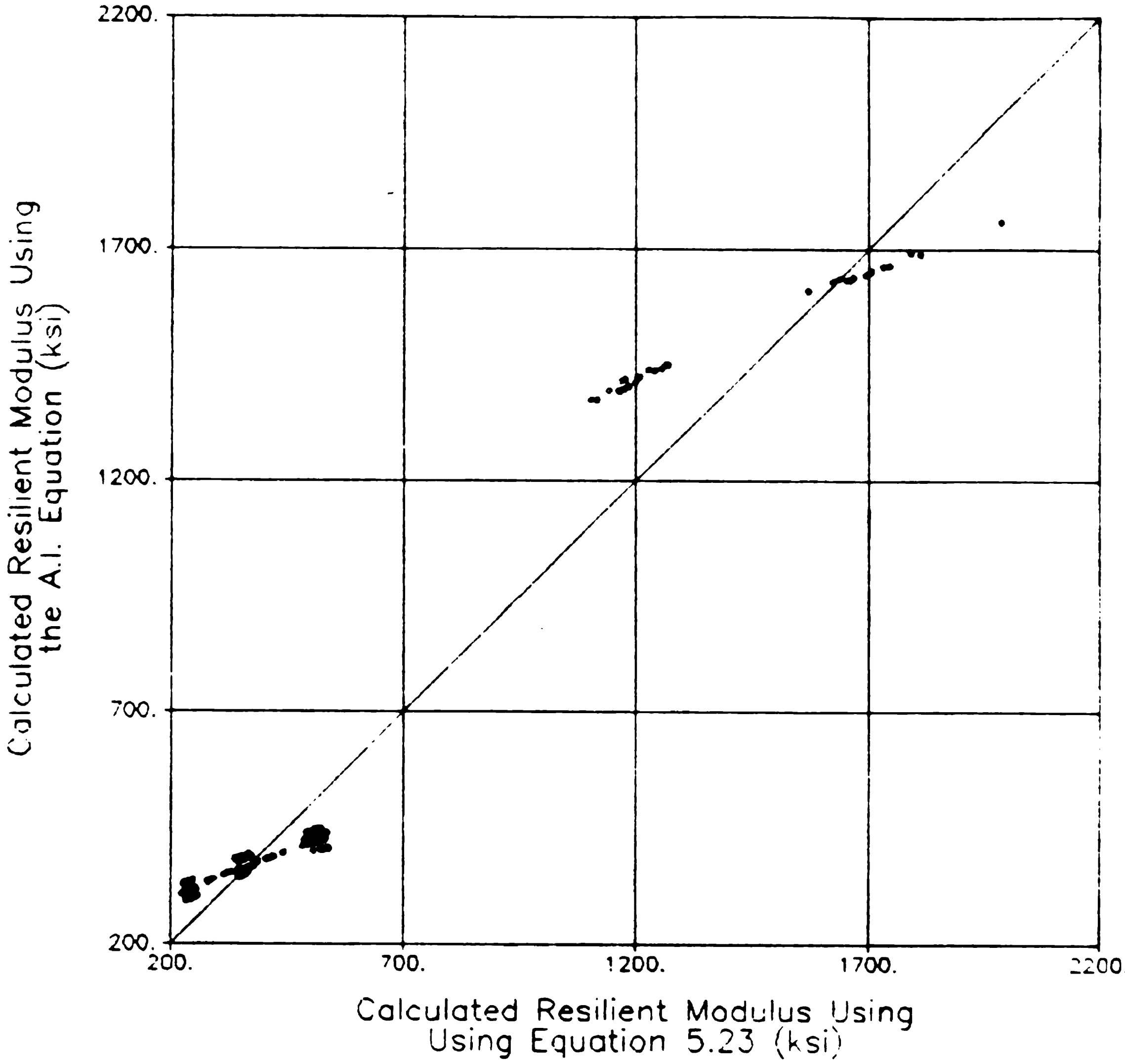


Figure 5.26 Calculated resilient modulus using the A.I. equation versus calculated resilient modulus using equation 5.23.

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).

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

$R^2 = 0.997$; 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.

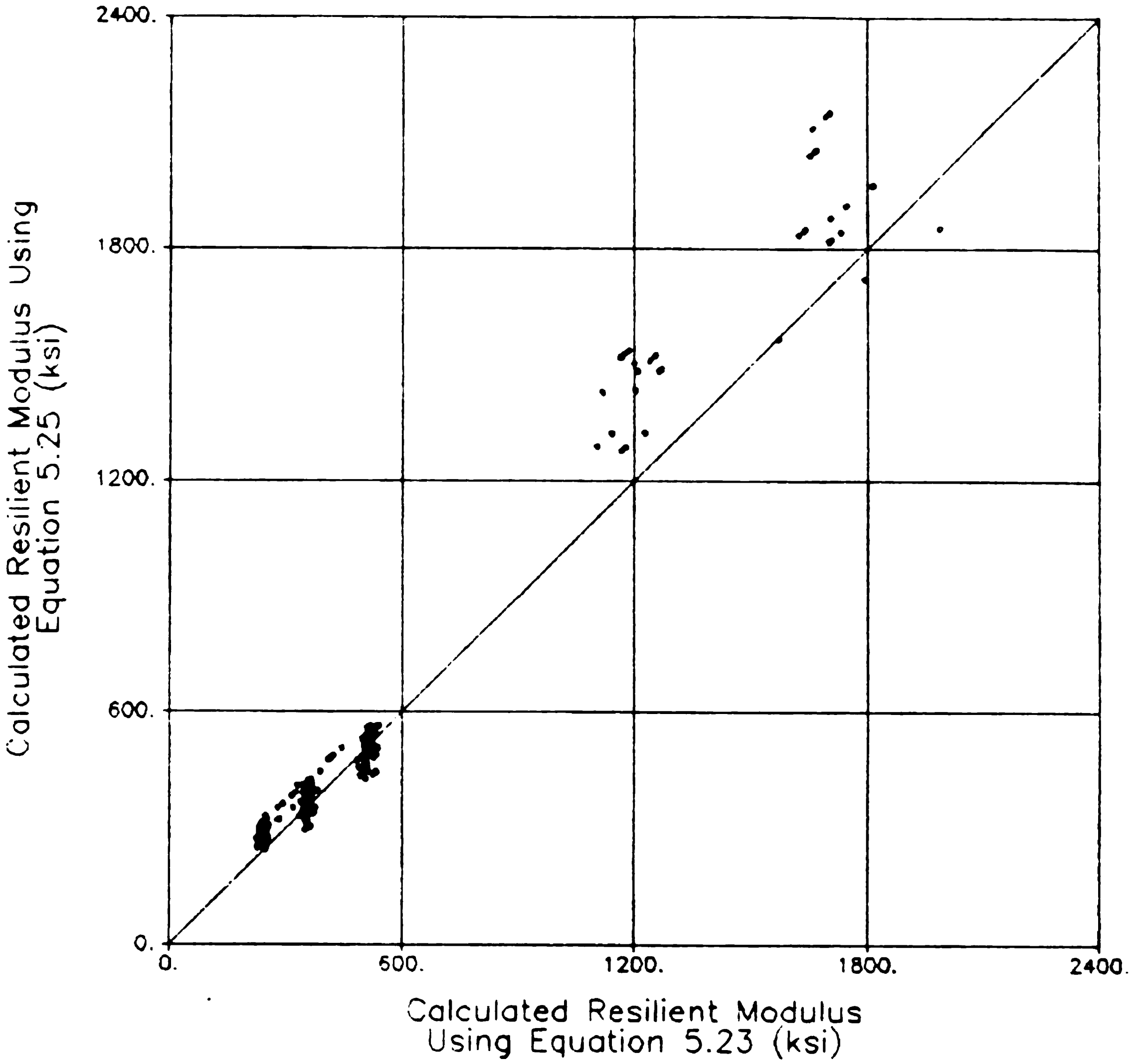


Figure 5.27 Calculated resilient modulus using equation 5.25 versus calculated resilient modulus using equation 5.23.

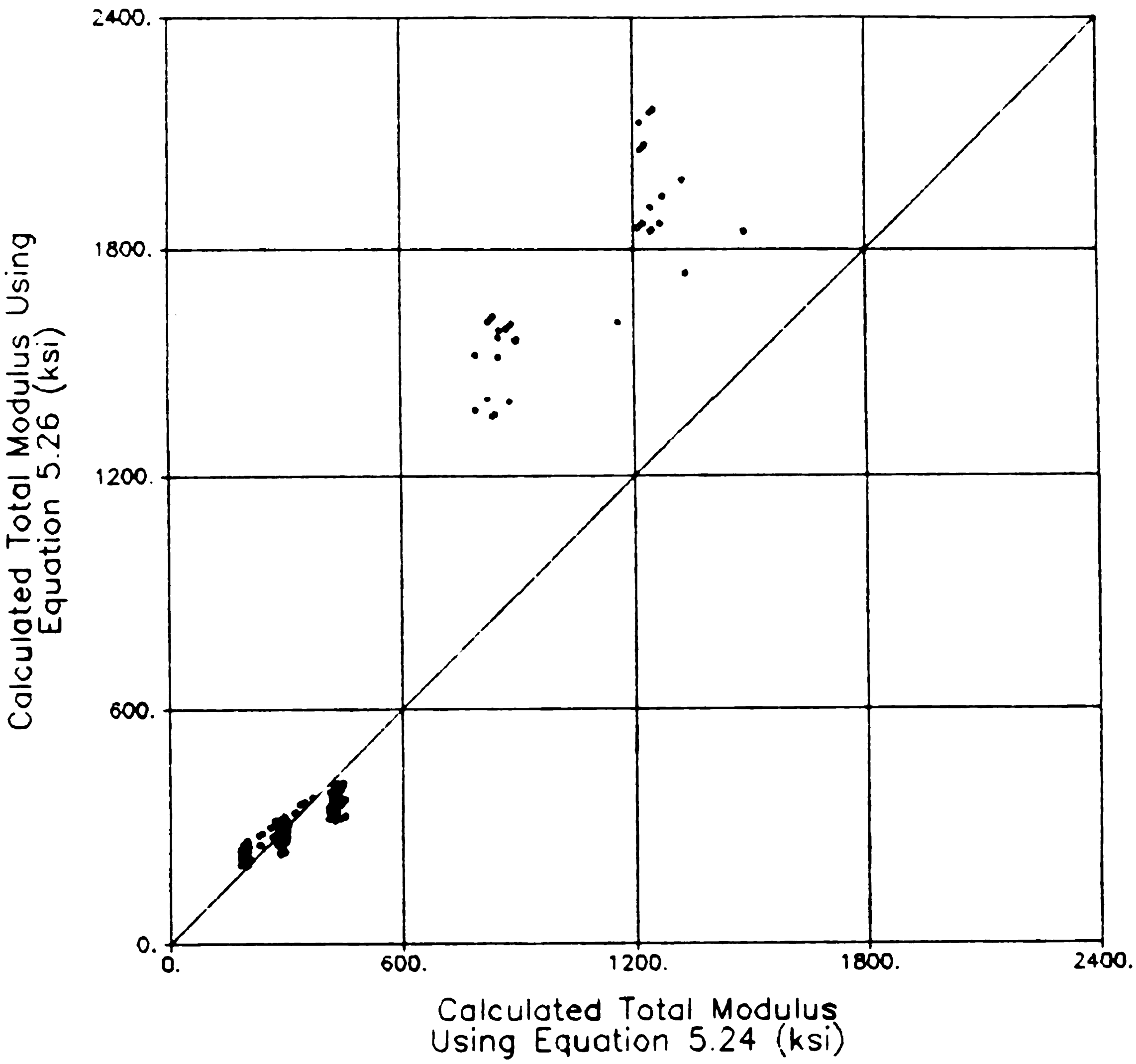


Figure 5.28 Calculated total modulus using equation 5.26 versus calculated total modulus using equation 5.24.

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^{o}F relative to its stiffness at 77^{o}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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APPENDICES

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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.) 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	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.) 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.
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 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	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 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	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 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	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 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	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	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	34.4	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	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	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.) 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	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.) 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	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)
11110632	10000	450	4.31	50	200

DEFORMATION (inches X

CYCLE NUMBER	LVDT #1(0.0 IN.) ELA.	TOT.	PLA.	LVDT #2(2.0 IN.) ELA.	TOT.	PLA.	LVD ELA
100	44.3	50.0	21.3	20.3	22.9	8.5	15.
500	34.8	39.9	54.0	15.6	17.8	20.0	10.
1000	31.4	36.5	90.2	13.9	16.1	32.4	9.
5000	24.7	28.1	231.7	10.6	12.1	77.3	6.
10000	22.2	25.3	390.5	9.5	10.8	126.2	5.
36000	18.3	21.8	805.2	7.6	9.1	245.1	4.
161600	14.6	16.8	2269.1	5.9	6.8	642.6	2.

SAMPLE NUMBER	WA (gr)	WB (gr)	AC (%)	SL (lbs)	CL (lbs:
11110615	10000	450	4.31	50	500

DEFORMATION (inches >

CYCLE NUMBER	LVDT #1(0.0 IN.) ELA.	TOT.	PLA.	LVDT #2(2.0 IN.) ELA.	TOT.	PLA.	LVI ELA.
100	127.1	146.5	99.2	48.2	55.6	32.8	30.4
500	99.9	115.8	251.5	36.8	42.7	77.0	21.1
1000	90.0	102.4	416.9	32.8	37.3	123.4	17.9
5000	70.7	81.4	1082.8	24.9	28.7	296.0	12.2
10000	63.7	73.0	1837.8	22.2	25.4	485.1	10
20000	57.4	66.7	2646.8	19.7	22.9	674.5	8
40000	51.7	60.1	4463.1	17.5	20.3	1097.4	7
44200	51.0	57.8	4336.6	17.2	19.5	1060.9	6

WA = TOTAL WEIGHT OF DRY AGGREGATES;
AC = PERCENT ASPHALT CONTENT;
WBA = WEIGHT OF SAMPLE IN AIR;
WBW = WEIGHT OF SAMPLE IN WATER;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCI
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATIOI

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 THEÓRETICAL 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	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	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	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	58.3	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	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	46.3	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	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	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	76.9	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	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	18.5	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	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	21.2	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.) 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	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.) 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	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	566.2	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	94.3	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;
AC = PERCENT ASPHALT CONTENT;
WBA = WEIGHT OF SAMPLE IN AIR;
WBW = WEIGHT OF SAMPLE IN WATER;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.
WB = WEIGHT OF BITUMEN;
SL = SUSTAINED LOAD;
CL = CYCLIC LOAD;
AV = PERCENT AIR VOIDS;

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	11.6	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	4.95

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	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	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	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	26.7	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	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	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	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	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	266.3	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	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	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	69.9
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 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	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 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	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	65.6	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	992.7	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	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	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	4349.8	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	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	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	292.9	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	65.3	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	159.3	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	195.8	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	265.8	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	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	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	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	103.3	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	28.8	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	-
165700	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 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.
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 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.
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	3361.8	7.4	8.6	750.6	3.2	3.7	274.7	0.7	0.8	51.8

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

WB = WEIGHT OF BITUMEN;
SL = SUSTAINED LOAD;
CL = CYCLIC LOAD;
AV = PERCENT AIR VOIDS;

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	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	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	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	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 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.
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 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.
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	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	27.2	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	60.8	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	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	48.2	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 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	48.3	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	11.6	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 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	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 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	118.2	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	68.6	2433.3	21.0	24.3	655.3	9.6	11.2	261.8	2.8	3.2	65.2
19500	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 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	118.6	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	419	4.02	50	500	5916.0	10110.0	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	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	392.0	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	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	23.0	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	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	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	164.7	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	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	46.0	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	168.1	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	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	45.9	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	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	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	119.3	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	292.1	-	-	-

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	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	18.2	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	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	20.8	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	192.4	3.8	4.4	70.9	2.5	2.8	39.2	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	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	20.6	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	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	36.0	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
26600	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	59.4	506.0	23.6	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	368.0	-	-	-

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

WB = WEIGHT OF BITUMEN;
SL = SUSTAINED LOAD;
CL = CYCLIC LOAD;
AV = PERCENT AIR VOIDS;

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	-	-	-
62200	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	5958.0	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 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	23.6	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 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	24.7	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;
AC = PERCENT ASPHALT CONTENT;
WBA = WEIGHT OF SAMPLE IN AIR;
WBW = WEIGHT OF SAMPLE IN WATER;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

WB = WEIGHT OF BITUMEN;
SL = SUSTAINED LOAD;
CL = CYCLIC LOAD;
AV = PERCENT AIR VOIDS;

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	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	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	264.4	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	10163.0	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	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	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	116.9	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	269.4	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	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.
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	2646.5	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	5.6	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	35.8	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	2681.6	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	9.3	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	165.9	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;
AC = PERCENT ASPHALT CONTENT;
WBA = WEIGHT OF SAMPLE IN AIR;
WBW = WEIGHT OF SAMPLE IN WATER;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

WB = WEIGHT OF BITUMEN;
SL = SUSTAINED LOAD;
CL = CYCLIC LOAD;
AV = PERCENT AIR VOIDS;

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	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	157.6	179.1	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	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	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	166.3	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 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.
145	145.6	164.7	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	792.5	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 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	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	192.7	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	791.1	8.5	9.7	266.3	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.) 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.
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.) 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	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.

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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	79.1	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;
AC = PERCENT ASPHALT CONTENT;
WBA = WEIGHT OF SAMPLE IN AIR;
WBW = WEIGHT OF SAMPLE IN WATER;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.

WB = WEIGHT OF BITUMEN;
SL = SUSTAINED LOAD;
CL = CYCLIC LOAD;
AV = PERCENT AIR VOIDS;

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	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	147.5	171.3	191.7	46.3	53.7	52.4	26.1	30.3	27.6	-	-	-
500	115.9	134.4	519.3	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	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	146.3	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	928.6	7.8	8.9	303.9	1.6	1.8	54.9
13000	73.6	84.9	4835.9	19.9	23.0	986.1	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	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	30.1	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	5749.0	9954.0	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	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	164.9	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	-	-	-
129200	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.

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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	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	59.3	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
22160	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	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	59.7	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	2663.5	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.

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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 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	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 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	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.

[redacted]

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 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	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 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	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 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	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 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	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.

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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	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	48.0	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	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	48.5	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.

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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.

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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	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	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	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	27.6	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	281.8	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	49.0	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	62.5	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	363.1	-	-	-

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	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	46.7	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	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	118.9	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	1914.0	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	3912.0	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	10049.0	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	17.6	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	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	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	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	13.9	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	11.6	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	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	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	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	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
339200	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;
AC = PERCENT ASPHALT CONTENT;
WBA = WEIGHT OF SAMPLE IN AIR;
WBW = WEIGHT OF SAMPLE IN WATER;
GMM = MAXIMUM THEORETICAL SPECIFIC GRAVITY;
ELA. AND TOT. = ELASTIC AND TOTAL DEFORMATION/CYCLE;
PLA. = CUMULATIVE PLASTIC (PERMANENT) DEFORMATION.
WB = WEIGHT OF BITUMEN;
SL = SUSTAINED LOAD;
CL = CYCLIC LOAD;
AV = PERCENT AIR VOIDS;

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 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	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 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	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	26.8
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 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	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 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	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	9935.0	2.52	4.89

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	10.9	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	9905.0	2.52	4.94

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	14.7	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 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	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 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	11.4	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	49.5
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	0.02186
	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	0.02068
	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	0.9986	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	-.3488	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	0.01925		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	0.03526		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	-.6261	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	-.6055	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	-.6363	0.9965	0.03106		4	0.3812	-.3628	0.9919	0.04196
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	0.02269
	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	-.0016	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	0.02479
	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	0.9970	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	-.2685	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	0.02292		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	0.02797		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	0.2970	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	-.3428	0.9935	0.03953
21210631	1	0.6699	-.1666	0.9992	0.02193	21310621	1	0.6899	-.2191	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	0.6922	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	0.9926	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	0.3937	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	0.02288
	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	0.5164	-.5306	0.9988	0.02180
	4	0.3177	-.4928	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	0.02975		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	0.01950
	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	0.5921	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	0.9873	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	0.0297	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	0.01798
	3	0.5143	0.2745	0.9981	0.02329		3	0.5100	0.2725	0.9988	0.01799
	4	-	-	-	-		4	-	-	-	-

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.
32110625	1	0.6451	0.6871	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	0.9611	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, 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	0.9927	0.9876	0.03009
	3	0.0871	1.3571	0.9984	0.00459		3	0.1463	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, 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.
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	0.5957	-.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	0.5936	-.4858	0.9952	0.05049		2	0.0797	1.2466	0.9926	0.00918
	3	0.5175	-.4740	0.9958	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	0.9977	0.03486						
	3	0.5304	-.5021	0.9979	0.02904						
	4	-	-	-	-						

S,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	0.468
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	-0.887	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	0.036
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 defl
beam specimens.

SD#	AV	N	B	A	SD#
		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	32120635
		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	

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 ^{o}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 (^{o}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 ^oF 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 (^oF);
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 ^{o}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 (^{o}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 (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
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 ^{o}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 (^{o}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	465023
		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	569641			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)
		1050	613183	513989
		5000	676832	570758
		10000	696125	591357
21110531	2.958	100	500000	414114
		500	581150	481379
		1100	622593	525092
		5000	685534	577765
		10200	711937	597547
21110512	2.914	100	509243	436298
		500	589759	498965
		1000	627029	527872
		5000	694365	584338
		10600	718712	605286
21110522	2.998	100	500000	415461
		500	578750	475841
		1000	617233	486208
		5000	685331	565427
		10000	705764	599963
21110532	3.099	100	494220	406044
		500	565813	469382
		1000	601855	507542
		5000	668159	558108
		10400	690866	571600
21110515	3.118	120	493576	406019
		500	555677	450509
		1000	591166	482813
		5000	656097	526348
		10000	677442	568653
21110525	2.975	100	500000	418477
		500	582241	480989
		1000	619885	520877
		5000	687168	577520
		10000	707792	597726
21110535	3.171	100	490062	403400
		500	559682	465542
		1000	595232	499508
		5000	659790	555122
		10000	680351	561475
21110611	4.737	100	360220	297110
		500	416337	347167
		1000	440755	353081
		5000	493151	401007
		10000	510256	424847
21110621	4.912	100	347398	277698
		500	400496	329927
		1000	425805	345823
		5400	477027	388838
		10900	491913	405999
21110631	4.955	100	345362	280824
		500	397354	327882
		1000	422220	337623
		5000	472596	393183
		10000	487515	404401
21110612	4.973	100	344351	283965
		500	397376	323654
		1000	422285	351065
		5000	470289	378940
		10000	486769	397028
21110622	5.090	100	334352	273916
		500	386832	317807
		1000	410162	332944
		5000	458009	376770
		10000	473291	394941
21110632	5.094	100	334352	273916
		500	386832	304472
		1000	410162	338002
		5000	458009	378976
		10000	473291	387113
21110615	5.086	100	334940	264408
		500	387149	308811
		1000	410481	337202
		5000	458056	368218
		10000	473690	388955
21110625	5.010	100	340099	280194
		500	393689	310757
		1000	417396	336100
		5000	465776	367481
		10000	481457	391033
21110635	4.977	100	343747	275590
		500	397340	326742
		1000	421596	335166
		5000	470682	397465
		10600	486776	405365
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 tc
FEM program

SAMPLE NUMBER	AV	N	MR (psi)	E (psi)	SAMPLE NUMBER	AV
		1000	314180	258453		
		5500	357595	291856		
		10900	368291	298426		
		30000	384803	313998		
		57000	384803	313998	22110612	4.96
12310715	7.078	100	250418	194726		
		500	292078	238855		
		1000	311108	244736		
		2000	329977	264552		
		5000	351407	282278		
		7000	358138	288211		
		9000	363625	295221	22110622	5.04
12310725	7.125	100	248074	194918		
		500	289350	231551		
		1000	308360	251865		
		2000	326851	264609		
		5000	348204	285966		
		8000	356678	285966		
		9000	360733	293032	22110632	5.11
12310735	6.991	100	253876	199256		
		500	296423	242264		
		1000	315740	248098		
		5000	354221	291347		
		6000	360279	294615		
		7000	364350	300659		
22110611	4.775	100	364693	302279	22110615	4.98
		500	422984	334943		
		1000	448432	368815		
		5000	498887	410005		
		10000	516341	418857		
		30000	542975	444628		
		163000	542975	444628		
22110621	4.802	100	364693	292072	22110625	5.084
		500	422984	349428		
		1000	448432	375766		
		5500	502171	412458		
		10200	516064	424897		
		27800	531795	451095		
		189865	531795	451095		
22110631	4.929	100	355933	293711	22110635	5.1
		500	413060	344631		
		1000	437120	354066		

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	292869	11120531	3.166	100	1557572	1075930
		500	418018	341028			500	1804090	1379284
		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	807663
		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
		147950	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.

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 E. Calculated resilient and
FEM program

SAMPLE NUMBER	AV	N	MR (psi)	E (psi)	SAMPLE NUMBER	
		5000	468740	380568		
		10000	484734	401008		
		23200	500238	427302		
		33000	507015	417782		
32110611	5.195	100	339271	279291	32110615	
		500	391336	327805		
		1000	415323	345569		
		5000	462916	379938		
		10000	485831	399064		
		27000	499917	405838		
		184700	499917	415849		
32110621	5.078	100	345362	271669	32110625	
		500	397354	323075		
		1000	422220	342643		
		5000	472596	393380		
		10345	494553	386068		
		25000	507624	421172		
		162000	507624	421172		
32110631	5.182	100	339271	276190	32110635	
		500	391336	321085		
		1000	415323	340163		
		5000	462916	376030		
		10850	484898	401055		
		30000	497481	410905		
		164300	497481	416883		
32110612	5.127	100	343345	277734	11120511	:
		500	397337	321208		
		1000	420664	336739		
		5100	471096	381002		
		10000	484996	399119		
		28000	502117	410652		
		206700	502117	410652		
32110622	4.955	100	353769	281595	11120521	3
		500	409833	327921		
		1000	433402	352811		
		5000	482909	385613		
		11300	507600	417290		
		26000	518553	427587		
		170200	518553	427587		
32110632	4.854	100	361357	292889	11120531	3
		500	418018	341028		
		1000	444479	365624		

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 t(
FEM program

SAMPLE NUMBER	AV	N	MR (psi)	E (psi)	SAMPLE NUMBER	A
		5000	1859015	1375283		
		11100	1922812	1410661		
		31800	2174536	1735628		
		171600	2206978	1649504		
11320515	2.431	100	1726380	1306044	22120612	4.
		500	1806835	1352966		
		1000	1907729	1485960		
		5000	1865440	1320446		
		10150	2177106	1763950		
		35900	2151127	1663126		
		157900	2354756	1911962		
11320525	2.961	100	1696626	1343729	22120622	4.
		500	1766813	1378208		
		1000	1807463	1405759		
		5000	1775662	1271296		
		10700	1908640	1461984		
		20750	1831399	1282089		
		191200	1996902	1446656		
11320535	3.642	100	1440709	1030432	22120632	5.
		500	1499385	1057239		
		1000	1732970	1378516		
		5300	1699072	1239810		
		10225	1662999	1168603		
		30000	1790578	1326965		
		153100	2089451	1688184		
22120611	4.886	100	1409797	1048327	22120615	5.
		500	1483301	1099758		
		1000	1537544	1151777		
		7700	1696892	1313383		
		10500	1579399	1096456		
		134600	1782958	1298768		
		309300	1890778	1428689		
22120621	4.944	100	1366169	988184	22120625	4.
		500	1408937	1005992		
		1000	1615163	1283869		
		5000	1615163	1186539		
		10000	1615163	1156870		
		30500	1615163	1101702		
		185800	1852475	1380064		
22120631	5.076	100	1272697	876578	22120635	5.
		500	1428105	1047690		
		1240	1579457	1248046		

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	807663
		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

SAMPLE NUMBER	AV	N	MR (psi)	E (psi)
		1000	1429049	1053822
		5000	1538128	1185835
		10000	1465620	1014638
		22700	1543350	1122505
		147950	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.