# Study of LTPP Laboratory Resilient Modulus Test Data and Response Characteristics: Final Report

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U.S. Department of Transportation
**Federal Highway Administration**

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA  22101-2296

# Foreword

The elastic or resilient modulus of pavement materials is an important material property in any mechanistically based design/analysis procedure for flexible pavements. Repeated load resilient modulus tests are being performed on all unbound materials and soils of the Specific Pavement Studies (SPS) and General Pavement Studies (GPS) test sections that are in the Federal Highway Administration (FHWA) Long Term Pavement Performance (LTPP) program in accordance with LTPP test protocol P46. Previous studies have shown that the resilient modulus test results can be affected by sampling technique, testing procedure, and errors that can occur during the testing program. Thus, the FHWA sponsored a detailed review of the resilient modulus test results that have a Level E status in the LTPP database, i.e., they have passed all levels of the quality control (QC) checks.

This report documents the first comprehensive review and evaluation of the resilient modulus test data measured on pavement materials and soils recovered from the LTPP test sections. The resilient modulus test data were found generally to be in excellent condition with less than 10 percent of the tests exhibiting potential anomalies or discrepancies in the data.

The resilient modulus data were further investigated to evaluate relationships between resilient modulus and the physical properties of the unbound materials and soils. The primary result from these studies is that the resilient modulus can be reasonably predicted from the physical properties included in the LTPP database, but there is a bias present in the calculated values. Thus, until additional test results become available to improve or confirm these relationships, it is recommended that at least some laboratory tests be performed to measure the resilient modulus for unbound pavement materials and soils.

T. Paul Teng, P.E.
Director
Office of Infrastructure
Research and Development

# Notice

# Technical Report Documentation Page

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**16. Abstract**
The resilient modulus of every unbound structural layer of the Long Term Pavement Performance (LTPP) Specific Pavement and General Pavement Studies Test Sections is being measured in the laboratory using LTPP test protocol P46. A total of 2,014 resilient modulus tests have passed all quality control checks and are included in the LTPP database with a Level E data status. As of October 2000, there were 1,639 resilient modulus tests yet to be performed. In some cases, these missing tests may have been performed, but did not achieve a Level E status (did not pass all quality control checks) in the LTPP database. However, these test results have not been evaluated in detail. This report documents the first comprehensive review and evaluation of the resilient modulus test data measured on pavement materials and soils recovered from the LTPP test sections.

The resilient modulus data were reviewed in detail to identify anomalies or potential errors in the database. From this review, a total of 185 resilient modulus tests were identified with possible problems or data entry errors. These tests were reported to FHWA for further review and/or retesting. The resilient modulus test data were found generally to be in excellent condition with less than 10 percent of the tests exhibiting potential anomalies or discrepancies in the data.

The resilient modulus test data were then studied for the effect of test variables, such as the test and sampling procedures, on the resulting resilient moduli. These data were analyzed by material code for the base and subbase aggregate layers and by soil type for the subgrade. Sampling technique (auger versus test pit) was found to have the most effect on the crushed stone aggregate and uncrushed gravel base materials. For the subgrade soils, sampling technique (Shelby tubes versus auger samples) had the most effect on the clay soils. Sampling technique was found to have little to no effect on the sand base/subbase materials and sand soils.

The resilient modulus data were further investigated to evaluate relationships between resilient modulus and the physical properties of the unbound materials and soils. Using nonlinear regression optimization techniques, equations for each base and soil type were developed to calculate the resilient modulus at a specific stress state from physical properties of the base materials and soils. The primary result from these studies is that the resilient modulus can be reasonably predicted from the physical properties included in the LTPP database, but there is a bias present in the calculated values. Thus, until additional test results become available to improve or confirm these relationships, it is recommended that at least some laboratory tests be performed to measure the resilient modulus for unbound pavement materials and soils.

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# SI* (MODERN METRIC) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| yd | yards | 0.914 | meters | m |
| mi | miles | 1.61 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 645.2 | square millimeters | $mm^2$ |
| $ft^2$ | square feet | 0.093 | square meters | $m^2$ |
| $yd^2$ | square yard | 0.836 | square meters | $m^2$ |
| ac | acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | square kilometers | $km^2$ |
| | | **VOLUME** | | |
| fl oz | fluid ounces | 29.57 | milliliters | mL |
| gal | gallons | 3.785 | liters | L |
| $ft^3$ | cubic feet | 0.028 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | cubic meters | $m^3$ |
| NOTE: volumes greater than 1000 L shall be shown in $m^3$ | | | | |
| | | **MASS** | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams (or "metric ton") | Mg (or "t") |
| | | **TEMPERATURE (exact degrees)** | | |
| $^oF$ | Fahrenheit | 5 (F-32)/9 or (F-32)/1.8 | Celsius | $^oC$ |
| | | **ILLUMINATION** | | |
| fc | foot-candles | 10.76 | lux | lx |
| fl | foot-Lamberts | 3.426 | candela/$m^2$ | cd/$m^2$ |
| | | **FORCE and PRESSURE or STRESS** | | |
| lbf | poundforce | 4.45 | newtons | N |
| lbf/$in^2$ | poundforce per square inch | 6.89 | kilopascals | kPa |

## APPROXIMATE CONVERSIONS FROM SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.039 | inches | in |
| m | meters | 3.28 | feet | ft |
| m | meters | 1.09 | yards | yd |
| km | kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| $mm^2$ | square millimeters | 0.0016 | square inches | $in^2$ |
| $m^2$ | square meters | 10.764 | square feet | $ft^2$ |
| $m^2$ | square meters | 1.195 | square yards | $yd^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | square kilometers | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| mL | milliliters | 0.034 | fluid ounces | fl oz |
| L | liters | 0.264 | gallons | gal |
| $m^3$ | cubic meters | 35.314 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.307 | cubic yards | $yd^3$ |
| | | **MASS** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.202 | pounds | lb |
| Mg (or "t") | megagrams (or "metric ton") | 1.103 | short tons (2000 lb) | T |
| | | **TEMPERATURE (exact degrees)** | | |
| $^oC$ | Celsius | 1.8C+32 | Fahrenheit | $^oF$ |
| | | **ILLUMINATION** | | |
| lx | lux | 0.0929 | foot-candles | fc |
| cd/$m^2$ | candela/$m^2$ | 0.2919 | foot-Lamberts | fl |
| | | **FORCE and PRESSURE or STRESS** | | |
| N | newtons | 0.225 | poundforce | lbf |
| kPa | kilopascals | 0.145 | poundforce per square inch | lbf/$in^2$ |

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2002)

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# CHAPTER 1. INTRODUCTION

## BACKGROUND

The elastic or resilient modulus of pavement materials is an important material property in any mechanistically based design/analysis procedure for flexible pavements. In fact, the resilient modulus ($M_R$) is the material property required for the 1993 American Association of State Highway and Transportation Officials (AASHTO) Design Guide, which is an empirically based design procedure, and is the primary material input parameter for the 2002 Design Guide.(1) The 2002 Design Guide is being developed based on mechanistically based principles under National Cooperative Highway Research Program (NCHRP) Project 1-37A, "Development of Design Procedure for New and Rehabilitated Pavements."

Repeated load resilient modulus tests are being performed on all unbound materials and soils of the Specific Pavement Studies (SPS) and General Pavement Studies (GPS) test sections that are in the Federal Highway Administration (FHWA) Long Term Pavement Performance (LTPP) program in accordance with LTPP test protocol P46.(2) The $M_R$ of unbound pavement materials and soils is a measure of the elastic modulus of the material at a given stress state. It is mathematically defined as the applied deviator stress divided by the "recoverable" strain that occurs when the applied load is removed from the test specimen.

$$M_R = \frac{\sigma_d}{\varepsilon_r} \tag{1}$$

Where:

| | | |
|---|---|---|
| $\sigma_d$ | = | applied deviator stress in a repeated load triaxial test. |
| $\varepsilon_r$ | = | recoverable or resilient strain. |

The $M_R$ measured at different stress states have been included in the LTPP Information Management System (IMS), but the test results have not been evaluated for use in future research studies.

Previous studies have shown that the resilient modulus test results can be affected by sampling technique, testing procedure, and errors that can occur during the testing program. Some of these errors include incorrect conditioning/stress sequence, leaks in the membrane, incorrect stress levels, unstable Linear Variable Differential Transducer (LVDT) clamps attached to the specimen, exceeding the LVDT linear range limits, and specimen disturbance at the higher stress states. Thus, FHWA authorized a detailed review of the resilient modulus test results that have a Level E status in the LTPP database, i.e., they have passed all levels of the quality control (QC) checks. This report summarizes the findings from the detailed review of the resilient modulus test data.

## STUDY OBJECTIVES

This study focused on determining anomalies in the unbound resilient modulus data in the database to ensure data quality and to identify any bias between different data sets. The $M_R$ data were extracted first from the April 2000 data release and updated with additional $M_R$ tests from the October 2000 release. The $M_R$ data were obtained from the TST_UG07_SS07_WKSHT_ SUM table in the IMS. The following tasks define the work performed to accomplish the goals of the study:

> Task 1: Identify any and all of the repeated load resilient modulus data for unbound pavement materials and soils that are not at Level E.
>
> Task 2: Review and evaluate the resilient modulus data to identify any anomalies in the database.

$M_R$ tests with potential anomalies were flagged and a "cleaned" data set was used to determine any bias in the data and identify other factors that influence the tests results. The cleaned data set also was used to perform correlation studies between the $M_R$ of the selected constitutive equation and the physical properties of the unbound materials and soils in support of NCHRP Project 1-37A.

## SCOPE OF REPORT

This report summarizes the review of the resilient modulus test results that have a Level E status in the LTPP database. The report is divided into five chapters, including the introduction (chapter 1). Chapter 2 provides the process of identifying missing tests and anomalies in the Level E data. Chapter 3 discusses the effect of test variables on resilient modulus. A correlation between the $M_R$ determined from the selected constitutive equation and physical properties of the tests specimens is presented in chapter 4. Chapter 5 summarizes all of the findings and provides recommendations for future research.

# CHAPTER 2. REVIEW OF RESILIENT MODULUS TEST DATA

## IDENTIFICATION OF MISSING RESILIENT MODULUS TESTS

A total of 1,970 resilient modulus tests were extracted from the April 2000 LTPP database (most current at the time of data extraction) of unbound materials and soils. The October 2000 data release was cross-checked with the April release for additional tests to update the review and findings. A total of 44 additional resilient modulus tests were extracted from the October release, resulting in a total of 2,014 $M_R$ tests.

The resilient modulus tests in the LTPP database were organized by State and layer type for each SPS project and by State, layer number, layer type, and section identification number for the GPS test sections. The data were cross-checked with the required number of resilient modulus tests per layer for each project to determine the number of missing tests.

Table 1 summarizes the number of completed and missing resilient modulus tests by layer type as of the October 2000 data release. The numbers of completed and missing tests do not add up to the number of tests required because extra tests were performed. The resilient modulus tests in the database that are counted as complete are identified as Level E data. The number of missing tests includes those $M_R$ tests that have not been performed plus those that have been completed, but which have not passed all QC levels.

Table 1. Summary of completed and missing resilient modulus tests as of the October 2000 LTPP data release.

| Layer Type | Soil Type | No. of Tests Required | No. of Tests Completed | No. of Tests Missing |
|---|---|---|---|---|
| Subgrade Soil | All | 1886 | 1347 | 594 |
| | Clay | 652 | 513 | 168 |
| | Gravel | 262 | 123 | 140 |
| | Rock | 24 | 3 | 21 |
| | Sand | 765 | 580 | 208 |
| | Silt | 169 | 116 | 55 |
| | Unknown | 14 | 12 | 2 |
| Granular Subbase | All | 685 | 259 | 427 |
| Granular Base | All | 956 | 385 | 573 |
| Unknown | Unknown | -- | 23 | -- |
| Total | | 3527 | 2014 | 1594 |

The missing resilient modulus tests were categorized by LTPP region, State, experiment type, and layer type. Data feedback reports for the missing tests were summarized by region and submitted to LTPP. There are a total of 23 $M_R$ tests that cannot be summarized using the layer type due to missing layer structure information. The $M_R$ tests for the subgrade soils were further divided into soil type (i.e., clay, gravel, rock, sand, and silt) since more than half of the total required resilient modulus tests are for the subgrade. Some tests cannot be grouped by soil type due to missing soil classification information.

In summary, more than half of the required testing has been completed and the data have achieved a Level E status. The other half of the required tests either have not been completed or the tests have been performed, but the QC process is incomplete. It is expected that the number of completed $M_R$ tests with a Level E data status will significantly increase in future data releases.

**Observation:** 2,014 $M_R$ tests of unbound pavement materials and soils have a Level E data status as of the October 200 LTPP data release, while 1,594 have not yet obtained a Level E status.

## RESILIENT MODULUS CONSTITUTIVE EQUATION

LTPP test protocol P46 is being used to measure the $M_R$ of unbound pavement materials and subgrade soils. This test is performed over a wide range of vertical stresses and confining pressures to measure the nonlinear (stress-sensitivity) elastic behavior of these materials and soils. Various types of relationships have been used to represent the repeated-load $M_R$ test results of coarse-grained and fine-grained soils. However, Von Quintus and Killingsworth found that the so-called "universal" constitutive equation provided a very good fit to the LTPP $M_R$ test data.[3] The specific equation used is given below:

$$M_R = K_1 P_a \left[\frac{\theta}{P_a}\right]^{K_2} \left[\frac{\sigma_d}{P_a}\right]^{K_3} \tag{2}$$

As noted in chapter 1, the 2002 Design Guide uses $M_R$ as the primary material property for all unbound pavement layers and subgrade soils. The constitutive equation used for determining the $M_R$ of a material is given below and represents an expanded version of equation 2:[4]

$$M_R = k_1 P_a \left[\frac{\theta - 3k_6}{P_a}\right]^{k_2} \left[\frac{\tau_{oct}}{P_a} + 1\right]^{k_3} \tag{3}$$

where: $P_a$ = atmospheric pressure.

$\theta$ = bulk stress:

$$\theta = \sigma_1 + \sigma_2 + \sigma_3 . \tag{4}$$

$\sigma_1$ = major principal stress.

$\sigma_2$ = intermediate principal stress = $\sigma_3$ for $M_R$ test on cylindrical specimen.

$\sigma_3$ = minor principal stress/confining pressure.

$\tau_{oct}$ = octahedral shear stress:

$$\tau_{oct} = \frac{1}{3}\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2} \tag{5}$$

$k_1$, $k_2$, $k_3$, $k_6$ = regression constants.

Coefficient $k_1$ is proportional to Young's modulus. Thus, the values for $k_1$ should be positive since $M_R$ can never be negative. Increasing the volumetric stress ($\theta$) should produce a stiffening or hardening of the material, which results in a higher $M_R$. Therefore, the exponent ($k_2$) of the bulk stress term for the above constitutive equation should also be positive. Coefficient $k_6$ is intended to account for pore-water pressure or cohesion and is a measure of the material's ability to resist tension. The values for $k_6$ are expected to be negative or, when positive, less than or equal to a third of the bulk stress. Coefficient $k_3$ is the exponent of the octahedral shear stress term. The values for $k_3$ should be negative since increasing the shear stress will produce a softening of the material, i.e., a lower $M_R$.

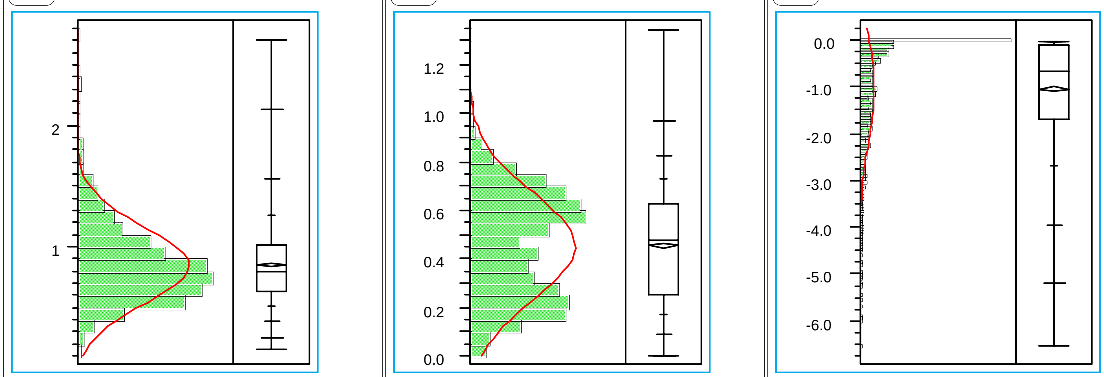
The regression for the four k-coefficients in equation 3 was performed, restraining the regression constants to their physical limits using the LTPP April and October 2000 data releases. Only those resilient modulus tests with 12 or more data points were used, resulting in a total of 1,920 tests. A total of 94 $M_R$ tests (approximately 4 percent of the total number of tests) had less than 12 data points. It is important to note that all regressions were performed using units of *MPa* for $M_R$ and *kPa* for the stress and pressure parameters in equation 3.

More than half of the $k_6$ values were equal to zero, while the non-zero values were highly variable with a uniform distribution. Therefore, $k_6$ was set to zero and the regression was repeated. No significant effect was observed on the regression statistics setting $k_6$ equal to zero. Figure 1 presents the distributions of the final results for the k-coefficients. The values for the k-coefficients are presented in appendix A.

**Observation:** Coefficient $k_6$ in equation 3 was found to be zero for more than 50 percent of the $M_R$ tests.

Coefficient $k_1$ ranged from 0 to 3. These values are actually factors of a thousand because the $M_R$ value used was in *MPa* instead of *kPa*. Coefficient $k_2$ ranged from 0 to 1.5 and has a bi-normal population. The bi-normal population suggests two different groups of soils. Figures 2 through 4 confirm that the coarse-grained soils are different from the fine-grained soils. Coefficient $k_3$ ranged from 0 to -7 and has a skewed distribution. About 25 percent of the values were equal to zero. The majority of $M_R$ tests with a $k_3$ coefficient equal to zero were for the unbound aggregate materials or coarse-grained soils.

Figures 2 through 4 present the distributions of the k-coefficients for the unbound aggregate materials and coarse-grained and fine-grained soils, while table 2 summarizes a comparison of the median and mean values for the coefficients from each data group. As shown, coefficients $k_1$ and $k_2$ have a normal distribution, while $k_3$ has a skewed distribution for the base/subbase materials (figure 2). However, the distributions for $k_1$ and $k_2$ become skewed as the material becomes finer, while the distribution for $k_3$ becomes more normal (figures 3 and 4).




**K1 — Quantiles**

| | | |
|---|---|---|
| maximum | 100.0% | 2.7055 |
| | 99.5% | 2.1431 |
| | 97.5% | 1.5692 |
| | 90.0% | 1.2637 |
| quartile | 75.0% | 1.0150 |
| median | 50.0% | 0.8036 |
| quartile | 25.0% | 0.6391 |
| | 10.0% | 0.5174 |
| | 2.5% | 0.3913 |
| | 0.5% | 0.2629 |
| minimum | 0.0% | 0.1583 |

**K1 — Moments**

| | |
|---|---|
| Mean | 0.855 |
| Std Dev | 0.313 |
| Std Error Mean | 0.007 |
| Upper 95% Mean | 0.869 |
| Lower 95% Mean | 0.841 |
| N | 1920.000 |
| Sum Weights | 1920.000 |

**K2 — Quantiles**

| | | |
|---|---|---|
| maximum | 100.0% | 1.3450 |
| | 99.5% | 0.9747 |
| | 97.5% | 0.8275 |
| | 90.0% | 0.7299 |
| quartile | 75.0% | 0.6335 |
| median | 50.0% | 0.4824 |
| quartile | 25.0% | 0.2570 |
| | 10.0% | 0.1710 |
| | 2.5% | 0.0902 |
| | 0.5% | 0.0000 |
| minimum | 0.0% | 0.0000 |

**K2 — Moments**

| | |
|---|---|
| Mean | 0.457 |
| Std Dev | 0.219 |
| Std Error Mean | 0.005 |
| Upper 95% Mean | 0.467 |
| Lower 95% Mean | 0.447 |
| N | 1920.000 |
| Sum Weights | 1920.000 |

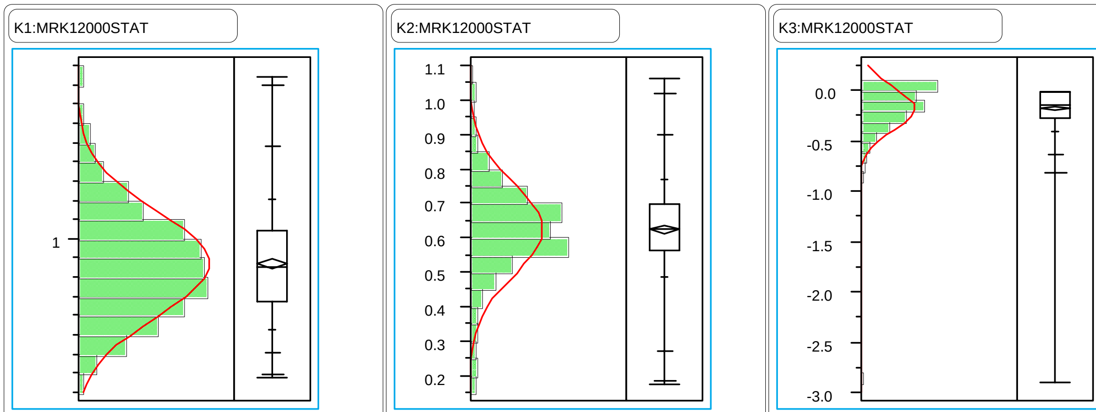
**K3 — Quantiles**

| | | |
|---|---|---|
| maximum | 100.0% | 0.0000 |
| | 99.5% | 0.0000 |
| | 97.5% | 0.0000 |
| | 90.0% | 0.0000 |
| quartile | 75.0% | -0.0948 |
| median | 50.0% | -0.6536 |
| quartile | 25.0% | -1.6649 |
| | 10.0% | -2.6841 |
| | 2.5% | -3.9364 |
| | 0.5% | -5.1932 |
| minimum | 0.0% | -6.5304 |

**K3 — Moments**

| | |
|---|---|
| Mean | -1.033 |
| Std Dev | 1.132 |
| Std Error Mean | 0.026 |
| Upper 95% Mean | -0.983 |
| Lower 95% Mean | -1.084 |
| N | 1920.000 |
| Sum Weights | 1920.000 |

Figure 1. Distribution of the k-coefficients of constitutive equation 3, assuming $k_6 = 0$, for the entire LTPP resilient modulus database.




Quantiles

| | | K1 | K2 | K3 |
|---|---|---|---|---|
| maximum | 100.0% | 1.8474 | 1.0622 | 0.0000 |
| | 99.5% | 1.8002 | 1.0211 | 0.0000 |
| | 97.5% | 1.4835 | 0.9025 | 0.0000 |
| | 90.0% | 1.2097 | 0.7712 | 0.0000 |
| quartile | 75.0% | 1.0498 | 0.7000 | 0.0000 |
| median | 50.0% | 0.8527 | 0.6280 | -0.1294 |
| quartile | 25.0% | 0.6778 | 0.5646 | -0.2606 |
| | 10.0% | 0.5267 | 0.4867 | -0.4007 |
| | 2.5% | 0.4105 | 0.2738 | -0.6245 |
| | 0.5% | 0.3013 | 0.1880 | -0.8154 |
| minimum | 0.0% | 0.2809 | 0.1741 | -2.8978 |

Moments

| | K1 | K2 | K3 |
|---|---|---|---|
| Mean | 0.8732 | 0.6261 | -0.1696 |
| Std Dev | 0.2726 | 0.1330 | 0.2148 |
| Std Error Mean | 0.0133 | 0.0065 | 0.0104 |
| Upper 95% Mean | 0.8993 | 0.6388 | -0.1490 |
| Lower 95% Mean | 0.8472 | 0.6134 | -0.1901 |
| N | 423.0000 | 423.0000 | 423.0000 |
| Sum Weights | 423.0000 | 423.0000 | 423.0000 |

Figure 2. Distribution of the k-coefficients of constitutive equation 3, assuming $k_6 = 0$, for the unbound aggregate base and subbase materials.

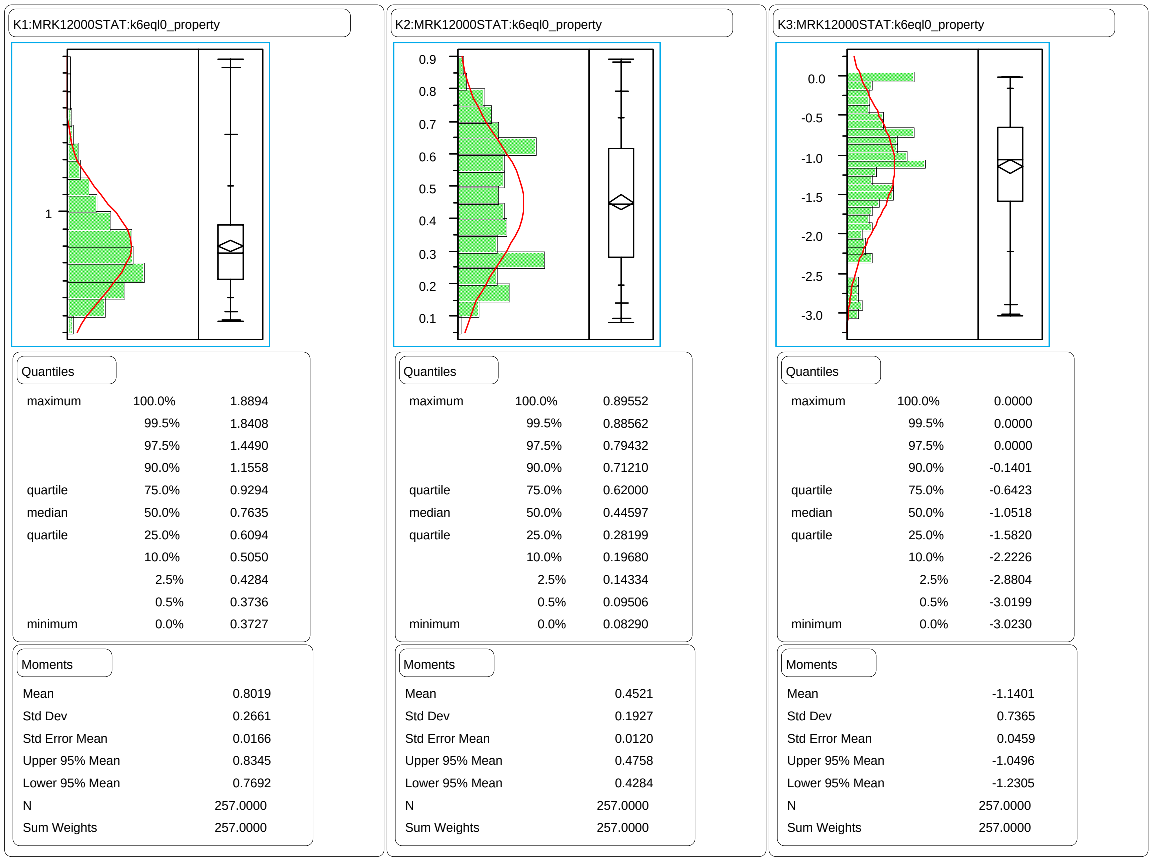



Figure 3. Distribution of the k-coefficients of constitutive equation 3, assuming $k_6 = 0$, for the coarse-grained subgrade soils.

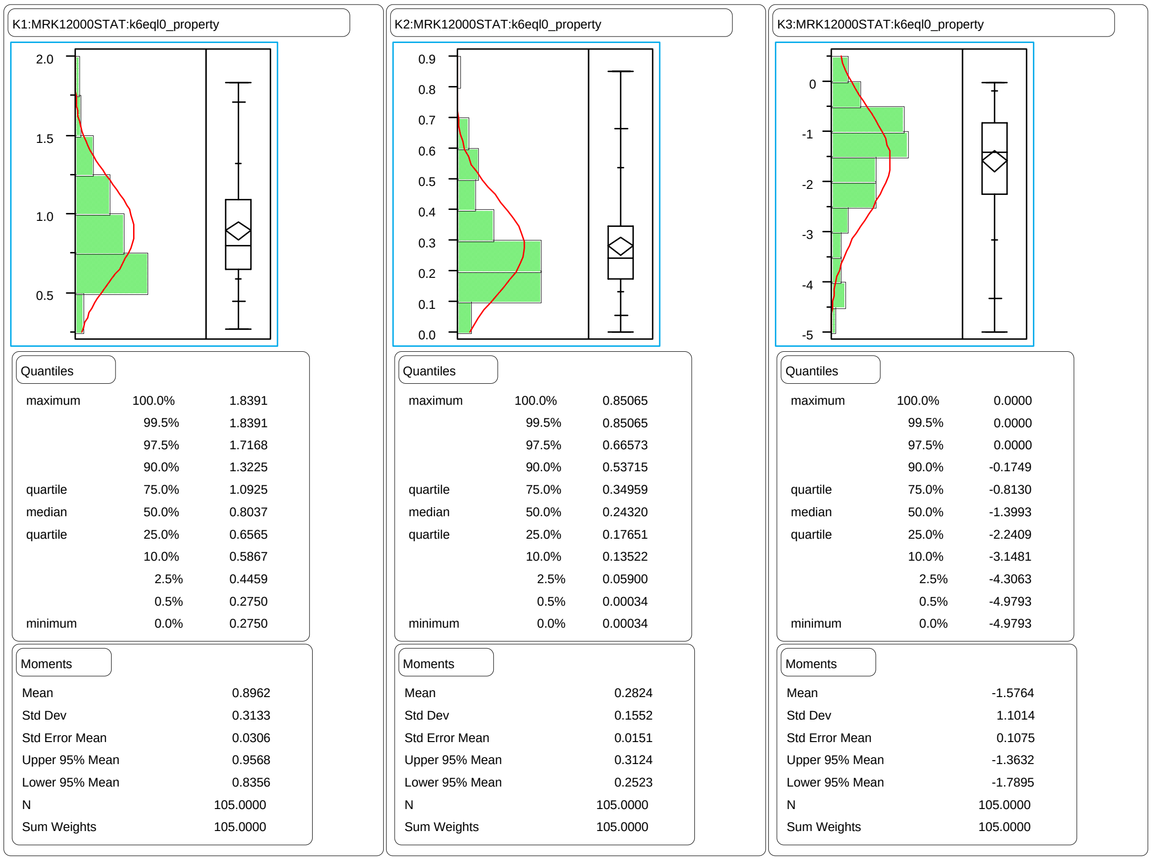



Figure 4. Distribution of the k-coefficients of constitutive equation 3, assuming $k_6 = 0$, for the fine-grained subgrade soils.

Table 2. Summary of the median and mean values for each coefficient of constitutive equation 3, assuming $k_6 = 0$, for each of the base and subbase pavement materials and subgrade soils.

| Coefficient | | Material/Soil Group | | |
|---|---|---|---|---|
| | | Unbound Base-Subbase Materials | Coarse-Grained Soils | Fine-Grained Soils |
| $k_1$ | Median | 0.853 | 0.764 | 0.804 |
| | Mean | 0.873 | 0.802 | 0.896 |
| | Standard Deviation | 0.2726 | 0.2661 | 0.3133 |
| $k_2$ | Median | 0.628 | 0.446 | 0.243 |
| | Mean | 0.626 | 0.452 | 0.282 |
| | Standard Deviation | 0.1330 | 0.1927 | 0.1552 |
| $k_3$ | Median | -0.129 | -1.052 | -1.399 |
| | Mean | -0.170 | -1.140 | -1.576 |
| | Standard Deviation | 0.2148 | 0.7365 | 1.1014 |
| Number of Tests | | 423 | 257 | 105 |

Table 2 shows that the median value for coefficient $k_2$ increases as the amount of fines in the material/soil increases (fine-grained soils to unbound aggregate base material). Similarly, the median value for $k_3$ becomes more negative as the material/soil becomes more fine-grained. The majority of the zero values for $k_3$ were from the unbound base materials and coarse-grained soils, approximately 25 percent of the $M_R$ tests for the unbound aggregate base/subbase materials and 10 percent of the tests for the coarse-grained subgrade soils. Thus, the regressed k-coefficients from the LTPP $M_R$ test results are consistent with previous experience.

Figures 5 and 6 compare the calculated $M_R$ from the regressed k-coefficients of the constitutive equation to the measured $M_R$ for the test pit and augured samples, respectively. Figures 7 and 8 compare the calculated $M_R$ from the regressed k-coefficients of the constitutive equation to the measured $M_R$ for the gravel and clay soil groups, respectively. As shown, the constitutive equation provides an excellent fit to the LTPP $M_R$ test data. The universal constitutive equation provides a similar good fit to the other base materials and subgrade soils.

**Observation:** Equation 3 provides an excellent fit to the LTPP resilient modulus test data.

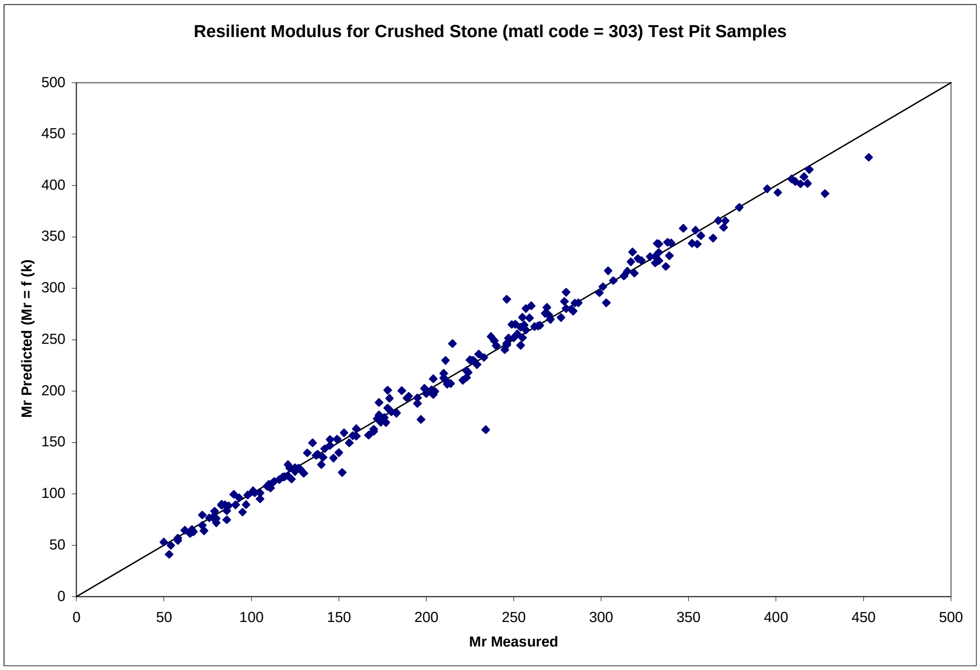



Figure 5. Comparison of measured and predicted resilient modulus (from regressed k values from measured $M_R$ data) for the crushed stone materials sampled from the test pit locations.

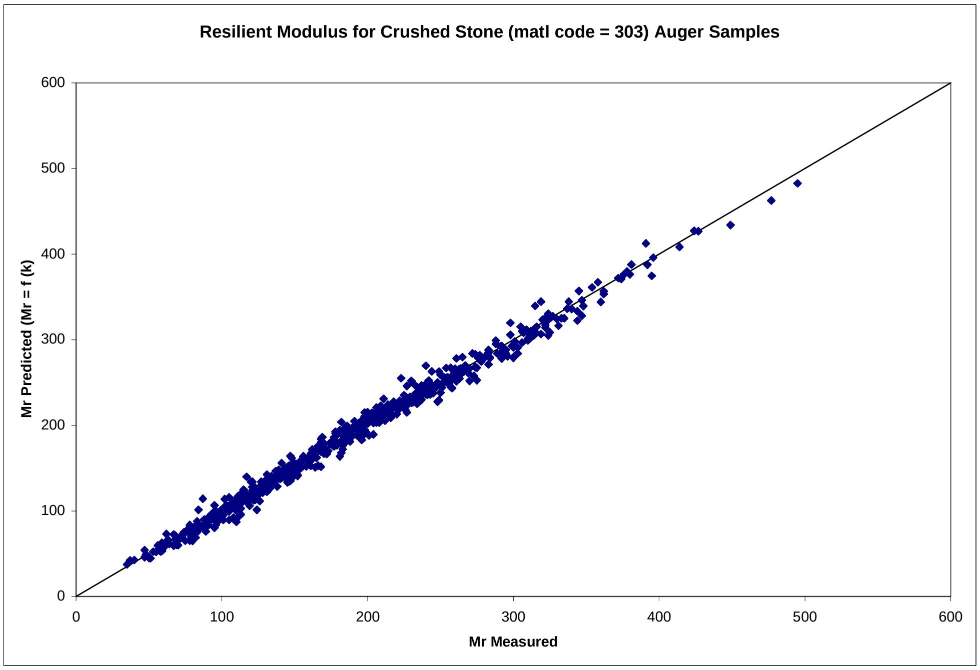



Figure 6. Comparison of measured and predicted resilient modulus (from regressed k values from measured $M_R$ data) for the crushed stone materials sampled from the auger locations.

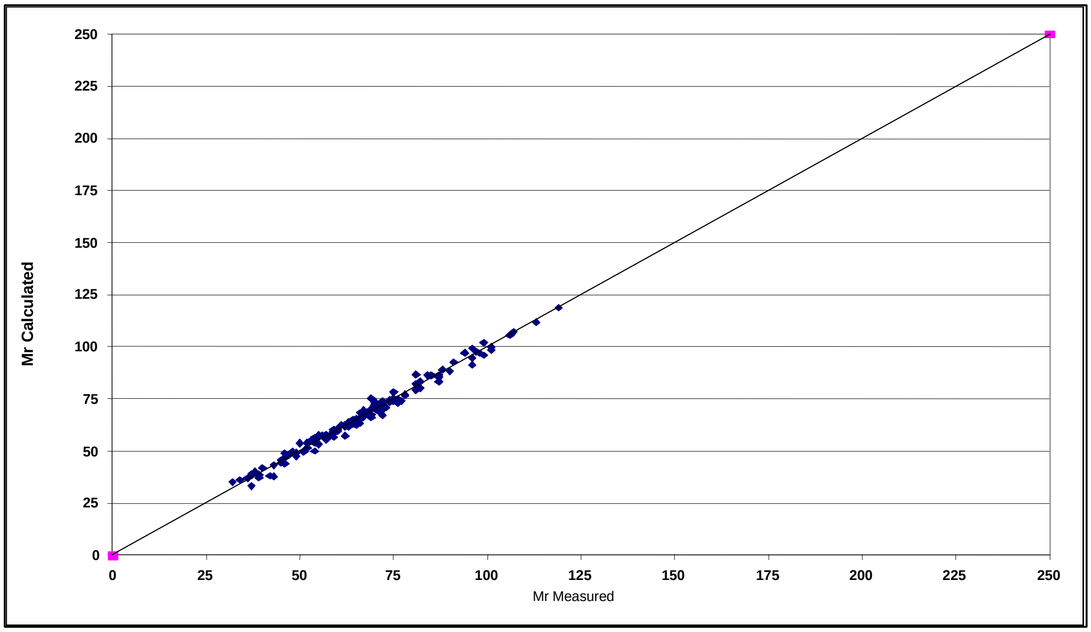



Figure 7. Graphical comparison of the calculated $M_R$ (using the regressed k-coefficients from the LTPP test results) to the measured $M_R$ for the gravel soils.

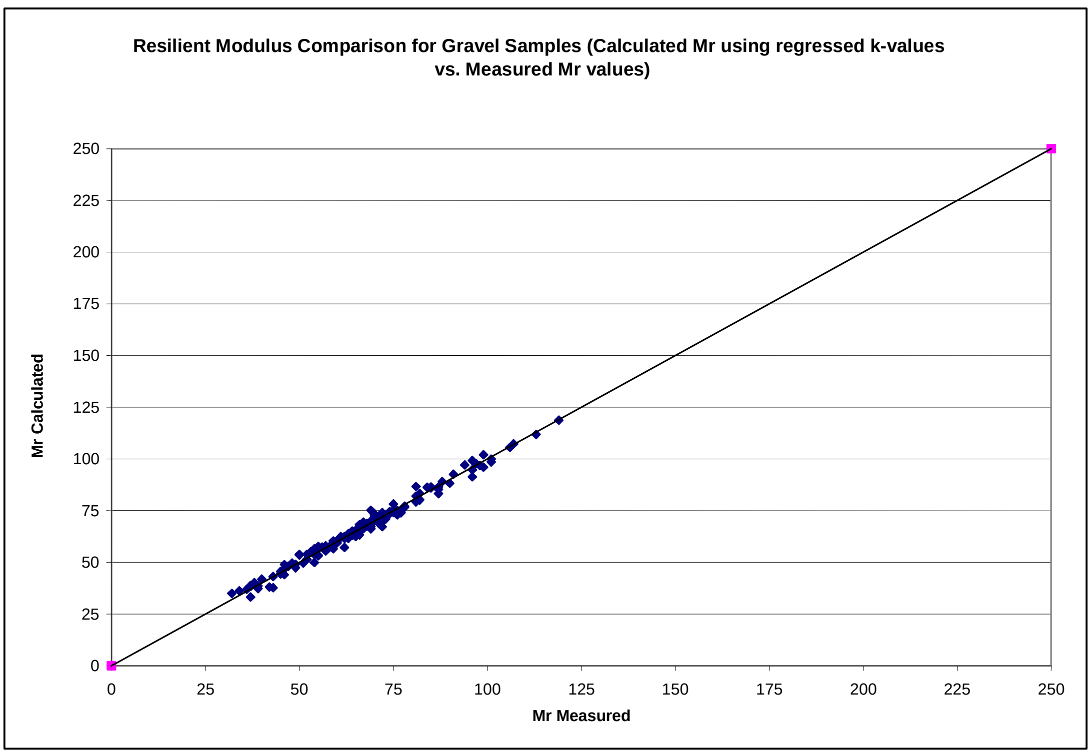



Figure 8. Graphical comparison of the calculated $M_R$ (using the regressed k-coefficients from the LTPP test results) to the measured $M_R$ for the clay soils.

## IDENTIFICATION OF TEST DATA ANOMALIES

Approximately 10 percent of the regression results for the k-coefficients have $s_e/s_y$ values greater than 0.5, suggesting that the regressions are not good fits. The reason for the poor fit could be a result of errors that occurred during the test procedure or that the constitutive equation does not represent the actual behavior of selected unbound materials and soils. It is important to ensure that the data are of good quality and without errors prior to making an assessment on the applicability of equation 3. Some possible problems that can occur during the $M_R$ test are listed below:

- Different conditioning sequences or different stress application sequences used in the test program.
- Leaks occurring in the membrane during the test (i.e., an unconfined test).
- Different stress states (applied stress and confining pressure) used in the test program than required by the test protocol.
- Test specimens that begin to fail or exhibit disturbance at the higher stress states.
- LVDT clamps that begin to move or move suddenly because of vibrations during the loading sequence.
- LVDTs that begin to drift during the testing sequence or become restricted due to friction in the measurement system.
- Measured deformations that begin to exceed the linear range of the LVDTs.

The second objective of this study was to identify any possible anomalies that may exist in the resilient modulus database and to determine their possible cause. The process used to identify and flag the resilient modulus test data, with possible anomalies, is summarized below:

Step 1. The resilient modulus test data were organized by material type or code for the review.

Step 2. A regression analysis was conducted of the resilient modulus test data to define selected statistical parameters of the relationship between stress and resilient modulus.

Step 3. A correlation matrix of the resilient modulus test data (resilient modulus correlation with bulk stress and octahedral shear stress) was determined.

Step 4. A summary of the results from the regression ($R^2$, $s_e/s_y$) and correlation matrix by material type was prepared.

Step 5. The resilient modulus tests, with possible anomalies, using the following criteria or threshold values, were identified and flagged:

*$R^2$<0.99

*$s_e/s_y$>0.50

*Absolute Values of the Correlation Matrix <0.50

Step 6. For those resilient modulus tests that were flagged, a graphical presentation of the data was prepared for a detailed review to confirm the test data anomaly, identify any similarities between these data sets or tests, and determine the probable cause of and recommend an action for the anomaly. If an anomaly could not be observed in the graphical presentation of the data, the $M_R$ test was de-flagged.

Previous studies have found that equation 3 is a good simulation of the measured responses from repeated-load resilient modulus tests. The authors have also found that many anomalies that can and do occur in resilient modulus tests are difficult to identify after the testing has been completed. To ensure that all possible anomalies or discrepancies in the resilient modulus data were identified, fairly restrictive criteria or threshold values were used, as noted in Step 5. These threshold values were used to ensure that the test results were initially reviewed for which equation 3 is not an extremely close mimic of the test results. Simply flagging the test data does not mean that the test results have anomalies. Some of the tests were critically reviewed and were de-flagged because no anomaly could be identified, as noted in Step 6.

Out of 1,920 $M_R$ tests, 212 were flagged using the criteria in Step 5 above. These tests (resilient modulus versus vertical stress) were plotted for the detailed review, as described in step 6. As an example, graphical presentations of the flagged and non-flagged resilient modulus test data summarized in table 3 are shown in figures 9 through 13 and explained briefly below.

- Figures 9 and 10 for test sections 014073 and 480802, respectively, were flagged (see table 3). The resilient modulus test from test section 014073 (figure 9) is characteristic of a coarse-grained soil. The $M_R$ increases with increasing confining pressure as expected. However, the incremental change in $M_R$ increases with repeated vertical stress for the lowest and highest confining pressures, while the incremental change in resilient modulus decreases with increasing repeated vertical stress for the mid-range confining pressure. This characteristic can be the result of binding (friction) in the LVDT core, which can restrict movement of the LVDTs at the lower or smaller repeated vertical loads for a specific confinement level. Figure 10, for test section 480802, shows that the $M_R$ increases with confining pressure between the lower and mid-range confinement, but significantly decreases for the highest confinement, implying a softening effect. In addition, the $M_R$ increases between the first two repeated vertical stresses applied to the test specimen, but then continues to decrease with increasing repeated vertical stresses. This characteristic can be caused by leaks developing in the membrane during the application of the series of vertical loads for the mid-range confinement. Both tests (figures 9 and 10) were identified as questionable.

- The resilient modulus test on section 352007 initially was flagged (see table 3). Figure 11 shows that the resilient modulus test from this test section is characteristic of fine-grained soils. Fine-grained soils typically soften (decreasing resilient modulus) with increasing vertical pressures. However, no anomalies were observed in the test data. Since no anomaly was observed, this test was de-flagged. The statistical parameters from the regression for the k-coefficients for this test suggest that the constitutive equation may not describe the material/soil response characteristics accurately.

- Figures 12 and 13 for test sections 390209 and 481093, respectively, were not flagged because they meet all of the above criteria. These graphs of non-flagged data are provided for comparative purposes.

After step 6 was completed, 185 $M_R$ tests were flagged for potential anomalies (about 10 percent of the tests). These flagged $M_R$ tests were divided into seven groups of anomalies that are defined in table 4. Figures 14 through 20 are graphical examples for each potential anomaly.

Table 3. Example results of the statistical analyses of the repeated-load resilient modulus tests performed on unbound pavement materials and soils from the LTPP test sections.

| STATE CODE | SHRP ID | LAYER NO. | TEST NO. | LOC NO. | SAMPLE NO. | $R^2$ | $S_E/S_Y$ | MATL CODE | N Cycles | Correlations with $M_R$ | | $M_R$ Test Initially Flagged |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | BULK STRESS | BULK STRESS | |
| 1 | 4073 | 3 | 1 | BA* | BG** | 0.8508 | 0.7095 | 308 | | 0.2039 | 0.8829 | 2 |
| 35 | 2007 | 2 | 1 | BA* | BS** | 0.9873 | 0.8197 | 309 | 15 | 0.6279 | -0.3566 | 2 |
| 39 | 0209 | 2 | 1 | B22 | BG22 | 0.9996 | 0.0676 | 303 | 15 | 0.9959 | 0.7118 | |
| 48 | 0802 | 3 | 2 | B4 | BG01 | 0.9924 | 1 | 302 | 13 | -0.4163 | 0.0445 | 2 |
| 48 | 1093 | 2 | 1 | BA* | BG** | 0.9995 | 0.0469 | 303 | 15 | 0.9985 | 0.8394 | |

* - reference to LTPP database code list
** - reference to LTPP database code list

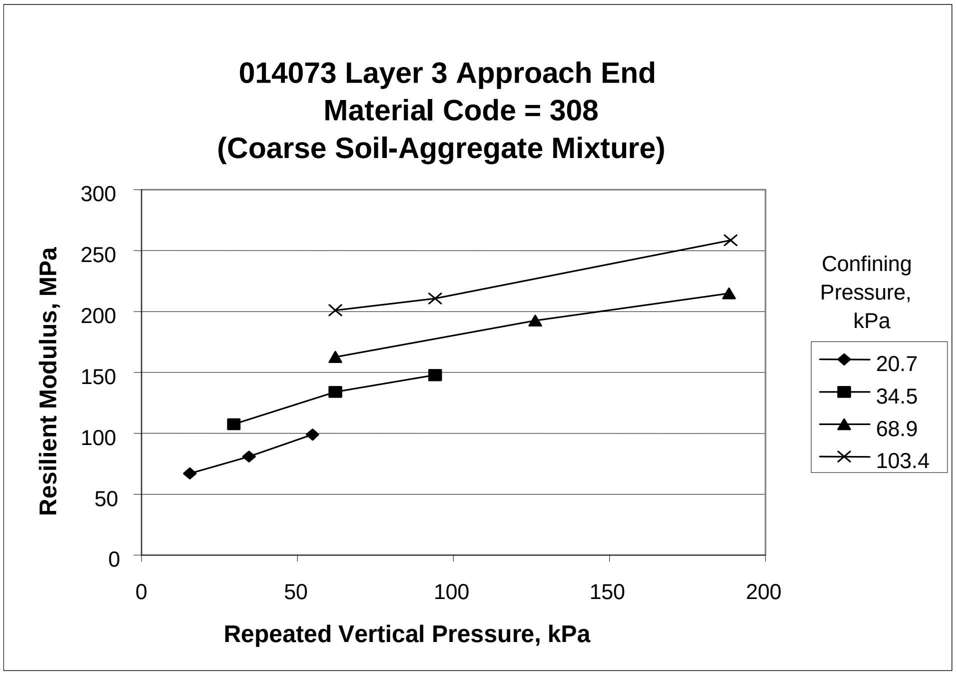



Figure 9. Repeated-load resilient modulus test results for section 014073, layer 3, at the approach end.

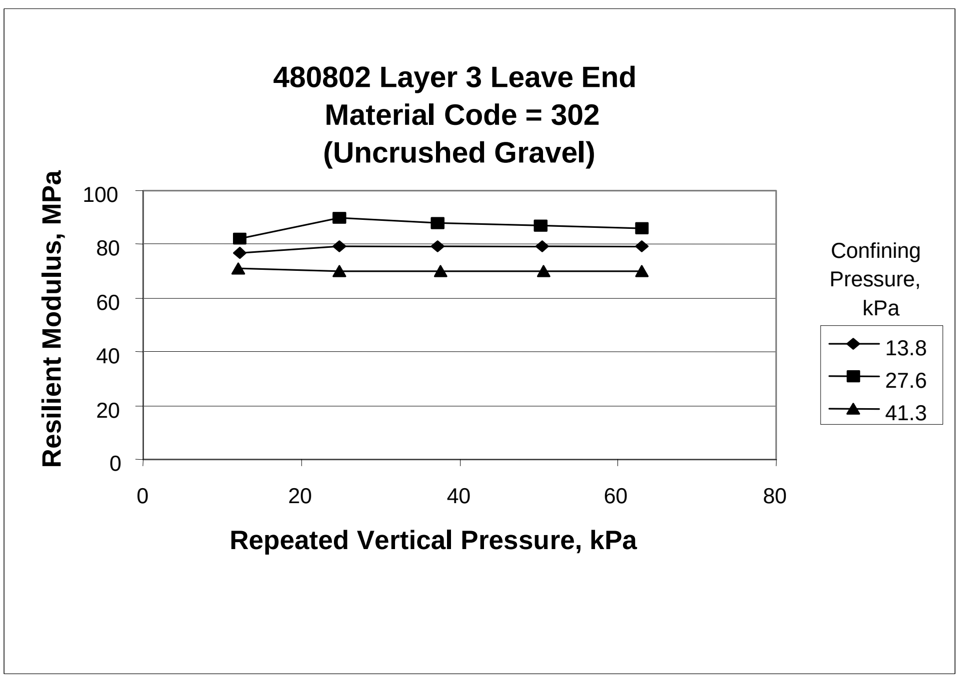



Figure 10. Repeated-load resilient modulus test results for section 480802, layer 3, at the leave end.

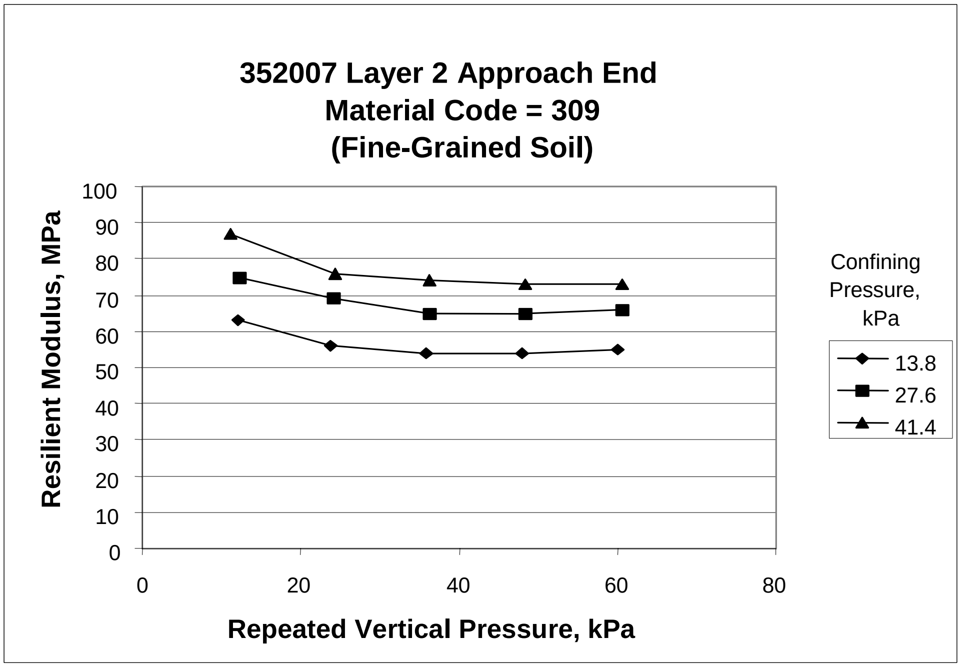



Figure 11. Repeated-load resilient modulus test results for section 352007, layer 2, at the approach end.

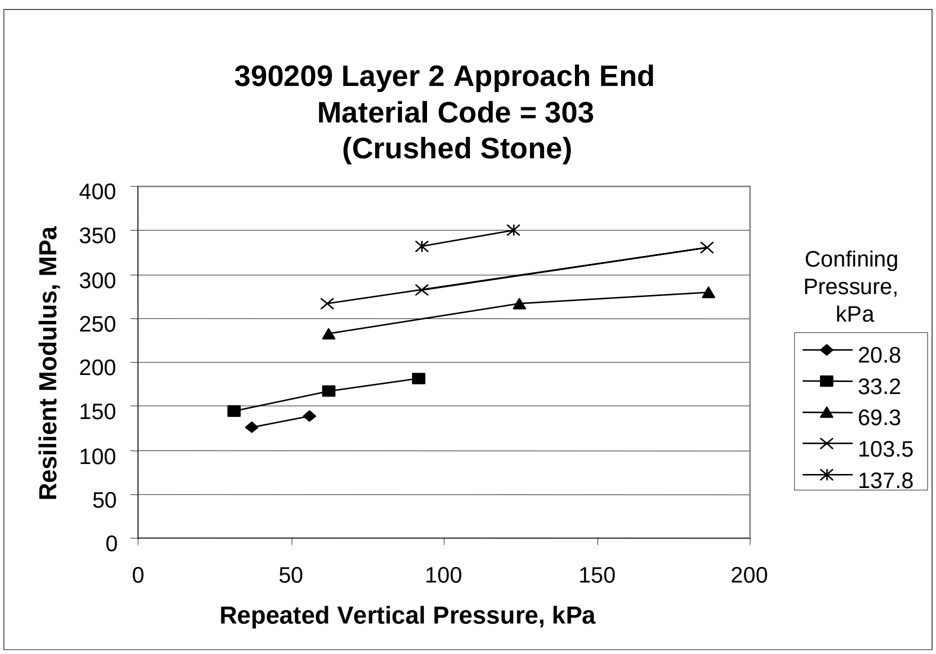



Figure 12. Repeated-load resilient modulus test results for section 390209, layer 2, at the approach end.

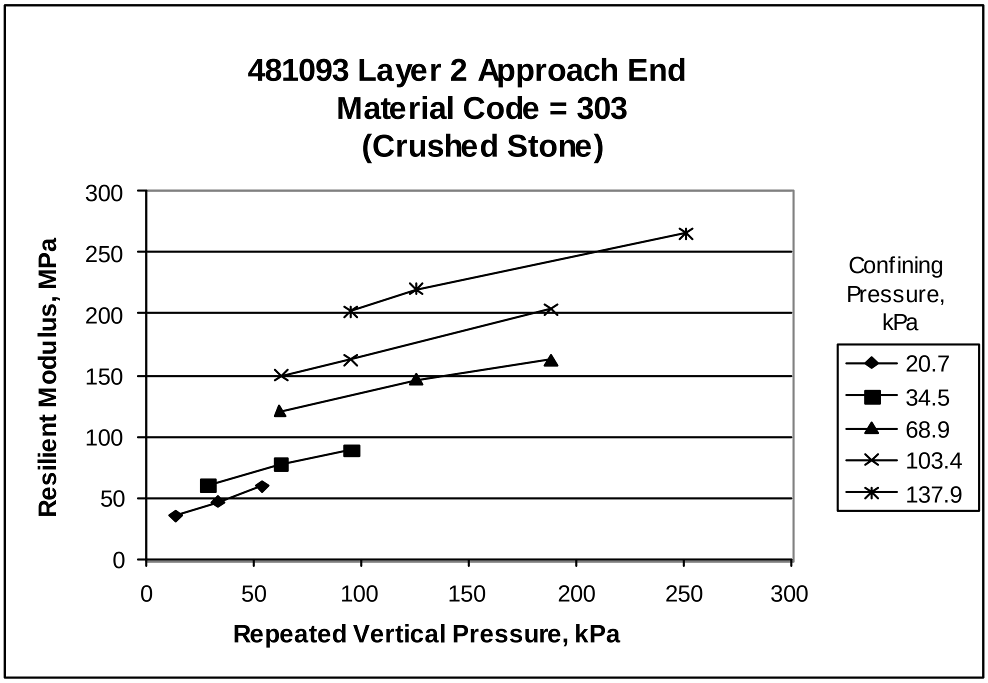



Figure 13. Repeated-load resilient modulus test results for section 481093, layer 2, at the approach end.

Table 4. Summary of identified anomaly types.

| Type of Anomaly | Definition of Anomaly | Number of $M_R$ Tests |
|---|---|---|
| Type 1 | Potential disturbance or excessive softening of test specimen at the higher repeated vertical stresses. | 17 |
| Type 2 | Big gap between confining pressure for the lower repeated loads, which reduces or begins to merge for the higher loads. | 15 |
| Type 3 | A sudden drop in $M_R$ for a specific confinement, after which the $M_R$ continues to increase with higher vertical loads. | 10 |
| Type 4 | The different confinement curves cross – one confinement has a different stress sensitivity than the other confinement curve. | 103 |
| Type 5 | The curves for each of the confining pressures are completely out of order (e.g., highest confinement below mid-confinement). | 11 |
| Type 6 | All confinements show nearly the same $M_R$ for the lower repeated vertical loads. | 20 |
| Type 7 | Possible data entry error with both the $M_R$ and vertical stress at zero. | 9 |

- *Type 1 Anomaly Example – Figure 14.* This test shows that the $M_R$ increases and then decreases with increasing repeated vertical loads for each confining pressure. These results are characteristic of specimen disturbance or excess softening at the higher repeated vertical loads. More examples of type 1 anomalies are presented in appendix B, figures 34 through 37.

- *Type 2 Anomaly Example – Figure 15.* This test shows large gaps between different confining pressures for the lower repeated loads (i.e., significant effect of confining pressure), which decreases to almost no effect of confining pressure at the higher repeated loads. In other words, the $M_R$ for the different confining pressures merge with increasing repeated vertical loads. More examples of type 2 anomalies are presented in appendix B, figures 38 through 41.

- *Type 3 Anomaly Example – Figure 16.* This test shows a sudden drop and then increase in the $M_R$ for the highest confining pressure, while the $M_R$ slightly decreases with increasing repeated vertical loads for the two lower confining pressures. This anomaly can be characteristic of re-zeroing the LVDTs in the middle of the test or an unstable LVDT clamp as the specimen deforms under load. More examples of type 3 anomalies are presented in appendix B, figures 42 through 45.

- *Type 4 Anomaly Example – Figure 17.* The change in $M_R$ with increasing repeated vertical loads do not follow the same trend or have the same stress sensitivity for the different confining pressures. In other words, one confining pressure exhibits stress-hardening characteristics, while another exhibits stress-softening characteristics. This characteristic can be the result of restrictions in LVDT movement or unstable LVDT clamps. A majority of the flagged tests fall into this category (see table 4). More examples of type 4 anomalies are presented in appendix B, figures 46 through 49.

- *Type 5 Anomaly Example – Figure 18.* The curves of resilient moduli for the different confining pressures are out of order. The highest confining pressure results in lower resilient modulus. This anomaly can be characteristic of leaks that develop in the membrane during the test. Additional examples of type 5 anomalies are presented in appendix B, figures 50 through 53.

- *Type 6 Anomaly Example – Figure 19.* All confining pressures show nearly the same resilient modulus at the lower repeated vertical loads. In other words, the resilient modulus is independent of confining pressure for the lower repeated vertical loads, but dependent on confinement for the higher loads, in direct opposition to a type 2 anomaly. Additional examples of type 6 anomalies are presented in appendix B, figures 54 through 57.

- *Type 7 Anomaly Example – Figure 20.* There appears to be a data entry error with both the resilient modulus and the vertical stress at zero. More examples of type 7 anomalies are presented in appendix B, figures 58 through 61.

All anomalous data (measured responses and computations) should be checked to confirm that the data are correct. If correct, the data should be removed, a comment should be added to the test result (i.e., "possible anomalous data"), or the material from the specific layer and location should be retested. It is suggested that the flagged samples be retested, because none of the test sections had the same layer or material flagged from both ends of the same section.

For tests where more than one anomaly type is present, the type that best describes the data anomaly was selected. Anomaly types 3, 4, and 5 are usually a result of laboratory test problems. Anomaly types 1, 2, and 6 could be representative of the inability of the selected constitutive equation to describe the soil's response characteristics. Twenty-seven flagged $M_R$ tests were de-flagged after step 6, resulting in 185 tests that were identified as having potential anomalies. This represents just over 8 percent of the $M_R$ tests for which the constitutive equation does not accurately describe the material/soil response characteristics.

Feedback reports were prepared to identify and document those tests with possible anomalies by the seven groups and the reports were submitted to FHWA. [Tables 17 through 23 in appendix C summarize the anomaly types 1 through 7, respectively, along with the anomaly's initial description for each flagged test.]

**Observation:** Almost 92 percent of the LTPP $M_R$ tests have response characteristics that are accurately simulated by the "universal" constitutive equation selected for the 2002 Design Guide.

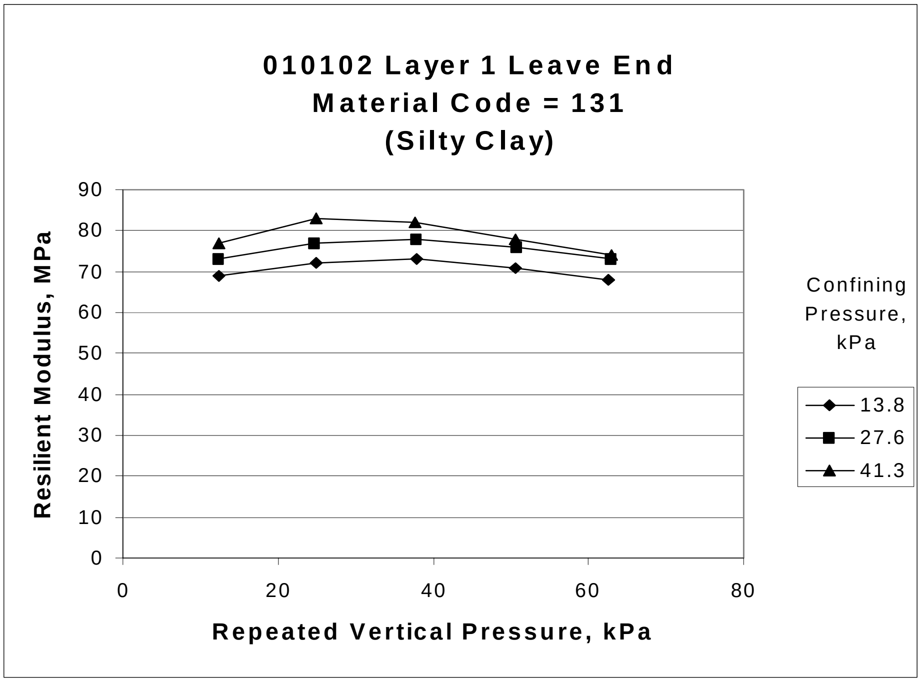



Figure 14. Sample from test section 010102, layer 1, at the leave end exhibits specimen distortion or excess softening.

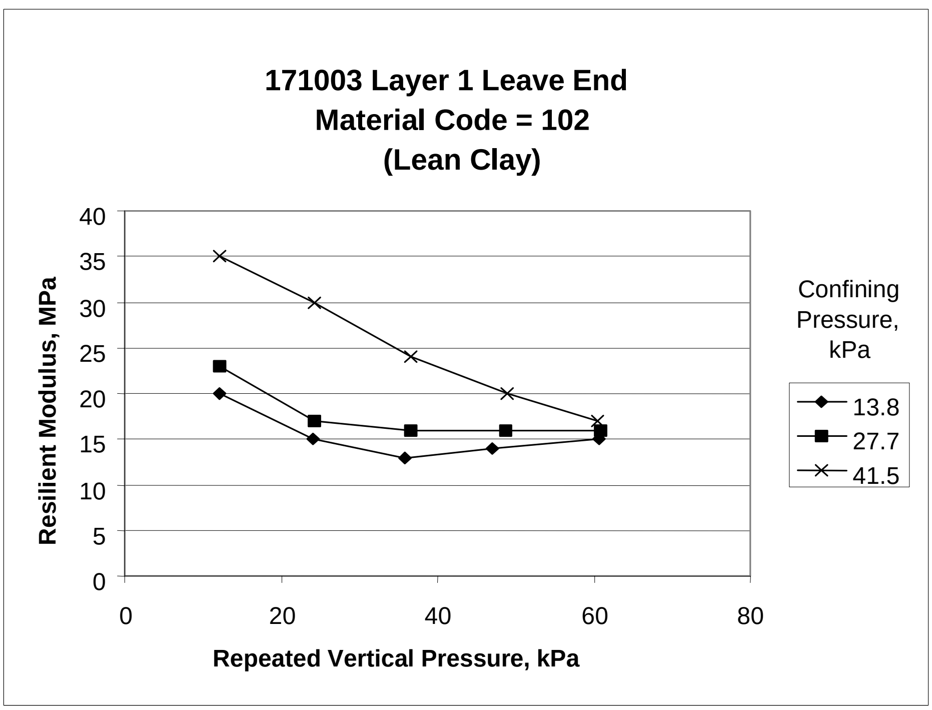



Figure 15. Sample from test section 171003, layer 1, at the leave end shows significant effect of confining pressure on resilient modulus.

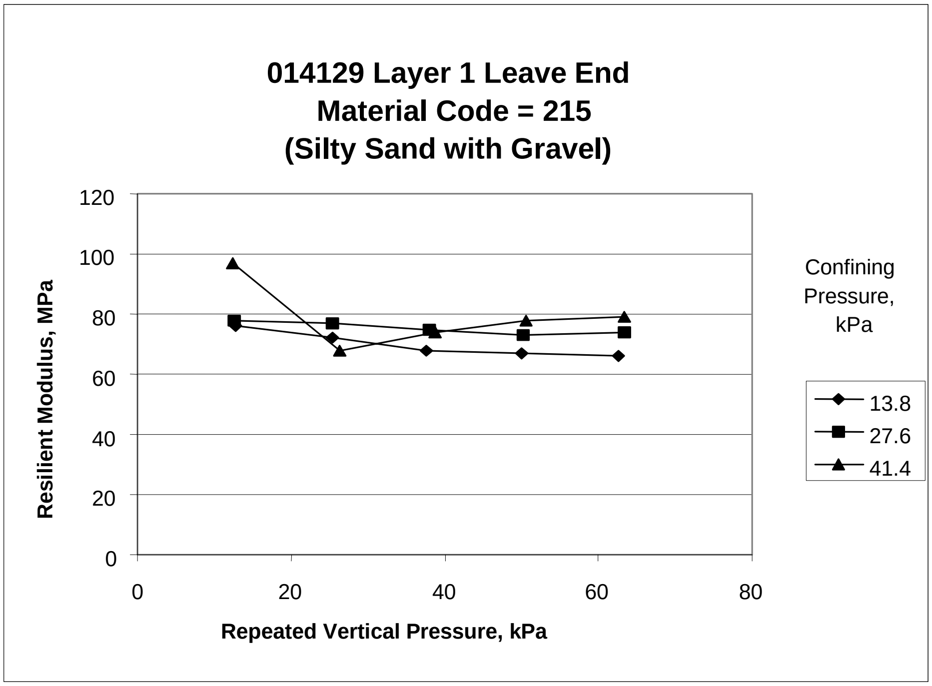



Figure 16. Sample from test section 014129, layer 1, at the leave end shows sudden drop and then increase in resilient modulus.

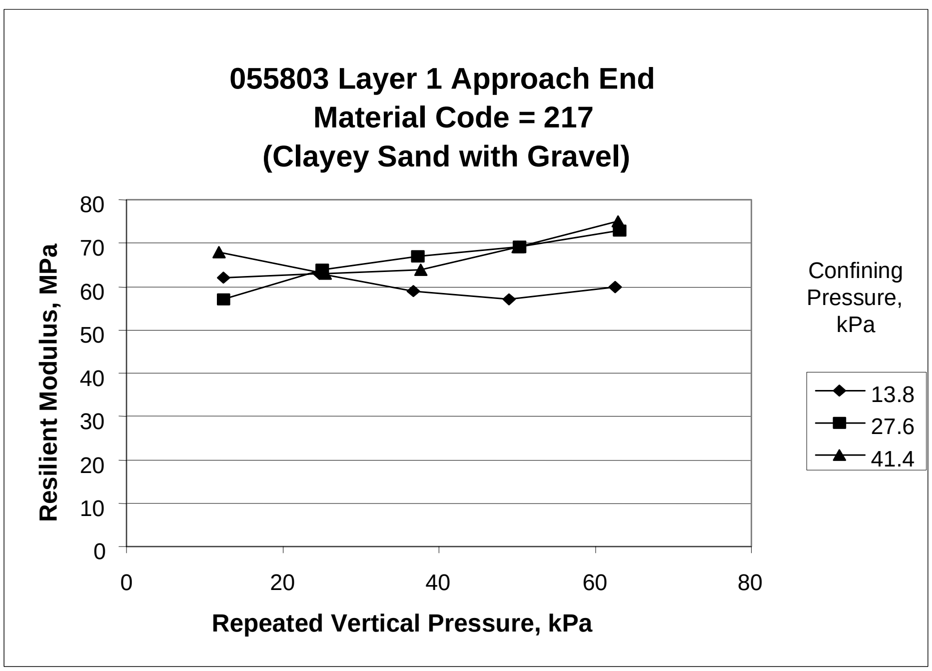



Figure 17. Sample from test section 055803, layer 1, at the approach end exhibiting localized softening or disturbance of the specimen during the test or LVDT movement.

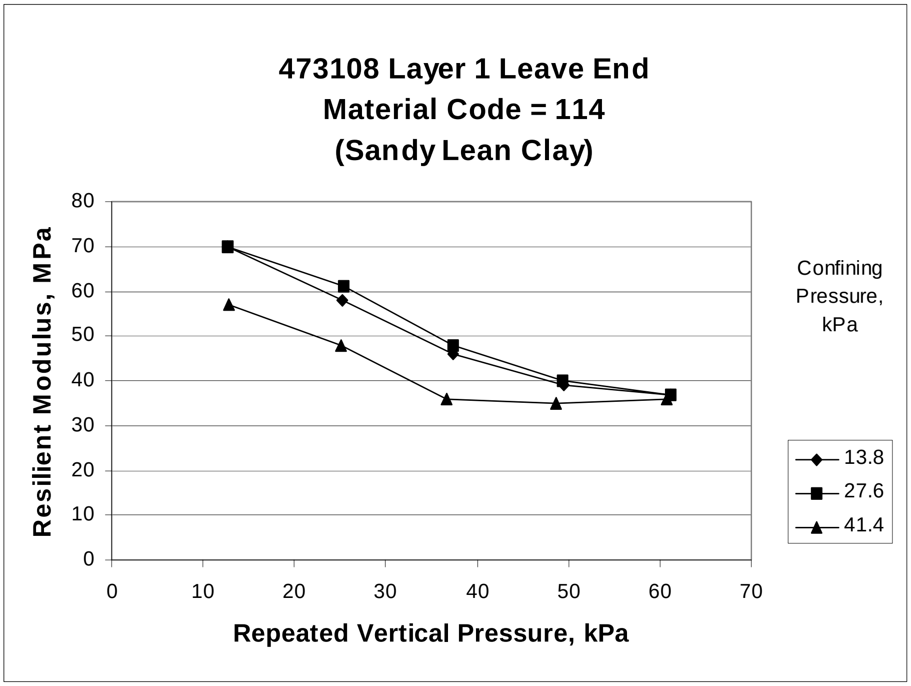



Figure 18. Sample from test section 473108, layer 1, at the leave end shows higher confining pressures result in lower resilient modulus.

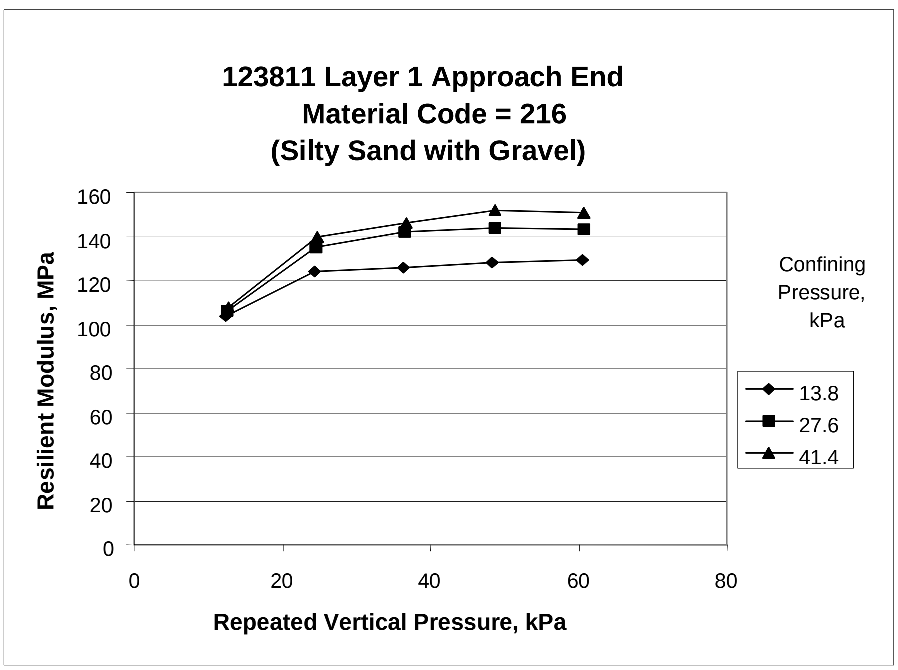



Figure 19. Sample from test section 123811, layer 1, at the approach end shows that resilient modulus is independent of confining pressure at the lowest vertical stress.

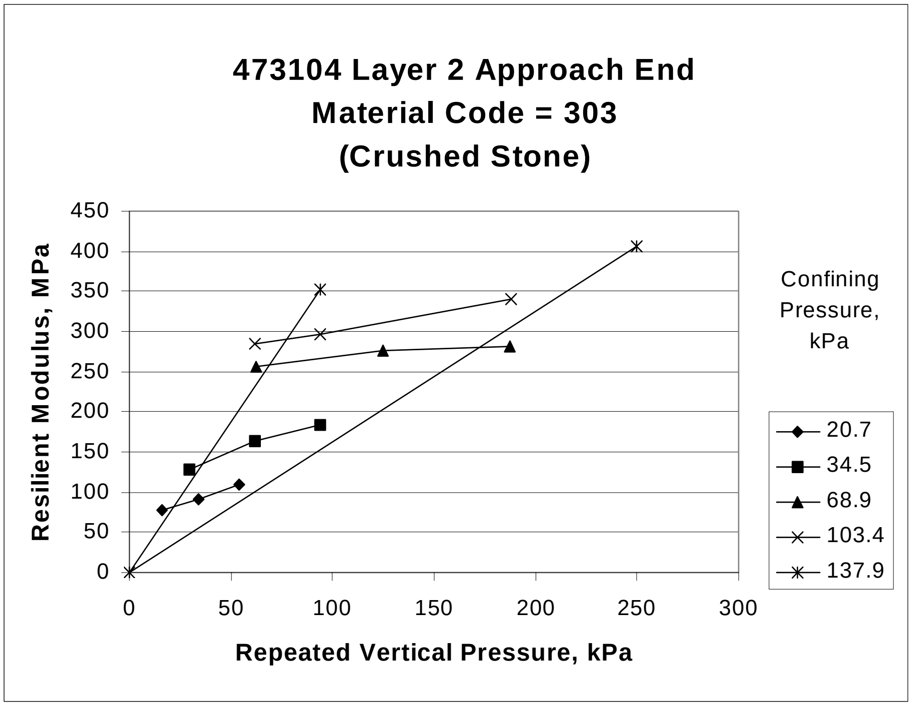



Figure 20. Sample from test section 473104, layer 2, at the approach end shows possible data entry error.

# CHAPTER 3. EFFECT OF SAMPLING TECHNIQUE ON RESILIENT MODULUS

As mentioned in chapter 1, previous studies have shown that the $M_R$ can be affected by sampling technique and errors that may occur during the testing program. Chapter 2 focused on identifying anomalies in the resilient modulus test data, while this chapter focuses on the effect of sampling technique.

The materials used for the resilient modulus tests were obtained from one of three sampling techniques: (1) pavement materials and soils sampled from the augers, (2) pavement materials and soils removed from test pits, and (3) soils extracted from Shelby tubes. The difference between auger-test pit samples and auger-Shelby tube samples was evaluated using the cleaned data set (i.e., excluding the anomalies).

There are three other factors, however, that can cause variability and possible bias in the resilient modulus test data. These factors include: (1) the use of different testing contractors and/or operators, (2) test specimen preparation technique, and (3) material variation along a project. Each of these potential sources of variation in resilient modulus test data was considered in evaluating the effect of sampling technique on resilient modulus, with the exception of testing contractor and/or operator.

## DATA GROUPS EVALUATED – SOURCES OF VARIABILITY

The laboratory test procedure used for coarse-grained soils (base/subbase materials) is different from that used for fine-grained soils. To eliminate the testing procedure effect, the base/subbase materials were evaluated separately from the subgrade soils. Typical testing errors that can occur during repeated load resilient modulus testing were assumed to be random within a specific material/soil group. Random errors should have no bias on the effect of sampling technique on the resilient modulus test results.

In coarse-grained materials, the sampling technique used can change the gradation of the material. The base/subbase materials were grouped by material codes as defined using LTPP terminology. For each base/subbase group, resilient modulus test results for the auger samples were compared to the test pit samples for each site. The auger versus test pit samples analysis was repeated for the subgrade soils since coarse-grained soils also are present in the subgrade. The resilient modulus for both data groups (test pit and auger samples) was measured on test specimens recompacted to the moisture content and density of the in-place materials. Differences caused by the compaction process or moisture content and density differences between the in-place material and test specimens were assumed to be random within a specific materials/soil group.

The subgrade soils were grouped by soil type (i.e., clay, gravel, sand, and silt). The difference between auger and Shelby tube samples was evaluated because the undisturbed samples in thin-walled Shelby tubes were retained for nearly 2 years prior to removal and testing for some of the test sections. As noted above, moisture content and density differences exist between the undisturbed (Shelby tube sample) test specimens and those recompacted in the laboratory (augured or test pit samples). However, these differences were assumed to be random within each soil group and have no bias on the effect of sampling technique on the resilient modulus test results.

Materials and soils recovered from the test pits were always taken from the leave end of the test section, while the augured materials and soils were taken from the approach end. Although this represents a systematic difference due to sample location, there is no reason these materials and soils would be consistently different between the ends of the test section. The location of the GPS test sections was selected at random along a project. The differences between the ends of a test section due to sample location were assumed to be random.

Table 5 lists the data groups evaluated for both the base/subbase materials and subgrade soils. The test results that were compared included the $M_R$ at specific stress states and the regressed k-coefficients of the constitutive equation (equation 3). The first comparison was completed on the $M_R$ measured at each stress state. This comparison was then followed by a comparison of the regressed k-values from equation 3. Comparisons of the k-values were completed to determine if there is an effect due to sampling differences on a specific part of the constitutive equation that is not detected by the individual $M_R$.

Table 5. Data groups for the base/subbase and subgrade soils.

| Pavement Layer Type | Material Code/Type* | Number of Tests by Sampling Technique | | | Total Number of Tests |
|---|---|---|---|---|---|
| | | Auger | Test Pit | Shelby Tube | |
| Base/Subbase | All | 405 | 212 | NA | 617 |
| | 302, Uncrushed Gravel | 48 | 33 | NA | 81 |
| | 303, Crushed Stone | 63 | 46 | NA | 109 |
| | 304, Crushed Gravel | 32 | 17 | NA | 49 |
| | 306, Sand | 47 | 19 | NA | 66 |
| | 307, Fine-Grained Soil-Aggregate Mixture | 22 | 10 | NA | 32 |
| | 308, Coarse-Grained Soil-Aggregate Mixture | 127 | 60 | NA | 187 |
| | 309, Fine-Grained Soil | 65 | 27 | NA | 92 |
| Subgrade Soil | All | 476 | 319 | 456 | 1,251 |
| | Gravel | 78 | 32 | 12 | 122 |
| | Sand | 223 | 150 | 136 | 509 |
| | Silt | 42 | 34 | 32 | 108 |
| | Clay | 133 | 103 | 276 | 512 |
| Total Number of Tests | | 881 | 531 | 456 | 1,868 |

Those material codes not listed above had too few $M_R$ tests to be included in the test of significance for the effect of sampling technique.
NA – Not applicable

## IDENTIFICATION OF OUTLIERS

The student t-test was used to test any difference in the k-coefficients of samples obtained by different techniques. The student t-test assumes that the data have a normal distribution. Therefore, each data group listed in table 5 was checked initially for normality using the Shapiro-Wilk W Test.[(5)] The data for some of the groups were not distributed normally. These data then were checked for outliers using the Mahalanobis outlier distance plot. The identified outliers were removed before the student t-test was performed. For those data sets that were not distributed normally even after removing the outliers, the Welch analysis of variance (ANOVA) test was used to determine if the different data groups were from the same population of data.

## COMPARISON OF RESILIENT MODULUS TEST RESULTS

### Effect of Stress State

An ANOVA was completed on the $M_R$ measured at the different stress states included in the test procedure to determine if sampling technique has an effect on the test results. The data were first checked for outliers and normality, as noted above. A model of one variable (sampling technique) was used in the ANOVA. The one variable has two choices or discrete values related to sampling the materials – test pits or augers and augers or Shelby tubes.

Results from the one-way ANOVA are summarized in table 6. Table 6 identifies those materials and soils for which the $M_R$ ratio was found to be independent or dependent on stress state. The $M_R$ ratio is defined in table 6. The $M_R$ ratio was found to be independent of stress state for most base/subbase materials and all soils. For the materials and soils for which the $M_R$ ratio is independent of stress state, the $M_R$ ratios determined at each stress state can be combined in the analysis to determine if sampling technique has a significant effect on the test results. Material codes 306 (sand) and 308 (coarse-grained soil-aggregate mixture) were the only materials and soils for which the $M_R$ ratio was dependent on stress state.

Table 6. Results of ANOVA to determine if the resilient modulus ratio (auger versus test pit test specimens) is a function of stress.

| Material/Soil Type | | ANOVA, Prob.>*F* | $M_R$ Ratio is a Function of Stress(1) |
|---|---|---|---|
| Base/Subbase Materials | All | 0.0238 | Yes – Vertical Loads |
| | 302, Uncrushed Gravel | 0.3769 | No |
| | 303, Crushed Stone | 0.2874 | No |
| | 304, Crushed Gravel | 0.4809 | No |
| | 306, Sand | 0.0123 | Yes – Confinement |
| | 307, Fine-Grained Soil-Aggregate Mixture | 0.9112 | No |
| | 308, Coarse-Grained Soil-Aggregate Mixture | 0.0022 | Yes – Vertical Loads |
| | 309, Fine-Grained Soil | 0.1057 | No |
| Subgrade Soils | All | 0.1598 | No |
| | Gravel | 0.4932 | No |
| | Sand | 0.6691 | No |
| | Silt | 0.8497 | No |
| | Clay | 0.3552 | No |

(1) $M_R$ Ratio = Resilient modulus of test specimens prepared from materials recovered from auger samples divided by the resilient modulus of test specimens prepared from materials recovered from test pits; $M_R$(Auger)/$M_R$(Test Pit).

**Unbound Aggregate Layers – Test Pit Versus Auger Samples**

The samples for the base/subbase resilient modulus test were either obtained from the augering process or from cutting a test pit and removing bulk samples of the material. The augering process can degrade the larger diameter aggregates. Therefore, the resilient modulus test results for the augured samples were compared to the test results for the test pit samples.

The data were first checked for outliers and normality, as noted above. Assuming that the sample variance is equal to the population variance, a student t-test was then performed with a 95-percent confidence level using the following null and alternative hypotheses in comparing the two data sets:

$$H_o: \quad \frac{k_a}{k_{tp}} = 1 \qquad \text{or} \qquad \frac{M_{Ra}}{M_{Rtp}} = 1$$

$$H_A: \quad \frac{k_a}{k_{tp}} \neq 1 \qquad \text{or} \qquad \frac{M_{Ra}}{M_{Rtp}} \neq 1$$

Table 7 provides a summary of the results from the ANOVA to determine if the sampling technique auger versus test pits has an effect on resilient modulus. In summary, sampling technique does appear to have a significant effect on the resilient modulus ratio for uncrushed gravel, crushed stone, fine-grained soil-aggregate mixture, and fine-grained soil base material groups. The crushed gravel base material is considered borderline as to the effect of sampling technique on the resilient modulus because the probability value is slightly greater than 0.05 (refer to table 7). Sand and coarse-grained soil-aggregate base materials are the only data groups for which the sampling technique of the base materials appears to have no effect on the $M_R$ ratio.

Table 8 summarizes the probability from the student t-test that the k-coefficients and exponents for the auger and test pit samples are equal. With a 95-percent confidence level, a probability value less than 0.05 rejects the null hypothesis. The shaded cells show the data groups that are indifferent.

No difference was observed when all the base/subbase materials were tested together. However, when the materials are grouped by material codes, $k_{1a}$ and $k_{1tp}$ were different from each other for the uncrushed gravel. For the crushed stone material, both $k_1$ and $k_3$ were found to be different between augured and test pit samples. Although not all the k-coefficients for the uncrushed gravel and the crushed stone were different, it is reasonable to conclude that the sampling technique has an effect on the $M_R$ test results since $k_1$ is directly proportional to $M_R$.

Table 9 provides a summary of the results from the different analyses for comparing the differences between two populations of data that are defined by different sampling techniques using the k-values and resilient modulus. As tabulated, the results are similar for the base and subbase materials, except for the soil-aggregate mixtures.

Table 7. Summary of ANOVA to determine effect of sampling technique (auger versus test pit) on resilient modulus.

| Material/Soil Type | | Stress State[1] | Median $M_R$ Ratio | Mean $M_R$ Ratio | Standard Deviation | ANOVA, Prob.>[t] | Null Hypothesis, $M_R$ Ratio = 1[2] |
|---|---|---|---|---|---|---|---|
| Base/ Subbase Materials | All | Low | 0.9706 | 0.9763 | 0.1875 | 0.2022 | Accept |
| | | Medium | 1.0000 | 1.0092 | 0.1264 | 0.4308 | Accept |
| | | High | 1.0000 | 1.0111 | 0.1183 | 0.3146 | Accept |
| | 302, Uncrushed Gravel | All Values | 1.0253 | 1.0438 | 0.1712 | <0.0001 | REJECT |
| | 303, Crushed Stone | All Values | 0.9527 | 0.9391 | 0.1621 | <0.0001 | REJECT |
| | 304, Crushed Gravel | All Values | 1.0444 | 1.0323 | 0.1841 | 0.0670 | Accept |
| | 306, Sand | Low | 0.9706 | 1.0540 | 0.1882 | 0.4143 | Accept |
| | | Medium | 1.0000 | 0.9971 | 0.0539 | 0.8759 | Accept |
| | | High | 0.9563 | 0.9735 | 0.0664 | 0.2652 | Accept |
| | 307, Fine-Grained Soil-Aggregate Mixture | All Values | 1.0041 | 1.0494 | 0.1660 | 0.0145 | REJECT |
| | 308, Coarse-Grained Soil-Aggregate Mixture | Low | 0.9592 | 0.9321 | 0.2097 | 0.0720 | Accept |
| | | Medium | 1.0000 | 1.0124 | 0.1307 | 0.5631 | Accept |
| | | High | 1.0327 | 1.0253 | 0.1666 | 0.3303 | Accept |
| | 309, Fine-Grained Soil | All Values | 1.0092 | 1.0331 | 0.1264 | <0.0001 | REJECT |
| Subgrade Soils | All | All Values | 1.0476 | 1.0600 | 0.2810 | <0.0001 | REJECT |
| | Gravel | All Values | 1.2226 | 1.2437 | 0.2690 | <0.0001 | REJECT |
| | Sand | All Values | 1.0099 | 0.9990 | 0.2016 | 0.8980 | Accept |
| | Silt | All Values | 1.1061 | 1.0886 | 0.3112 | 0.0010 | REJECT |
| | Clay | All Values | 1.2803 | 1.1606 | 0.3283 | <0.0001 | REJECT |

(1) Low: Confinement = 20.7 kPa, Cyclic Load = 18.6 kPa; Medium: Confinement = 68.9 kPa, Cyclic Load = 124.1 kPa; High: Confinement = 137.9 kPa, Cyclic Load = 248.2 kPa.
(2) Null Hypothesis: $M_R$(Auger)/$M_R$(Test Pit) = 1.

Table 8. Summary of the student t-test on the difference between augered and test pit samples for the base/subbase materials and subgrade soils.

| Material/Soil Type | | Student t-Test Probability (Prob > \|t\|) | | |
|---|---|---|---|---|
| | | $k_1$ | $k_2$ | $k_3$ |
| Base/Subbase Materials | All | 0.2378 | 0.5846 | 0.5070 |
| | 302, Uncrushed Gravel | 0.0260 | 0.0850 | 0.3919 |
| | 303, Crushed Stone | 0.0350 | 0.1868 | 0.0025 |
| | 304, Crushed Gravel | 0.5228 | 0.7903 | 0.5193 |
| | 306, Sand | 0.3149 | 0.1512 | 0.7767* |
| | 307, Fine-Grained Soil-Aggregate Mixture | 0.4134 | 0.3213 | 0.8316 |
| | 308, Coarse-Grained Soil-Aggregate Mixture | 0.3731 | 0.4863 | 0.0192* |
| | 309, Fine-Grained Soil | 0.3931 | 0.6256 | 0.4354 |
| Subgrade Soils | All | 0.0328 | 0.0013 | 0.6553 |
| | Gravel | 0.0710 | 0.9120 | 0.0169 |
| | Sand | 0.8287 | 0.0050 | 0.3052 |
| | Silt | 0.1059 | 0.1569 | 0.2512 |
| | Clay | 0.1153 | 0.1594 | 0.9407 |

*Student t-test not valid because sample population not normally distributed.

Table 9. Comparison of results using k-values and resilient modulus values to determine effect of sampling technique (auger versus test pits) on resilient modulus test data.

| Material/Soil Type | | k-Values; Hypothesis, $k_a/k_{tp} = 1$ | | | $M_R$ Values; Hypothesis, $M_{Ra}/M_{Rtp} = 1$ |
|---|---|---|---|---|---|
| | | $k_1$ | $k_2$ | $k_3$ | |
| Base/Subbase Materials | All | Accept | Accept | Accept | Accept |
| | 302 | REJECT | Accept | Accept | REJECT |
| | 303 | REJECT | Accept | REJECT | REJECT |
| | 304 | Accept | Accept | Accept | Accept |
| | 306 | Accept | Accept | Accept | Accept |
| | 307 | Accept | Accept | Accept | REJECT |
| | 308 | Accept | Accept | REJECT | Accept |
| | 309 | Accept | Accept | Accept | REJECT |
| Subgrade Soil | All | REJECT | REJECT | Accept | REJECT |
| | Gravel | Accept | Accept | REJECT | REJECT |
| | Sand | Accept | REJECT | Accept | Accept |
| | Silt | Accept | Accept | Accept | REJECT |
| | Clay | Accept | Accept | Accept | REJECT |

**Observation:** Sampling technique of base materials (auger versus test pit samples) has an effect on the $M_R$ test results for the uncrushed gravels and crushed stone materials.

**Soils – Test Pit Versus Auger Samples**

Table 7 summarizes the difference between the resilient modulus measured on test specimens prepared from soils recovered from test pit samples and those from augured samples. As tabulated, the resilient modulus values are different for all subgrade soil groups with the exception of sand. This observation is consistent with previous experience.

The difference between the k-coefficients regressed from $M_R$ tests performed on test specimens compacted from auger and test pit samples was evaluated for the subgrade soils. Table 8 summarizes the findings of the analysis and comparisons. The shaded cells show the data groups that are the same, i.e., student t-test probability greater than 0.05.

Differences were observed for $k_1$ and $k_2$ of the overall subgrade data group, $k_3$ of the gravel group, and $k_2$ of the sand group. Note that some differences in the exponents were found for the coarse-grained soils, but no differences were found for the fine-grained soils. This observation is consistent with the base/subbase materials, with the exception of the crushed gravels (material code 304) and sands (material code 306).

Based on the results summarized in table 9, the sampling effect on the $M_R$ ratio is dependent on the type of analysis. Since only one k-coefficient was found to be different for the gravel and sand soil groups, the effect of sampling technique (auger versus test pit) is believed to be small. However, comparison of the $M_R$ ratio suggests that there is a difference caused by sampling technique for all soils, but sand.

**Soils – Shelby Tubes (Undisturbed) Versus Recompacted (Disturbed) Samples**

The undisturbed samples recovered from thin-walled Shelby tubes were retained in the tubes in some cases for nearly 2 years prior to removal and testing. The effect of storage time in the Shelby tubes on resilient modulus is unknown. However, the $M_R$ of some high-plasticity clays is known to be sensitive to sample preparation (disturbed versus undisturbed test specimens). Therefore, the $M_R$ test results in the LTPP database were evaluated to determine if there are significant differences in the regressed k-coefficients between the Shelby tubes (undisturbed) and recompacted (disturbed) samples. The effect of time retained in the Shelby tubes was not studied because there were too few $M_R$ tests within each of the subgroups at different times.

For each of the data groups listed in table 5, the data were first tested for outliers, normality, and equal sample variances. Student t-tests were then performed with a 95-percent confidence level and the following null and alternative hypotheses:

$H_o$: $k_a = k_{ST}$ or $M_{Ra} = M_{RST}$

$H_A$: $k_a \neq k_{ST}$ or $M_{Ra} \neq M_{RST}$

Table 10 summarizes the effects of sampling technique on the measured resilient modulus between undisturbed and disturbed subgrade soil samples. As shown, the resilient modulus is affected by sampling technique for all soil groups, with the exception of sand. This finding is consistent with the previous experience of the authors.

Table 10. Summary of ANOVA to determine effect of sampling technique (Shelby tube versus auger) on resilient modulus.

| Soil Type | Variances | | Welch ANOVA Testing of Means With Unequal Variances, Prob.>*F* | ANOVA Testing of Means With Equal Variances, Prob.>*F* or Prob.>[t] | Absolute Difference — LSD | Null Hypothesis; $M_R$(Shelby Tube), Undisturbed = $M_R$(Auger), Disturbed |
|---|---|---|---|---|---|---|
| | Prob.>*F* | Equal Variances? | | | | |
| All | <0.0001 | No | <0.0001 | --- | 6.034 | REJECT |
| Gravel | 0.0045 | No | <0.0001 | --- | 11.653 | REJECT |
| Sand | <0.0001 | No | 0.2725 | --- | -0.514 | Accept |
| Silt | 0.5582 | Yes | --- | <0.0001 | 9.964 | REJECT |
| Clay | 0.9484 | Yes | --- | <0.0001 | 10.582 | REJECT |

Table 11 summarizes the probability from the student t-test that the k-coefficient and exponents for the undisturbed and disturbed samples are equal. With a 95-percent confidence level, a probability value less than 0.05 rejects the null hypothesis. The shaded cells show the data groups that are indifferent. Five of the data groups failed the equal variance test. For these five groups, the Welch ANOVA test was used instead, as noted above.

Table 11. Summary of the student t-test on the difference between disturbed and undisturbed samples for the subgrade soils.

| Material Type | Student t-Test Probability (Prob > \|t\|) | | |
|---|---|---|---|
| | $k_1$ | $k_2$ | $k_3$ |
| All | 0.7475 | <0.0001* | <0.0001* |
| Clay | 0.0314 | 0.8948* | 0.0002 |
| Gravel | 0.5080 | 0.2379 | 0.0001 |
| Sand | 0.8865 | 0.0122 | 0.7961* |
| Silt | 0.9978* | 0.1687 | <0.0001 |

* Welch ANOVA testing equal means, allowing unequal variance.

The shaded cells show the data groups that are the same within a 95-percent confidence level (student t-test probability greater than 0.05). As shown, at least one of the k-coefficients for all groups tested was different. The coefficients from the undisturbed (Shelby tube) and disturbed (auger and test pit) data sets were found to be different for $k_1$ of the clay soils, $k_2$ of the overall and sand soil groups, and $k_3$ of all soil groups, except for sand. Separating the subgrade into soil types reduced the sampling effect except for the clay soils. It is recommended that the $M_R$ results for the clay soils be considered different between the disturbed and undisturbed test specimens. Since only one k-coefficient was different for the other soil types, any sampling effect is considered small for these soil types, especially since $k_3$ was zero for several $M_R$ tests.

**Observation:** Sampling technique of subgrade soils (undisturbed versus disturbed test specimens) has an effect on the $M_R$ test results for the clay soils.
**Observation:** Sampling technique of base and subgrade soils has no effect on the $M_R$ test results for sand base materials and soils.

Table 12 summarizes the results from the different analyses for comparing the differences between two populations of resilient modulus data that are defined by different sampling techniques using the k-values and resilient modulus. As shown, the results are similar for the subgrade soils.

Table 12. Comparison of results using k-values and resilient modulus values to determine the effect of sampling technique of undisturbed (Shelby tubes) and disturbed (auger) test specimens on resilient modulus test data.

| Soil Type | k-Value; Hypothesis, $k_a = k_{st}$ | | | $M_R$ Values; Hypothesis, $M_{Ra} = M_{Rst}$ |
|---|---|---|---|---|
| | $k_1$ | $k_2$ | $k_3$ | |
| All | Accept | REJECT | REJECT | REJECT |
| Gravel | Accept | Accept | REJECT | REJECT |
| Sand | Accept | REJECT | Accept | Accept |
| Silt | Accept | Accept | REJECT | REJECT |
| Clay | REJECT | Accept | REJECT | REJECT |

## SUMMARY

The data groups listed in table 5 were analyzed for the effects of sampling techniques. All materials were tested for differences between auger and test pit samples. The subgrade soils were also tested for differences between disturbed (auger and test pits) and undisturbed (Shelby tube) samples.

Tables 9 and 12 summarize the results from the different analyses for comparing the differences between two populations of resilient modulus data that are defined by different sampling techniques using the k-values and resilient modulus values. Table 9 shows that the auger and test pit samples are different for some of the material groups. The difference was considered significant for the uncrushed gravel, crushed stone, and the overall subgrade data group. However, the difference was insignificant when the soils were divided into the four major soil types (i.e., clay, gravel, sand, and silt). Table 12 shows that the disturbed and undisturbed test specimens are different for the overall subgrade and clay data groups. The difference is only considered significant for the clay soils when the subgrade is divided into the four soil types.

It is interesting to note that the null hypothesis from the ANOVA was rejected when the resilient modulus ratio was found to be independent of the stress states and was accepted for those materials when the resilient modulus ratio was dependent on stress state in all cases, with the exception of base material code 304 (crushed gravel) and sand subgrades (refer to tables 6 and 7). Another interesting observation is that the coarse-grained soils were found to have equal variances between the resilient modulus values measured on undisturbed (Shelby tubes) test specimens and disturbed (auger) test specimens. The significance of these observations is unknown.

Table 13 provides an overall summary comparison of the different statistical methodologies used. Most of the results from these comparisons are consistent with previous experience. The following summarizes the recommendations for further data analyses for each material and soil type:

- All sand base materials can be combined into one group, independent of sampling technique. In addition, all sand subgrades can also be combined into a single group for analysis purposes.

- The resilient modulus of the crushed stone and uncrushed gravel base materials are dependent on the type of sampling technique used to recover samples for testing. These data groups should be kept separate for further data analyses.

- The resilient modulus of the clay soils is dependent on whether the sample is undisturbed (recovered by Shelby tubes) or disturbed (sampled from augers or recovered from test pits and recompacted). These data groups should be kept separate for further data analyses.

- The effect of sampling technique on the remaining data groups is dependent on the type of analysis used. Thus, it is suggested that the different data groups be combined for simplicity, but caution be taken in analyzing and using these data.

These observations are considered important regarding the future use of the repeated load resilient modulus test data in the LTPP database to accomplish the objectives stated in the introduction chapter to this report and some of the overall LTPP objectives. For example, any differences caused by sampling technique must be clearly defined to determine the relationship between laboratory-measured resilient modulus and backcalculated elastic layer modulus.

Table 13. Summary comparison of the resilient modulus test results for different sampling techniques.

<table>
<tr><th colspan="2">Sampling Technique</th><th>Consistently Different Results or Different Populations of Data</th><th>Borderline – Dependent on Type of Data Used</th><th>Consistently Indifferent Results or Populations of Data are the Same</th></tr>
<tr><td rowspan="7">Auger Versus Test Pit</td><td rowspan="4">Base and Subbase</td><td rowspan="3">302, Uncrushed gravel</td><td rowspan="3">307, Fine-grained soil-aggregate mixture</td><td>304, Crushed gravel</td></tr>
<tr><td>306, Sand</td></tr>
<tr><td rowspan="2">308, Coarse-grained soil-aggregate mixture</td></tr>
<tr><td>303, Crushed stone</td><td>309, Fine-grained soil</td></tr>
<tr><td rowspan="3">Subgrade Soils</td><td rowspan="3">None</td><td>Gravel</td><td rowspan="3">Sand</td></tr>
<tr><td>Silt</td></tr>
<tr><td>Clay</td></tr>
<tr><td rowspan="2">Undisturbed (Shelby Tubes) Versus Disturbed (Auger)</td><td rowspan="2">Subgrade Soil</td><td rowspan="2">Clay</td><td>Gravel</td><td rowspan="2">Sand</td></tr>
<tr><td>Silt</td></tr>
</table>

# CHAPTER 4. EFFECT OF PHYSICAL PROPERTIES ON RESILIENT MODULUS

As stated in chapter 1, the $M_R$ is the material property required for all unbound materials and soils for the 1986 and 1993 AASHTO Design Guide.[1] In 1995, Darter, et al., found that about 75 percent of the State Highway Agencies (SHAs) in the United States use either the 1986 or 1993 versions of the AASHTO Design Guide.[6] However, most of these agencies do not routinely measure the $M_R$ in the laboratory. The design $M_R$ is estimated from experience or from other material or soil properties (for example, CBR, R-value, or physical properties).

A potential benefit of estimating the $M_R$ from physical properties is that seasonal variations in resilient modulus can be estimated from seasonal changes in the materials' physical properties. Seasonal variations are critical for determining the design $M_R$ for a particular project. The concept being used in development of the 2002 Design Guide under NCHRP Project 1-37A is to apply the Enhanced Integrated Climatic Model (EICM) to predict changes in the physical properties of unbound pavement materials and soils and to estimate the effect those changes have on the resilient modulus.

Some SHAs have developed relationships between the physical and/or strength properties of the soil and $M_R$. Determining the $M_R$ from physical properties of unbound materials can capture the effect of the seasonal variations of the $M_R$ as a result of seasonal changes in the material's physical properties, but it does not capture the effect of stress sensitivity. To capture the effects of stress sensitivity, the coefficients of the selected constitutive equation have been regressed for relationships to the soils physical properties. Von Quintus and Killingsworth and Santha, among others, have developed these types of relationships for use in design to capture the effect of stress sensitivity in determining the design $M_R$.[3,7]

Previous studies have developed relationships between the soil properties and the regressed k-coefficients and exponents of the constitutive model. Those relationships that have good statistics were generally confined to specific soil types.[7] Other studies that have used a wide range of soil types and conditions have generally resulted in poor correlations.[3] The focus of this chapter is to use the cleaned database and determine those physical properties that have an effect on the $M_R$ test results and to determine the accuracy of developing relationships between physical properties and $M_R$ with the LTPP database.

## PHYSICAL PROPERTIES USED IN STUDY

The anomalies identified in chapter 2 were removed from the data set based on the April and October 2000 data releases that were used in a nonlinear optimization regression analysis relating the physical properties of the test specimen to the $M_R$ from the constitutive equation. The classification data (including gradation, Atterberg limits, density, moisture, optimum density, moisture contents, and other physical properties) were extracted from the LTPP database of unbound materials. For most LTPP test sections, the strength (e.g., CBR and R-value) of a material or soil is unavailable in the database. Table 14 summarizes all the variables used in the regression analysis and the IMS tables from which the data were extracted. The range, mean, and median values for each of these variables are included in appendix D for the base and subbase materials and subgrade soils.

Table 14. Summary of the $M_R$ physical property regression variables.

| Variable | Description | Table(s) From the IMS |
|---|---|---|
| $k_1$ (MPa) | Regression constant of $M_R$ constitutive equation | -- |
| $k_2$ | Regression constant of $M_R$ constitutive equation | -- |
| $k_3$ | Regression constant of $M_R$ constitutive equation | -- |
| $P_{3/8''}$, % | Percentage passing 3/8" sieve | TST_SS01_UG01_UG02 |
| $P_{No. 4}$, % | Percentage passing No. 4 sieve | TST_SS01_UG01_UG02 |
| $P_{No. 40}$, % | Percentage passing No. 40 sieve | TST_SS01_UG01_UG02 |
| $P_{No. 200}$, % | Percentage passing No. 200 sieve | TST_SS01_UG01_UG02 |
| % Silt | Percentage of silt | TST_SS02_UG03 |
| % Clay | Percentage of clay | TST_SS02_UG03 |
| LL, % | Liquid limit of soil | TST_UG04_SS03 |
| PI, % | Plasticity index of soil | TST_UG04_SS03 |
| $w_{opt}$, % | Optimum water content | TST_UG05_SS05 |
| $\gamma_{d, opt}$ (kg/m$^3$) | Maximum dry unit weight of soil | TST_UG05_SS05 |
| $w_s$, % | Water content of the test specimen | TST_UG07_SS07_A, TST_UG07_SS07_B |
| $\gamma_s$ (kg/m$^3$) | Dry density of the test specimen | TST_UG07_SS07_A, TST_UG07_SS07_B |

1 in = 25.4 mm

## STATISTICAL PROCEDURE

A nonlinear optimization regression analysis was performed using SAS® statistical analysis system software relating the physical properties (listed in table 14) of the test specimen to the $M_R$ used in the constitutive equation on the "clean" data set. A stepwise regression analysis was initially performed relating the physical properties to the resilient modulus to identify the important variables. The procedure combined the forward and backward stepwise regression methods.

A variable (physical property) with a 0.25 probability was selected to enter the regression and was removed with a 0.1 probability to stay. The regression started with no variables in the model. The *F* statistics were calculated for each independent variable. The variable with the most significant level greater than 0.25 was entered into the model first. All variables were entered individually with this entry criterion. The variables already in the model did not necessarily remain, because after a variable is added, the stepwise method considers all the variables already included and deletes any variable that does not yield an *F* statistic at a level of significance greater than 0.1. The process was completed when no more variables outside the model had a level of significance greater than 0.25 to enter and 0.1 to delete.

## CORRELATION STUDY FOR MODEL DEVELOPMENT

As discussed in chapter 3, the base/subbase materials should be analyzed separately from the subgrade materials. The base/subbase materials were grouped by material code from LTPP terminology for pavement materials and soils. The crushed stone and uncrushed gravel materials were separated into auger and test pit samples to see the effect of sampling technique as discussed in chapter 3. The subgrade material was grouped by material type (clay, gravel, silt, and sand) and the clay soils were further grouped into: (1) disturbed samples and (2) undisturbed samples.

The test specimens from the Shelby tubes were taken at various depths through the sampling tubes, while the samples from which the physical properties were measured were confined to the top 0.3 m of the subgrade. As a result, the resilient modulus tests and some of the physical property tests could have been performed on entirely different soils. Von Quintus and Killingsworth identified this fact as a problem in completing similar correlations in 1996.[(3)] Thus, the undisturbed test specimens (Shelby tube samples) were not included in the correlations between resilient modulus and physical properties.

Appendix E summarizes the properties that were found to be important and the resulting statistical measures of the correlation for each of the data groups analyzed. Table 15 presents an overall summary of those physical properties that were found to be important for each material and soil. Observations from these correlation studies are noted below:

- The maximum or optimum dry unit weight was found to be important for all base and subbase material types, with the exception of the fine-grained soil (LTPP material code 309); while the optimum moisture content and percent passing the 3/8-in (9.5 mm) sieve were found to be important for most coarse-grained base materials.

- The plasticity index and the percent passing the No. 40 sieve were the only properties found to be important for the fine-grained soil base material group (LTPP material code 309).

- The water content and percent clay for the test specimen are important for all soil groups.

- The liquid limit is important for all soils except the silt group, while the percent silt is important for all soils except the gravel group.

Table 15. Summary of the physical properties that were found to be important for predicting resilient modulus for each material and soil type.

| Independent Variable | Base/Subbase Material | | | | | | | Soils | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 303, Crushed Stone | 304, Crushed Gravel | 302, Uncrushed Gravel | 306, Sand | 308, Coarse-Grained Soil-Aggr. Mixture | 307, Fine-Grained Soil-Aggr. Mixture | 309, Fine-Grained Soil | Gravel | Sand | Silt | Clay |
| Percent passing 3/8-in sieve, $P_{3/8}$ | √ | √ | | √ | √ | √ | | √ | √ | | |
| Percent passing No. 4 sieve, $P_4$ | | | | | √ | √ | | | √ | | √ |
| Percent passing No. 40 sieve, $P_{40}$ | √ | √ | | √ | √ | | √ | | | | √ |
| Percent passing No. 200 sieve, $P_{200}$ | | | √ | | √ | √ | | | √ | | √ |
| Percent Clay, %Clay | | | | | | | | √ | √ | √ | √ |
| Percent Silt, %Silt | | | | | | | | | √ | √ | √ |
| Liquid Limit, LL | √ | √ | | √ | | √ | | √ | √ | | √ |
| Plasticity Index, PI | | √ | | √ | √ | | √ | √ | | √ | |
| Water content of test specimen, $W_s$ | | √ | √ | | √ | | | √ | √ | √ | √ |
| Dry density of test specimen, $\gamma_s$ | | √ | √ | | √ | √ | | | √ | | √ |
| Optimum water content, $W_{opt}$ | √ | √ | √ | | √ | √ | | | √ | | √ |
| Maximum dry unit weight, $\gamma_{opt}$ | √ | √ | √ | √ | √ | √ | | | √ | | √ |
| Number of $M_R$ Tests | 109 | 49 | 81 | 66 | 187 | 32 | 92 | 122 | 509 | 108 | 512 |

1 in = 25.4 mm

## Effect of Material/Soil Type

Dividing the base/subbase materials by material code improves the regression statistics from the overall base/subbase model (see appendix E). When the crushed stone material was separated into auger and test pit samples, as recommended in chapter 3, some improvement was observed. However, this improvement is inconclusive and debatable because the greater correlation may be the result of the smaller sample size. The uncrushed gravel was not separated into auger and test pit samples due to a limited number of data points (refer to table 5).

Sorting the subgrade by soil type also improved the regression statistics as compared to the overall soil model (see appendix E). The subgrade materials were not classified in accordance with AASHTO, because the number of data points was limited for some of the classifications. Sampling technique (auger versus test pit samples) did not improve the regression statistics. The remaining part of this chapter presents the regression equations that resulted from the nonlinear optimization for each base material type and soil group. The residuals (bias) for each of the prediction models are provided in appendix E. The symbols used in the following equations were defined in chapter 2 (equation 3) and in table 15.

## Unbound Aggregate Base/Subbase Materials

Crushed Stone Materials – LTPP Material Code 303

$$M_R = \left[0.7632 + 0.0084(P_{3/8}) + 0.0088LL - 0.0371W_{opt} - 0.0001\gamma_{opt}\right] p_a * \left[\frac{\theta}{p_a}\right]^{\left(2.2159 - 0.0016P_{3/8} + 0.0008LL - 0.038W_{opt} - 0.0006\gamma_{opt} + 2.4x10^{-7}\left[\frac{\gamma^2{}_{opt}}{P_{40}}\right]\right)} * \left[\frac{\tau_{oct}}{p_a} + 1\right]^{-1.1720 - 0.0082LL - 0.0014W_{opt} + 0.0005\gamma_{opt}} \quad (6)$$

| | | |
|---|---|---|
| Number of points | = | 853 |
| Mean squared error | = | 1699.6 |
| $S_e$ | = | 41.23 |
| $S_y$ | = | 87.42 |
| $S_e/S_y$ | = | 0.4716 |

Figure 21 shows a comparison of the measured and predicted resilient modulus using equation 6 at the appropriate stress states used to test crushed stone base materials.

Crushed Gravel – LTPP Material Code 304

$$M_R = \begin{bmatrix} -0.8282 - 0.0065(P_{3/8}) + 0.0114LL + 0.0004PI - 0.0187W_{opt} + 0.0036W_s + \\ 0.0013\gamma_s - 2.6x10^{-6}\left(\frac{\gamma_{opt}^2}{P_{40}}\right) \end{bmatrix}$$

$$p_a\left[\frac{\theta}{p_a}\right]^{\left(4.9555 - 0.0057LL - 0.0075PI - 0.0470W_s - 0.0022\gamma_{opt} + 2.8x10^{-6}\left[\frac{\gamma^2{}_{opt}}{P_{40}}\right]\right)}\left[\frac{\tau_{oct}}{p_a} + 1\right]^{-3.514 + 0.0016\gamma_s} \quad (7)$$

| | | |
|---|---|---|
| Number of points | = | 404 |
| Mean squared error | = | 854.4 |
| $S_e$ | = | 29.23 |
| $S_y$ | = | 66.74 |
| $S_e/S_y$ | = | 0.4380 |

Figure 22 shows a comparison of the measured and predicted resilient modulus using equation 7 at the appropriate stress states used to test crushed gravel base materials.

Uncrushed Gravel – LTPP Material Code 302

$$M_R = \left[-1.8961 + 0.0014(\gamma_s) - 0.1184\left(\frac{W_s}{W_{opt}}\right)\right]p_a\left[\frac{\theta}{p_a}\right]^{\left(0.4960 - 0.0074P_{200} - 0.0007\gamma_s + 1.6972\left(\frac{\gamma_s}{\gamma_{opt}}\right) + 0.1199\left(\frac{W_s}{W_{opt}}\right)\right)} *$$

$$\left[\frac{\tau_{oct}}{p_a} + 1\right]^{\left(-0.5979 + 0.0349W_{opt} + 0.0004\gamma_{opt} - 0.5166\left[\frac{W_s}{W_{opt}}\right]\right)} \quad (8)$$

| | | |
|---|---|---|
| Number of points | = | 461 |
| Mean squared error | = | 475.9 |
| $S_e$ | = | 21.81 |
| $S_y$ | = | 63.05 |
| $S_e/S_y$ | = | 0.3460 |

Figure 23 shows a comparison of the measured and predicted resilient modulus using equation 8 at the appropriate stress states used to test crushed gravel base materials.

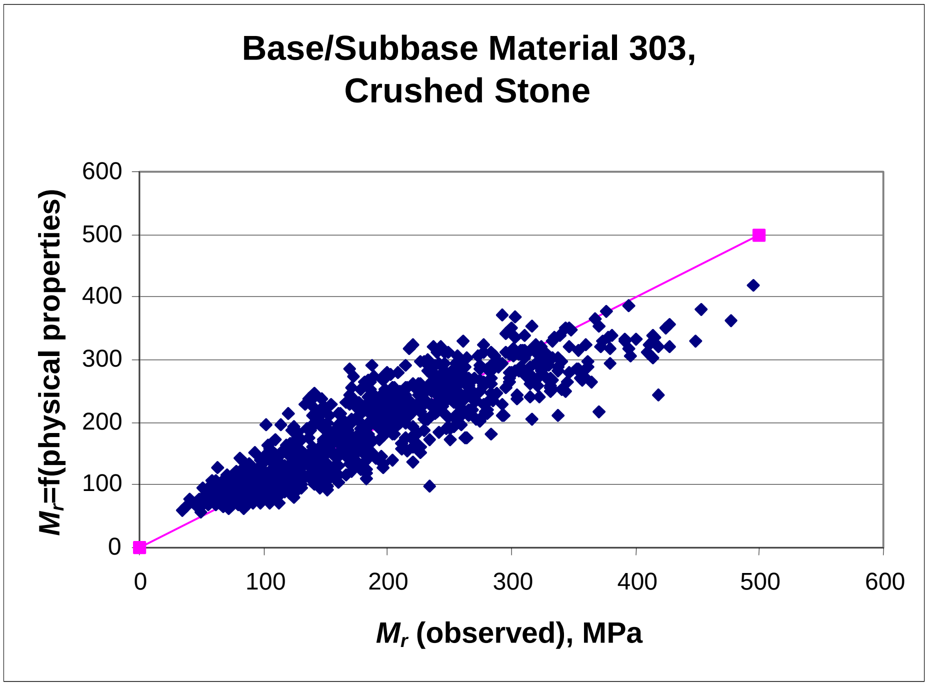



Figure 21. Graphical comparison of the predicted and measured resilient modulus for the crushed stone base materials.

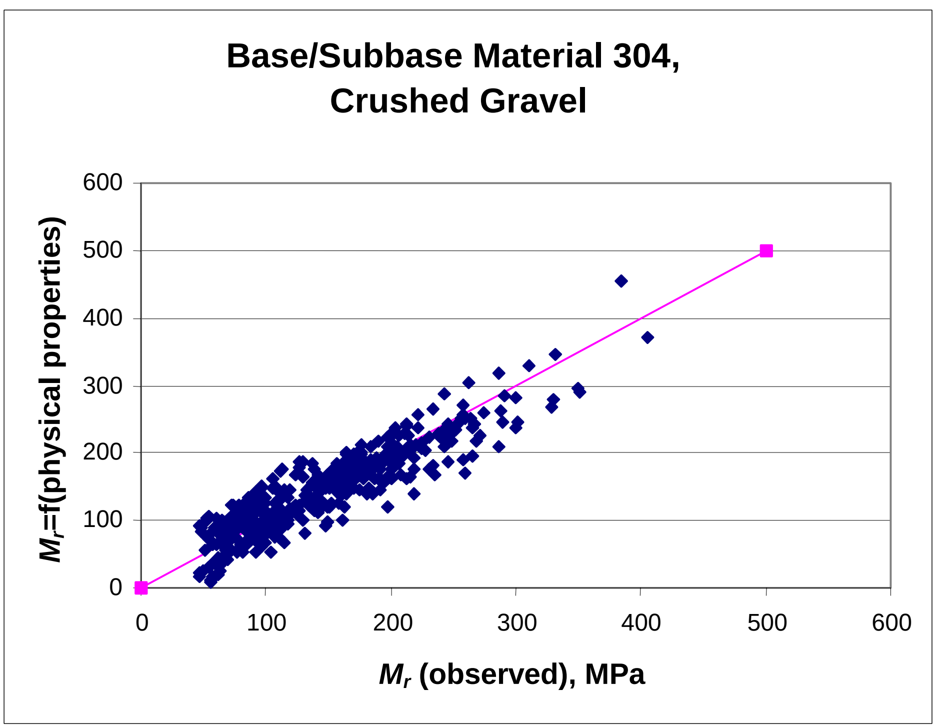



Figure 22. Graphical comparison of the predicted and measured resilient modulus for the crushed gravel base materials.

Sand – LTPP Material Code 306

$$M_R = \left[ -0.2786 + 0.0097 P_{3/8} + 0.0219 LL - 0.0737 PI + 1.8x10^{-7} \left( \frac{\gamma_{opt}^2}{P_{40}} \right) \right] p_a * \left[ \frac{\theta}{p_a} \right]^{\left( 1.1148 - 0.0053 P_{3/8} - 0.0095 LL + 0.0325 PI + 7.2x10^{-7} \left( \frac{\lambda_{opt}^2}{P_{40}} \right) \right)} \left[ \frac{\tau_{oct}}{p_a} + 1 \right]^{(-0.4508 + 0.0029 P_{3/8} - 0.0185 LL + 0.0798 PI)} \quad (9)$$

Number of points = 519
Mean squared error = 512.7
$S_e$ = 22.64
$S_y$ = 51.61
$S_e/S_y$ = 0.4388

Figure 24 shows a comparison of the measured and predicted resilient modulus using equation 9 at the appropriate stress states used to test sand base materials.

Coarse-Grained Soil-Aggregate Mixture – LTPP Material Code 308

$$M_R = \left[ \begin{matrix} -0.5856 + 0.0130 P_{3/8} - 0.0174 P_4 + 0.0027 P_{200} + 0.0149 PI + 1.6x10^{-6} (\gamma_{opt}) \\ -0.0426 W_s + 1.6456 \left( \frac{\gamma_s}{\gamma_{opt}} \right) + 0.3932 \left( \frac{W_s}{W_{opt}} \right) - 8.2x10^{-7} \left( \frac{\gamma_{opt}^2}{P_{40}} \right) \end{matrix} \right] p_a * \left[ \frac{\theta}{p_a} \right]^{\left( 0.7833 - 0.0060 P_{200} - 0.0081 PI + 0.0001 \gamma_{opt} - 0.1483 \left( \frac{W_s}{W_{opt}} \right) - 2.7x10^{-7} \left( \frac{\gamma_{opt}^2}{P_{40}} \right) \right)} \left[ \frac{\tau_{oct}}{p_a} + 1 \right]^{\left( -0.1906 - 0.0026 P_{200} + 8.1x10^{-7} \left( \frac{\gamma_{opt}^2}{P_{40}} \right) \right)} \quad (10)$$

Number of points = 2,323
Mean squared error = 1883.9
$S_e$ = 43.40
$S_y$ = 80.19
$S_e/S_y$ = 0.5413

Figure 25 shows a comparison of the measured and predicted resilient modulus using equation 10 at the appropriate stress states used to test coarse-grained soil-aggregate base materials.

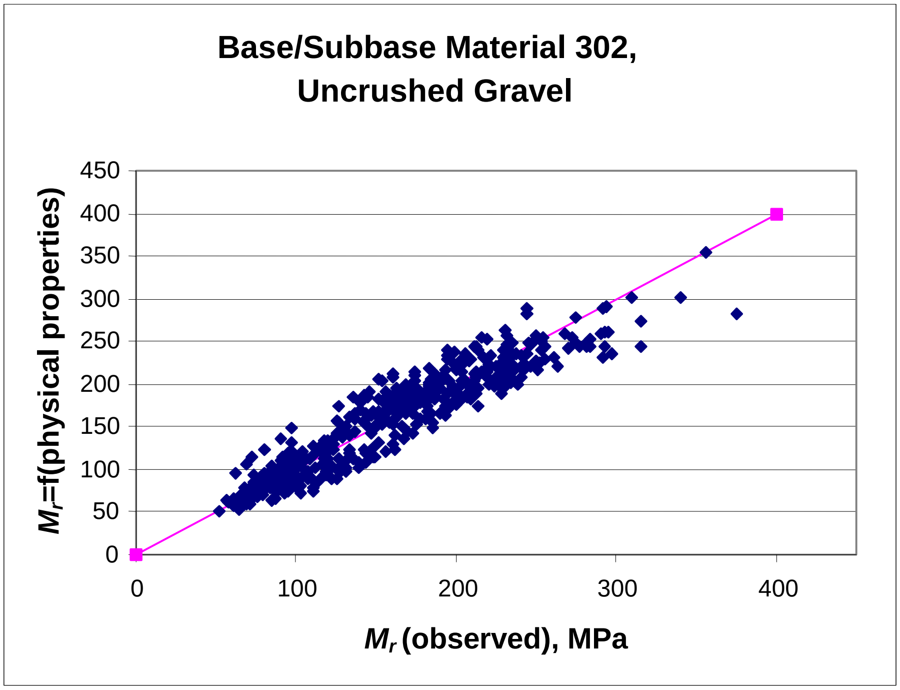



Figure 23. Graphical comparison of the predicted and measured resilient modulus for the uncrushed gravel base materials.

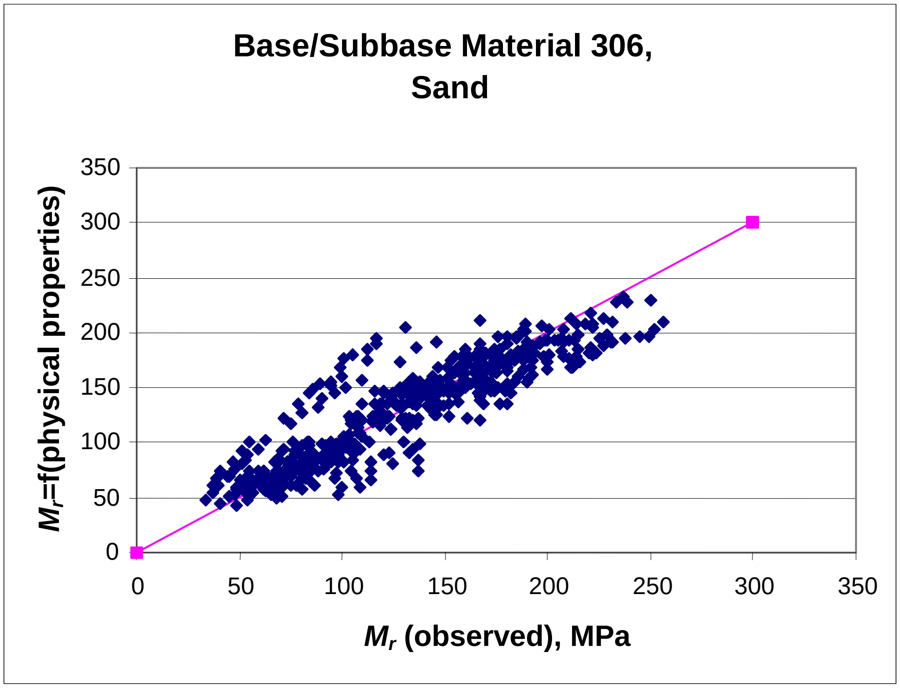



Figure 24. Graphical comparison of the predicted and measured resilient modulus for the sand base materials.

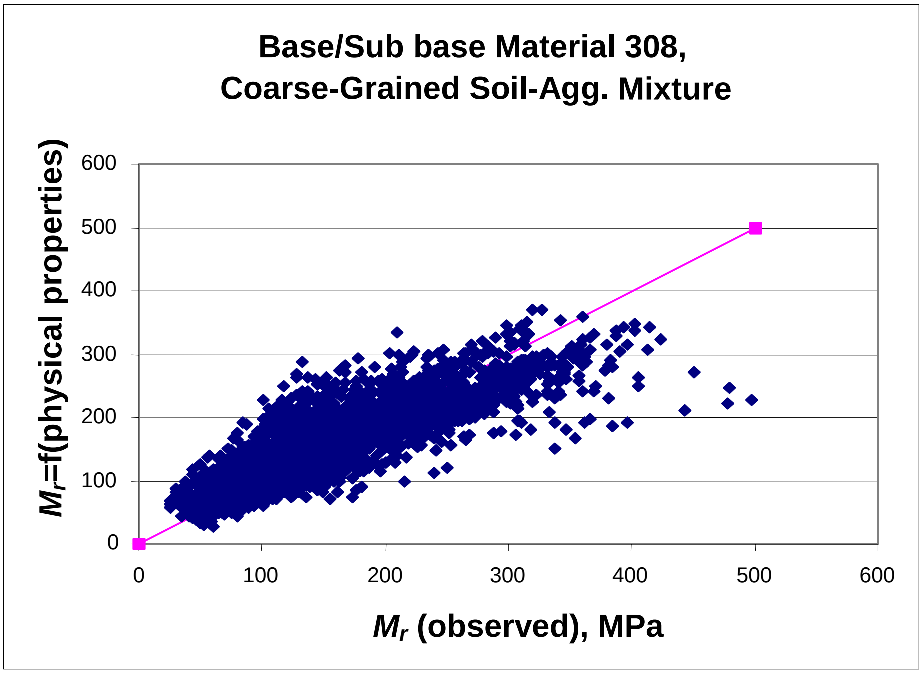



Figure 25. Graphical comparison of the predicted and measured resilient modulus for the coarse-grained soil-aggregate base materials.

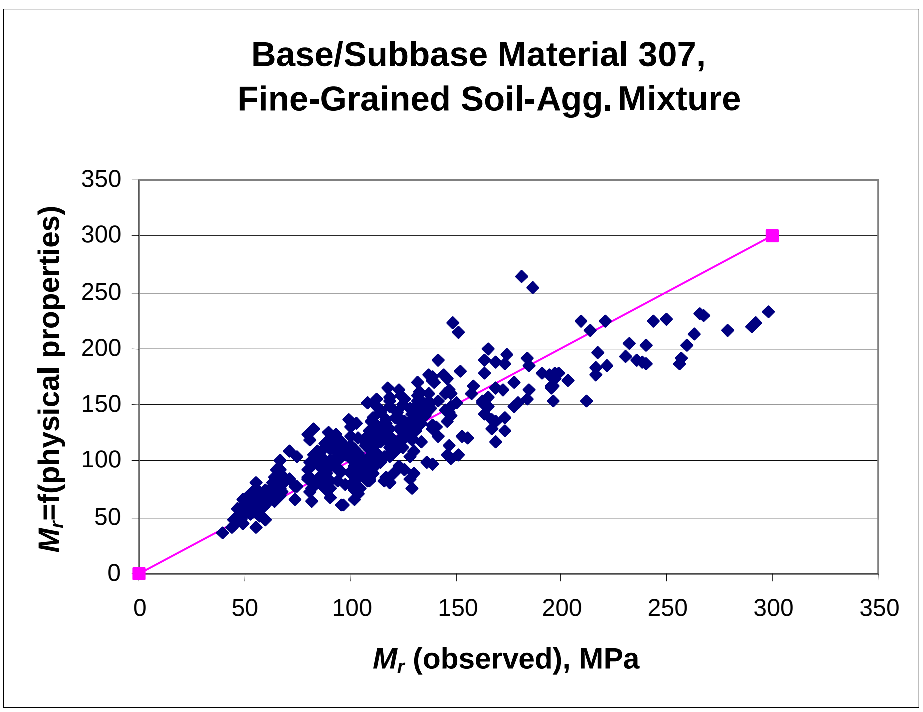



Figure 26. Graphical comparison of the predicted and measured resilient modulus for the fine-grained soil-aggregate base materials.

Fine-Grained Soil-Aggregate Mixture – LTPP Material Code 307

$$M_R = \left[ -0.7668 + 0.0051P_4 + 0.0128P_{200} + 0.0030LL - 0.0510W_{opt} + 1.1729\left(\frac{\gamma_s}{\gamma_{opt}}\right)\right] p_a \; *$$

$$\left[\frac{\theta}{p_a}\right]^{\left(0.4951 - 0.0141P_4 - 0.0061P_{200} + 1.3941\left(\frac{\lambda_s}{\gamma_{opt}}\right)\right)} \left[\frac{\tau_{oct}}{p_a} + 1\right]^{\left(0.9303 + 0.0293P_{3/8} + 0.0036LL - 3.8903\left(\frac{\gamma_s}{\gamma_{opt}}\right)\right)} \tag{11}$$

| | | |
|---|---|---|
| Number of points | = | 390 |
| Mean squared error | = | 588.2 |
| $S_e$ | = | 24.25 |
| $S_y$ | = | 49.37 |
| $S_e/S_y$ | = | 0.4912 |

Figure 26 shows a comparison of the measured and predicted resilient modulus using equation 11 at the appropriate stress states used to test fine-grained soil-aggregate base materials.

Fine-Grained Soil – LTPP Material Code 309

$$M_R = \left[0.8409 + 0.0004P_{40} + 0.0161PI\right] p_a \left[\frac{\theta}{p_a}\right]^{(0.6668 - 0.0007P_{40} - 0.0139PI)} \left[\frac{\tau_{oct}}{p_a} + 1\right]^{(-0.1667 - 0.0207PI)} \tag{12}$$

| | | |
|---|---|---|
| Number of points | = | 1,079 |
| Mean squared error | = | 1,167 |
| $S_e$ | = | 34.16 |
| $S_y$ | = | 62.80 |
| $S_e/S_y$ | = | 0.5440 |

Figure 27 shows a comparison of the measured and predicted resilient modulus using equation 12 at the appropriate stress states used to test fine-grained soil base materials.

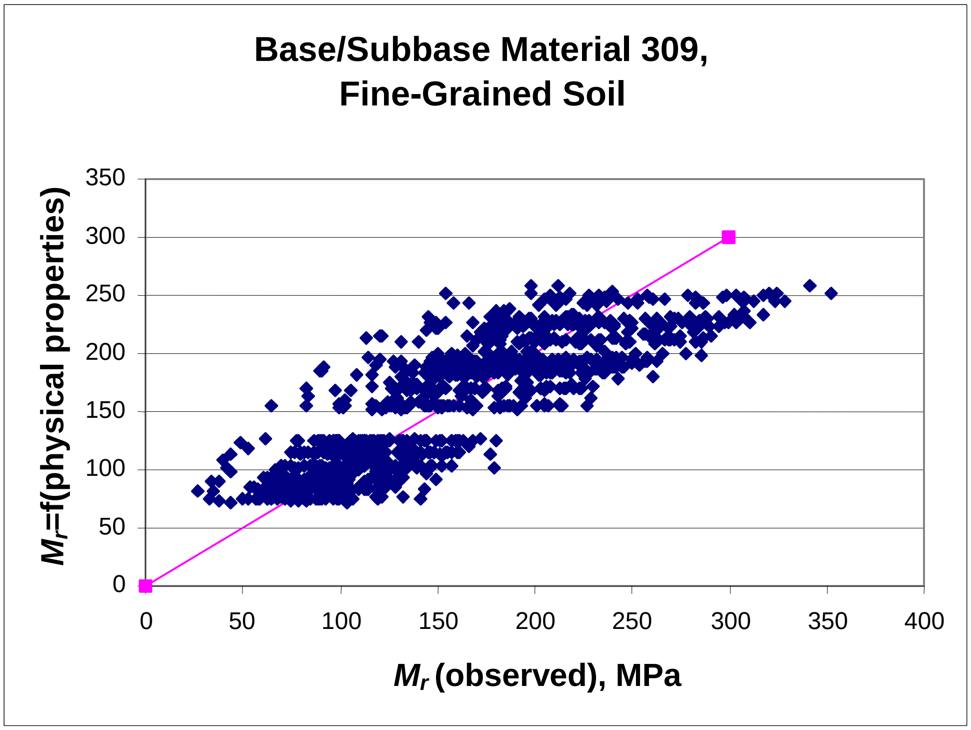



Figure 27. Graphical comparison of the predicted and measured resilient modulus for the fine-grained soil base materials.

**Subgrade Soils**

<u>Coarse-Grained Gravel Soils</u>

$$M_R = \left[1.3429 - 0.0051P_{3/8} + 0.0124(\%Clay) + 0.0053LL - 0.0231W_s\right]p_a * \left[\frac{\theta}{p_a}\right]^{(0.3311+0.0010P_{3/8}-0.0019(\%Clay)-0.0050LL-0.0072PI+0.0093W_s)} * \left[\frac{\tau_{oct}}{p_a}+1\right]^{(1.5167-0.0302P_{3/8}+0.0435(\%Clay)+0.0626LL+0.0377PI-0.2353W_s)} \quad (13)$$

| | | |
|---|---|---|
| Number of points | = | 957 |
| Mean squared error | = | 301.3 |
| $S_e$ | = | 17.36 |
| $S_y$ | = | 26.81 |
| $S_e/S_y$ | = | 0.6474 |

Figure 28 shows a comparison of the measured and predicted resilient modulus using equation 13 at the appropriate stress states used to test coarse-grained gravel soils.

Coarse-Grained Sand Soils

$$M_R = \left[3.2868 - 0.0412P_{3/8} + 0.0267P_4 + 0.0137(\%Clay) + 0.0083LL - 0.0379W_{opt} - 0.0004\gamma_s\right]p_a \, * \left[\frac{\theta}{p_a}\right]^{\left(0.5670+0.0045P_{3/8}-2.98x10^{-5}(P_4)-0.0043(\%Silt)-0.0102(\%Clay)-0.0041LL+0.0014W_{opt}-3.41x10^{-5}\gamma_s-0.4582\left(\frac{\gamma_s}{\gamma_{opt}}\right)+0.1779\left(\frac{W_s}{W_{opt}}\right)\right)} * \left[\frac{\tau_{oct}}{p_a}+1\right]^{\left(-3.5677+0.1142P_{3/8}-0.0839P_4-0.1249P_{200}+0.1030(\%Silt)+0.1191(\%Clay)-0.0069LL-0.0103W_{opt}-0.0017\gamma_s+4.3177\left(\frac{\gamma_s}{\lambda_{opt}}\right)-1.1095\left(\frac{W_s}{W_{opt}}\right)\right)} \tag{14}$$

| | | |
|---|---|---|
| Number of points | = | 3,117 |
| Mean squared error | = | 357.7 |
| $S_e$ | = | 18.91 |
| $S_y$ | = | 24.79 |
| $S_e/S_y$ | = | 0.7630 |

Figure 29 shows a comparison of the measured and predicted resilient modulus using equation 14 at the appropriate stress states used to test coarse-grained sand soils.

Fine-Grained Silt Soils

$$M_R = \left[1.0480 + 0.0177(\%Clay) + 0.0279PI - 0.370W_s\right]p_a\left[\frac{\theta}{p_a}\right]^{(0.5097-0.0286PI)} * \left[\frac{\tau_{oct}}{p_a}+1\right]^{(-0.2218+0.0047(\%Silt)+0.0849PI-0.1399W_s)} \tag{15}$$

| | | |
|---|---|---|
| Number of points | = | 464 |
| Mean squared error | = | 193.0 |
| $S_e$ | = | 13.89 |
| $S_y$ | = | 24.71 |
| $S_e/S_y$ | = | 0.5622 |

Figure 30 shows a comparison of the measured and predicted resilient modulus using equation 15 at the appropriate stress states used to test fine-grained silt soils.

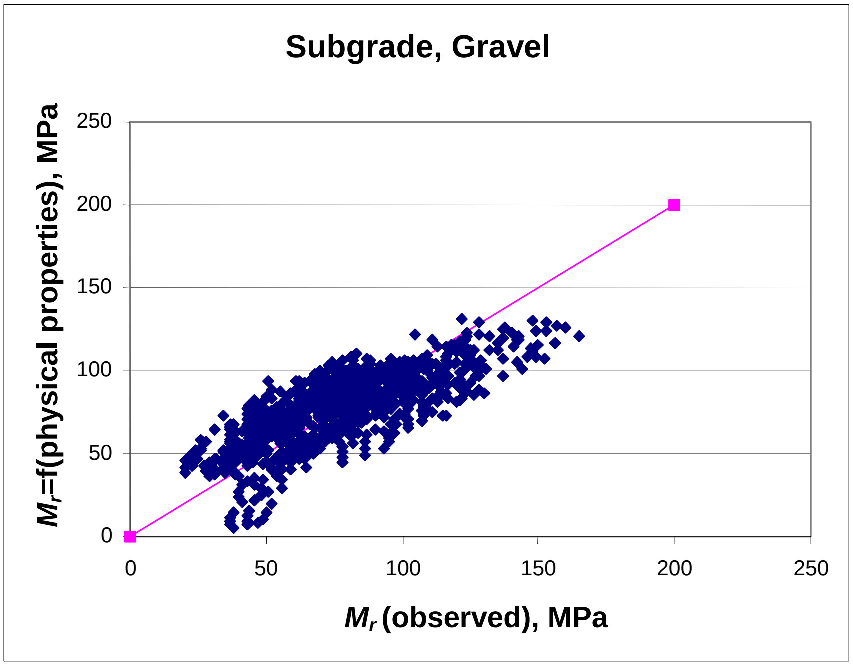



Figure 28. Graphical comparison of the predicted and measured resilient modulus for the coarse-grained gravel soils.

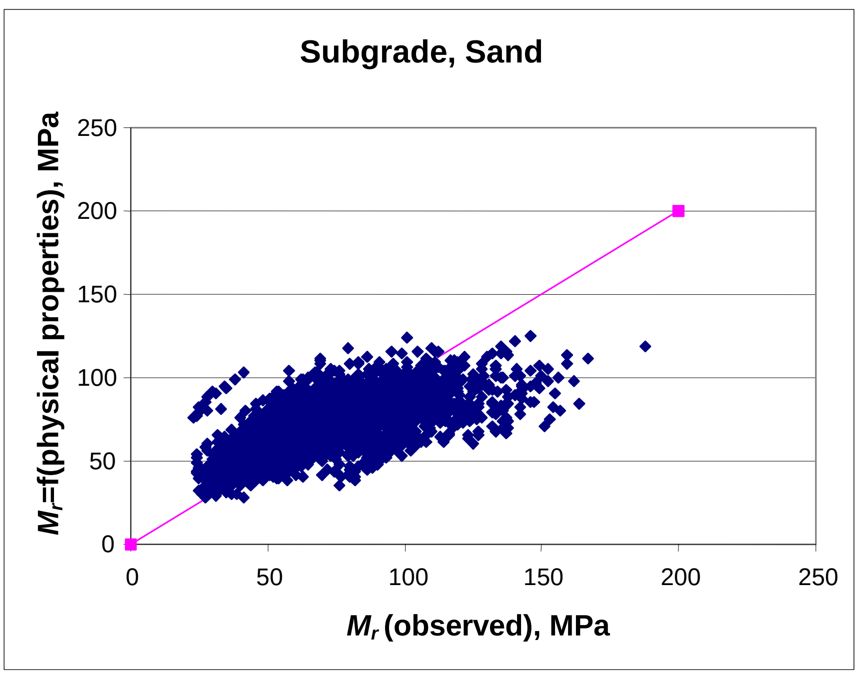



Figure 29. Graphical comparison of the predicted and measured resilient modulus for the coarse-grained sand soils.

Fine-Grained Clay Soils

$$M_R = [1.3577 + 0.0106(\%Clay) - 0.0437W_s]p_a\left[\frac{\theta}{p_a}\right]^{(0.5193 - 0.0073P_4 + 0.0095P_{40} - 0.0027P_{200} - 0.0030LL - 0.0049W_{opt})} *$$

$$\left[\frac{\tau_{oct}}{p_a} + 1\right]^{\left(1.4258 - 0.0288P_4 + 0.0303P_{40} - 0.0521P_{200} + 0.0251(\%Silt) + 0.0535LL - 0.0672W_{opt} - 0.0026\gamma_{opt} + 0.0025\gamma_s - 0.6055\left(\frac{W_s}{W_{opt}}\right)\right)} \qquad (16)$$

| | | |
|---|---|---|
| Number of points | = | 1,484 |
| Mean squared error | = | 557.9 |
| $S_e$ | = | 23.62 |
| $S_y$ | = | 29.22 |
| $S_e/S_y$ | = | 0.8082 |

Figure 31 shows a comparison of the measured and predicted resilient modulus using equation 16 at the appropriate stress states used to test fine-grained clay soils.

**SUMMARY**

The results from the nonlinear optimization regression study were compared to those from earlier studies. The statistical parameters for some of the unbound aggregate base and subbase layers improved, indicating that the defined anomalies and use of nonlinear regression techniques were important. In summary, the physical properties show fair to good correlations between the physical properties and $M_R$. The following are some of the more important findings from these correlation studies:

- Several key factors affect the correlation between the material physical properties of the pavement materials and soils and $M_R$. For example, recompacting the materials may have changed some of the physical features of the test specimens from what was measured for the bulk samples.

- The statistics for all models were generally fair to good for both the unbound aggregate materials and the subgrade soils. Breaking the data groups into subgroups by sampling technique did improve on the regression statistics. Most of the $s_e/s_y$ terms are less than 0.7. The base materials generally have better statistical parameters than the soils.

- The primary result from these correlation studies is that the resilient modulus from constitutive equation 3 can be reasonably predicted from the physical properties that are included in the LTPP database.

- The physical properties of percent clay and test specimen moisture content or density are important for all soil groups.

- Percent silt was an important property for all soil groups, except for the gravelly soils.

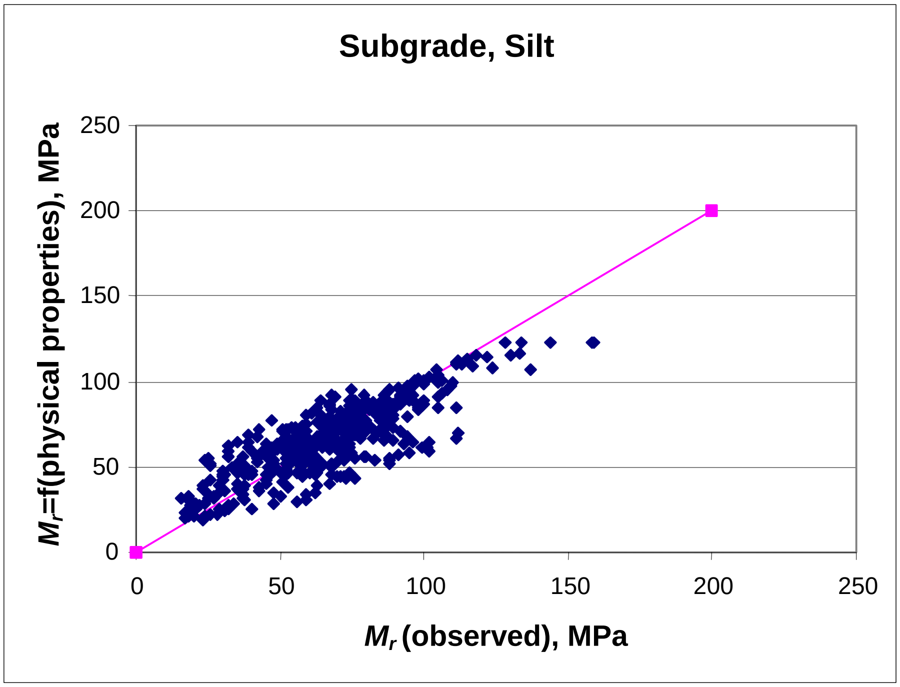



Figure 30. Graphical comparison of the predicted and measured resilient modulus for the fine-grained silt soils.

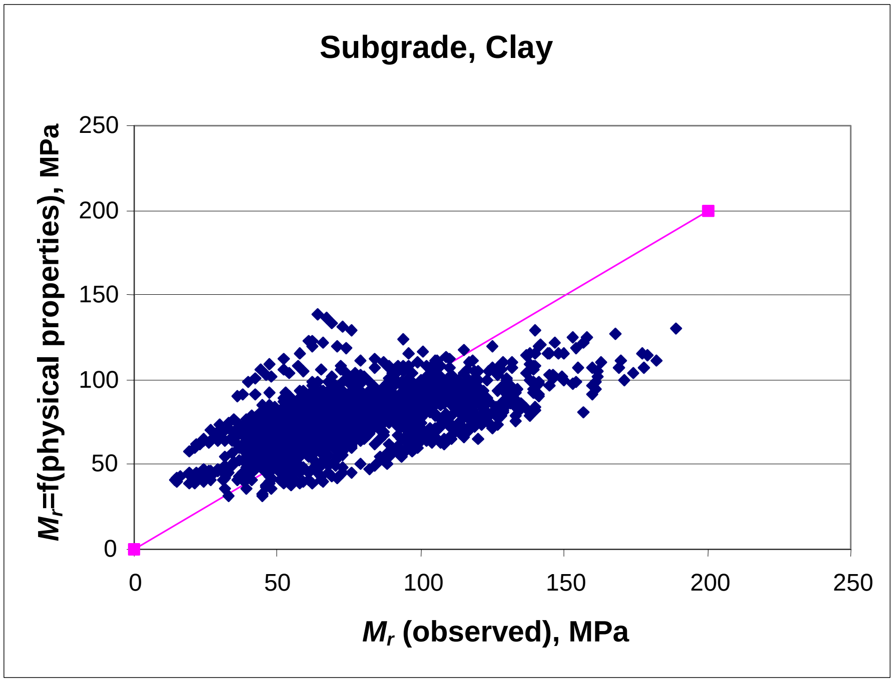



Figure 31. Graphical comparison of the predicted and measured resilient modulus for the fine-grained clay soils.

Figure 32 shows a comparison of the calculated $M_R$ between the test pit and augered samples using the regression equations to estimate the k-coefficients. A bias is present in the calculated $M_R$ values between the test pit and augered samples and supports the previous observation that there is an effect of sampling technique for the crushed stone base materials included in the LTPP database.

Figure 33 shows the comparison of the predicted $M_R$ using the regression models developed for the different sampling techniques for sand. The error in the calculated $M_R$ using the physical properties overshadows any difference caused by the different sampling techniques used.

The physical properties correlated to the resilient modulus varied between the different base/subbase material groups. No one physical property was included for all material types. However, the liquid limit, plasticity index, and the amount of material passing the smaller sieve sizes are important for the lower strength unbound base/subbase materials, while a measure of the moisture content and density are important for the higher strength materials. The amount of material passing the larger sieve sizes are related to the resilient modulus of the unbound base/subbase materials with the larger aggregate particles, as expected.

Until additional test results become available to improve or confirm these relationships, it is recommended that at least some resilient modulus tests be performed to measure the $M_R$ for unbound pavement materials and soils.

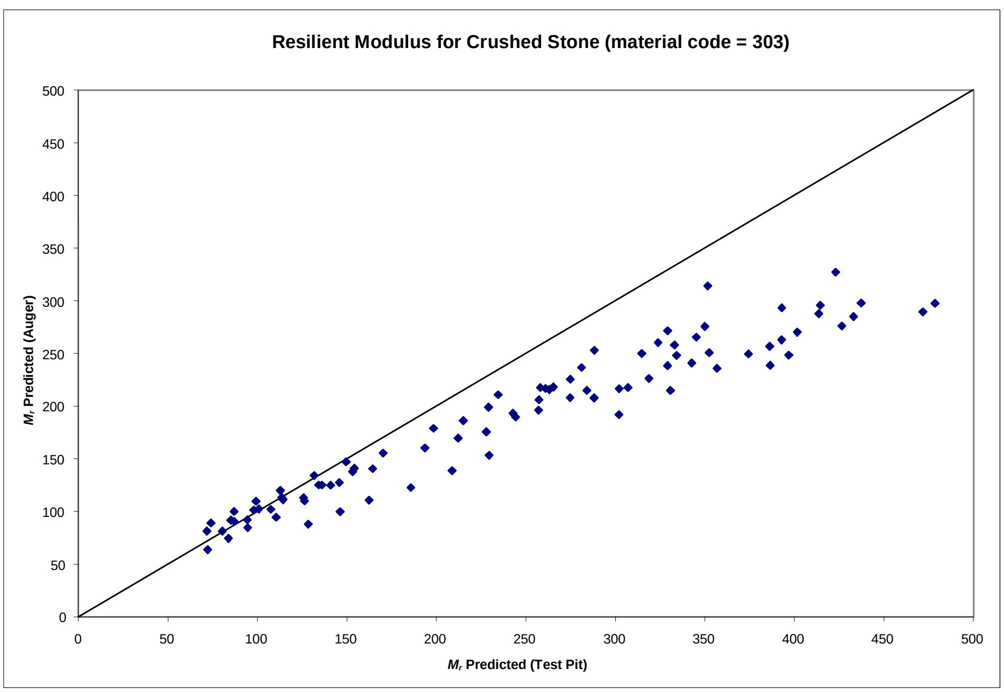



Figure 32. Comparison of the resilient modulus predicted from the data sets for crushed stone materials sampled from the test pit and auger locations.

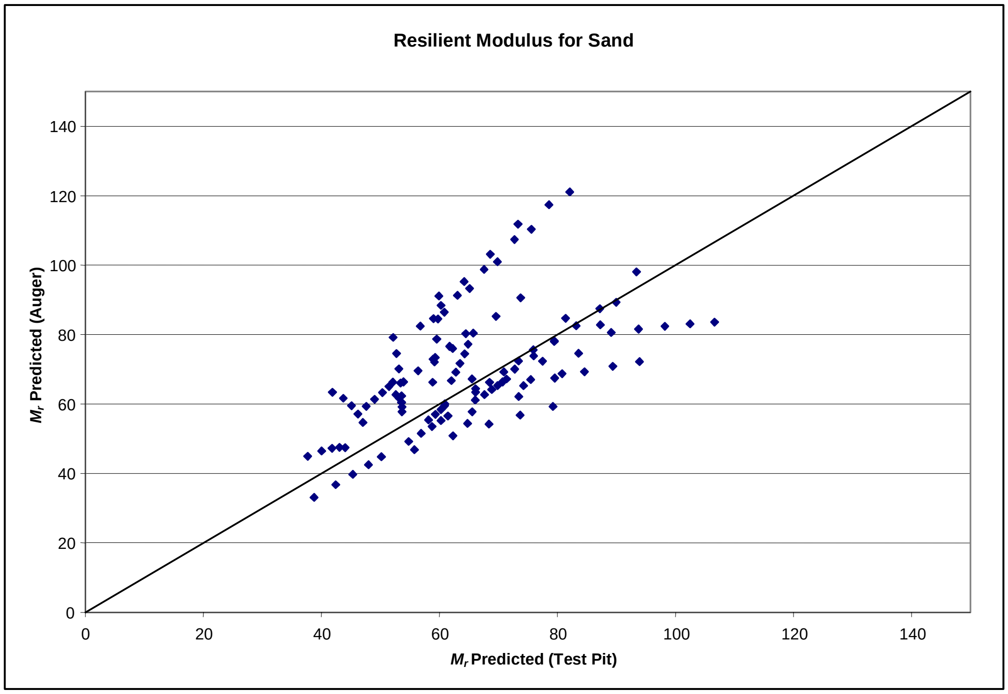



Figure 33. Graphical comparison of the calculated $M_R$ using the regressed k-coefficients from the physical properties of the sand soil group sampled from augers and test pits.

# CHAPTER 5. SUMMARY AND FUTURE RECOMMENDATIONS

Repeated-load resilient modulus tests are being performed on all unbound pavement materials and soils from the SPS and GPS test sections included in FHWA's LTPP program in accordance with LTPP test protocol P46. The overall goal of this study was to complete a detailed review of the LTPP $M_R$ data and to identify potential anomalies and bias in those data. To accomplish that goal, correlation studies and regression analysis were completed in evaluating $M_R$ test results. The correlation and regression studies included:

- Regression of the k-coefficients of equation 3.
- Comparison of the distributions of each k-coefficient for different data groups to identify any bias or differences between different data sets.
- Identification of the physical properties and other parameters that affect the response characteristics of the materials and soils tested.

## FINDINGS AND OBSERVATIONS

The following is a summary of the findings and recommendations from this study:

- A total of 2,014 $M_R$ tests of unbound pavement materials and soils have a Level E data status, while 1,594 tests have not yet obtained a Level E status in the LTPP database as of the October 2000 data release. It is expected that the number of completed $M_R$ tests with a Level E status will significantly increase in future data releases.
- Constitutive equation 3 was found to be an excellent fit to the $M_R$ test results included in the LTPP database. Specifically, almost 92 percent of the LTPP $M_R$ test results have response characteristics that can be accurately simulated by constitutive equation 3. Constitutive equation 3 is the equation selected for use in development of the 2002 Design Guide. It is important to note that the values for the $k_1$ coefficient reported herein from the regression studies were determined using units of *kPa* for the pressure and stress parameters and units of *MPa* for the $M_R$.
- Coefficient $k_6$ (pore-water pressure or cohesion term) in equation 3 was found to be zero for more than 50 percent of the $M_R$ tests. The non-zero values of $k_6$ were highly variable and have a uniform distribution. Thus, $k_6$ was assumed to be zero for all of the correlation studies and analyses performed on the $M_R$ test data. This assumption should be checked and confirmed as additional $M_R$ test results reach a Level E data status in the LTPP database.
- Coefficient $k_3$ was found to be zero for nearly 25 percent of the $M_R$ tests performed on the unbound aggregate base/subbase materials and about 10 percent of the tests performed on the coarse-grained subgrade soils.

- There were 185 $M_R$ tests (approximately 8 percent) that were flagged with potential anomalies. Most of the anomalous tests (103 of 185 flagged tests) were defined as a type 4 anomaly. A type 4 anomaly exhibits a different stress sensitivity between the different confining pressures. Some of these differences are large enough that the higher confining pressure will result in a lower $M_R$ than a lower confining pressure at the same repeated vertical load. Samples that exhibit this type of anomaly should be retested.

- Sampling technique (auger versus test pit samples) does have an effect on the $M_R$ test results for the uncrushed gravel and crushed stone base/subbase materials. No significant difference was found between the augered and test pit samples of the other base/subbase materials.

- Sampling technique also has an effect on the $M_R$ test results for the subgrade soils. However, only one of the k-coefficients regressed from the $M_R$ test data for the augered and test pit samples were found to be different for the coarse-grained soils and no difference was found for the fine-grained soils. Conversely, at least one of the k-coefficients was found to be different for all soil groups when comparing undisturbed and disturbed test specimens. Multiple k-coefficients (including $k_1$) were found to be different for the clay soils. Thus, it appears that there is a significant difference in the $M_R$ test results for selected data groups that can be attributed to, or explained by, the use of different sampling techniques. These data groups include undisturbed versus disturbed test specimens for the clay soils and augered versus test pit specimens for the crushed stone base/subbase materials. At a minimum, these data groups should be considered as different populations of $M_R$ test data.

- The physical properties correlated to resilient modulus varied between the different materials and soils. No one physical property was included for all materials and soils. However, the following summarizes the properties related to the k-coefficients for many of the data groups:

  - Liquid limit, plasticity index, and the amount of material passing the smaller sieve sizes were found to be important as related to the resilient modulus for the lower strength unbound aggregate base/subbase materials, while the moisture content and density were important as related to the higher strength materials.

  - The amount of material passing the larger sieve sizes was important for the unbound aggregate base/subbase materials with larger aggregates.

  - Percent clay and test specimen moisture content or density are important for all soil groups.

  - Percent silt was important for all soil groups except gravel.

- The statistics for all models relating the resilient modulus to physical properties were fair to good for most data groups. Breaking the data groups into subgroups by sampling technique and material or soil type did improve on the regression statistics. Thus, the primary result from these regression studies is that the resilient modulus can be reasonably predicted from those physical properties that are included in the LTPP database. It should be noted that these correlation and regression studies did not consider any effect that may have been caused by the use of different testing contractors.

## RECOMMENDATIONS

Two important recommendations are a result of this study:

1. The review process identified in chapter 2 should be performed on the resilient modulus test results after each test is completed. In other words, the review process to identify anomalous data should become a part of the QC process, but the review should be performed immediately after testing. Retests can then be scheduled and performed for those tests that are flagged.

2. The findings and observations from this study should be verified and confirmed after all $M_R$ tests have been completed, checked through the QC process, and have reached a Level E data status in the LTPP database.

The final recommendation or suggestion is to determine if there is any effect or bias in the resilient modulus test results between the different testing contractors (i.e., operator- or equipment-dependent). The bias for each prediction model was provided in appendix E. The resilient modulus data should be studied in more detail to identify any causes of the bias that appear to be material- and/or stress-state-dependent.

# APPENDIX A.

## SUMMARY OF k-COEFFICIENTS FOR THE LTPP RESILIENT MODULUS TESTS

Appendix A, table 16, provides a tabulation of the k-coefficients that were determined for each resilient modulus test using nonlinear regression techniques for the “universal” constitutive equation. Various statistical parameters are also tabulated for each test. These statistical parameters include the following:

RMSE = Root Mean Squared Error
MSE = Mean Squared Error
$R^2$
$S_e/S_y$

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials.

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0101 | 1 | 2 | B6 | BS06 | 0.7371 | 0.1236 | -0.7748 | 15 | 4.1656 | 2.0358 | 4.1447 | 0.9991 | 0.4887 |
| 1 | 0102 | 1 | 2 | B7 | BS07 | 0.7810 | 0.1497 | -0.4579 | 15 | 4.3337 | 2.4088 | 5.8023 | 0.9990 | 0.5558 |
| 1 | 0103 | 1 | 2 | B5 | BS05 | 0.7471 | 0.1952 | -1.2825 | 15 | 5.9738 | 1.9974 | 3.9898 | 0.9991 | 0.3344 |
| 1 | 0106 | 1 | 2 | B4 | BS04 | 0.7514 | 0.1787 | -0.2832 | 15 | 4.6260 | 1.8647 | 3.4770 | 0.9994 | 0.4031 |
| 1 | 0107 | 1 | 2 | B1 | BS01 | 0.6701 | 0.2137 | -1.0366 | 15 | 4.9454 | 1.4704 | 2.1620 | 0.9994 | 0.2973 |
| 1 | 0108 | 1 | 2 | B2 | BS02 | 0.7619 | 0.1612 | -0.4410 | 15 | 4.1196 | 1.6944 | 2.8708 | 0.9995 | 0.4113 |
| 1 | 0111 | 1 | 2 | B3 | BS03 | 0.7628 | 0.1344 | -0.2691 | 15 | 4.1827 | 2.7063 | 7.3239 | 0.9988 | 0.6470 |
| 1 | 0502 | 1 | 1 | TP1 | BS55 | 0.6190 | 0.3902 | 0.0000 | 15 | 9.0806 | 1.9745 | 3.8986 | 0.9992 | 0.2174 |
| 1 | 0502 | 2 | 1 | TP1 | BG56 | 0.6188 | 0.5133 | -0.0405 | 15 | 33.6647 | 1.1438 | 1.3084 | 0.9999 | 0.0340 |
| 1 | 0502 | 2 | 2 | TP1 | BG56 | 0.5948 | 0.4399 | 0.0000 | 15 | 9.8985 | 1.9707 | 3.8836 | 0.9991 | 0.1991 |
| 1 | 1001 | 2 | 2 | TP1 | BG56 | 0.7172 | 0.7705 | -0.0458 | 15 | 78.1141 | 6.6861 | 44.7042 | 0.9987 | 0.0856 |
| 1 | 1001 | 2 | 2 | TP1 | BG57 | 0.7268 | 0.7067 | -0.1472 | 15 | 62.5584 | 5.6975 | 32.4613 | 0.9988 | 0.0911 |
| 1 | 1011 | 1 | 1 | A1 | TS01 | 0.8228 | 0.1655 | -2.2042 | 15 | 9.7575 | 4.6641 | 21.7535 | 0.9946 | 0.4780 |
| 1 | 1011 | 1 | 2 | A2 | TS03 | 1.7600 | 0.4354 | -3.1476 | 15 | 25.0337 | 4.9273 | 24.2783 | 0.9984 | 0.1968 |
| 1 | 1011 | 2 | 1 | BA* | BG** | 0.9145 | 0.5503 | 0.0000 | 15 | 57.9386 | 4.5896 | 21.0643 | 0.9994 | 0.0792 |
| 1 | 1011 | 2 | 2 | BA* | BG** | 0.9613 | 0.6280 | -0.1737 | 15 | 65.4470 | 5.6762 | 32.2189 | 0.9992 | 0.0867 |
| 1 | 1011 | 3 | 1 | BA* | BG** | 0.5700 | 0.9897 | 0.0000 | 15 | 103.5283 | 6.7758 | 45.9112 | 0.9990 | 0.0654 |
| 1 | 1019 | 1 | 1 | A1 | TS02 | 1.2501 | 0.4131 | -1.2442 | 15 | 15.3623 | 5.3629 | 28.7604 | 0.9978 | 0.3491 |
| 1 | 1019 | 1 | 2 | A2 | TS03 | 0.5343 | 0.4178 | 0.0000 | 15 | 8.9320 | 3.2359 | 10.4713 | 0.9971 | 0.3623 |
| 1 | 1019 | 2 | 1 | BA* | BG** | 0.9962 | 0.6250 | 0.0000 | 15 | 80.1910 | 17.8706 | 319.3589 | 0.9934 | 0.2229 |
| 1 | 1019 | 2 | 2 | TP1 | BG55 | 0.7799 | 0.6658 | -0.1396 | 15 | 61.1355 | 6.8790 | 47.3208 | 0.9984 | 0.1125 |
| 1 | 1021 | 1 | 1 | A1 | TS01 | 0.8648 | 0.5048 | -2.3817 | 15 | 12.6630 | 4.1558 | 17.2709 | 0.9963 | 0.3282 |
| 1 | 1021 | 1 | 2 | A2 | TS03 | 1.2172 | 0.2507 | -2.9302 | 15 | 15.9592 | 5.0640 | 25.6442 | 0.9966 | 0.3173 |
| 1 | 1021 | 2 | 1 | BA* | BG** | 0.9483 | 0.6619 | -0.1447 | 15 | 72.2560 | 4.8052 | 23.0902 | 0.9994 | 0.0665 |
| 1 | 1021 | 2 | 2 | TP1 | BG55 | 0.8984 | 0.7054 | -0.2732 | 15 | 70.3500 | 8.9635 | 80.3441 | 0.9979 | 0.1274 |
| 1 | 3028 | 1 | 1 | BA* | BS** | 1.2131 | 0.2656 | 0.0000 | 15 | 24.3307 | 21.2344 | 450.8977 | 0.9750 | 0.8727 |
| 1 | 3028 | 1 | 2 | BA* | BS** | 1.8894 | 0.2760 | -2.2448 | 15 | 20.6635 | 2.8790 | 8.2887 | 0.9996 | 0.1393 |
| 1 | 3028 | 2 | 1 | BA* | BG** | 1.4464 | 0.5184 | -0.0799 | 15 | 77.6224 | 17.7199 | 313.9942 | 0.9956 | 0.2283 |
| 1 | 3028 | 2 | 2 | BA* | BG** | 1.2310 | 0.7180 | -0.6733 | 15 | 76.8463 | 22.2049 | 493.0587 | 0.9905 | 0.2890 |
| 1 | 3028 | 3 | 1 | BA* | BG** | 1.0271 | 0.6810 | 0.0000 | 15 | 90.4006 | 11.0833 | 122.8406 | 0.9979 | 0.1226 |
| 1 | 3028 | 3 | 2 | BA* | BG** | 1.5955 | 0.5814 | 0.0000 | 15 | 110.8525 | 14.2134 | 202.0195 | 0.9982 | 0.1282 |
| 1 | 3998 | 1 | 2 | BA* | BS** | 1.0637 | 0.3231 | -1.0555 | 15 | 10.6735 | 3.7247 | 13.8734 | 0.9986 | 0.3490 |
| 1 | 3998 | 3 | 1 | BA1 | BG** | 0.9738 | 0.5864 | -0.2905 | 15 | 52.9351 | 6.8765 | 47.2866 | 0.9985 | 0.1299 |
| 1 | 3998 | 3 | 2 | BA4 | BG04 | 0.8006 | 0.6053 | -0.2377 | 14 | 45.7415 | 3.5012 | 12.2582 | 0.9994 | 0.0765 |
| 1 | 4007 | 1 | 1 | BA* | BS** | 0.8141 | 0.4355 | -3.0154 | 15 | 12.1330 | 4.3485 | 18.9090 | 0.9944 | 0.3584 |
| 1 | 4007 | 1 | 2 | BA* | BS** | 1.3948 | 0.2649 | -2.8767 | 15 | 17.6589 | 2.3832 | 5.6795 | 0.9994 | 0.1350 |
| 1 | 4007 | 2 | 1 | BA* | BG** | 0.9494 | 0.5808 | -0.1435 | 15 | 57.4057 | 7.0918 | 50.2932 | 0.9985 | 0.1235 |
| 1 | 4007 | 2 | 2 | BA* | BG** | 0.8383 | 0.5634 | 0.0000 | 15 | 54.5472 | 10.8640 | 118.0265 | 0.9959 | 0.1992 |
| 1 | 4007 | 3 | 1 | BA* | BG** | 1.3816 | 0.5590 | 0.0000 | 15 | 91.1401 | 12.7308 | 162.0725 | 0.9979 | 0.1397 |
| 1 | 4007 | 3 | 2 | BA* | BG** | 0.9497 | 0.7222 | 0.0000 | 15 | 94.7404 | 13.2385 | 175.2568 | 0.9969 | 0.1397 |
| 1 | 4073 | 1 | 1 | BA* | BS** | 0.9002 | 0.1355 | -0.2725 | 15 | 6.4609 | 5.2374 | 27.4301 | 0.9968 | 0.8106 |
| 1 | 4073 | 1 | 2 | A2 | TS03 | 0.7229 | 0.1997 | 0.0000 | 15 | 16.3509 | 15.4884 | 239.8912 | 0.9618 | 0.9473 |
| 1 | 4073 | 3 | 1 | BA* | BG** | 0.9836 | 0.2466 | 0.0000 | 15 | 84.1259 | 81.9652 | 6718.2890 | 0.7186 | 0.9743 |
| 1 | 4073 | 3 | 2 | BA* | BG** | 0.8174 | 0.7952 | -0.1003 | 15 | 90.1776 | 6.7010 | 44.9029 | 0.9990 | 0.0743 |
| 1 | 4084 | 1 | 1 | A1 | TS01 | 0.8795 | 0.1582 | -0.4664 | 15 | 5.0256 | 2.5857 | 6.6857 | 0.9991 | 0.5145 |
| 1 | 4084 | 1 | 2 | BA* | BS** | 1.0375 | 0.2973 | -0.5501 | 15 | 10.1901 | 4.1911 | 17.5656 | 0.9984 | 0.4113 |
| 1 | 4084 | 2 | 1 | BA* | BG** | 0.5990 | 0.7892 | -0.1143 | 15 | 63.8606 | 3.1233 | 9.7553 | 0.9996 | 0.0489 |
| 1 | 4084 | 2 | 2 | BA* | BG** | 0.7972 | 0.5885 | 0.0000 | 15 | 69.4017 | 50.4695 | 2547.1710 | 0.9121 | 0.7272 |
| 1 | 4084 | 3 | 1 | BA* | BG** | 0.6778 | 0.7146 | 0.0000 | 15 | 64.6516 | 9.1687 | 84.0648 | 0.9970 | 0.1418 |
| 1 | 4084 | 3 | 2 | BA* | BG** | 0.7800 | 0.8275 | -0.0167 | 15 | 97.7705 | 5.2889 | 27.9730 | 0.9995 | 0.0541 |
| 1 | 4125 | 1 | 1 | BA* | BS** | 0.8059 | 0.1801 | -0.3696 | 15 | 7.6389 | 6.1378 | 37.6726 | 0.9944 | 0.8035 |
| 1 | 4125 | 1 | 2 | BA* | BS** | 1.1292 | 0.2901 | -1.0669 | 15 | 10.8659 | 4.6570 | 21.6877 | 0.9980 | 0.4286 |
| 1 | 4125 | 2 | 1 | BA* | BG** | 0.8139 | 0.6263 | -0.1825 | 15 | 53.9916 | 5.5835 | 31.1760 | 0.9989 | 0.1034 |
| 1 | 4125 | 2 | 2 | BA* | BG** | 1.1805 | 0.5535 | -0.7258 | 15 | 43.2580 | 15.0289 | 225.8680 | 0.9924 | 0.3474 |
| 1 | 4126 | 1 | 1 | A1 | TS01 | 0.7751 | 0.2980 | -1.6994 | 15 | 8.9400 | 4.5929 | 21.0945 | 0.9951 | 0.5137 |
| 1 | 4126 | 1 | 2 | BA* | BS** | 0.7809 | 0.4647 | -1.1358 | 15 | 10.8483 | 3.5572 | 12.6540 | 0.9977 | 0.3279 |
| 1 | 4126 | 2 | 1 | BA* | BG** | 1.0471 | 0.6218 | 0.0000 | 15 | 80.4536 | 7.2282 | 52.2470 | 0.9990 | 0.0898 |
| 1 | 4126 | 2 | 2 | BA* | BG** | 0.6490 | 0.7825 | 0.0000 | 15 | 73.9168 | 7.9356 | 62.9744 | 0.9980 | 0.1074 |
| 1 | 4127 | 1 | 1 | A1 | TS01 | 1.1422 | 0.3306 | -2.7938 | 15 | 14.2538 | 2.6335 | 6.9355 | 0.9990 | 0.1848 |
| 1 | 4127 | 1 | 2 | BA* | BS** | 1.3265 | 0.0829 | -1.7482 | 15 | 13.6162 | 6.0374 | 36.4507 | 0.9969 | 0.4434 |
| 1 | 4127 | 2 | 1 | BA* | BG** | 0.7026 | 0.7705 | 0.0000 | 15 | 77.0454 | 8.5414 | 72.9563 | 0.9980 | 0.1109 |
| 1 | 4127 | 2 | 2 | BA* | BG** | 0.5337 | 0.7125 | 0.0000 | 15 | 52.2137 | 16.6248 | 276.3824 | 0.9845 | 0.3184 |
| 1 | 4129 | 1 | 1 | BA* | BS** | 1.1543 | 0.3027 | -2.8987 | 15 | 15.1453 | 3.7856 | 14.3305 | 0.9979 | 0.2499 |
| 1 | 4129 | 1 | 2 | TP1 | BS55 | 0.8461 | 0.1659 | -0.9872 | 15 | 7.4661 | 5.4494 | 29.6957 | 0.9951 | 0.7299 |
| 1 | 4129 | 2 | 2 | TP1 | BG56 | 0.8022 | 0.8315 | -0.6935 | 15 | 62.8943 | 5.7104 | 32.6087 | 0.9989 | 0.0908 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4129 | 3 | 1 | BA* | BG** | 1.1371 | 0.6745 | 0.0000 | 15 | 100.0928 | 7.6607 | 58.6858 | 0.9992 | 0.0765 |
| 1 | 4129 | 3 | 2 | TP1 | BG55 | 1.0055 | 0.6922 | 0.0000 | 15 | 91.2690 | 10.4864 | 109.9647 | 0.9981 | 0.1149 |
| 1 | 4155 | 1 | 1 | BA* | BS** | 1.0195 | 0.7429 | -0.7080 | 15 | 28.4700 | 15.6947 | 246.3234 | 0.9799 | 0.5513 |
| 1 | 4155 | 1 | 2 | A2 | TS03 | 2.0801 | 0.4302 | -2.2159 | 15 | 26.3755 | 5.4274 | 29.4568 | 0.9989 | 0.2058 |
| 1 | 4155 | 2 | 1 | BA* | BG** | 1.2935 | 0.5532 | 0.0000 | 15 | 84.6003 | 16.1815 | 261.8409 | 0.9961 | 0.1913 |
| 1 | 4155 | 2 | 2 | BA* | BG** | 1.1041 | 0.6834 | -0.0930 | 15 | 92.5873 | 6.6830 | 44.6630 | 0.9993 | 0.0722 |
| 1 | 5008 | 1 | 1 | A1 | TS01 | 1.0711 | 0.2380 | -3.5698 | 15 | 16.1103 | 5.9652 | 35.5836 | 0.9927 | 0.3703 |
| 1 | 5008 | 1 | 2 | A2 | TS03 | 0.7008 | 0.3522 | -1.7352 | 15 | 8.1650 | 3.1471 | 9.9044 | 0.9972 | 0.3854 |
| 1 | 6012 | 1 | 1 | A1 | TS01 | 0.6492 | 0.3830 | -0.5643 | 15 | 8.5206 | 3.4496 | 11.8995 | 0.9973 | 0.4049 |
| 1 | 6012 | 1 | 2 | A2 | TS03 | 0.7752 | 0.5601 | -1.7078 | 15 | 11.9012 | 3.1382 | 9.8480 | 0.9979 | 0.2637 |
| 1 | 6012 | 2 | 1 | BA* | BG** | 0.8778 | 0.5954 | -0.1138 | 15 | 57.2686 | 4.1081 | 16.8766 | 0.9995 | 0.0717 |
| 1 | 6012 | 2 | 2 | TP1 | BG55 | 1.0494 | 0.7489 | -0.4188 | 15 | 80.4753 | 15.7269 | 247.3352 | 0.9952 | 0.1954 |
| 1 | 6019 | 1 | 1 | A1 | TS01 | 0.7928 | 0.3903 | -0.9354 | 15 | 9.8595 | 3.9358 | 15.4902 | 0.9973 | 0.3992 |
| 1 | 6019 | 1 | 2 | BA* | BS** | 0.8190 | 0.4979 | -0.6530 | 15 | 12.7906 | 2.6269 | 6.9006 | 0.9990 | 0.2054 |
| 1 | 6019 | 2 | 1 | BA* | BG** | 0.7012 | 0.7925 | -0.3774 | 15 | 61.9985 | 3.7865 | 14.3375 | 0.9995 | 0.0611 |
| 1 | 6019 | 2 | 2 | BA* | BG** | 0.8196 | 0.6743 | -0.2775 | 15 | 57.5630 | 5.5761 | 31.0933 | 0.9989 | 0.0969 |
| 4 | 0114 | 1 | 2 | B309 | BS09 | 1.3826 | 0.2588 | -1.5020 | 15 | 12.2991 | 1.9360 | 3.7482 | 0.9997 | 0.1574 |
| 4 | 0115 | 1 | 2 | B303 | BS03 | 0.9022 | 0.5984 | -2.0181 | 15 | 14.4413 | 3.1117 | 9.6824 | 0.9983 | 0.2155 |
| 4 | 0213 | 1 | 2 | B311 | BS11 | 0.8746 | 0.5885 | -2.1306 | 15 | 13.6249 | 2.7469 | 7.5452 | 0.9986 | 0.2016 |
| 4 | 0216 | 1 | 2 | B306 | BS06 | 0.9361 | 0.5105 | -1.9370 | 15 | 13.0978 | 2.5639 | 6.5734 | 0.9989 | 0.1957 |
| 4 | 0217 | 1 | 2 | B309 | BS09 | 0.7398 | 0.6783 | -1.8964 | 15 | 13.2388 | 2.6095 | 6.8093 | 0.9984 | 0.1971 |
| 4 | 0222 | 1 | 2 | B303 | BS03 | 0.9586 | 0.6219 | -2.2077 | 14 | 15.2084 | 1.9614 | 3.8471 | 0.9994 | 0.1290 |
| 4 | 0223 | 1 | 2 | B308 | BS08 | 0.8278 | 0.7128 | -1.8388 | 14 | 16.0995 | 3.0501 | 9.3029 | 0.9983 | 0.1895 |
| 4 | 0608 | 1 | 2 | B* | BS** | 0.6853 | 0.4443 | -1.5710 | 15 | 8.7977 | 2.7190 | 7.3927 | 0.9980 | 0.3091 |
| 4 | 1001 | 1 | 1 | BA* | BS** | 0.4998 | 0.4101 | -1.1300 | 15 | 5.9936 | 1.5315 | 2.3456 | 0.9989 | 0.2555 |
| 4 | 1001 | 1 | 2 | TP1 | BS91 | 0.7853 | 0.3092 | -0.9687 | 15 | 7.4687 | 2.2560 | 5.0894 | 0.9991 | 0.3021 |
| 4 | 1003 | 1 | 1 | BA* | BS** | 0.8319 | 0.3211 | -1.1004 | 15 | 7.9000 | 1.4748 | 2.1751 | 0.9996 | 0.1867 |
| 4 | 1003 | 1 | 2 | TP1 | BS92 | 0.7813 | 0.2274 | -1.4264 | 15 | 6.6783 | 1.6462 | 2.7100 | 0.9994 | 0.2465 |
| 4 | 1006 | 1 | 1 | BA* | BS** | 0.6460 | 0.4283 | -1.5221 | 15 | 8.2016 | 2.5962 | 6.7405 | 0.9979 | 0.3166 |
| 4 | 1006 | 1 | 2 | TP1 | BS92 | 0.8157 | 0.2828 | -0.9575 | 15 | 7.1581 | 2.2317 | 4.9804 | 0.9992 | 0.3118 |
| 4 | 1006 | 2 | 2 | TP1 | BG91 | 0.4255 | 0.5981 | -0.0512 | 15 | 28.7498 | 1.3155 | 1.7306 | 0.9998 | 0.0458 |
| 4 | 1007 | 1 | 1 | BA* | BS** | 0.7197 | 0.2933 | -1.0219 | 15 | 6.8125 | 2.6900 | 7.2359 | 0.9984 | 0.3949 |
| 4 | 1007 | 1 | 2 | TP1 | BS91 | 0.6616 | 0.5148 | -1.5365 | 15 | 9.4708 | 1.8007 | 3.2424 | 0.9991 | 0.1901 |
| 4 | 1015 | 1 | 1 | BA* | BS** | 0.9300 | 0.2290 | 0.0000 | 15 | 8.3995 | 3.0906 | 9.5517 | 0.9990 | 0.3679 |
| 4 | 1015 | 1 | 2 | TP1 | BS92 | 1.0206 | 0.1451 | 0.0000 | 15 | 7.1933 | 4.7344 | 22.4147 | 0.9981 | 0.6582 |
| 4 | 1016 | 2 | 1 | BA* | BG** | 0.8553 | 0.4920 | -0.4112 | 15 | 32.5506 | 10.2399 | 104.8550 | 0.9940 | 0.3146 |
| 4 | 1017 | 1 | 1 | BA* | BS** | 1.0919 | 0.1256 | 0.0000 | 15 | 10.0247 | 8.6811 | 75.3617 | 0.9945 | 0.8660 |
| 4 | 1018 | 1 | 2 | TP1 | BS92 | 0.3435 | 0.3740 | -2.3961 | 15 | 4.2840 | 1.1042 | 1.2193 | 0.9983 | 0.2578 |
| 4 | 1018 | 2 | 1 | BA* | BG** | 1.0551 | 0.2786 | -0.1404 | 15 | 21.7065 | 1.3288 | 1.7656 | 0.9999 | 0.0612 |
| 4 | 1021 | 1 | 1 | BA* | BS** | 0.5579 | 0.6154 | -1.3122 | 15 | 9.7458 | 2.1006 | 4.4126 | 0.9984 | 0.2155 |
| 4 | 1021 | 1 | 2 | TP1 | BS92 | 0.5287 | 0.6330 | -1.6658 | 15 | 9.1766 | 2.3003 | 5.2912 | 0.9977 | 0.2507 |
| 4 | 1022 | 1 | 2 | TP1 | BS93 | 0.9034 | 0.2029 | 0.0000 | 15 | 7.0697 | 2.2604 | 5.1096 | 0.9995 | 0.3197 |
| 4 | 1024 | 1 | 1 | BA* | BS** | 1.0553 | 0.2244 | 0.0000 | 15 | 10.2502 | 5.3602 | 28.7313 | 0.9978 | 0.5229 |
| 4 | 1024 | 1 | 2 | TP1 | BS92 | 1.0418 | 0.1763 | -0.5128 | 15 | 5.7677 | 1.3073 | 1.7091 | 0.9998 | 0.2267 |
| 4 | 1024 | 2 | 1 | BA* | BG** | 1.3847 | 0.2193 | 0.0000 | 15 | 26.1743 | 6.0040 | 36.0478 | 0.9989 | 0.2294 |
| 4 | 1034 | 1 | 2 | TP1 | BS92 | 0.7936 | 0.3787 | -1.5099 | 15 | 8.9016 | 2.0526 | 4.2131 | 0.9991 | 0.2306 |
| 4 | 1036 | 1 | 2 | TP1 | BS70 | 0.7304 | 0.2685 | -0.7325 | 15 | 6.2587 | 2.2873 | 5.2318 | 0.9990 | 0.3655 |
| 4 | 1062 | 1 | 1 | BA* | BS** | 0.6933 | 0.2804 | -0.2882 | 15 | 6.8334 | 2.6882 | 7.2262 | 0.9986 | 0.3934 |
| 4 | 1065 | 1 | 1 | BA* | BS** | 0.8859 | 0.2622 | -0.4837 | 15 | 7.4782 | 2.4435 | 5.9709 | 0.9993 | 0.3268 |
| 4 | 6053 | 1 | 1 | BA* | BS** | 0.7658 | 0.3751 | -1.3903 | 15 | 8.3569 | 1.4713 | 2.1647 | 0.9995 | 0.1761 |
| 4 | 6053 | 1 | 2 | TP1 | BS92 | 0.7798 | 0.3288 | -0.6940 | 15 | 7.9809 | 2.5445 | 6.4745 | 0.9989 | 0.3188 |
| 4 | 6054 | 1 | 1 | BA* | BS** | 0.6366 | 0.5542 | -1.5157 | 15 | 9.7897 | 2.1944 | 4.8154 | 0.9986 | 0.2242 |
| 4 | 6054 | 1 | 2 | TP1 | BS92 | 0.6613 | 0.5143 | -1.2380 | 15 | 9.6204 | 2.0383 | 4.1547 | 0.9989 | 0.2119 |
| 4 | 6054 | 2 | 1 | BA* | BG** | 0.4914 | 0.5684 | -0.0938 | 15 | 29.7610 | 4.0400 | 16.3213 | 0.9982 | 0.1357 |
| 4 | 6055 | 1 | 1 | BA1 | BS63 | 0.8699 | 0.2678 | -0.5267 | 15 | 7.7263 | 3.1824 | 10.1275 | 0.9987 | 0.4119 |
| 4 | 6060 | 1 | 2 | TP1 | BS92 | 1.0603 | 0.1957 | -0.7465 | 15 | 6.7068 | 1.7628 | 3.1075 | 0.9997 | 0.2628 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 7079 | 1 | 1 | TP1 | BG92 | 0.7094 | 0.1720 | 0.0000 | 15 | 4.9828 | 2.2408 | 5.0212 | 0.9991 | 0.4497 |
| 4 | 7614 | 1 | 1 | BA* | BS** | 0.5153 | 0.6683 | -1.1108 | 15 | 10.0887 | 1.9554 | 3.8236 | 0.9985 | 0.1938 |
| 4 | 7614 | 1 | 2 | BA* | BS** | 0.5464 | 0.6406 | -1.4908 | 15 | 9.7356 | 2.2565 | 5.0919 | 0.9980 | 0.2318 |
| 5 | 0809 | 1 | 1 | A1 | TS01 | 1.1977 | 0.2272 | -1.3215 | 15 | 9.5534 | 1.3115 | 1.7199 | 0.9998 | 0.1373 |
| 5 | 0809 | 1 | 2 | B2 | BS02 | 1.0976 | 0.2637 | -1.6926 | 15 | 10.3730 | 1.5268 | 2.3312 | 0.9997 | 0.1472 |
| 5 | 0810 | 1 | 2 | B3 | BS03 | 0.7958 | 0.4785 | -1.7610 | 15 | 10.6583 | 2.0967 | 4.3962 | 0.9991 | 0.1967 |
| 5 | 3011 | 1 | 2 | A2 | TS03 | 0.8035 | 0.1570 | -0.8411 | 15 | 6.0174 | 4.0411 | 16.3302 | 0.9972 | 0.6716 |
| 5 | 3048 | 1 | 1 | A1 | TS01 | 0.5393 | 0.4559 | -4.7896 | 15 | 8.1492 | 1.5051 | 2.2654 | 0.9979 | 0.1847 |
| 5 | 3048 | 1 | 2 | A2 | TS03 | 0.7728 | 0.0727 | -0.0652 | 15 | 4.3403 | 3.9048 | 15.2474 | 0.9977 | 0.8997 |
| 5 | 3058 | 1 | 1 | A1 | TS02 | 0.7875 | 0.2825 | -3.7571 | 15 | 10.8575 | 1.4862 | 2.2089 | 0.9992 | 0.1369 |
| 5 | 3058 | 1 | 2 | A2 | TS04 | 0.5751 | 0.5593 | -1.4822 | 15 | 8.7576 | 1.4011 | 1.9631 | 0.9993 | 0.1600 |
| 5 | 3059 | 1 | 1 | A1 | TS01 | 0.7745 | 0.3783 | -0.6541 | 15 | 8.9815 | 1.3285 | 1.7650 | 0.9997 | 0.1479 |
| 5 | 3059 | 1 | 2 | A2 | TS03 | 0.6421 | 0.5358 | -0.8646 | 15 | 10.3293 | 1.8870 | 3.5607 | 0.9991 | 0.1827 |
| 5 | 3073 | 1 | 1 | BA* | BS** | 1.2130 | 0.1555 | -0.9743 | 15 | 11.1471 | 8.3210 | 69.2397 | 0.9945 | 0.7465 |
| 5 | 3073 | 1 | 2 | A2 | TS03 | 1.7246 | 0.4174 | -1.9475 | 15 | 20.9955 | 3.3692 | 11.3516 | 0.9994 | 0.1605 |
| 5 | 3073 | 2 | 2 | BA* | BG** | 0.7711 | 0.5753 | -0.0042 | 15 | 51.6329 | 3.3592 | 11.2845 | 0.9996 | 0.0651 |
| 5 | 3073 | 3 | 2 | BA* | BG** | 0.9091 | 0.6159 | -0.5333 | 15 | 44.9817 | 8.4644 | 71.6458 | 0.9970 | 0.1882 |
| 5 | 3074 | 1 | 1 | A1 | TS01 | 0.5447 | 0.4050 | -3.2925 | 15 | 7.6239 | 2.2466 | 5.0474 | 0.9966 | 0.2947 |
| 5 | 3074 | 1 | 2 | A2 | TS03 | 0.6514 | 0.3682 | -2.2002 | 15 | 8.1929 | 3.0916 | 9.5578 | 0.9965 | 0.3773 |
| 5 | 4019 | 1 | 1 | A1 | TS01 | 0.5482 | 0.4429 | -0.8866 | 15 | 7.3601 | 1.6951 | 2.8734 | 0.9990 | 0.2303 |
| 5 | 4019 | 1 | 2 | A2 | TS03 | 0.4647 | 0.4165 | -0.4198 | 15 | 6.4343 | 1.2036 | 1.4486 | 0.9994 | 0.1871 |
| 5 | 4019 | 2 | 1 | BA* | BG** | 0.5626 | 0.6400 | -0.0409 | 15 | 43.5697 | 2.2207 | 4.9314 | 0.9997 | 0.0510 |
| 5 | 4019 | 2 | 2 | BA* | BG** | 0.6635 | 0.6286 | -0.2518 | 15 | 42.0982 | 3.3810 | 11.4309 | 0.9993 | 0.0803 |
| 5 | 4021 | 1 | 1 | A1 | TS01 | 0.5824 | 0.0000 | -0.7731 | 15 | 7.4661 | 6.9580 | 48.4139 | 0.9841 | 0.9319 |
| 5 | 4021 | 1 | 2 | A2 | TS03 | 0.9402 | 0.4058 | -3.6363 | 15 | 13.8192 | 4.1893 | 17.5499 | 0.9956 | 0.3031 |
| 5 | 4021 | 2 | 1 | BA* | BG** | 0.9836 | 0.6125 | -0.3278 | 15 | 56.0750 | 7.3651 | 54.2453 | 0.9984 | 0.1313 |
| 5 | 4021 | 2 | 2 | BA* | BG** | 0.9931 | 0.6600 | -0.3497 | 15 | 63.3222 | 8.7766 | 77.0290 | 0.9980 | 0.1386 |
| 5 | 4021 | 3 | 1 | BA1 | BG01 | 0.8281 | 0.5985 | 0.0000 | 15 | 60.2221 | 5.7339 | 32.8770 | 0.9989 | 0.0952 |
| 5 | 4021 | 3 | 2 | BA* | BG** | 1.0234 | 0.6369 | -0.0277 | 15 | 79.9328 | 3.0210 | 9.1261 | 0.9998 | 0.0378 |
| 5 | 4023 | 1 | 2 | A2 | TS03 | 0.4008 | 0.0827 | -3.4340 | 15 | 5.6273 | 2.6811 | 7.1881 | 0.9909 | 0.4764 |
| 5 | 4046 | 1 | 1 | A1 | TS01 | 0.6732 | 0.1544 | -1.9907 | 15 | 6.6833 | 2.0732 | 4.2980 | 0.9985 | 0.3102 |
| 5 | 4046 | 1 | 2 | A2 | TS03 | 0.8173 | 0.2922 | -3.8799 | 15 | 11.5293 | 1.5947 | 2.5429 | 0.9991 | 0.1383 |
| 5 | 5803 | 1 | 1 | BA* | BS** | 0.6256 | 0.1622 | 0.0000 | 15 | 5.4467 | 4.0120 | 16.0961 | 0.9964 | 0.7366 |
| 5 | 5803 | 1 | 2 | BA* | BS** | 0.7263 | 0.2834 | -0.1316 | 15 | 7.5957 | 2.7507 | 7.5666 | 0.9988 | 0.3621 |
| 5 | 5803 | 2 | 2 | BA* | BG** | 0.8995 | 0.5434 | -0.7994 | 15 | 30.2501 | 10.1542 | 103.1070 | 0.9935 | 0.3357 |
| 5 | 5805 | 1 | 1 | BA* | BS** | 1.6165 | 0.3330 | -1.6501 | 15 | 16.8797 | 3.4987 | 12.2411 | 0.9994 | 0.2073 |
| 5 | 5805 | 1 | 2 | BA* | BS** | 0.6384 | 0.2468 | 0.0000 | 15 | 7.3310 | 4.5288 | 20.5105 | 0.9958 | 0.6178 |
| 6 | 1253 | 1 | 1 | BA* | BS** | 0.8830 | 0.2074 | 0.0000 | 15 | 8.3341 | 5.0314 | 25.3147 | 0.9972 | 0.6037 |
| 6 | 2002 | 1 | 1 | BA* | BS** | 0.5407 | 0.4460 | -1.4504 | 15 | 6.8813 | 1.6833 | 2.8334 | 0.9988 | 0.2446 |
| 6 | 2004 | 1 | 1 | BA* | BS** | 0.5721 | 0.4024 | -2.1477 | 15 | 7.3549 | 2.4186 | 5.8499 | 0.9972 | 0.3288 |
| 6 | 2004 | 2 | 1 | BA* | BG** | 0.4943 | 0.6108 | -0.1061 | 15 | 33.3267 | 2.5404 | 6.4536 | 0.9994 | 0.0762 |
| 6 | 2004 | 2 | 2 | TP1 | BG91 | 0.5026 | 0.6098 | -0.0964 | 15 | 34.1735 | 1.8080 | 3.2689 | 0.9997 | 0.0529 |
| 6 | 2038 | 1 | 1 | BA* | BS** | 0.4972 | 0.6936 | -2.3137 | 15 | 8.8919 | 1.8030 | 3.2507 | 0.9981 | 0.2028 |
| 6 | 2038 | 1 | 2 | TP1 | BS92 | 0.6524 | 0.5741 | -2.5869 | 15 | 10.1151 | 2.1687 | 4.7034 | 0.9982 | 0.2144 |
| 6 | 2051 | 1 | 2 | TP1 | BG55 | 1.0052 | 0.1877 | 0.0000 | 15 | 7.7662 | 3.5491 | 12.5962 | 0.9989 | 0.4570 |
| 6 | 2053 | 1 | 1 | A1 | TS01 | 0.8825 | 0.1566 | -0.2485 | 15 | 4.6260 | 1.5040 | 2.2621 | 0.9997 | 0.3251 |
| 6 | 2647 | 2 | 1 | BA* | BG** | 0.5444 | 0.5276 | -0.1809 | 15 | 27.2446 | 4.3768 | 19.1567 | 0.9980 | 0.1607 |
| 6 | 3010 | 1 | 2 | BA* | BS** | 1.3127 | 0.2247 | 0.0000 | 15 | 14.8622 | 10.1830 | 103.6940 | 0.9949 | 0.6852 |
| 6 | 3013 | 1 | 1 | BA* | BS** | 0.8532 | 0.2000 | -0.5983 | 15 | 5.7296 | 2.4640 | 6.0711 | 0.9991 | 0.4300 |
| 6 | 3013 | 1 | 2 | BA* | BS** | 0.4936 | 0.6305 | -1.0905 | 15 | 9.0275 | 1.4499 | 2.1021 | 0.9991 | 0.1606 |
| 6 | 3019 | 1 | 1 | BA* | BS** | 0.7663 | 0.4057 | -0.2891 | 15 | 10.4449 | 1.4168 | 2.0072 | 0.9997 | 0.1356 |
| 6 | 3019 | 1 | 2 | BA* | BS** | 0.7604 | 0.2688 | -1.5229 | 15 | 7.2058 | 2.1095 | 4.4500 | 0.9990 | 0.2927 |
| 6 | 3019 | 2 | 1 | BA* | BG** | 0.5335 | 0.5526 | -0.1776 | 15 | 28.8139 | 3.7393 | 13.9823 | 0.9985 | 0.1298 |
| 6 | 3019 | 2 | 2 | BA* | BG** | 1.0167 | 0.2303 | -0.2524 | 15 | 14.1596 | 4.1284 | 17.0438 | 0.9989 | 0.2916 |
| 6 | 3021 | 1 | 1 | BA* | BS** | 0.5388 | 0.5868 | -1.5125 | 15 | 8.7723 | 2.0862 | 4.3521 | 0.9982 | 0.2378 |
| 6 | 3021 | 1 | 2 | BA* | BS** | 0.5064 | 0.6617 | -1.0518 | 15 | 9.8043 | 1.9581 | 3.8342 | 0.9985 | 0.1997 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 3021 | 2 | 1 | BA* | BG** | 0.4928 | 0.6465 | -0.2440 | 15 | 32.9003 | 2.5309 | 6.4056 | 0.9994 | 0.0769 |
| 6 | 3021 | 2 | 2 | BA* | BG** | 0.5105 | 0.5973 | -0.2913 | 15 | 28.6124 | 4.7970 | 23.0112 | 0.9974 | 0.1677 |
| 6 | 3024 | 1 | 1 | BA* | BS** | 0.5822 | 0.5992 | -1.2084 | 15 | 9.9676 | 2.4363 | 5.9355 | 0.9981 | 0.2444 |
| 6 | 3024 | 1 | 2 | BA* | BS** | 0.7776 | 0.2866 | -1.3810 | 15 | 7.5612 | 2.8038 | 7.8610 | 0.9983 | 0.3708 |
| 6 | 3030 | 1 | 1 | BA* | BS** | 0.8068 | 0.1653 | -1.0192 | 15 | 5.8611 | 2.9328 | 8.6010 | 0.9984 | 0.5004 |
| 6 | 3030 | 1 | 2 | BA* | BS** | 0.9139 | 0.1248 | -0.9845 | 15 | 6.0340 | 2.8551 | 8.1513 | 0.9988 | 0.4732 |
| 6 | 3042 | 1 | 1 | A1 | TS01 | 0.6981 | 0.2199 | -0.9301 | 15 | 5.3745 | 2.4178 | 5.8458 | 0.9986 | 0.4499 |
| 6 | 3042 | 1 | 2 | A2 | TS03 | 0.9515 | 0.2904 | -0.8062 | 15 | 8.4724 | 2.3378 | 5.4654 | 0.9993 | 0.2759 |
| 6 | 6044 | 1 | 1 | BA* | BS** | 0.9247 | 0.1324 | 0.0000 | 15 | 5.4406 | 3.0952 | 9.5801 | 0.9990 | 0.5689 |
| 6 | 6044 | 1 | 2 | TP1 | BS93 | 0.7369 | 0.1989 | -2.3643 | 15 | 8.2537 | 1.3385 | 1.7916 | 0.9994 | 0.1622 |
| 6 | 7452 | 1 | 2 | A2 | TS03 | 0.6432 | 0.3418 | -1.2512 | 15 | 6.7767 | 2.2228 | 4.9408 | 0.9985 | 0.3280 |
| 6 | 7455 | 1 | 1 | BA1 | BS01 | 0.8728 | 0.1182 | 0.0000 | 15 | 4.6547 | 2.7182 | 7.3885 | 0.9991 | 0.5840 |
| 6 | 7456 | 1 | 2 | A2 | TS03 | 0.8811 | 0.0643 | -0.4024 | 15 | 2.4339 | 0.8551 | 0.7311 | 0.9999 | 0.3513 |
| 6 | 7493 | 1 | 1 | BA* | BS** | 0.5549 | 0.6356 | -1.0915 | 15 | 10.2181 | 1.9574 | 3.8316 | 0.9987 | 0.1916 |
| 6 | 8149 | 1 | 2 | TP1 | BS91 | 0.9513 | 0.1694 | -0.1897 | 15 | 5.8538 | 2.5974 | 6.7465 | 0.9993 | 0.4437 |
| 6 | 8150 | 1 | 2 | TP1 | BS92 | 0.4707 | 0.6219 | -1.1504 | 15 | 8.4080 | 1.6630 | 2.7654 | 0.9987 | 0.1978 |
| 6 | 8150 | 2 | 1 | BA* | BG** | 0.4453 | 0.6237 | -0.1413 | 15 | 30.1870 | 2.5970 | 6.7446 | 0.9992 | 0.0860 |
| 6 | 8151 | 1 | 2 | TP1 | BS91 | 0.5315 | 0.5758 | -0.8936 | 15 | 9.1063 | 1.2846 | 1.6502 | 0.9994 | 0.1411 |
| 6 | 8153 | 1 | 1 | BA* | BS** | 0.7594 | 0.1639 | -0.7032 | 15 | 4.4315 | 1.7877 | 3.1959 | 0.9994 | 0.4034 |
| 6 | 8153 | 1 | 2 | TP1 | BS94 | 0.6883 | 0.1763 | -2.0942 | 15 | 7.0488 | 0.9471 | 0.8969 | 0.9997 | 0.1344 |
| 6 | 8153 | 1 | 3 | TP1 | BG93 | 1.1350 | 0.1914 | -0.3936 | 15 | 10.6225 | 4.4039 | 19.3948 | 0.9988 | 0.4146 |
| 6 | 8153 | 2 | 2 | TP1 | BG93 | 0.4428 | 0.5861 | -0.0425 | 15 | 29.6008 | 1.1971 | 1.4332 | 0.9998 | 0.0404 |
| 6 | 8153 | 2 | 3 | TP1 | BG93 | 1.1350 | 0.1914 | -0.3936 | 15 | 10.6225 | 4.4039 | 19.3948 | 0.9988 | 0.4146 |
| 6 | 8153 | 3 | 2 | TP1 | BG92 | 0.4420 | 0.5875 | -0.0444 | 15 | 29.5751 | 1.1627 | 1.3520 | 0.9998 | 0.0393 |
| 6 | 8201 | 1 | 1 | BA* | BS** | 0.5413 | 0.5647 | -1.9937 | 15 | 8.5161 | 2.6525 | 7.0357 | 0.9966 | 0.3115 |
| 6 | 8201 | 1 | 2 | TP1 | BS92 | 0.6662 | 0.3175 | 0.0000 | 15 | 8.0593 | 1.9978 | 3.9911 | 0.9993 | 0.2479 |
| 6 | 8201 | 2 | 2 | TP1 | BG91 | 0.5414 | 0.6000 | -0.2937 | 15 | 30.4806 | 4.0225 | 16.1808 | 0.9984 | 0.1320 |
| 6 | 8202 | 1 | 1 | BA* | BS** | 0.4824 | 0.7120 | -1.1406 | 15 | 9.9833 | 1.5382 | 2.3662 | 0.9990 | 0.1541 |
| 6 | 8202 | 1 | 2 | TP1 | BS91 | 0.3727 | 0.5896 | -1.0324 | 15 | 6.6640 | 2.0966 | 4.3955 | 0.9967 | 0.3146 |
| 6 | 8534 | 1 | 1 | BA* | BS** | 0.7072 | 0.2134 | -1.4977 | 15 | 5.9096 | 0.5461 | 0.2982 | 0.9999 | 0.0924 |
| 6 | 8534 | 1 | 2 | TP1 | BS93 | 0.4252 | 0.3246 | -2.6240 | 15 | 5.2915 | 1.2751 | 1.6259 | 0.9984 | 0.2410 |
| 6 | 8534 | 2 | 2 | TP1 | BG92 | 0.5610 | 0.5810 | -0.0542 | 15 | 36.5819 | 1.4494 | 2.1009 | 0.9998 | 0.0396 |
| 6 | 8535 | 1 | 1 | A1 | TS01 | 0.5029 | 0.3376 | -1.9250 | 15 | 5.5908 | 1.4715 | 2.1653 | 0.9987 | 0.2632 |
| 6 | 8535 | 1 | 2 | A2 | TS03 | 0.5417 | 0.3562 | -1.3171 | 15 | 5.7005 | 1.3056 | 1.7045 | 0.9993 | 0.2290 |
| 6 | 9048 | 1 | 1 | BA* | BS** | 0.5375 | 0.6285 | -1.3856 | 15 | 9.4481 | 2.1530 | 4.6355 | 0.9982 | 0.2279 |
| 6 | 9048 | 1 | 2 | BA* | BS** | 0.5465 | 0.6292 | -1.3501 | 15 | 9.8377 | 2.8307 | 8.0129 | 0.9970 | 0.2877 |
| 6 | 9049 | 1 | 1 | A1 | TS01 | 0.7127 | 0.1235 | -0.9651 | 15 | 4.0178 | 0.4537 | 0.2059 | 1.0000 | 0.1129 |
| 6 | 9049 | 1 | 2 | A2 | TS03 | 0.7360 | 0.1862 | -1.2697 | 15 | 5.4746 | 1.1072 | 1.2259 | 0.9997 | 0.2022 |
| 8 | 0214 | 1 | 2 | B2 | BG02 | 1.1189 | 0.3250 | -2.0816 | 14 | 12.3003 | 2.1884 | 4.7892 | 0.9994 | 0.1779 |
| 8 | 0217 | 1 | 2 | B4 | BG04 | 1.3112 | 0.1767 | -1.4419 | 15 | 10.2377 | 1.1300 | 1.2770 | 0.9999 | 0.1104 |
| 8 | 0219 | 1 | 2 | B3 | BG03 | 1.3788 | 0.2140 | -1.6695 | 15 | 12.2618 | 1.6644 | 2.7703 | 0.9998 | 0.1357 |
| 8 | 0221 | 1 | 2 | B6 | BG06 | 0.9585 | 0.1916 | -2.3908 | 15 | 10.6023 | 0.9962 | 0.9925 | 0.9998 | 0.0940 |
| 8 | 0223 | 1 | 2 | B7 | BG07 | 0.6255 | 0.7108 | -0.9095 | 14 | 13.8320 | 1.6283 | 2.6513 | 0.9994 | 0.1177 |
| 8 | 0224 | 1 | 2 | B5 | BG05 | 1.2216 | 0.2435 | -1.5363 | 15 | 10.7491 | 1.4619 | 2.1371 | 0.9998 | 0.1360 |
| 8 | 0501 | 1 | 1 | B* | BS** | 1.1849 | 0.2166 | -1.2534 | 15 | 9.0370 | 1.0671 | 1.1387 | 0.9999 | 0.1181 |
| 8 | 0505 | 1 | 1 | TP2 | BS91 | 1.3927 | 0.2213 | -0.9915 | 15 | 9.7688 | 0.9878 | 0.9757 | 0.9999 | 0.1011 |
| 8 | 0508 | 1 | 1 | B* | BS** | 0.9520 | 0.1973 | -2.2349 | 15 | 10.0915 | 1.3494 | 1.8208 | 0.9997 | 0.1337 |
| 8 | 1029 | 1 | 1 | A1 | TS01 | 0.9247 | 0.2617 | -0.2430 | 15 | 8.4363 | 2.9342 | 8.6097 | 0.9991 | 0.3478 |
| 8 | 1029 | 1 | 1 | BA* | BS** | 0.5784 | 0.2836 | -1.3818 | 15 | 5.3301 | 1.4073 | 1.9804 | 0.9992 | 0.2640 |
| 8 | 1029 | 1 | 2 | TP1 | BS93 | 0.4591 | 0.6161 | -1.8004 | 15 | 7.6083 | 1.8823 | 3.5430 | 0.9978 | 0.2474 |
| 8 | 1047 | 1 | 1 | A1 | TS01 | 0.8582 | 0.2892 | -2.0809 | 15 | 9.2864 | 1.6277 | 2.6493 | 0.9994 | 0.1753 |
| 8 | 1047 | 1 | 1 | BA* | BS** | 0.9428 | 0.1879 | -0.1674 | 15 | 6.1085 | 1.5757 | 2.4828 | 0.9997 | 0.2579 |
| 8 | 1047 | 1 | 2 | TP1 | BS94 | 0.8107 | 0.1773 | -1.0178 | 15 | 5.3966 | 1.3862 | 1.9216 | 0.9997 | 0.2569 |
| 8 | 1047 | 2 | 2 | TP1 | BS94 | 0.8763 | 0.1689 | -0.6857 | 15 | 7.6830 | 4.4079 | 19.4298 | 0.9973 | 0.5737 |
| 8 | 1053 | 1 | 2 | A2 | JS03 | 0.5975 | 0.3772 | -1.4540 | 15 | 6.5444 | 1.0662 | 1.1369 | 0.9996 | 0.1629 |
| 8 | 1053 | 1 | 2 | TP1 | BS93 | 0.7768 | 0.1609 | -1.4560 | 15 | 6.2503 | 1.3835 | 1.9141 | 0.9996 | 0.2213 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 1057 | 1 | 2 | A2 | TS03 | 0.3642 | 0.3101 | -3.3758 | 15 | 5.0775 | 1.3795 | 1.9029 | 0.9969 | 0.2717 |
| 8 | 1057 | 1 | 2 | TP1 | BG93 | 0.6293 | 0.3166 | -1.8557 | 15 | 6.7153 | 1.2149 | 1.4759 | 0.9995 | 0.1809 |
| 8 | 2008 | 1 | 1 | A1 | TS01 | 0.6497 | 0.3169 | -3.1272 | 15 | 8.5790 | 1.4344 | 2.0575 | 0.9990 | 0.1672 |
| 8 | 2008 | 1 | 1 | BA* | BS** | 0.6313 | 0.1892 | -1.2603 | 15 | 4.9058 | 1.7088 | 2.9201 | 0.9991 | 0.3483 |
| 8 | 2008 | 1 | 2 | TP1 | BS93 | 0.6182 | 0.1704 | -0.9772 | 15 | 4.2235 | 1.8128 | 3.2863 | 0.9990 | 0.4292 |
| 8 | 2008 | 2 | 2 | TP1 | BG92 | 1.3752 | 0.2144 | 0.0000 | 15 | 24.9279 | 4.2035 | 17.6696 | 0.9995 | 0.1686 |
| 8 | 6002 | 1 | 1 | A1 | TS01 | 0.8081 | 0.1188 | -1.0092 | 15 | 5.0351 | 1.9369 | 3.7515 | 0.9993 | 0.3847 |
| 8 | 6002 | 1 | 1 | BA* | BS** | 0.6856 | 0.1867 | -2.6215 | 15 | 8.1211 | 0.9616 | 0.9247 | 0.9996 | 0.1184 |
| 8 | 6002 | 1 | 2 | A2 | TS03 | 0.6370 | 0.1238 | -1.4454 | 15 | 5.0803 | 1.4370 | 2.0649 | 0.9993 | 0.2829 |
| 8 | 6002 | 1 | 2 | TP1 | BS92 | 0.7331 | 0.1433 | -0.7818 | 15 | 3.9857 | 1.2319 | 1.5176 | 0.9997 | 0.3091 |
| 8 | 6013 | 1 | 1 | BA* | BS** | 0.6407 | 0.3661 | -0.3677 | 15 | 7.8237 | 2.1590 | 4.6613 | 0.9990 | 0.2760 |
| 8 | 6013 | 1 | 2 | TP1 | BS93 | 1.1514 | 0.2051 | 0.0000 | 15 | 9.4315 | 3.7882 | 14.3503 | 0.9991 | 0.4017 |
| 8 | 6013 | 2 | 1 | BA* | BG** | 0.5359 | 0.5580 | -0.0894 | 15 | 31.8523 | 1.9124 | 3.6571 | 0.9997 | 0.0600 |
| 8 | 6013 | 2 | 2 | TP1 | BG** | 0.5387 | 0.5594 | -0.0662 | 15 | 32.7039 | 2.0364 | 4.1469 | 0.9996 | 0.0623 |
| 8 | 7035 | 1 | 1 | BA* | BS** | 0.6074 | 0.3382 | -2.7277 | 15 | 7.6669 | 1.2863 | 1.6546 | 0.9992 | 0.1678 |
| 8 | 7035 | 1 | 2 | A2 | TS04 | 0.5484 | 0.2235 | -1.7124 | 15 | 5.3745 | 2.0893 | 4.3652 | 0.9979 | 0.3887 |
| 8 | 7035 | 1 | 2 | BA* | BS** | 0.6203 | 0.1806 | -1.0651 | 15 | 4.4668 | 1.7725 | 3.1418 | 0.9990 | 0.3968 |
| 8 | 7035 | 2 | 1 | BA* | BG** | 0.4811 | 0.5986 | -0.0881 | 15 | 31.9707 | 1.6310 | 2.6602 | 0.9997 | 0.0510 |
| 8 | 7035 | 3 | 1 | BA* | BG** | 0.4806 | 0.5932 | -0.0714 | 15 | 31.7352 | 2.3839 | 5.6831 | 0.9994 | 0.0751 |
| 8 | 7035 | 3 | 2 | BA* | BG** | 0.7105 | 0.4240 | -0.2531 | 15 | 23.7531 | 3.3991 | 11.5540 | 0.9990 | 0.1431 |
| 8 | 7036 | 1 | 1 | A1 | TS01 | 0.3881 | 0.5582 | -2.8959 | 15 | 6.0929 | 1.7446 | 3.0437 | 0.9963 | 0.2863 |
| 8 | 7036 | 1 | 1 | BA* | BS** | 0.7979 | 0.2077 | 0.0000 | 15 | 6.1412 | 0.8793 | 0.7732 | 0.9999 | 0.1432 |
| 8 | 7036 | 1 | 2 | A2 | TS03 | 0.4793 | 0.3088 | -2.6789 | 15 | 5.9745 | 1.3679 | 1.8710 | 0.9985 | 0.2289 |
| 8 | 7036 | 1 | 2 | BA* | BS** | 0.7042 | 0.2395 | -1.0344 | 15 | 5.5403 | 1.7052 | 2.9077 | 0.9993 | 0.3078 |
| 8 | 7776 | 1 | 1 | BA* | BS** | 0.7249 | 0.3053 | -0.6783 | 15 | 6.7273 | 1.4822 | 2.1968 | 0.9996 | 0.2203 |
| 8 | 7776 | 1 | 1 | BA1 | BS01 | 0.9382 | 0.2499 | -0.7301 | 15 | 7.2585 | 1.9369 | 3.7517 | 0.9995 | 0.2669 |
| 8 | 7776 | 1 | 2 | BA* | BS** | 0.7562 | 0.2275 | -0.5597 | 15 | 5.4362 | 1.6924 | 2.8641 | 0.9995 | 0.3113 |
| 8 | 7776 | 2 | 1 | BA* | BG** | 1.0640 | 0.2134 | -0.1404 | 15 | 15.5649 | 3.2166 | 10.3466 | 0.9994 | 0.2067 |
| 8 | 7781 | 1 | 1 | A1 | TS01 | 0.6418 | 0.2204 | -0.8799 | 15 | 4.7539 | 1.7793 | 3.1659 | 0.9991 | 0.3743 |
| 8 | 7781 | 1 | 1 | BA* | BS** | 0.7049 | 0.1353 | -0.9915 | 15 | 4.6731 | 2.1478 | 4.6132 | 0.9989 | 0.4596 |
| 8 | 7781 | 1 | 2 | BA* | BS** | 0.7338 | 0.3807 | -1.6433 | 15 | 8.3478 | 1.8657 | 3.4807 | 0.9991 | 0.2235 |
| 8 | 7783 | 1 | 2 | TP1 | BS93 | 0.2536 | 0.0824 | -3.0950 | 15 | 3.7771 | 1.9410 | 3.7673 | 0.9876 | 0.5139 |
| 8 | 9019 | 1 | 1 | A1 | TS01 | 0.3696 | 0.3750 | -0.8599 | 15 | 4.1346 | 0.9031 | 0.8155 | 0.9994 | 0.2184 |
| 8 | 9019 | 1 | 1 | BA* | BS** | 0.9485 | 0.2802 | 0.0000 | 15 | 12.3508 | 7.5625 | 57.1918 | 0.9947 | 0.6123 |
| 8 | 9019 | 1 | 2 | A2 | TS03 | 0.6984 | 0.2732 | -1.9740 | 15 | 7.3140 | 1.5861 | 2.5157 | 0.9992 | 0.2169 |
| 8 | 9019 | 1 | 2 | BA* | BS** | 0.4042 | 0.5291 | -2.3357 | 15 | 6.0922 | 2.1659 | 4.6913 | 0.9955 | 0.3555 |
| 8 | 9020 | 1 | 2 | BA* | BS** | 1.0004 | 0.1542 | -0.7844 | 15 | 5.6627 | 1.8133 | 3.2881 | 0.9996 | 0.3202 |
| 9 | 4008 | 1 | 1 | BA3 | BS03 | 0.6505 | 0.3644 | 0.0000 | 15 | 9.8329 | 4.6889 | 21.9862 | 0.9958 | 0.4769 |
| 9 | 4008 | 1 | 2 | BA* | BS** | 0.5737 | 0.8205 | -0.9856 | 15 | 14.2618 | 2.4301 | 5.9052 | 0.9984 | 0.1704 |
| 9 | 4020 | 1 | 1 | BA2 | BS02 | 0.7663 | 0.7455 | -1.2817 | 15 | 16.2299 | 2.4766 | 6.1335 | 0.9989 | 0.1526 |
| 9 | 4020 | 2 | 1 | BA* | BG** | 0.5391 | 0.7107 | -0.0837 | 15 | 48.4510 | 2.8189 | 7.9459 | 0.9995 | 0.0582 |
| 9 | 5001 | 1 | 1 | BA2 | BS02 | 0.5722 | 0.7457 | 0.0000 | 15 | 19.1067 | 10.7988 | 116.6134 | 0.9767 | 0.5652 |
| 10 | 0102 | 1 | 1 | B2 | BS02 | 0.4871 | 0.5315 | -0.9233 | 15 | 7.7870 | 2.0947 | 4.3880 | 0.9981 | 0.2690 |
| 10 | 0102 | 1 | 2 | B9 | BS09 | 0.5034 | 0.5382 | -0.2964 | 15 | 9.2644 | 1.3894 | 1.9306 | 0.9994 | 0.1500 |
| 10 | 0102 | 1 | 3 | A5 | TS09 | 0.5967 | 0.5457 | -0.2679 | 15 | 11.1688 | 1.5807 | 2.4987 | 0.9994 | 0.1415 |
| 10 | 0103 | 1 | 2 | B10 | BS10 | 0.5404 | 0.5512 | -0.6219 | 15 | 9.3859 | 1.5664 | 2.4536 | 0.9992 | 0.1669 |
| 10 | 0103 | 1 | 3 | A9 | TS17 | 0.5965 | 0.5502 | -0.3580 | 15 | 10.9991 | 1.6094 | 2.5901 | 0.9994 | 0.1463 |
| 10 | 0103 | 1 | 1 | B3 | BS03 | 0.8096 | 0.1229 | -0.2659 | 15 | 3.9677 | 2.4820 | 6.1605 | 0.9991 | 0.6256 |
| 10 | 0104 | 1 | 1 | B7 | BS07 | 0.4675 | 0.6321 | -0.4759 | 15 | 9.7209 | 1.2112 | 1.4671 | 0.9994 | 0.1246 |
| 10 | 0107 | 1 | 1 | B1 | BS01 | 0.6174 | 0.4327 | -0.9619 | 15 | 8.0131 | 2.3818 | 5.6729 | 0.9984 | 0.2972 |
| 10 | 0107 | 1 | 2 | B8 | BS08 | 0.4873 | 0.5850 | -0.1576 | 15 | 10.2251 | 1.7274 | 2.9838 | 0.9990 | 0.1689 |
| 10 | 0107 | 1 | 3 | A2 | TS03 | 0.5169 | 0.5536 | 0.0000 | 15 | 10.8724 | 2.4980 | 6.2399 | 0.9983 | 0.2298 |
| 10 | 0108 | 1 | 1 | B5 | BS05 | 0.5706 | 0.5549 | -1.3240 | 15 | 8.9576 | 2.1710 | 4.7134 | 0.9983 | 0.2424 |
| 10 | 0108 | 1 | 3 | A14 | TS28 | 0.5804 | 0.4935 | -2.2309 | 15 | 8.1387 | 2.0369 | 4.1491 | 0.9981 | 0.2503 |
| 10 | 0112 | 1 | 1 | B11 | BS11 | 0.5580 | 0.5114 | -0.7176 | 15 | 8.8172 | 2.0666 | 4.2710 | 0.9987 | 0.2344 |
| 10 | 0112 | 1 | 2 | B4 | BS04 | 0.8166 | 0.2650 | -0.9352 | 15 | 7.2230 | 3.1764 | 10.0897 | 0.9983 | 0.4398 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 0201 | 1 | 2 | B12 | BS06 | 0.4610 | 0.5518 | -0.4218 | 15 | 8.5228 | 1.8790 | 3.5306 | 0.9986 | 0.2205 |
| 10 | 0201 | 1 | 3 | A17 | TS33 | 0.5080 | 0.5210 | 0.0000 | 15 | 10.0048 | 2.0051 | 4.0205 | 0.9988 | 0.2004 |
| 10 | 0201 | 2 | 1 | B6 | BG06 | 0.4745 | 0.6041 | -0.2803 | 15 | 9.9403 | 1.6500 | 2.7226 | 0.9990 | 0.1660 |
| 10 | 0202 | 1 | 1 | B3 | BG03 | 0.5146 | 0.6021 | -0.3152 | 15 | 10.8641 | 3.0002 | 9.0010 | 0.9972 | 0.2762 |
| 10 | 0202 | 1 | 2 | B9 | BS03 | 0.5223 | 0.5351 | -0.7636 | 15 | 8.5846 | 1.8367 | 3.3736 | 0.9988 | 0.2140 |
| 10 | 0204 | 1 | 3 | A2 | TS03 | 0.5974 | 0.4958 | 0.0000 | 15 | 11.5726 | 3.8093 | 14.5104 | 0.9969 | 0.3292 |
| 10 | 0204 | 2 | 2 | B1 | BG01 | 0.5278 | 0.6023 | -0.5789 | 15 | 10.1254 | 1.4023 | 1.9663 | 0.9994 | 0.1385 |
| 10 | 0207 | 1 | 1 | B10 | BS04 | 0.7416 | 0.3477 | -1.4035 | 15 | 8.0000 | 2.5807 | 6.6600 | 0.9985 | 0.3226 |
| 10 | 0207 | 1 | 3 | A11 | TS21 | 0.5275 | 0.4735 | 0.0000 | 15 | 9.5334 | 2.4055 | 5.7863 | 0.9984 | 0.2523 |
| 10 | 0207 | 2 | 2 | B4 | BG04 | 0.5149 | 0.5627 | -0.4112 | 15 | 9.5877 | 1.3647 | 1.8625 | 0.9994 | 0.1423 |
| 10 | 0211 | 1 | 2 | B11 | BS05 | 0.6758 | 0.3955 | -1.1849 | 15 | 8.0196 | 2.5438 | 6.4710 | 0.9983 | 0.3172 |
| 10 | 0211 | 1 | 3 | A14 | TS27 | 0.5715 | 0.4488 | 0.0000 | 15 | 9.6174 | 1.8783 | 3.5280 | 0.9992 | 0.1953 |
| 10 | 0212 | 1 | 1 | B2 | BG02 | 0.5013 | 0.5471 | -0.3572 | 15 | 9.1963 | 1.3752 | 1.8911 | 0.9994 | 0.1495 |
| 10 | 0212 | 1 | 2 | B8 | BS02 | 0.5802 | 0.5153 | -0.8925 | 15 | 8.9857 | 2.0707 | 4.2878 | 0.9987 | 0.2304 |
| 10 | 1201 | 1 | 1 | BA** | BS** | 0.9346 | 0.5452 | -1.4123 | 14 | 14.1229 | 4.2089 | 17.7146 | 0.9977 | 0.2980 |
| 10 | 1201 | 1 | 2 | BA** | BS** | 0.8074 | 0.5196 | -0.7583 | 15 | 12.9585 | 2.8740 | 8.2597 | 0.9988 | 0.2218 |
| 10 | 1201 | 2 | 1 | BA1 | BG03 | 0.6557 | 0.7192 | -0.3295 | 14 | 50.8403 | 3.7755 | 14.2546 | 0.9993 | 0.0743 |
| 10 | 4002 | 2 | 1 | BA* | BG** | 0.8164 | 0.6761 | -0.3259 | 15 | 55.3411 | 6.6851 | 44.6902 | 0.9984 | 0.1208 |
| 10 | 4002 | 2 | 2 | BA* | BG** | 0.6919 | 0.7114 | -0.3183 | 15 | 52.1586 | 3.7721 | 14.2287 | 0.9993 | 0.0723 |
| 10 | 5004 | 2 | 1 | BA2 | BG02 | 0.6689 | 0.7362 | -0.1552 | 14 | 58.6943 | 3.1649 | 10.0163 | 0.9996 | 0.0539 |
| 10 | 5004 | 2 | 2 | BA* | BG** | 0.7930 | 0.6578 | -0.2301 | 14 | 55.4522 | 5.1026 | 26.0365 | 0.9990 | 0.0920 |
| 10 | 5005 | 1 | 1 | BA1 | BS01 | 0.7943 | 0.6288 | -1.1734 | 15 | 14.2839 | 2.7062 | 7.3232 | 0.9988 | 0.1895 |
| 10 | 5005 | 1 | 2 | BA6 | BS06 | 0.6353 | 0.5872 | 0.0000 | 15 | 15.0943 | 5.9591 | 35.5111 | 0.9936 | 0.3948 |
| 10 | 5005 | 2 | 1 | BA* | BG** | 0.7074 | 0.7208 | -0.2847 | 15 | 55.6949 | 4.2563 | 18.1164 | 0.9993 | 0.0764 |
| 12 | 0101 | 1 | 1 | B5 | BS05 | 0.5973 | 0.5024 | 0.0000 | 15 | 11.2088 | 1.6014 | 2.5645 | 0.9994 | 0.1429 |
| 12 | 0104 | 1 | 2 | B4 | BS04 | 0.6657 | 0.4732 | 0.0000 | 15 | 11.9236 | 2.6877 | 7.2239 | 0.9987 | 0.2254 |
| 12 | 0106 | 1 | 2 | B2 | BS02 | 0.6817 | 0.4674 | -0.2324 | 15 | 11.4547 | 3.4737 | 12.0663 | 0.9978 | 0.3033 |
| 12 | 0107 | 1 | 2 | B1 | BS01 | 0.6119 | 0.6186 | -0.1422 | 15 | 13.6845 | 2.0042 | 4.0167 | 0.9992 | 0.1465 |
| 12 | 0112 | 1 | 2 | B3 | BS03 | 0.6652 | 0.5724 | -0.2718 | 15 | 13.2259 | 1.9549 | 3.8217 | 0.9993 | 0.1478 |
| 12 | 1030 | 1 | 1 | A1 | TS01 | 0.7635 | 0.8401 | -1.0871 | 15 | 20.2395 | 7.2234 | 52.1774 | 0.9917 | 0.3569 |
| 12 | 1030 | 1 | 2 | TP1 | BS55 | 1.0741 | 0.5049 | 0.0000 | 15 | 20.5735 | 3.9253 | 15.4082 | 0.9990 | 0.1908 |
| 12 | 1030 | 2 | 1 | BA* | BG** | 1.1649 | 0.5985 | -0.2235 | 15 | 69.8153 | 3.9118 | 15.3021 | 0.9997 | 0.0560 |
| 12 | 1030 | 2 | 2 | TP1 | BG56 | 1.0276 | 0.5576 | 0.0000 | 15 | 66.2582 | 6.3145 | 39.8731 | 0.9991 | 0.0953 |
| 12 | 1030 | 3 | 1 | BA* | BG** | 0.7311 | 0.7292 | -0.0214 | 15 | 71.7623 | 12.6045 | 158.8739 | 0.9953 | 0.1756 |
| 12 | 1030 | 3 | 2 | TP1 | BG55 | 0.9320 | 0.6805 | 0.0000 | 15 | 82.1426 | 10.4899 | 110.0383 | 0.9978 | 0.1277 |
| 12 | 1370 | 2 | 1 | BA* | BG** | 0.7739 | 0.7513 | -0.2882 | 15 | 68.6942 | 11.3641 | 129.1437 | 0.9959 | 0.1654 |
| 12 | 1370 | 2 | 2 | TP1 | BG56 | 0.7039 | 0.6223 | 0.0000 | 15 | 53.6308 | 5.1446 | 26.4664 | 0.9989 | 0.0959 |
| 12 | 1370 | 3 | 2 | TP1 | BG55 | 0.9465 | 0.7224 | -0.1113 | 15 | 86.1236 | 6.7845 | 46.0291 | 0.9991 | 0.0788 |
| 12 | 3804 | 1 | 1 | A1 | TS01 | 0.9070 | 0.6862 | -1.3881 | 15 | 17.4432 | 3.6151 | 13.0690 | 0.9982 | 0.2073 |
| 12 | 3804 | 1 | 2 | BA* | BS** | 0.9657 | 0.5709 | -0.2772 | 15 | 19.2490 | 3.2761 | 10.7328 | 0.9991 | 0.1702 |
| 12 | 3811 | 1 | 1 | BA* | BS** | 1.2626 | 0.2499 | 0.0000 | 15 | 15.9368 | 10.9476 | 119.8507 | 0.9937 | 0.6869 |
| 12 | 3811 | 1 | 2 | A2 | TS03 | 1.0453 | 0.3358 | -0.8567 | 15 | 12.0285 | 6.0151 | 36.1813 | 0.9964 | 0.5001 |
| 12 | 3811 | 2 | 1 | BA* | BG** | 0.8395 | 0.6029 | -0.2223 | 15 | 51.1611 | 3.7397 | 13.9853 | 0.9995 | 0.0731 |
| 12 | 3811 | 2 | 2 | BA* | BG** | 0.5468 | 0.6922 | 0.0000 | 15 | 49.2982 | 6.4105 | 41.0949 | 0.9976 | 0.1300 |
| 12 | 3995 | 1 | 1 | A1 | TS01 | 0.6758 | 0.6123 | -0.3224 | 15 | 14.8891 | 3.4067 | 11.6056 | 0.9980 | 0.2288 |
| 12 | 3995 | 1 | 2 | TP1 | BS55 | 0.8587 | 0.4460 | 0.0000 | 15 | 14.8411 | 4.6674 | 21.7851 | 0.9977 | 0.3145 |
| 12 | 3995 | 2 | 2 | TP1 | BG56 | 0.8732 | 0.5308 | 0.0000 | 15 | 51.7569 | 3.2508 | 10.5679 | 0.9996 | 0.0628 |
| 12 | 3995 | 3 | 1 | BA* | BG** | 0.5862 | 0.7820 | 0.0000 | 15 | 66.3438 | 22.8761 | 523.3177 | 0.9800 | 0.3448 |
| 12 | 3995 | 3 | 2 | TP1 | BG55 | 1.0498 | 0.6834 | 0.0000 | 15 | 93.5001 | 14.8367 | 220.1285 | 0.9965 | 0.1587 |
| 12 | 3996 | 1 | 1 | BA* | BS** | 1.1853 | 0.5631 | -0.3406 | 15 | 22.7466 | 3.7254 | 13.8786 | 0.9992 | 0.1638 |
| 12 | 3996 | 1 | 2 | A2 | TS03 | 0.7946 | 0.6264 | -0.6460 | 15 | 16.2255 | 3.5180 | 12.3766 | 0.9982 | 0.2168 |
| 12 | 3996 | 2 | 1 | BA* | BG** | 1.2738 | 0.5697 | -0.2774 | 15 | 66.8735 | 7.1835 | 51.6032 | 0.9990 | 0.1074 |
| 12 | 3996 | 2 | 2 | TP1 | BG56 | 1.1808 | 0.6139 | -0.1975 | 15 | 75.3561 | 5.1741 | 26.7718 | 0.9995 | 0.0687 |
| 12 | 3996 | 3 | 2 | TP1 | BG55 | 1.2266 | 0.5697 | -0.2059 | 15 | 68.3164 | 10.4957 | 110.1605 | 0.9979 | 0.1536 |
| 12 | 3997 | 1 | 1 | BA* | BS** | 0.9690 | 0.4790 | -0.2001 | 15 | 16.4152 | 3.3933 | 11.5143 | 0.9990 | 0.2067 |
| 12 | 3997 | 1 | 2 | A2 | TS02 | 0.5257 | 0.7256 | -1.0220 | 15 | 11.7866 | 1.6129 | 2.6014 | 0.9991 | 0.1368 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 3997 | 2 | 1 | BA* | BG** | 0.6290 | 0.8039 | -0.3322 | 15 | 58.9405 | 4.6904 | 21.9994 | 0.9990 | 0.0796 |
| 12 | 3997 | 2 | 2 | TP1 | BG56 | 0.6511 | 0.7805 | -0.2947 | 15 | 59.1027 | 4.8368 | 23.3942 | 0.9990 | 0.0818 |
| 12 | 3997 | 3 | 1 | BA* | BG** | 0.9810 | 0.6149 | 0.0000 | 15 | 87.3458 | 56.1647 | 3154.4790 | 0.9313 | 0.6430 |
| 12 | 3997 | 3 | 2 | TP1 | BG55 | 1.8166 | 0.6821 | -0.3972 | 15 | 119.9431 | 11.8271 | 139.8806 | 0.9989 | 0.0986 |
| 12 | 4000 | 1 | 1 | A1 | TS01 | 0.7079 | 0.1281 | 0.0000 | 15 | 13.2043 | 12.7528 | 162.6327 | 0.9723 | 0.9658 |
| 12 | 4000 | 1 | 2 | A2 | TS04 | 0.6955 | 0.5877 | -0.3577 | 15 | 14.1808 | 2.9421 | 8.6558 | 0.9985 | 0.2075 |
| 12 | 4057 | 1 | 1 | A1 | TS01 | 1.0015 | 0.6071 | -0.2501 | 15 | 22.2544 | 7.1691 | 51.3967 | 0.9959 | 0.3221 |
| 12 | 4057 | 1 | 2 | A2 | TS03 | 1.1368 | 0.7373 | -0.6570 | 15 | 28.9109 | 8.2250 | 67.6514 | 0.9956 | 0.2845 |
| 12 | 4057 | 2 | 1 | BA* | BG** | 1.1329 | 0.5996 | -0.1200 | 15 | 73.9796 | 3.5863 | 12.8614 | 0.9998 | 0.0485 |
| 12 | 4057 | 2 | 2 | BA* | BG** | 1.1356 | 0.5978 | -0.1918 | 15 | 70.0804 | 5.2201 | 27.2492 | 0.9994 | 0.0745 |
| 12 | 4059 | 1 | 1 | A1 | TS01 | 0.7213 | 0.5814 | 0.0000 | 15 | 17.4465 | 7.2319 | 52.3008 | 0.9926 | 0.4145 |
| 12 | 4059 | 1 | 2 | BA* | BS** | 0.8018 | 0.3872 | -0.3412 | 15 | 11.6937 | 6.1376 | 37.6695 | 0.9948 | 0.5249 |
| 12 | 4059 | 2 | 1 | BA* | BG** | 1.6715 | 0.5319 | -0.4455 | 15 | 68.3669 | 12.1150 | 146.7725 | 0.9979 | 0.1772 |
| 12 | 4059 | 2 | 2 | BA* | BG** | 1.5439 | 0.5875 | -0.3898 | 15 | 77.7682 | 7.6240 | 58.1253 | 0.9992 | 0.0980 |
| 12 | 4096 | 1 | 1 | A1 | TS01 | 0.5874 | 0.6335 | 0.0000 | 15 | 14.8558 | 4.6186 | 21.3318 | 0.9956 | 0.3109 |
| 12 | 4096 | 1 | 2 | A2 | TS03 | 0.6756 | 0.8444 | -0.6089 | 15 | 19.4696 | 4.5569 | 20.7655 | 0.9964 | 0.2341 |
| 12 | 4096 | 2 | 1 | BA* | BG** | 0.8613 | 0.5729 | -0.1239 | 15 | 52.0244 | 3.7153 | 13.8037 | 0.9995 | 0.0714 |
| 12 | 4096 | 2 | 2 | TP1 | BG55 | 0.5867 | 0.7227 | -0.1420 | 15 | 51.8209 | 1.8257 | 3.3332 | 0.9998 | 0.0352 |
| 12 | 4097 | 1 | 1 | A1 | TS01 | 0.8105 | 0.4330 | -0.4685 | 15 | 11.8615 | 3.5622 | 12.6895 | 0.9982 | 0.3003 |
| 12 | 4097 | 1 | 2 | A2 | TS03 | 1.1159 | 0.5017 | -1.1770 | 15 | 16.3963 | 4.1717 | 17.4031 | 0.9984 | 0.2544 |
| 12 | 4099 | 1 | 1 | BA* | BS** | 0.9644 | 0.5428 | 0.0000 | 15 | 20.0649 | 4.5685 | 20.8710 | 0.9983 | 0.2277 |
| 12 | 4099 | 1 | 2 | TP1 | BS55 | 1.0681 | 0.5000 | 0.0000 | 13 | 21.3952 | 3.1893 | 10.1714 | 0.9993 | 0.1491 |
| 12 | 4099 | 2 | 1 | BA* | BG** | 0.9989 | 0.6266 | -0.1209 | 15 | 69.0869 | 3.5593 | 12.6688 | 0.9997 | 0.0515 |
| 12 | 4099 | 2 | 2 | TP1 | BG56 | 1.0873 | 0.5745 | -0.0372 | 15 | 71.0889 | 3.6850 | 13.5794 | 0.9997 | 0.0518 |
| 12 | 4099 | 3 | 1 | BA* | BG** | 1.0777 | 0.5905 | -0.1316 | 15 | 67.4197 | 7.5809 | 57.4708 | 0.9987 | 0.1124 |
| 12 | 4100 | 1 | 1 | A1 | TS01 | 0.5159 | 0.5230 | 0.0000 | 15 | 10.5456 | 3.3422 | 11.1702 | 0.9968 | 0.3169 |
| 12 | 4100 | 1 | 2 | A2 | TS03 | 0.5491 | 0.5933 | 0.0000 | 15 | 12.4663 | 2.5676 | 6.5927 | 0.9984 | 0.2060 |
| 12 | 4100 | 2 | 1 | BA* | BG** | 0.8429 | 0.6516 | -0.3325 | 15 | 53.9442 | 4.1538 | 17.2545 | 0.9994 | 0.0770 |
| 12 | 4100 | 2 | 2 | TP1 | BG55 | 0.8432 | 0.5865 | -0.0964 | 15 | 53.9411 | 2.6795 | 7.1797 | 0.9997 | 0.0497 |
| 12 | 4101 | 1 | 1 | A1 | TS01 | 0.4948 | 0.6069 | -0.6083 | 15 | 9.7897 | 1.1690 | 1.3665 | 0.9995 | 0.1194 |
| 12 | 4101 | 1 | 2 | A2 | TS03 | 0.5166 | 0.5130 | -0.4348 | 15 | 9.1641 | 3.1218 | 9.7458 | 0.9968 | 0.3407 |
| 12 | 4101 | 2 | 1 | BA* | BG** | 1.0272 | 0.6928 | -0.3993 | 15 | 69.2829 | 6.7941 | 46.1596 | 0.9989 | 0.0981 |
| 12 | 4101 | 2 | 2 | TP1 | BG56 | 0.7937 | 0.7175 | -0.2933 | 15 | 62.0190 | 3.8732 | 15.0015 | 0.9995 | 0.0625 |
| 12 | 4101 | 3 | 1 | BA* | BG** | 1.4702 | 0.4829 | -0.2496 | 15 | 60.6487 | 9.7178 | 94.4349 | 0.9984 | 0.1602 |
| 12 | 4101 | 3 | 2 | TP1 | BG55 | 1.0903 | 0.5542 | -0.0534 | 15 | 66.7345 | 9.8639 | 97.2973 | 0.9979 | 0.1478 |
| 12 | 4102 | 1 | 1 | A1 | TS02 | 0.5231 | 0.4857 | 0.0000 | 15 | 13.8822 | 10.2642 | 105.3530 | 0.9713 | 0.7394 |
| 12 | 4102 | 1 | 2 | A2 | TS03 | 0.4947 | 0.7199 | -0.6812 | 15 | 11.7526 | 2.8602 | 8.1807 | 0.9971 | 0.2434 |
| 12 | 4102 | 2 | 1 | BA* | BG** | 0.9817 | 0.6666 | -0.1654 | 15 | 73.8272 | 3.6918 | 13.6293 | 0.9997 | 0.0500 |
| 12 | 4102 | 2 | 2 | TP1 | BG56 | 0.9340 | 0.6579 | -0.1694 | 15 | 69.4508 | 6.6583 | 44.3335 | 0.9989 | 0.0959 |
| 12 | 4102 | 3 | 1 | BA* | BG** | 1.0586 | 0.6259 | -0.1294 | 15 | 73.0574 | 8.9601 | 80.2832 | 0.9983 | 0.1226 |
| 12 | 4102 | 3 | 2 | TP1 | BG55 | 1.0933 | 0.5949 | 0.0000 | 15 | 77.8220 | 11.9144 | 141.9525 | 0.9974 | 0.1531 |
| 12 | 4103 | 1 | 1 | BA* | BS** | 0.6491 | 0.6565 | 0.0000 | 15 | 33.0970 | 29.0194 | 842.1244 | 0.8766 | 0.8768 |
| 12 | 4103 | 1 | 2 | TP1 | BS55 | 0.8813 | 0.6075 | -0.3588 | 14 | 18.7143 | 2.0665 | 4.2704 | 0.9996 | 0.1104 |
| 12 | 4103 | 2 | 1 | BA* | BG** | 1.3077 | 0.6478 | 0.0000 | 15 | 107.1725 | 12.7980 | 163.7882 | 0.9981 | 0.1194 |
| 12 | 4103 | 2 | 2 | BA* | BG** | 1.3077 | 0.6478 | 0.0000 | 15 | 107.1725 | 12.7980 | 163.7882 | 0.9981 | 0.1194 |
| 12 | 4103 | 2 | 2 | TP1 | BG56 | 1.4307 | 0.5687 | -0.2639 | 15 | 75.8032 | 16.7789 | 281.5308 | 0.9958 | 0.2213 |
| 12 | 4103 | 3 | 1 | BA* | BG** | 0.2985 | 1.0083 | 0.0000 | 15 | 55.7031 | 7.1588 | 51.2488 | 0.9960 | 0.1285 |
| 12 | 4103 | 3 | 2 | TP1 | BG55 | 0.3982 | 1.0622 | 0.0000 | 15 | 84.1613 | 5.0229 | 25.2297 | 0.9991 | 0.0597 |
| 12 | 4105 | 1 | 1 | BA* | BS** | 0.9902 | 0.5251 | -0.3831 | 15 | 17.5494 | 3.3652 | 11.3245 | 0.9990 | 0.1918 |
| 12 | 4105 | 1 | 2 | BA* | BS** | 0.8644 | 0.6456 | -0.3097 | 15 | 19.2942 | 2.9455 | 8.6757 | 0.9991 | 0.1527 |
| 12 | 4105 | 2 | 1 | BA* | BG** | 0.9147 | 0.6413 | -0.1892 | 15 | 63.5754 | 2.7306 | 7.4561 | 0.9998 | 0.0430 |
| 12 | 4105 | 2 | 2 | BA* | BG** | 0.9363 | 0.5835 | -0.1520 | 15 | 57.1025 | 3.0922 | 9.5615 | 0.9997 | 0.0542 |
| 12 | 4105 | 3 | 1 | BA* | BG** | 1.1295 | 0.6654 | -0.2417 | 15 | 79.3272 | 10.5297 | 110.8754 | 0.9980 | 0.1327 |
| 12 | 4105 | 3 | 2 | BA* | BG** | 1.2034 | 0.5859 | 0.0000 | 15 | 83.1151 | 16.2179 | 263.0190 | 0.9958 | 0.1951 |
| 12 | 4106 | 1 | 1 | A1 | TS01 | 0.7348 | 0.7280 | -0.4088 | 15 | 18.9957 | 4.8558 | 23.5786 | 0.9965 | 0.2556 |
| 12 | 4106 | 1 | 2 | A2 | TS03 | 0.8087 | 0.6480 | -0.2570 | 15 | 18.8068 | 4.1161 | 16.9422 | 0.9980 | 0.2189 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 4106 | 2 | 1 | BA* | BG** | 0.7192 | 0.8682 | 0.0000 | 15 | 108.7992 | 58.5846 | 3432.1540 | 0.9310 | 0.5385 |
| 12 | 4106 | 2 | 2 | TP1 | BG56 | 0.9003 | 0.6710 | -0.2002 | 15 | 66.7200 | 3.0393 | 9.2374 | 0.9997 | 0.0456 |
| 12 | 4106 | 3 | 1 | BA* | BG** | 1.1197 | 0.5430 | 0.0000 | 15 | 95.5868 | 69.3999 | 4816.3440 | 0.9070 | 0.7260 |
| 12 | 4106 | 3 | 2 | TP1 | BG55 | 1.1762 | 0.7253 | -0.1736 | 15 | 102.0559 | 6.7128 | 45.0612 | 0.9994 | 0.0658 |
| 12 | 4107 | 1 | 1 | A1 | TS01 | 0.6872 | 0.5268 | 0.0000 | 15 | 14.7283 | 5.9662 | 35.5950 | 0.9943 | 0.4051 |
| 12 | 4107 | 2 | 1 | BA* | BG** | 1.1597 | 0.7404 | -0.1617 | 15 | 106.3249 | 9.6466 | 93.0578 | 0.9988 | 0.0907 |
| 12 | 4108 | 2 | 1 | BA* | BG** | 0.8199 | 0.6055 | -0.0285 | 15 | 58.4847 | 2.6824 | 7.1953 | 0.9998 | 0.0459 |
| 12 | 4108 | 2 | 2 | TP1 | BG55 | 0.8789 | 0.6536 | -0.3168 | 15 | 56.9647 | 3.7440 | 14.0179 | 0.9995 | 0.0657 |
| 12 | 4136 | 1 | 2 | TP1 | BS55 | 0.8085 | 0.4982 | 0.0000 | 15 | 15.1585 | 1.1706 | 1.3704 | 0.9998 | 0.0772 |
| 12 | 4153 | 2 | 1 | BA* | BG** | 1.2416 | 0.7259 | -0.2695 | 15 | 100.7053 | 8.0287 | 64.4608 | 0.9992 | 0.0797 |
| 12 | 4153 | 2 | 2 | TP1 | BG55 | 1.2721 | 0.6403 | -0.2794 | 15 | 82.4839 | 6.7410 | 45.4406 | 0.9993 | 0.0817 |
| 12 | 4154 | 2 | 1 | BA* | BG** | 1.1643 | 0.4996 | 0.0000 | 15 | 62.6633 | 9.4596 | 89.4846 | 0.9981 | 0.1510 |
| 12 | 4154 | 2 | 2 | TP1 | BG55 | 1.1360 | 0.4973 | -0.0894 | 15 | 56.3619 | 7.5011 | 56.2666 | 0.9986 | 0.1331 |
| 12 | 9054 | 3 | 2 | TP1 | BG55 | 0.5994 | 1.0198 | -0.1789 | 15 | 102.6889 | 8.1423 | 66.2965 | 0.9985 | 0.0793 |
| 13 | 0507 | 1 | 1 | BA* | BS** | 0.9499 | 0.3930 | -1.8450 | 15 | 11.4068 | 3.0205 | 9.1235 | 0.9985 | 0.2648 |
| 13 | 0507 | 2 | 1 | BA* | BG** | 1.0362 | 0.6794 | -0.2521 | 14 | 77.5624 | 5.6562 | 31.9925 | 0.9993 | 0.0729 |
| 13 | 0509 | 2 | 2 | BA* | BG** | 1.0046 | 0.6334 | -0.1394 | 15 | 70.8226 | 3.8759 | 15.0225 | 0.9997 | 0.0547 |
| 13 | 1001 | 2 | 1 | BA* | BG** | 0.6046 | 0.8342 | -0.1435 | 15 | 69.6931 | 2.4606 | 6.0544 | 0.9998 | 0.0353 |
| 13 | 1001 | 2 | 2 | TP1 | BG55 | 0.8146 | 0.7086 | -0.1135 | 15 | 70.9952 | 3.9226 | 15.3864 | 0.9996 | 0.0553 |
| 13 | 1004 | 2 | 1 | BA* | BG** | 0.8050 | 0.8342 | -0.3270 | 15 | 80.9104 | 6.9782 | 48.6952 | 0.9988 | 0.0862 |
| 13 | 1004 | 2 | 2 | TP1 | BG55 | 0.7927 | 0.5838 | -0.0444 | 15 | 52.7293 | 3.6009 | 12.9665 | 0.9995 | 0.0683 |
| 13 | 1005 | 2 | 2 | TP1 | BG55 | 0.9928 | 0.5953 | -0.2068 | 15 | 59.5105 | 5.7688 | 33.2787 | 0.9991 | 0.0969 |
| 13 | 1031 | 2 | 1 | BA* | BG** | 0.8214 | 0.5996 | -0.4204 | 15 | 42.0999 | 8.9091 | 79.3714 | 0.9962 | 0.2116 |
| 13 | 1031 | 2 | 2 | TP1 | BG55 | 0.3498 | 1.0213 | -0.6299 | 15 | 43.9569 | 4.9407 | 24.4102 | 0.9976 | 0.1124 |
| 13 | 3007 | 2 | 1 | BA* | BG** | 0.9088 | 0.7512 | -0.0006 | 15 | 94.9349 | 9.6074 | 92.3022 | 0.9984 | 0.1012 |
| 13 | 3007 | 2 | 2 | TP1 | BG55 | 0.9234 | 0.7572 | 0.0000 | 15 | 99.2485 | 3.7725 | 14.2316 | 0.9998 | 0.0380 |
| 13 | 3016 | 2 | 1 | BA3 | BG03 | 0.9990 | 0.6250 | -0.0824 | 15 | 72.5807 | 7.0308 | 49.4323 | 0.9989 | 0.0969 |
| 13 | 3016 | 2 | 2 | BA* | BG** | 0.6669 | 0.7000 | -0.0929 | 15 | 57.7468 | 5.5427 | 30.7210 | 0.9987 | 0.0960 |
| 13 | 3019 | 2 | 1 | BA* | BG** | 0.4957 | 0.6388 | 0.0000 | 15 | 40.1800 | 4.8493 | 23.5156 | 0.9981 | 0.1207 |
| 13 | 3019 | 2 | 2 | BA* | BG** | 0.6419 | 0.6839 | -0.0113 | 15 | 57.4828 | 4.1381 | 17.1239 | 0.9993 | 0.0720 |
| 13 | 4111 | 2 | 1 | BA* | BG** | 0.4531 | 0.9688 | -0.3873 | 15 | 60.2849 | 7.0552 | 49.7762 | 0.9973 | 0.1170 |
| 13 | 4111 | 2 | 2 | TP1 | BG55 | 1.2044 | 0.5349 | -0.1181 | 15 | 65.0076 | 10.4045 | 108.2534 | 0.9978 | 0.1601 |
| 13 | 4119 | 2 | 1 | BA* | BG** | 0.6039 | 0.6786 | -0.0545 | 15 | 51.9033 | 4.9568 | 24.5703 | 0.9987 | 0.0955 |
| 13 | 4119 | 2 | 2 | BA* | BG** | 1.0735 | 0.6537 | -0.1402 | 15 | 79.4028 | 5.7009 | 32.4999 | 0.9994 | 0.0718 |
| 15 | 1003 | 1 | 1 | BA* | BS** | 1.1801 | 0.2744 | 0.0000 | 15 | 14.2170 | 7.7635 | 60.2712 | 0.9964 | 0.5461 |
| 15 | 1003 | 1 | 2 | TP1 | BS93 | 0.8037 | 0.2713 | -1.9778 | 15 | 8.4386 | 1.6830 | 2.8324 | 0.9993 | 0.1994 |
| 15 | 1006 | 1 | 2 | TP1 | BS93 | 0.8282 | 0.2533 | -1.5392 | 15 | 7.6364 | 2.0750 | 4.3055 | 0.9991 | 0.2717 |
| 16 | 1005 | 1 | 1 | BA* | BS** | 0.8133 | 0.1709 | -0.8203 | 15 | 5.0351 | 1.8550 | 3.4410 | 0.9994 | 0.3684 |
| 16 | 1005 | 1 | 2 | TP1 | BS92 | 0.5412 | 0.4771 | -1.4878 | 15 | 7.4495 | 2.3277 | 5.4183 | 0.9977 | 0.3125 |
| 16 | 1005 | 2 | 1 | BA* | BG** | 0.4444 | 0.6073 | -0.0347 | 15 | 31.3161 | 3.0125 | 9.0752 | 0.9990 | 0.0962 |
| 16 | 1009 | 1 | 1 | BA* | BS** | 0.6956 | 0.3369 | -1.2859 | 15 | 7.1661 | 2.1588 | 4.6603 | 0.9988 | 0.3013 |
| 16 | 1009 | 1 | 2 | TP1 | BS92 | 0.5343 | 0.5533 | -2.0868 | 15 | 8.0575 | 2.0946 | 4.3874 | 0.9978 | 0.2600 |
| 16 | 1010 | 1 | 1 | BA* | BS** | 0.4761 | 0.7369 | -0.7215 | 15 | 10.9948 | 1.4424 | 2.0805 | 0.9992 | 0.1312 |
| 16 | 1010 | 1 | 2 | TP1 | BS92 | 0.4972 | 0.6362 | -0.8064 | 15 | 9.7003 | 1.8796 | 3.5330 | 0.9987 | 0.1938 |
| 16 | 1020 | 1 | 1 | BA* | BS** | 0.6778 | 0.2134 | -0.4236 | 15 | 4.8472 | 2.0117 | 4.0467 | 0.9991 | 0.4150 |
| 16 | 1020 | 1 | 2 | TP1 | BS93 | 0.5297 | 0.5317 | -2.4055 | 15 | 7.8619 | 2.0733 | 4.2987 | 0.9975 | 0.2637 |
| 16 | 3017 | 1 | 1 | BA* | BS** | 0.6379 | 0.4009 | -1.4634 | 15 | 7.6108 | 2.4823 | 6.1619 | 0.9981 | 0.3262 |
| 16 | 3017 | 1 | 2 | BA* | BS** | 0.5082 | 0.5484 | -1.0714 | 15 | 8.1807 | 2.2643 | 5.1271 | 0.9979 | 0.2768 |
| 16 | 3023 | 1 | 1 | BA* | BS** | 0.6797 | 0.2082 | -1.0948 | 15 | 5.0972 | 1.7088 | 2.9202 | 0.9992 | 0.3353 |
| 16 | 3023 | 1 | 2 | BA* | BS** | 0.5490 | 0.5495 | -1.2113 | 15 | 8.6421 | 2.2628 | 5.1203 | 0.9981 | 0.2618 |
| 16 | 3023 | 2 | 1 | BA* | BG** | 0.8836 | 0.2666 | -0.1515 | 15 | 16.9276 | 3.1961 | 10.2148 | 0.9992 | 0.1888 |
| 16 | 5025 | 1 | 2 | BA* | BS** | 0.8766 | 0.2593 | -0.9251 | 15 | 7.1760 | 2.3484 | 5.5150 | 0.9992 | 0.3273 |
| 16 | 6027 | 1 | 2 | TP1 | BS93 | 1.4416 | 0.2028 | 0.0000 | 15 | 16.3454 | 12.3673 | 152.9498 | 0.9937 | 0.7566 |
| 16 | 9032 | 1 | 2 | TP1 | BS92 | 0.4390 | 0.1143 | -4.2765 | 15 | 7.0326 | 2.1370 | 4.5666 | 0.9933 | 0.3039 |
| 16 | 9034 | 1 | 2 | TP1 | BS91 | 0.5695 | 0.7125 | -1.7816 | 15 | 10.8869 | 2.3033 | 5.3054 | 0.9980 | 0.2116 |
| 17 | 1002 | 1 | 1 | A1 | TS01 | 1.3479 | 0.2225 | -1.7115 | 15 | 12.2467 | 1.5635 | 2.4446 | 0.9998 | 0.1277 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 1002 | 1 | 2 | TP* | BS** | 0.7694 | 0.7533 | -4.0159 | 15 | 14.2552 | 3.3959 | 11.5320 | 0.9956 | 0.2382 |
| 17 | 1003 | 1 | 1 | BA* | BS** | 0.8986 | 0.2605 | -1.6956 | 15 | 8.4724 | 0.9582 | 0.9182 | 0.9998 | 0.1131 |
| 17 | 1003 | 1 | 2 | TP* | BS** | 0.3314 | 0.7253 | -4.3621 | 15 | 6.2427 | 2.3750 | 5.6405 | 0.9872 | 0.3804 |
| 17 | 4074 | 1 | 1 | BA* | BS** | 0.6099 | 0.2265 | -0.5543 | 15 | 4.4508 | 1.7885 | 3.1987 | 0.9991 | 0.4018 |
| 17 | 4074 | 1 | 2 | BA* | BS** | 1.6972 | 0.3568 | -0.8437 | 15 | 17.5860 | 1.9087 | 3.6430 | 0.9999 | 0.1085 |
| 17 | 4082 | 1 | 1 | A1 | TS01 | 0.9277 | 0.0669 | -1.7470 | 15 | 8.4504 | 0.8743 | 0.7644 | 0.9999 | 0.1035 |
| 17 | 4082 | 1 | 2 | A2 | TS03 | 0.8998 | 0.2462 | -3.5207 | 15 | 12.6540 | 1.6305 | 2.6587 | 0.9992 | 0.1289 |
| 17 | 5020 | 1 | 1 | A1 | TS01 | 0.4670 | 0.1470 | -3.8974 | 15 | 6.9946 | 0.9860 | 0.9722 | 0.9988 | 0.1410 |
| 17 | 5020 | 1 | 2 | A2 | TS03 | 1.1749 | 0.2575 | -2.7268 | 15 | 14.3371 | 1.2611 | 1.5903 | 0.9998 | 0.0880 |
| 17 | 5151 | 1 | 1 | BA* | BS** | 0.6819 | 0.7680 | -0.7372 | 15 | 16.5946 | 2.5366 | 6.4344 | 0.9988 | 0.1529 |
| 17 | 5151 | 1 | 2 | BA* | BS** | 0.7360 | 0.7417 | -1.1850 | 15 | 15.6336 | 2.3824 | 5.6759 | 0.9990 | 0.1524 |
| 17 | 5217 | 1 | 1 | A1 | TS01 | 0.6774 | 0.1698 | -3.3220 | 15 | 9.2644 | 1.1282 | 1.2728 | 0.9994 | 0.1218 |
| 17 | 5217 | 2 | 1 | BA* | BG** | 0.8709 | 0.6651 | -0.0736 | 15 | 69.5484 | 3.1945 | 10.2050 | 0.9997 | 0.0459 |
| 17 | 5217 | 2 | 2 | BA* | BG** | 0.7451 | 0.6239 | 0.0000 | 15 | 56.5062 | 4.3643 | 19.0473 | 0.9993 | 0.0772 |
| 17 | 5423 | 1 | 1 | A1 | TS01 | 1.0361 | 0.1443 | -1.6573 | 15 | 8.9427 | 1.3387 | 1.7921 | 0.9998 | 0.1497 |
| 17 | 5423 | 1 | 2 | A2 | TS03 | 1.4215 | 0.3107 | -1.6122 | 15 | 14.0604 | 1.9613 | 3.8465 | 0.9997 | 0.1395 |
| 17 | 5453 | 1 | 1 | A1 | TS01 | 0.8921 | 0.3810 | -4.5791 | 15 | 14.6102 | 3.1721 | 10.0621 | 0.9963 | 0.2171 |
| 17 | 5453 | 1 | 2 | A2 | TS03 | 1.2888 | 0.1400 | -2.6957 | 15 | 15.7843 | 1.1936 | 1.4247 | 0.9998 | 0.0756 |
| 17 | 5843 | 1 | 1 | A1 | TS01 | 0.9798 | 0.1512 | -1.9692 | 15 | 9.4602 | 1.0294 | 1.0596 | 0.9998 | 0.1088 |
| 17 | 5843 | 1 | 2 | A2 | TS03 | 1.3123 | 0.1087 | -1.4823 | 15 | 10.4129 | 1.3978 | 1.9538 | 0.9998 | 0.1342 |
| 17 | 5849 | 1 | 1 | BA* | BS** | 1.5837 | 0.3030 | -1.2764 | 15 | 14.5645 | 2.2465 | 5.0468 | 0.9997 | 0.1542 |
| 17 | 5849 | 1 | 2 | TP* | BS** | 1.3882 | 0.3634 | -2.2505 | 15 | 16.5394 | 3.1663 | 10.0255 | 0.9992 | 0.1914 |
| 17 | 5854 | 1 | 1 | BA* | BS** | 0.2378 | 0.0231 | -2.0798 | 15 | 3.3094 | 2.2278 | 4.9629 | 0.9856 | 0.6732 |
| 17 | 5854 | 1 | 2 | A2 | TS03 | 1.1069 | 0.1574 | -2.2795 | 15 | 11.9754 | 1.0224 | 1.0453 | 0.9999 | 0.0854 |
| 17 | 5869 | 1 | 1 | BA* | BS** | 0.9555 | 0.5101 | -2.8228 | 14 | 14.1501 | 3.1949 | 10.2077 | 0.9979 | 0.2258 |
| 17 | 5908 | 1 | 1 | BA* | BS** | 1.2271 | 0.3164 | -1.8914 | 15 | 12.7384 | 0.9803 | 0.9609 | 0.9999 | 0.0770 |
| 17 | 5908 | 1 | 2 | A2 | TS03 | 1.1184 | 0.2961 | -3.5981 | 15 | 16.0926 | 1.8435 | 3.3986 | 0.9994 | 0.1146 |
| 17 | 6050 | 1 | 1 | BA* | BS** | 0.5312 | 0.4764 | -5.0924 | 15 | 8.9320 | 1.4586 | 2.1276 | 0.9975 | 0.1633 |
| 17 | 6050 | 1 | 2 | TP1 | BS** | 1.3150 | 0.2621 | -0.9935 | 14 | 9.3291 | 1.0072 | 1.0144 | 0.9999 | 0.1080 |
| 17 | 6050 | 2 | 1 | BA* | BG** | 0.8542 | 0.6403 | 0.0000 | 15 | 67.3355 | 6.1253 | 37.5189 | 0.9990 | 0.0910 |
| 17 | 6050 | 2 | 2 | TP* | BG** | 1.0270 | 0.5903 | 0.0000 | 15 | 71.1082 | 5.7426 | 32.9779 | 0.9993 | 0.0808 |
| 17 | 6050 | 3 | 1 | BA* | BG** | 1.0193 | 0.7123 | -0.0121 | 15 | 96.3697 | 5.9577 | 35.4946 | 0.9994 | 0.0618 |
| 17 | 6050 | 3 | 2 | TP* | BG** | 1.2085 | 0.5660 | 0.0000 | 14 | 74.4341 | 6.2652 | 39.2524 | 0.9994 | 0.0842 |
| 17 | 7937 | 1 | 1 | BA* | BS** | 0.7524 | 0.3875 | -2.9406 | 15 | 10.3680 | 2.7066 | 7.3259 | 0.9975 | 0.2611 |
| 17 | 7937 | 1 | 2 | A2 | TS03 | 0.4952 | 0.4619 | -4.4102 | 15 | 8.3478 | 2.7544 | 7.5866 | 0.9914 | 0.3300 |
| 17 | 7937 | 2 | 1 | BA* | BG** | 0.6658 | 0.5978 | -0.0450 | 15 | 45.4803 | 8.8611 | 78.5189 | 0.9959 | 0.1948 |
| 17 | 7937 | 2 | 2 | TP* | BG** | 0.5436 | 0.7482 | -0.0841 | 15 | 52.4847 | 8.8776 | 78.8126 | 0.9957 | 0.1691 |
| 17 | 9267 | 1 | 2 | BA* | BS** | 0.6401 | 0.6992 | -0.5095 | 15 | 14.7535 | 1.3112 | 1.7193 | 0.9997 | 0.0889 |
| 17 | 9327 | 1 | 1 | A2 | TS03 | 0.7987 | 0.2157 | -3.6060 | 15 | 11.3381 | 0.8968 | 0.8042 | 0.9997 | 0.0791 |
| 17 | 9327 | 1 | 1 | BA* | BS** | 0.3284 | 0.2792 | -3.6669 | 14 | 5.5589 | 3.1555 | 9.9571 | 0.9787 | 0.5676 |
| 17 | 9327 | 2 | 1 | BA* | BG** | 0.9241 | 0.5903 | 0.0000 | 15 | 64.0460 | 2.9739 | 8.8442 | 0.9998 | 0.0464 |
| 17 | 9327 | 2 | 2 | TP* | BG** | 0.8682 | 0.5603 | -0.0696 | 15 | 52.2651 | 7.1054 | 50.4874 | 0.9982 | 0.1360 |
| 18 | 1028 | 1 | 1 | A1 | TS01 | 1.0185 | 0.2041 | -3.9905 | 15 | 15.4858 | 3.0842 | 9.5120 | 0.9976 | 0.1992 |
| 18 | 1028 | 1 | 2 | A2 | TS03 | 1.4511 | 0.2260 | -0.8881 | 15 | 10.0773 | 1.0247 | 1.0499 | 0.9999 | 0.1017 |
| 18 | 1037 | 1 | 1 | BA* | BS** | 0.2130 | 0.4021 | 0.0000 | 15 | 4.3622 | 3.0453 | 9.2739 | 0.9839 | 0.6981 |
| 18 | 1037 | 1 | 2 | TP* | BS** | 0.3652 | 0.3284 | -2.6868 | 15 | 5.9362 | 4.0843 | 16.6813 | 0.9775 | 0.6880 |
| 18 | 2008 | 1 | 2 | A2 | TS03 | 2.2960 | 0.3122 | -2.1867 | 14 | 21.8729 | 2.7116 | 7.3526 | 0.9998 | 0.1240 |
| 18 | 2009 | 2 | 1 | BA1 | BG01 | 1.3611 | 0.4370 | -0.5682 | 14 | 37.4322 | 13.9977 | 195.9342 | 0.9941 | 0.3739 |
| 18 | 2009 | 2 | 2 | TP* | BG** | 2.3228 | 0.3086 | -1.1605 | 13 | 36.0690 | 22.8971 | 524.2750 | 0.9892 | 0.6348 |
| 18 | 3002 | 1 | 1 | A1 | TS01 | 1.2879 | 0.3377 | -1.7600 | 15 | 13.6057 | 1.6677 | 2.7812 | 0.9998 | 0.1226 |
| 18 | 3002 | 1 | 2 | A2 | TS03 | 0.9382 | 0.2318 | -2.0386 | 15 | 9.5444 | 1.0347 | 1.0707 | 0.9998 | 0.1084 |
| 18 | 3002 | 2 | 1 | BA* | BG** | 0.9557 | 0.6382 | 0.0000 | 14 | 69.4903 | 3.1152 | 9.7045 | 0.9998 | 0.0448 |
| 18 | 3002 | 2 | 2 | TP* | BG** | 1.0218 | 0.6626 | -0.0370 | 14 | 76.4659 | 4.3353 | 18.7947 | 0.9996 | 0.0567 |
| 18 | 3003 | 1 | 1 | BA* | BS** | 0.3717 | 0.7565 | -1.5394 | 15 | 8.9240 | 4.9152 | 24.1593 | 0.9807 | 0.5508 |
| 18 | 3003 | 1 | 2 | TP* | BS** | 0.4990 | 0.8898 | -0.9009 | 15 | 14.0401 | 2.2433 | 5.0324 | 0.9983 | 0.1598 |
| 18 | 3030 | 1 | 1 | A1 | TS01 | 1.9430 | 0.3907 | -1.6994 | 15 | 22.5046 | 5.3663 | 28.7969 | 0.9990 | 0.2385 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 3030 | 1 | 2 | TP* | BS** | 1.1469 | 0.3549 | -4.5930 | 15 | 18.2983 | 2.5840 | 6.6769 | 0.9985 | 0.1412 |
| 18 | 3031 | 1 | 1 | A1 | TS01 | 1.3715 | 0.1639 | -1.9271 | 15 | 13.1501 | 1.3828 | 1.9121 | 0.9998 | 0.1052 |
| 18 | 3031 | 1 | 2 | A2 | TS03 | 0.8333 | 0.2519 | -4.4471 | 15 | 13.0738 | 1.6140 | 2.6049 | 0.9989 | 0.1235 |
| 18 | 4021 | 1 | 1 | A1 | TS01 | 1.0102 | 0.5087 | -5.5454 | 15 | 17.6751 | 4.9346 | 24.3500 | 0.9914 | 0.2792 |
| 18 | 4021 | 1 | 2 | TP* | BS** | 1.3495 | 0.3534 | -4.1962 | 15 | 20.7422 | 2.4830 | 6.1655 | 0.9991 | 0.1197 |
| 18 | 4042 | 1 | 1 | BA* | BS** | 1.2089 | 0.3601 | -1.8826 | 15 | 13.8914 | 2.8705 | 8.2395 | 0.9992 | 0.2066 |
| 18 | 4042 | 1 | 2 | BA* | BS** | 0.6107 | 0.6534 | -1.3516 | 15 | 11.2059 | 2.3325 | 5.4403 | 0.9984 | 0.2081 |
| 18 | 5022 | 1 | 1 | BA* | BS** | 0.7935 | 0.6230 | -2.7372 | 13 | 11.2278 | 2.9441 | 8.6679 | 0.9974 | 0.2622 |
| 18 | 5022 | 1 | 2 | A2 | TS04 | 1.5391 | 0.2834 | -1.3788 | 15 | 13.8058 | 1.8257 | 3.3333 | 0.9998 | 0.1322 |
| 18 | 5043 | 1 | 1 | BA* | BS** | 1.1261 | 0.2032 | -2.3606 | 15 | 12.4491 | 1.2976 | 1.6838 | 0.9998 | 0.1042 |
| 18 | 5043 | 1 | 2 | BA* | BS** | 0.8842 | 0.3176 | -4.2421 | 15 | 13.7885 | 2.8014 | 7.8476 | 0.9972 | 0.2032 |
| 18 | 5043 | 2 | 1 | BA* | BG** | 0.6851 | 0.7196 | -0.2192 | 15 | 56.5018 | 3.3685 | 11.3468 | 0.9995 | 0.0596 |
| 18 | 5043 | 2 | 2 | BA* | BG** | 0.5903 | 0.7128 | -0.1781 | 15 | 49.1084 | 5.7173 | 32.6873 | 0.9982 | 0.1164 |
| 18 | 5518 | 1 | 1 | BA* | BS** | 0.6409 | 0.7795 | -0.9907 | 15 | 15.1877 | 3.1805 | 10.1157 | 0.9977 | 0.2094 |
| 18 | 5518 | 1 | 2 | BA* | BS** | 0.5421 | 0.8955 | -2.2834 | 15 | 12.2338 | 1.6973 | 2.8807 | 0.9987 | 0.1387 |
| 18 | 5518 | 2 | 1 | BA* | BG** | 0.8349 | 0.6897 | -0.1683 | 14 | 61.7587 | 4.0735 | 16.5930 | 0.9995 | 0.0660 |
| 18 | 5518 | 2 | 2 | BA* | BG** | 1.0768 | 0.4659 | 0.0000 | 15 | 52.0478 | 8.0773 | 65.2426 | 0.9982 | 0.1552 |
| 18 | 5528 | 1 | 1 | BA* | BS** | 0.5961 | 1.3450 | -5.0231 | 15 | 15.8556 | 5.7838 | 33.4519 | 0.9792 | 0.3648 |
| 18 | 5528 | 2 | 1 | BA* | BG** | 0.5415 | 0.7558 | -0.2264 | 14 | 46.4155 | 2.8352 | 8.0383 | 0.9995 | 0.0611 |
| 18 | 5528 | 2 | 2 | BA* | BG** | 0.5918 | 0.7527 | -0.2666 | 15 | 51.4652 | 3.1689 | 10.0419 | 0.9995 | 0.0616 |
| 18 | 5538 | 1 | 1 | BA* | BS** | 0.6547 | 0.7629 | -0.8125 | 15 | 15.6929 | 3.5963 | 12.9334 | 0.9974 | 0.2292 |
| 18 | 5538 | 1 | 2 | BA* | BS** | 0.6262 | 0.7890 | -0.8639 | 15 | 15.3877 | 2.2576 | 5.0969 | 0.9989 | 0.1467 |
| 18 | 5538 | 2 | 1 | BA* | BG** | 0.6834 | 0.5664 | -0.1700 | 15 | 38.8131 | 6.4711 | 41.8752 | 0.9975 | 0.1667 |
| 18 | 5538 | 2 | 2 | BA* | BG** | 0.7562 | 0.4858 | -0.1272 | 15 | 35.0845 | 6.5490 | 42.8899 | 0.9975 | 0.1867 |
| 18 | 6012 | 1 | 1 | A1 | TS01 | 1.4520 | 0.1806 | -2.2634 | 15 | 15.7662 | 1.1087 | 1.2292 | 0.9999 | 0.0703 |
| 18 | 6012 | 1 | 2 | A2 | TS03 | 1.3473 | 0.2058 | -3.0076 | 15 | 17.5070 | 1.3145 | 1.7279 | 0.9998 | 0.0751 |
| 18 | 9020 | 1 | 1 | A1 | TS02 | 1.8770 | 0.3469 | -0.7316 | 15 | 19.4777 | 3.0350 | 9.2112 | 0.9997 | 0.1558 |
| 18 | 9020 | 1 | 2 | A2 | TS04 | 1.5309 | 0.1642 | -1.3203 | 15 | 11.3356 | 1.6831 | 2.8328 | 0.9998 | 0.1485 |
| 18 | 9020 | 2 | 1 | BA* | BG** | 0.8442 | 0.5724 | -0.0204 | 15 | 54.5464 | 6.2601 | 39.1891 | 0.9987 | 0.1148 |
| 18 | 9020 | 2 | 2 | BA* | BG** | 0.6308 | 0.7969 | -0.1728 | 15 | 64.1682 | 4.6479 | 21.6026 | 0.9992 | 0.0724 |
| 19 | 0102 | 1 | 3 | A5 | TS10 | 1.4885 | 0.2082 | -0.7352 | 14 | 9.2961 | 0.7045 | 0.4963 | 1.0000 | 0.0758 |
| 19 | 0103 | 1 | 3 | A1 | TS02 | 2.1248 | 0.2735 | 0.0000 | 15 | 21.6801 | 3.3727 | 11.3749 | 0.9998 | 0.1556 |
| 19 | 0106 | 1 | 3 | A13 | TS26 | 0.8838 | 0.1107 | -3.3215 | 15 | 12.2909 | 1.2949 | 1.6768 | 0.9995 | 0.1054 |
| 19 | 0110 | 1 | 3 | A10 | TS20 | 1.2411 | 0.1176 | -1.4465 | 15 | 9.7311 | 1.8654 | 3.4797 | 0.9997 | 0.1917 |
| 19 | 0110 | 1 | 3 | A11 | TS22 | 1.3405 | 0.1687 | -1.1501 | 15 | 9.0827 | 1.5498 | 2.4019 | 0.9998 | 0.1706 |
| 19 | 0112 | 1 | 3 | A9 | TS18 | 1.6401 | 0.1607 | -0.4726 | 15 | 8.2393 | 1.6502 | 2.7231 | 0.9999 | 0.2003 |
| 19 | 1044 | 1 | 1 | BA* | BS** | 1.6966 | 0.2525 | -1.3993 | 12 | 12.4633 | 1.4705 | 2.1623 | 0.9999 | 0.1180 |
| 19 | 1044 | 1 | 2 | A2 | TS03 | 2.0502 | 0.2428 | -0.8598 | 15 | 15.2075 | 2.8095 | 7.8932 | 0.9998 | 0.1847 |
| 19 | 3006 | 1 | 1 | A1 | TS01 | 0.9369 | 0.1784 | -3.9041 | 15 | 13.9932 | 1.9829 | 3.9321 | 0.9988 | 0.1417 |
| 19 | 3006 | 1 | 2 | A2 | TS03 | 1.4405 | 0.2547 | -2.2705 | 15 | 15.9696 | 1.7289 | 2.9892 | 0.9998 | 0.1083 |
| 19 | 3009 | 1 | 1 | BA* | BS** | 0.7151 | 0.7334 | -1.4018 | 15 | 14.5448 | 2.0739 | 4.3010 | 0.9991 | 0.1426 |
| 19 | 3009 | 1 | 2 | BA* | BS** | 0.8679 | 0.4185 | -1.8791 | 14 | 10.7663 | 2.3589 | 5.5645 | 0.9989 | 0.2191 |
| 19 | 3009 | 2 | 2 | BA* | BG** | 0.9315 | 0.4114 | -0.5268 | 15 | 24.1217 | 7.9768 | 63.6300 | 0.9959 | 0.3307 |
| 19 | 3009 | 2 | 1 | BA* | BG** | 2.1712 | 0.3023 | -0.3806 | 15 | 38.1122 | 4.4926 | 20.1835 | 0.9997 | 0.1179 |
| 19 | 3028 | 1 | 1 | BA* | BS** | 1.1183 | 0.2181 | -2.5405 | 15 | 12.9861 | 1.2676 | 1.6069 | 0.9998 | 0.0976 |
| 19 | 3028 | 1 | 2 | BA* | BS** | 0.8075 | 0.2894 | -3.0993 | 15 | 10.5754 | 1.2393 | 1.5358 | 0.9995 | 0.1172 |
| 19 | 3033 | 1 | 1 | A1 | TS01 | 1.2537 | 0.2884 | -2.1453 | 15 | 13.4837 | 2.4316 | 5.9129 | 0.9994 | 0.1803 |
| 19 | 3033 | 1 | 2 | A2 | TS03 | 1.4562 | 0.2610 | -1.8767 | 15 | 14.4529 | 2.0627 | 4.2547 | 0.9997 | 0.1427 |
| 19 | 3055 | 1 | 1 | A1 | TS01 | 0.7844 | 0.1595 | -2.7298 | 15 | 9.4542 | 0.7456 | 0.5560 | 0.9998 | 0.0789 |
| 19 | 3055 | 1 | 2 | TP* | BS** | 1.6817 | 0.2754 | -1.7494 | 15 | 16.1413 | 1.5473 | 2.3941 | 0.9999 | 0.0959 |
| 19 | 3055 | 2 | 1 | BA* | BG** | 0.8248 | 0.7487 | -0.1108 | 15 | 80.6146 | 7.5650 | 57.2297 | 0.9986 | 0.0938 |
| 19 | 3055 | 2 | 2 | TP* | BG** | 0.6546 | 0.7635 | -0.0902 | 15 | 65.5517 | 4.1582 | 17.2907 | 0.9994 | 0.0634 |
| 19 | 5042 | 1 | 2 | BA* | BS** | 0.9288 | 0.5303 | -2.7635 | 15 | 13.7502 | 2.3804 | 5.6664 | 0.9988 | 0.1731 |
| 19 | 5042 | 1 | 1 | BA* | BS** | 1.2637 | 0.3349 | -1.3799 | 15 | 12.7373 | 2.2182 | 4.9203 | 0.9996 | 0.1741 |
| 19 | 5046 | 1 | 1 | BA* | BS** | 0.9709 | 0.6113 | -1.9458 | 15 | 15.6701 | 2.9761 | 8.8572 | 0.9987 | 0.1899 |
| 19 | 5046 | 1 | 2 | TP* | BS** | 1.0231 | 0.5057 | -1.7480 | 15 | 14.2972 | 3.2284 | 10.4228 | 0.9987 | 0.2258 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 6049 | 1 | 1 | A1 | TS01 | 0.8254 | 0.1955 | -3.3212 | 15 | 11.3103 | 2.1609 | 4.6693 | 0.9985 | 0.1911 |
| 19 | 6049 | 1 | 2 | TP* | BS** | 1.0164 | 0.1962 | -3.3031 | 15 | 13.8351 | 1.5015 | 2.2546 | 0.9995 | 0.1085 |
| 19 | 6150 | 1 | 1 | BA* | BS* | 1.2065 | 0.2198 | -1.2748 | 15 | 9.2849 | 0.4994 | 0.2494 | 1.0000 | 0.0538 |
| 19 | 6150 | 1 | 2 | A2 | TS03 | 0.4963 | 0.6050 | -4.1992 | 15 | 8.4976 | 1.7196 | 2.9569 | 0.9970 | 0.2024 |
| 19 | 6150 | 2 | 1 | BA* | BG** | 1.5332 | 0.3766 | -0.5671 | 14 | 33.7438 | 13.8003 | 190.4490 | 0.9948 | 0.4090 |
| 19 | 6150 | 2 | 2 | BA* | BG** | 1.6464 | 0.4173 | -0.5915 | 14 | 40.4489 | 12.1557 | 147.7598 | 0.9967 | 0.3005 |
| 19 | 9126 | 1 | 1 | A1 | TS01 | 1.2189 | 0.3434 | -2.9238 | 15 | 16.0036 | 2.5706 | 6.6081 | 0.9991 | 0.1606 |
| 19 | 9126 | 1 | 2 | A2 | TS03 | 0.8953 | 0.3317 | -4.0784 | 15 | 13.3944 | 1.6416 | 2.6948 | 0.9991 | 0.1226 |
| 19 | 9126 | 3 | 1 | BA* | BG** | 0.7340 | 0.8203 | -0.1035 | 15 | 83.6418 | 8.1848 | 66.9905 | 0.9984 | 0.0979 |
| 19 | 9126 | 3 | 2 | TP* | BG** | 0.8565 | 0.5750 | 0.0000 | 15 | 56.6504 | 11.3103 | 127.9232 | 0.9958 | 0.1997 |
| 20 | 0101 | 1 | 3 | A5 | TS12 | 0.9228 | 0.2176 | -2.1077 | 14 | 9.1198 | 1.1220 | 1.2589 | 0.9998 | 0.1230 |
| 20 | 0110 | 1 | 3 | A23 | TS53 | 1.0282 | 0.3089 | -2.0891 | 15 | 11.2622 | 2.2341 | 4.9913 | 0.9993 | 0.1984 |
| 20 | 0203 | 1 | 2 | B1 | BS01 | 1.1307 | 0.2483 | -1.0144 | 15 | 8.7788 | 1.4964 | 2.2392 | 0.9998 | 0.1705 |
| 20 | 1005 | 1 | 1 | A1 | TS01 | 0.9171 | 0.0998 | -2.8131 | 15 | 11.7648 | 0.8882 | 0.7888 | 0.9998 | 0.0755 |
| 20 | 1005 | 1 | 2 | A2 | TS03 | 1.0058 | 0.2793 | -3.0416 | 15 | 13.2970 | 1.2214 | 1.4917 | 0.9997 | 0.0919 |
| 20 | 1006 | 1 | 1 | BA* | BS* | 1.0688 | 0.3618 | -2.5638 | 15 | 13.5425 | 2.8128 | 7.9117 | 0.9988 | 0.2077 |
| 20 | 1006 | 1 | 2 | TP* | BS** | 0.5343 | 0.3354 | -2.1834 | 15 | 6.4991 | 2.5681 | 6.5950 | 0.9963 | 0.3951 |
| 20 | 1009 | 1 | 2 | TP* | BS** | 1.4287 | 0.2558 | -2.7932 | 15 | 17.8480 | 2.7120 | 7.3549 | 0.9993 | 0.1519 |
| 20 | 1009 | 1 | 1 | BA* | BS** | 0.5444 | 0.7363 | -1.9292 | 15 | 10.6355 | 2.4440 | 5.9731 | 0.9974 | 0.2298 |
| 20 | 1010 | 1 | 1 | A1 | TS01 | 0.8326 | 0.3336 | -2.3971 | 15 | 9.9990 | 1.6626 | 2.7641 | 0.9993 | 0.1663 |
| 20 | 1010 | 1 | 2 | A2 | TS03 | 0.9594 | 0.3163 | -2.9697 | 15 | 12.6818 | 2.0378 | 4.1528 | 0.9991 | 0.1607 |
| 20 | 3013 | 1 | 1 | A1 | TS01 | 1.1909 | 0.1432 | -1.1052 | 15 | 7.6014 | 0.8713 | 0.7592 | 0.9999 | 0.1146 |
| 20 | 3013 | 1 | 2 | BA* | BS** | 1.0051 | 0.1964 | -1.7240 | 15 | 9.1026 | 1.4938 | 2.2315 | 0.9997 | 0.1641 |
| 20 | 3015 | 1 | 1 | A1 | TS01 | 1.1866 | 0.1883 | -1.1641 | 15 | 8.3484 | 1.1655 | 1.3584 | 0.9999 | 0.1396 |
| 20 | 3015 | 1 | 2 | BA* | BS** | 0.9001 | 0.2254 | -1.3863 | 15 | 7.3082 | 0.8490 | 0.7207 | 0.9999 | 0.1162 |
| 20 | 3060 | 1 | 1 | BA* | BS** | 1.0383 | 0.3049 | -1.9478 | 15 | 10.9510 | 1.4304 | 2.0462 | 0.9997 | 0.1306 |
| 20 | 3060 | 1 | 2 | A2 | TS03 | 0.8682 | 0.2030 | -2.7581 | 15 | 10.6802 | 0.8186 | 0.6701 | 0.9998 | 0.0766 |
| 20 | 4016 | 1 | 1 | BA* | BS** | 1.3182 | 0.1903 | -0.9351 | 15 | 8.4555 | 1.0999 | 1.2099 | 0.9999 | 0.1301 |
| 20 | 4016 | 1 | 2 | A2 | TS03 | 0.8293 | 0.2439 | -3.0881 | 15 | 10.9427 | 1.0727 | 1.1506 | 0.9996 | 0.0980 |
| 20 | 4016 | 2 | 1 | BA* | BG** | 0.9342 | 0.5967 | 0.0000 | 15 | 65.9965 | 4.3712 | 19.1073 | 0.9995 | 0.0662 |
| 20 | 4052 | 1 | 1 | BA* | BS** | 0.6744 | 0.5186 | -1.9799 | 13 | 9.6190 | 1.3937 | 1.9425 | 0.9994 | 0.1449 |
| 20 | 4052 | 1 | 2 | BA* | BS** | 0.6321 | 0.6997 | -0.7172 | 15 | 13.8640 | 2.4230 | 5.8709 | 0.9987 | 0.1748 |
| 20 | 4053 | 1 | 1 | BA* | BS** | 0.8396 | 0.4462 | -3.5158 | 15 | 12.6201 | 3.0494 | 9.2991 | 0.9971 | 0.2416 |
| 20 | 4053 | 1 | 2 | A2 | TS03 | 0.8677 | 0.2452 | -5.5103 | 15 | 14.7351 | 2.5128 | 6.3142 | 0.9969 | 0.1705 |
| 20 | 4054 | 1 | 1 | A1 | TS01 | 1.0542 | 0.1421 | -1.7260 | 15 | 9.2772 | 0.8409 | 0.7071 | 0.9999 | 0.0906 |
| 20 | 4054 | 1 | 2 | BA* | BS** | 0.9615 | 0.2514 | -0.9968 | 15 | 7.5498 | 1.5755 | 2.4823 | 0.9997 | 0.2087 |
| 20 | 4063 | 1 | 1 | A1 | TS02 | 0.6180 | 0.3951 | -4.0257 | 15 | 9.5802 | 2.1407 | 4.5824 | 0.9969 | 0.2234 |
| 20 | 4063 | 1 | 2 | BA* | BS** | 0.8238 | 0.6084 | -2.3082 | 15 | 13.1022 | 2.1113 | 4.4577 | 0.9990 | 0.1611 |
| 20 | 4067 | 1 | 1 | BA* | BS** | 0.5004 | 0.1924 | -5.4471 | 15 | 8.3854 | 0.8444 | 0.7131 | 0.9989 | 0.1007 |
| 20 | 4067 | 1 | 2 | A2 | TS04 | 1.4136 | 0.1418 | -1.2489 | 15 | 9.9226 | 1.7860 | 3.1896 | 0.9998 | 0.1800 |
| 20 | 4067 | 3 | 1 | BA* | BG** | 0.5290 | 0.8166 | -0.2554 | 13 | 47.7971 | 3.0617 | 9.3741 | 0.9995 | 0.0641 |
| 20 | 4067 | 3 | 2 | TP* | BG** | 0.7695 | 0.6528 | -0.0573 | 14 | 56.2055 | 2.8450 | 8.0940 | 0.9997 | 0.0506 |
| 20 | 6026 | 1 | 1 | A1 | TS01 | 1.3415 | 0.1781 | -1.0188 | 15 | 8.7244 | 1.9034 | 3.6229 | 0.9998 | 0.2182 |
| 20 | 6026 | 1 | 2 | A2 | TS04 | 1.4843 | 0.2690 | -0.5641 | 15 | 12.1988 | 1.9063 | 3.6340 | 0.9998 | 0.1563 |
| 20 | 7073 | 1 | 1 | BA* | BS** | 0.7014 | 0.6221 | -0.6926 | 15 | 13.5394 | 1.8848 | 3.5526 | 0.9993 | 0.1392 |
| 20 | 7073 | 1 | 2 | BA* | BS** | 0.6359 | 0.7141 | -0.7743 | 15 | 14.1462 | 1.2418 | 1.5421 | 0.9997 | 0.0878 |
| 20 | 7073 | 2 | 2 | BA* | BG** | 1.0509 | 0.4321 | 0.0000 | 15 | 45.7356 | 4.2702 | 18.2344 | 0.9994 | 0.0934 |
| 20 | 7073 | 2 | 1 | BA* | BG** | 0.6247 | 0.7330 | -0.2781 | 15 | 51.2025 | 2.2313 | 4.9787 | 0.9997 | 0.0436 |
| 20 | 7085 | 1 | 1 | A1 | TS01 | 0.6522 | 0.2634 | -3.6317 | 15 | 9.2618 | 0.8985 | 0.8073 | 0.9995 | 0.0970 |
| 20 | 7085 | 1 | 2 | A2 | TS03 | 1.0001 | 0.1866 | -2.0313 | 15 | 9.9657 | 0.8299 | 0.6887 | 0.9999 | 0.0833 |
| 20 | 7085 | 2 | 2 | BA* | BG** | 0.9166 | 0.6488 | -0.2080 | 15 | 62.9350 | 5.1951 | 26.9889 | 0.9992 | 0.0825 |
| 20 | 7085 | 2 | 1 | BA* | BG** | 1.1409 | 0.5790 | -0.4235 | 15 | 54.8568 | 7.9566 | 63.3077 | 0.9983 | 0.1450 |
| 20 | 9037 | 1 | 1 | A1 | TS02 | 0.6495 | 0.4006 | -3.3312 | 15 | 9.2880 | 1.9667 | 3.8678 | 0.9980 | 0.2117 |
| 20 | 9037 | 1 | 2 | A2 | TS03 | 0.8944 | 0.4029 | -3.3992 | 15 | 12.8256 | 2.0650 | 4.2644 | 0.9988 | 0.1610 |
| 20 | 9037 | 2 | 1 | BA* | BG** | 0.7377 | 0.7179 | 0.0000 | 15 | 70.8941 | 5.5094 | 30.3536 | 0.9991 | 0.0777 |
| 20 | 9037 | 2 | 2 | BA* | BG** | 1.5178 | 0.3971 | 0.0000 | 15 | 58.9320 | 4.4759 | 20.0333 | 0.9997 | 0.0759 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 1010 | 1 | 1 | BA* | BS** | 1.3140 | 0.3828 | -1.5136 | 14 | 14.3787 | 1.6804 | 2.8238 | 0.9998 | 0.1169 |
| 21 | 1010 | 1 | 2 | TP* | BS** | 1.5693 | 0.2436 | -1.3492 | 15 | 13.1105 | 1.7836 | 3.1812 | 0.9998 | 0.1360 |
| 21 | 1010 | 2 | 1 | BA* | BG** | 0.9395 | 0.7345 | 0.0000 | 15 | 93.9695 | 6.0900 | 37.0880 | 0.9994 | 0.0648 |
| 21 | 1010 | 2 | 2 | TP* | BG** | 1.0459 | 0.6707 | 0.0000 | 15 | 89.6545 | 10.0747 | 101.5000 | 0.9983 | 0.1124 |
| 21 | 1034 | 1 | 1 | BA* | BS** | 1.2691 | 0.1488 | -1.4909 | 15 | 10.5483 | 2.9698 | 8.8194 | 0.9992 | 0.2815 |
| 21 | 1034 | 1 | 2 | TP* | BS** | 1.5143 | 0.2963 | -0.8791 | 15 | 13.4625 | 2.5721 | 6.6158 | 0.9997 | 0.1911 |
| 21 | 3016 | 1 | 1 | BA* | BS** | 1.2755 | 0.3655 | -3.9170 | 15 | 19.1833 | 1.5922 | 2.5350 | 0.9996 | 0.0830 |
| 21 | 3016 | 1 | 2 | BA* | BS** | 1.4503 | 0.2515 | -2.0894 | 15 | 15.4633 | 2.7497 | 7.5611 | 0.9994 | 0.1778 |
| 21 | 3016 | 3 | 1 | BA* | BG** | 1.2765 | 0.6587 | -0.2201 | 14 | 85.0612 | 5.2495 | 27.5576 | 0.9996 | 0.0617 |
| 21 | 4025 | 2 | 1 | BA* | BG** | 1.8262 | 0.5918 | -0.8477 | 14 | 68.0482 | 21.4827 | 461.5070 | 0.9933 | 0.3157 |
| 21 | 4025 | 2 | 2 | BA* | BG** | 1.0295 | 0.5355 | 0.0000 | 15 | 61.0209 | 10.5917 | 112.1837 | 0.9972 | 0.1736 |
| 21 | 6040 | 1 | 1 | BA* | BS** | 1.8454 | 0.1822 | 0.0000 | 15 | 17.9828 | 13.0745 | 170.9435 | 0.9957 | 0.7271 |
| 21 | 6040 | 1 | 2 | TP* | BS** | 1.7626 | 0.3400 | -0.1478 | 12 | 21.5062 | 3.0622 | 9.3770 | 0.9997 | 0.1424 |
| 21 | 6040 | 2 | 1 | BA* | BG** | 0.7885 | 0.7352 | -0.0396 | 15 | 76.3275 | 5.6096 | 31.4680 | 0.9992 | 0.0735 |
| 21 | 6040 | 2 | 2 | TP* | BG** | 0.9805 | 0.6050 | 0.0000 | 15 | 70.4505 | 6.2345 | 38.8694 | 0.9991 | 0.0885 |
| 21 | 6043 | 1 | 2 | TP1 | BS** | 1.1778 | 0.2814 | -1.5852 | 15 | 11.1283 | 2.1033 | 4.4240 | 0.9996 | 0.1890 |
| 21 | 6043 | 2 | 1 | BA* | BG** | 0.8953 | 0.7648 | 0.0000 | 15 | 95.9820 | 6.9636 | 48.4916 | 0.9991 | 0.0726 |
| 21 | 6043 | 2 | 2 | TP* | BG** | 0.7641 | 0.7552 | -0.0122 | 15 | 78.9523 | 7.0479 | 49.6732 | 0.9987 | 0.0893 |
| 22 | 0113 | 1 | 1 | B6 | BS06 | 1.0059 | 0.1915 | 0.0000 | 15 | 9.4617 | 6.2752 | 39.3779 | 0.9966 | 0.6632 |
| 22 | 0113 | 3 | 2 | B12 | BG12 | 0.7163 | 0.2062 | -0.6477 | 15 | 4.8137 | 1.7752 | 3.1514 | 0.9994 | 0.3688 |
| 22 | 0117 | 1 | 2 | B5 | BS05 | 0.7686 | 0.1458 | 0.0000 | 15 | 4.8028 | 2.5121 | 6.3109 | 0.9991 | 0.5231 |
| 22 | 0118 | 1 | 2 | B4 | BS04 | 0.8679 | 0.1866 | 0.0000 | 15 | 7.4066 | 4.4189 | 19.5269 | 0.9978 | 0.5966 |
| 22 | 0118 | 2 | 1 | B10 | BG10 | 0.6805 | 0.3283 | -1.0674 | 15 | 6.6490 | 1.6997 | 2.8890 | 0.9993 | 0.2556 |
| 22 | 0119 | 1 | 2 | B1 | BS01 | 0.6042 | 0.2110 | -0.2100 | 15 | 4.4753 | 1.6793 | 2.8201 | 0.9993 | 0.3752 |
| 22 | 0119 | 2 | 1 | B7 | BG07 | 0.4108 | 0.5374 | -0.7097 | 15 | 6.8020 | 1.1648 | 1.3567 | 0.9992 | 0.1712 |
| 22 | 0121 | 1 | 2 | B2 | BS02 | 0.4437 | 0.4391 | -0.4960 | 15 | 6.3456 | 1.7877 | 3.1957 | 0.9985 | 0.2817 |
| 22 | 0124 | 1 | 1 | B3 | BS03 | 0.8404 | 0.1335 | 0.0000 | 15 | 5.1390 | 3.0860 | 9.5235 | 0.9988 | 0.6005 |
| 22 | 4001 | 1 | 1 | BA* | BS** | 1.4944 | 0.8507 | -2.3484 | 15 | 32.2921 | 11.1757 | 124.8952 | 0.9923 | 0.3461 |
| 22 | 4001 | 1 | 2 | BA* | BS** | 1.3809 | 0.3573 | -0.5343 | 15 | 15.8033 | 4.5453 | 20.6596 | 0.9990 | 0.2876 |
| 22 | 4001 | 2 | 1 | BA* | BG** | 0.6173 | 0.6772 | -0.3508 | 15 | 41.1482 | 6.8960 | 47.5550 | 0.9969 | 0.1676 |
| 23 | 0506 | 1 | 2 | TP1 | BS55 | 0.5087 | 0.5699 | -0.0732 | 15 | 10.6158 | 1.2952 | 1.6776 | 0.9995 | 0.1220 |
| 23 | 0506 | 2 | 2 | TP1 | BG56 | 0.4848 | 0.5852 | -0.0566 | 15 | 31.7366 | 1.3996 | 1.9590 | 0.9998 | 0.0441 |
| 23 | 1012 | 1 | 1 | BA* | BS** | 0.6022 | 0.5781 | 0.0000 | 15 | 13.3442 | 2.7335 | 7.4722 | 0.9985 | 0.2048 |
| 23 | 1012 | 1 | 2 | TP | BS55 | 0.6974 | 0.6371 | -1.5406 | 15 | 12.6867 | 4.1763 | 17.4412 | 0.9958 | 0.3292 |
| 23 | 1012 | 2 | 1 | BA* | BG** | 0.5464 | 0.7491 | -0.2655 | 14 | 48.4540 | 3.9740 | 15.7924 | 0.9990 | 0.0820 |
| 23 | 1026 | 1 | 2 | TP | BS55 | 0.8330 | 0.6087 | -0.9905 | 15 | 14.8574 | 1.8059 | 3.2613 | 0.9995 | 0.1215 |
| 23 | 3013 | 1 | 2 | BA* | BS** | 0.6755 | 0.6278 | -0.4215 | 15 | 14.2368 | 1.9750 | 3.9005 | 0.9993 | 0.1387 |
| 23 | 3013 | 2 | 1 | BA* | BG** | 0.6736 | 0.6746 | -0.1825 | 15 | 51.0720 | 3.2040 | 10.2659 | 0.9995 | 0.0627 |
| 23 | 3014 | 1 | 1 | BA* | BS** | 0.7205 | 0.7498 | -0.9058 | 15 | 16.4056 | 2.2938 | 5.2613 | 0.9991 | 0.1398 |
| 23 | 7023 | 1 | 1 | BA** | BS** | 0.6913 | 0.6144 | 0.0000 | 14 | 16.4290 | 3.1704 | 10.0515 | 0.9985 | 0.1930 |
| 23 | 7023 | 1 | 2 | BA* | BS** | 0.7092 | 0.6402 | 0.0000 | 15 | 17.3940 | 4.0928 | 16.7511 | 0.9976 | 0.2353 |
| 24 | 1632 | 2 | 1 | BA* | BG** | 0.5811 | 0.6991 | -0.0579 | 15 | 52.1860 | 2.9777 | 8.8666 | 0.9995 | 0.0571 |
| 24 | 1632 | 2 | 2 | TP | BG55 | 0.7274 | 0.6283 | -0.2507 | 15 | 46.4612 | 4.1235 | 17.0034 | 0.9992 | 0.0888 |
| 24 | 1634 | 1 | 2 | TP | BS55 | 0.8622 | 0.6097 | -0.6792 | 15 | 16.6796 | 3.7889 | 14.3557 | 0.9982 | 0.2272 |
| 24 | 1634 | 2 | 1 | BA1 | BG03 | 1.2617 | 0.5666 | -0.4912 | 15 | 55.4963 | 11.5692 | 133.8464 | 0.9969 | 0.2085 |
| 24 | 2401 | 3 | 1 | BA2 | BG02 | 1.1044 | 0.4425 | -0.0430 | 15 | 48.3967 | 11.6601 | 135.9578 | 0.9961 | 0.2409 |
| 24 | 2401 | 3 | 2 | TP | BG55 | 1.3128 | 0.5367 | -0.4288 | 15 | 55.4645 | 13.6206 | 185.5200 | 0.9959 | 0.2456 |
| 24 | 2805 | 2 | 1 | BA* | BG** | 0.8228 | 0.5139 | -0.1333 | 15 | 41.6713 | 3.4960 | 12.2221 | 0.9994 | 0.0839 |
| 24 | 5807 | 2 | 1 | BA* | BG** | 0.8824 | 0.5890 | -0.2614 | 15 | 49.5448 | 7.9898 | 63.8367 | 0.9976 | 0.1613 |
| 24 | 5807 | 2 | 2 | BA5 | BG05 | 0.8888 | 0.5661 | -0.0848 | 15 | 54.0839 | 8.5424 | 72.9731 | 0.9976 | 0.1579 |
| 25 | 1002 | 1 | 2 | TP | BS55 | 0.7155 | 0.6381 | -0.8656 | 15 | 14.1209 | 3.4568 | 11.9492 | 0.9978 | 0.2448 |
| 25 | 1004 | 1 | 1 | BA3 | BS03 | 0.6026 | 0.6496 | 0.0000 | 14 | 15.8268 | 4.9782 | 24.7828 | 0.9953 | 0.3145 |
| 26 | 0120 | 1 | 2 | B1 | BS01 | 1.4818 | 0.3113 | -2.9054 | 13 | 18.9804 | 1.3988 | 1.9567 | 0.9998 | 0.0737 |
| 26 | 0121 | 2 | 1 | B9 | BG01 | 1.0702 | 0.7188 | -0.0101 | 14 | 94.1332 | 18.6328 | 347.1815 | 0.9945 | 0.1979 |
| 26 | 0122 | 1 | 1 | B4 | BS04 | 1.4366 | 0.2674 | -1.4395 | 15 | 12.6822 | 1.5319 | 2.3466 | 0.9998 | 0.1208 |
| 26 | 0218 | 1 | 2 | B6 | BS06 | 1.4717 | 0.2640 | -1.5980 | 15 | 13.6706 | 2.1813 | 4.7582 | 0.9997 | 0.1596 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 0219 | 1 | 1 | B7 | BS07 | 1.3374 | 0.3864 | -2.0730 | 13 | 16.3868 | 1.8866 | 3.5591 | 0.9997 | 0.1151 |
| 26 | 0219 | 2 | 2 | B14 | BG14 | 1.4301 | 0.3172 | -2.8978 | 15 | 18.5673 | 1.8217 | 3.3184 | 0.9997 | 0.0981 |
| 26 | 0220 | 1 | 1 | B3 | BS03 | 1.3238 | 0.2598 | -3.4381 | 14 | 18.7605 | 1.3376 | 1.7890 | 0.9998 | 0.0713 |
| 26 | 0222 | 1 | 2 | B5 | BS05 | 1.0187 | 0.4008 | -4.7503 | 14 | 16.9487 | 2.5285 | 6.3933 | 0.9981 | 0.1492 |
| 26 | 0224 | 1 | 2 | B2 | BS02 | 1.1615 | 0.2411 | -3.9661 | 15 | 17.3543 | 1.8745 | 3.5138 | 0.9993 | 0.1080 |
| 26 | 0224 | 2 | 2 | B9 | BG09 | 1.4414 | 0.3682 | -2.1885 | 14 | 14.3291 | 0.8665 | 0.7509 | 0.9999 | 0.0605 |
| 26 | 1001 | 1 | 1 | BA* | BS** | 0.7635 | 0.6178 | -0.6505 | 15 | 15.6683 | 5.5531 | 30.8369 | 0.9952 | 0.3544 |
| 26 | 1001 | 2 | 1 | BA* | BG** | 1.2137 | 0.5162 | 0.0000 | 15 | 68.2490 | 8.0786 | 65.2642 | 0.9988 | 0.1184 |
| 26 | 1001 | 2 | 2 | TP* | BG** | 0.9975 | 0.6751 | -0.0387 | 15 | 84.1689 | 3.2104 | 10.3066 | 0.9998 | 0.0381 |
| 26 | 1004 | 1 | 1 | BA* | BS** | 0.9051 | 0.6812 | -1.0068 | 14 | 18.9593 | 4.0895 | 16.7237 | 0.9980 | 0.2157 |
| 26 | 1004 | 1 | 2 | TP* | BS** | 0.8749 | 0.6533 | -0.9488 | 15 | 18.2227 | 6.8059 | 46.3206 | 0.9941 | 0.3735 |
| 26 | 1004 | 2 | 2 | TP* | BG** | 0.6441 | 0.7193 | -0.0274 | 15 | 61.1261 | 3.4596 | 11.9692 | 0.9995 | 0.0566 |
| 26 | 1010 | 1 | 1 | BA* | BS** | 0.2186 | 0.7104 | 0.0000 | 15 | 7.3937 | 4.4017 | 19.3749 | 0.9726 | 0.5953 |
| 26 | 1010 | 1 | 2 | TP* | BS** | 0.2849 | 0.1893 | -0.9044 | 15 | 4.5930 | 4.2497 | 18.0598 | 0.9752 | 0.9253 |
| 26 | 1010 | 2 | 1 | BA* | BG** | 0.6960 | 0.6713 | -0.1122 | 15 | 54.7890 | 2.8313 | 8.0163 | 0.9997 | 0.0517 |
| 26 | 1010 | 2 | 2 | TP* | BG** | 0.5464 | 0.8224 | -0.4050 | 13 | 46.1708 | 2.4887 | 6.1938 | 0.9996 | 0.0539 |
| 26 | 1010 | 3 | 1 | BA* | BG** | 1.0904 | 0.5005 | 0.0000 | 15 | 58.7963 | 5.2456 | 27.5165 | 0.9993 | 0.0892 |
| 26 | 1010 | 3 | 2 | TP* | BG** | 0.8491 | 0.7005 | 0.0000 | 15 | 78.0328 | 5.7623 | 33.2042 | 0.9992 | 0.0738 |
| 26 | 1012 | 1 | 1 | BA* | BS** | 0.7369 | 0.7053 | -0.7929 | 15 | 16.5840 | 4.7026 | 22.1141 | 0.9963 | 0.2836 |
| 26 | 1012 | 1 | 2 | A2 | TS04 | 1.2862 | 0.1626 | -1.5326 | 15 | 10.3473 | 0.7875 | 0.6201 | 0.9999 | 0.0761 |
| 26 | 1012 | 2 | 1 | BA* | BG** | 0.7927 | 0.5511 | -0.1813 | 15 | 42.9293 | 6.8693 | 47.1871 | 0.9978 | 0.1600 |
| 26 | 1012 | 2 | 2 | TP* | BG** | 0.6790 | 0.8114 | -0.4863 | 15 | 57.6894 | 6.7627 | 45.7343 | 0.9981 | 0.1172 |
| 26 | 1012 | 3 | 2 | TP* | BG** | 0.8505 | 0.6235 | -0.2292 | 15 | 54.2979 | 6.9024 | 47.6425 | 0.9983 | 0.1271 |
| 26 | 1013 | 1 | 1 | BA* | BS** | 0.7225 | 0.7486 | -0.6051 | 15 | 17.5857 | 1.6345 | 2.6716 | 0.9996 | 0.0929 |
| 26 | 1013 | 2 | 1 | BA* | BG** | 0.5853 | 0.7240 | -0.1627 | 15 | 50.5296 | 5.9401 | 35.2853 | 0.9981 | 0.1176 |
| 26 | 1013 | 2 | 2 | TP* | BG** | 0.6525 | 0.6243 | -0.0706 | 15 | 46.6640 | 5.2572 | 27.6385 | 0.9986 | 0.1127 |
| 26 | 1013 | 3 | 1 | BA* | BG** | 0.5752 | 0.6509 | 0.0000 | 15 | 46.6444 | 7.1070 | 50.5094 | 0.9970 | 0.1524 |
| 26 | 1013 | 3 | 2 | TP* | BG** | 0.6082 | 0.7773 | -0.2590 | 15 | 55.6492 | 4.4721 | 19.9998 | 0.9991 | 0.0804 |
| 26 | 3069 | 1 | 1 | BA* | BS** | 0.7556 | 0.7524 | -0.6701 | 14 | 18.7552 | 1.8128 | 3.2862 | 0.9995 | 0.0967 |
| 26 | 3069 | 1 | 2 | TP* | BS** | 0.7152 | 0.7789 | -0.7880 | 13 | 16.3911 | 1.1601 | 1.3459 | 0.9998 | 0.0708 |
| 26 | 4015 | 1 | 1 | BA* | BS** | 1.2632 | 0.3423 | -3.0715 | 15 | 17.2530 | 3.4649 | 12.0054 | 0.9985 | 0.2008 |
| 26 | 4015 | 1 | 2 | TP* | BS** | 1.0766 | 0.4109 | -3.9369 | 15 | 16.3745 | 1.6421 | 2.6964 | 0.9994 | 0.1003 |
| 26 | 4015 | 2 | 1 | BA* | BG** | 0.6861 | 0.6778 | -0.0540 | 15 | 57.0374 | 5.6369 | 31.7743 | 0.9987 | 0.0988 |
| 26 | 4015 | 2 | 2 | TP* | BG** | 0.9150 | 0.5608 | -0.0688 | 15 | 55.2729 | 5.8685 | 34.4389 | 0.9989 | 0.1062 |
| 26 | 5363 | 2 | 1 | BA* | BG** | 0.9378 | 0.4957 | 0.0000 | 15 | 49.7299 | 4.4243 | 19.5743 | 0.9993 | 0.0890 |
| 26 | 5363 | 2 | 2 | TP* | BG** | 0.7150 | 0.6980 | -0.0108 | 15 | 64.8101 | 3.5763 | 12.7899 | 0.9996 | 0.0552 |
| 26 | 5363 | 3 | 1 | BA* | BG** | 0.8545 | 0.6235 | -0.1165 | 15 | 58.9102 | 8.5503 | 73.1082 | 0.9977 | 0.1451 |
| 26 | 5363 | 3 | 2 | TP* | BG** | 0.5204 | 0.6969 | 0.0000 | 15 | 47.1990 | 6.1308 | 37.5861 | 0.9976 | 0.1299 |
| 26 | 6016 | 1 | 1 | BA* | BS** | 0.6990 | 0.6532 | -0.5370 | 15 | 14.8837 | 2.0780 | 4.3179 | 0.9992 | 0.1396 |
| 26 | 6016 | 2 | 2 | TP* | BG** | 1.2267 | 0.4050 | -0.0344 | 15 | 47.4821 | 9.3367 | 87.1732 | 0.9978 | 0.1966 |
| 26 | 6016 | 2 | 1 | BA* | BG** | 0.7111 | 0.7467 | -0.3196 | 15 | 58.7317 | 2.7828 | 7.7439 | 0.9997 | 0.0474 |
| 26 | 6016 | 3 | 1 | BA* | BG** | 0.6625 | 0.6839 | -0.1188 | 15 | 53.2955 | 7.4471 | 55.4593 | 0.9975 | 0.1397 |
| 26 | 6016 | 3 | 2 | TP* | BG** | 0.7712 | 0.7104 | -0.1748 | 14 | 59.9572 | 3.6474 | 13.3032 | 0.9995 | 0.0608 |
| 26 | 7072 | 1 | 1 | BA* | BS** | 0.6671 | 0.8126 | -1.0981 | 14 | 15.5712 | 1.8731 | 3.5084 | 0.9992 | 0.1203 |
| 26 | 7072 | 1 | 2 | TP* | BS** | 2.3352 | 0.2824 | -0.8111 | 14 | 18.2108 | 1.3008 | 1.6921 | 1.0000 | 0.0714 |
| 26 | 7072 | 2 | 1 | BA* | BG** | 0.7257 | 0.7702 | -0.3289 | 15 | 62.3880 | 4.9261 | 24.2666 | 0.9991 | 0.0790 |
| 26 | 7072 | 2 | 2 | TP* | BG** | 0.5510 | 0.8236 | -0.0397 | 15 | 65.5310 | 5.3964 | 29.1217 | 0.9988 | 0.0824 |
| 26 | 7072 | 3 | 1 | BA* | BG** | 1.3205 | 0.4923 | 0.0000 | 15 | 69.2262 | 9.2379 | 85.3392 | 0.9985 | 0.1334 |
| 26 | 7072 | 3 | 2 | TP* | BG** | 0.8766 | 0.7457 | 0.0000 | 15 | 89.4937 | 7.4010 | 54.7755 | 0.9989 | 0.0827 |
| 26 | 9029 | 2 | 1 | BA* | BG** | 0.5808 | 0.7716 | -0.2813 | 15 | 51.7133 | 3.0769 | 9.4670 | 0.9995 | 0.0595 |
| 26 | 9029 | 3 | 1 | BA* | BG** | 0.7054 | 0.6211 | 0.0000 | 15 | 52.7891 | 6.2922 | 39.5924 | 0.9983 | 0.1192 |
| 26 | 9029 | 3 | 2 | BA* | BG** | 0.7859 | 0.5949 | 0.0000 | 15 | 55.0050 | 6.3423 | 40.2248 | 0.9985 | 0.1153 |
| 27 | 1016 | 1 | 1 | BA* | BS** | 0.7571 | 0.6718 | -0.7353 | 15 | 15.7782 | 1.5184 | 2.3057 | 0.9996 | 0.0962 |
| 27 | 1016 | 1 | 2 | TP* | BS** | 0.6648 | 0.7455 | -0.7598 | 15 | 15.4873 | 1.7236 | 2.9706 | 0.9994 | 0.1113 |
| 27 | 1016 | 2 | 1 | BA* | BG** | 0.7940 | 0.6779 | 0.0000 | 15 | 68.8309 | 5.3381 | 28.4953 | 0.9992 | 0.0776 |
| 27 | 1016 | 2 | 2 | TP* | BG** | 0.6633 | 0.6964 | 0.0000 | 15 | 60.3926 | 3.9359 | 15.4914 | 0.9994 | 0.0652 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | 1018 | 1 | 1 | BA* | BS** | 0.7145 | 0.6922 | -0.7367 | 15 | 15.3431 | 1.6328 | 2.6662 | 0.9995 | 0.1064 |
| 27 | 1018 | 1 | 2 | TP* | BS** | 0.5661 | 0.8358 | -0.8654 | 15 | 14.7254 | 1.3619 | 1.8547 | 0.9995 | 0.0925 |
| 27 | 1018 | 2 | 1 | BA* | BG** | 0.7521 | 0.6316 | -0.2637 | 15 | 47.3867 | 7.7311 | 59.7703 | 0.9973 | 0.1632 |
| 27 | 1018 | 2 | 2 | TP* | BG** | 0.4830 | 0.8376 | -0.3472 | 14 | 45.5099 | 4.0817 | 16.6607 | 0.9987 | 0.0897 |
| 27 | 1019 | 2 | 1 | BA* | BG** | 0.7410 | 0.6698 | -0.0688 | 15 | 60.1734 | 3.5661 | 12.7168 | 0.9995 | 0.0593 |
| 27 | 1019 | 2 | 2 | TP* | BG** | 0.9804 | 0.5447 | 0.0000 | 15 | 59.7106 | 7.0383 | 49.5374 | 0.9987 | 0.1179 |
| 27 | 1028 | 1 | 1 | BA* | BS** | 0.7300 | 0.7753 | -1.1021 | 15 | 16.7724 | 2.1937 | 4.8124 | 0.9991 | 0.1308 |
| 27 | 1028 | 1 | 2 | TP* | BS** | 0.7891 | 0.8533 | -1.4552 | 15 | 18.7266 | 2.1106 | 4.4548 | 0.9993 | 0.1127 |
| 27 | 1029 | 1 | 1 | BA* | BS** | 0.7796 | 0.5804 | -1.1021 | 15 | 12.9773 | 2.0276 | 4.1110 | 0.9993 | 0.1562 |
| 27 | 1029 | 1 | 2 | TP* | BS** | 0.7419 | 0.6791 | -0.9346 | 15 | 15.0403 | 1.8658 | 3.4814 | 0.9994 | 0.1241 |
| 27 | 1085 | 1 | 1 | BA* | BS** | 1.7532 | 0.2988 | -2.2666 | 15 | 19.7383 | 2.2788 | 5.1930 | 0.9997 | 0.1155 |
| 27 | 1085 | 1 | 2 | A2 | TS03 | 1.5602 | 0.3192 | -1.0676 | 15 | 14.9418 | 3.3932 | 11.5138 | 0.9995 | 0.2271 |
| 27 | 3003 | 1 | 1 | A1 | TS01 | 1.4477 | 0.2800 | -1.1707 | 15 | 12.5463 | 2.1119 | 4.4602 | 0.9997 | 0.1683 |
| 27 | 3003 | 1 | 2 | A2 | TS03 | 1.5063 | 0.2453 | -1.3728 | 15 | 12.5982 | 1.2990 | 1.6875 | 0.9999 | 0.1031 |
| 27 | 3003 | 2 | 1 | BA* | BG** | 0.8425 | 0.6046 | -0.2097 | 14 | 48.8306 | 4.1211 | 16.9831 | 0.9993 | 0.0844 |
| 27 | 3003 | 2 | 2 | TP* | BG** | 0.5108 | 0.8536 | -0.0885 | 15 | 63.0153 | 4.2206 | 17.8133 | 0.9992 | 0.0670 |
| 27 | 3013 | 1 | 2 | TP* | BS** | 0.6015 | 0.7370 | -1.1199 | 12 | 12.5224 | 1.0219 | 1.0442 | 0.9997 | 0.0816 |
| 27 | 4033 | 1 | 1 | C6 | BS01 | 0.5412 | 0.7300 | -1.0006 | 13 | 12.1560 | 1.7003 | 2.8911 | 0.9990 | 0.1399 |
| 27 | 4033 | 1 | 2 | TP* | BS** | 0.6682 | 0.7574 | -1.5541 | 15 | 13.8753 | 2.4022 | 5.7707 | 0.9985 | 0.1731 |
| 27 | 4034 | 1 | 1 | TP* | BS** | 0.7241 | 0.6873 | -0.7904 | 15 | 15.0627 | 1.7392 | 3.0247 | 0.9995 | 0.1155 |
| 27 | 4034 | 1 | 2 | TP* | BS** | 0.6477 | 0.5919 | -0.9236 | 15 | 11.6202 | 2.5074 | 6.2868 | 0.9985 | 0.2158 |
| 27 | 4034 | 2 | 1 | TP* | BG** | 0.7621 | 0.6335 | -0.0142 | 15 | 58.7706 | 4.4924 | 20.1821 | 0.9993 | 0.0764 |
| 27 | 4034 | 2 | 2 | TP* | BG** | 0.6644 | 0.7182 | -0.0591 | 15 | 60.9059 | 6.7047 | 44.9524 | 0.9983 | 0.1101 |
| 27 | 4037 | 1 | 1 | C6 | BS01 | 0.8953 | 0.6661 | -1.5409 | 15 | 16.1770 | 2.9636 | 8.7830 | 0.9987 | 0.1832 |
| 27 | 4037 | 1 | 2 | TP* | BS** | 0.4114 | 0.7488 | 0.0000 | 15 | 11.9312 | 1.6108 | 2.5947 | 0.9990 | 0.1350 |
| 27 | 4037 | 2 | 2 | TP* | BG** | 0.9164 | 0.6053 | 0.0000 | 15 | 66.4647 | 5.3933 | 29.0877 | 0.9992 | 0.0811 |
| 27 | 4040 | 1 | 1 | A1 | TS01 | 0.9116 | 0.1902 | -2.5367 | 15 | 10.5348 | 0.8562 | 0.7330 | 0.9998 | 0.0813 |
| 27 | 4040 | 1 | 2 | A2 | TS03 | 0.8461 | 0.1965 | -3.2454 | 15 | 11.3921 | 1.2857 | 1.6531 | 0.9995 | 0.1129 |
| 27 | 4040 | 2 | 1 | BA* | BG** | 0.4578 | 0.8095 | -0.0486 | 15 | 52.3923 | 4.5158 | 20.3924 | 0.9987 | 0.0862 |
| 27 | 4040 | 2 | 2 | TP* | BG** | 0.5690 | 0.7350 | -0.0515 | 15 | 54.5549 | 5.2740 | 27.8148 | 0.9986 | 0.0967 |
| 27 | 4054 | 1 | 1 | BA* | BS** | 0.6709 | 0.7337 | -0.9679 | 15 | 14.7367 | 1.7097 | 2.9232 | 0.9994 | 0.1160 |
| 27 | 4054 | 1 | 2 | BA* | BS** | 0.7898 | 0.8614 | -1.4658 | 14 | 17.7177 | 1.6678 | 2.7817 | 0.9996 | 0.0941 |
| 27 | 4054 | 2 | 1 | BA* | BG** | 1.0646 | 0.5307 | 0.0000 | 15 | 62.4086 | 6.8673 | 47.1599 | 0.9989 | 0.1100 |
| 27 | 4054 | 2 | 2 | BA* | BG** | 0.7552 | 0.6763 | 0.0000 | 15 | 64.9811 | 7.9268 | 62.8338 | 0.9980 | 0.1220 |
| 27 | 4055 | 1 | 1 | BA* | BS** | 0.8370 | 0.6106 | -1.0765 | 15 | 14.8269 | 2.7212 | 7.4048 | 0.9989 | 0.1835 |
| 27 | 4055 | 1 | 2 | TP* | BS** | 0.6854 | 0.5817 | -0.8830 | 15 | 11.9929 | 2.2371 | 5.0048 | 0.9989 | 0.1865 |
| 27 | 4055 | 2 | 2 | TP* | BG** | 0.6695 | 0.7695 | -0.2960 | 15 | 58.3902 | 7.7278 | 59.7194 | 0.9976 | 0.1323 |
| 27 | 4082 | 1 | 1 | A1 | TS01 | 0.9684 | 0.2068 | -2.6811 | 15 | 11.5540 | 1.1560 | 1.3364 | 0.9997 | 0.1001 |
| 27 | 4082 | 1 | 2 | TP* | BS** | 0.3577 | 0.9497 | -1.4417 | 14 | 10.0952 | 5.0992 | 26.0017 | 0.9814 | 0.5051 |
| 27 | 5076 | 1 | 1 | BA* | BS** | 1.1417 | 0.3884 | -2.1105 | 15 | 13.7096 | 2.4614 | 6.0586 | 0.9993 | 0.1795 |
| 27 | 5076 | 1 | 2 | BA* | BS** | 1.3797 | 0.2945 | -1.8713 | 15 | 14.0601 | 1.3203 | 1.7431 | 0.9999 | 0.0939 |
| 27 | 5076 | 2 | 1 | BA* | BG** | 0.7697 | 0.5864 | -0.0996 | 15 | 48.7001 | 6.3801 | 40.7062 | 0.9983 | 0.1310 |
| 27 | 5076 | 2 | 2 | BA* | BG** | 0.3297 | 0.9073 | -0.1510 | 15 | 43.6744 | 4.0163 | 16.1309 | 0.9984 | 0.0920 |
| 27 | 6251 | 1 | 1 | BA* | BS** | 0.7261 | 0.6619 | -0.8628 | 15 | 14.4888 | 1.7593 | 3.0952 | 0.9994 | 0.1214 |
| 27 | 6251 | 1 | 2 | TP* | BS** | 0.6138 | 0.8872 | -1.7640 | 15 | 14.5455 | 1.8369 | 3.3740 | 0.9990 | 0.1263 |
| 27 | 6251 | 2 | 2 | TP* | BG** | 0.7751 | 0.6919 | 0.0000 | 15 | 70.1171 | 4.1232 | 17.0004 | 0.9995 | 0.0588 |
| 27 | 6300 | 1 | 1 | A1 | TS01 | 1.1684 | 0.2273 | -3.1249 | 15 | 15.4081 | 1.7242 | 2.9730 | 0.9995 | 0.1119 |
| 27 | 6300 | 1 | 2 | TP* | BS** | 1.4667 | 0.3651 | -2.4260 | 15 | 17.8144 | 2.3072 | 5.3234 | 0.9996 | 0.1295 |
| 27 | 7090 | 1 | 1 | BA* | BS** | 0.6077 | 0.3404 | -3.8486 | 15 | 9.0333 | 1.6799 | 2.8222 | 0.9981 | 0.1860 |
| 27 | 7090 | 2 | 1 | BA* | BG** | 0.6938 | 0.5582 | -0.0688 | 15 | 41.7675 | 5.5503 | 30.8056 | 0.9983 | 0.1329 |
| 27 | 7090 | 2 | 2 | TP* | BG** | 0.7152 | 0.6393 | -0.2359 | 15 | 47.8012 | 4.7170 | 22.2499 | 0.9989 | 0.0987 |
| 27 | 7090 | 3 | 1 | BA* | BG** | 0.6122 | 0.6561 | -0.5419 | 14 | 31.8438 | 4.4535 | 19.8337 | 0.9985 | 0.1399 |
| 27 | 7090 | 3 | 2 | TP* | BG** | 0.4889 | 0.7558 | -0.3140 | 15 | 40.9719 | 7.1768 | 51.5069 | 0.9958 | 0.1752 |
| 27 | 9075 | 1 | 1 | BA* | BS** | 0.8421 | 0.2536 | -0.8485 | 15 | 6.3636 | 0.7034 | 0.4947 | 0.9999 | 0.1105 |
| 27 | 9075 | 1 | 2 | BA* | BS** | 1.1881 | 0.2096 | -1.2414 | 15 | 8.8678 | 0.6159 | 0.3793 | 1.0000 | 0.0695 |
| 28 | 0501 | 1 | 1 | A1 | TS01 | 0.4296 | 0.7504 | -0.4600 | 15 | 10.9965 | 1.7604 | 3.0991 | 0.9987 | 0.1601 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | 0501 | 1 | 2 | A2 | TS04 | 0.2136 | 0.4305 | -1.7715 | 15 | 2.9488 | 1.3894 | 1.9306 | 0.9943 | 0.4712 |
| 28 | 0503 | 1 | 1 | A7 | TS01 | 0.5346 | 0.5908 | 0.0000 | 15 | 12.8612 | 4.6447 | 21.5732 | 0.9945 | 0.3611 |
| 28 | 0504 | 1 | 2 | BA* | BS** | 1.3927 | 0.1484 | -1.3025 | 15 | 10.1278 | 2.0865 | 4.3534 | 0.9997 | 0.2060 |
| 28 | 0506 | 1 | 1 | A5 | TS01 | 0.5916 | 0.5060 | -1.2199 | 15 | 8.4808 | 2.1701 | 4.7095 | 0.9985 | 0.2559 |
| 28 | 0507 | 1 | 1 | A3 | TS01 | 1.1560 | 0.6145 | -0.7763 | 15 | 21.9812 | 6.6461 | 44.1702 | 0.9969 | 0.3024 |
| 28 | 0508 | 1 | 1 | A8 | TS01 | 0.6763 | 0.5245 | -3.0140 | 15 | 10.1980 | 2.5687 | 6.5980 | 0.9973 | 0.2519 |
| 28 | 0508 | 1 | 2 | A9 | TS03 | 0.6411 | 0.1921 | -0.2812 | 15 | 4.7929 | 2.7593 | 7.6139 | 0.9983 | 0.5757 |
| 28 | 0509 | 1 | 1 | A6 | TS01 | 0.9214 | 0.3365 | -4.0909 | 15 | 13.5794 | 2.9234 | 8.5465 | 0.9975 | 0.2153 |
| 28 | 1001 | 1 | 1 | A1 | TS01 | 0.4830 | 0.4098 | -4.9710 | 15 | 7.4909 | 1.7125 | 2.9327 | 0.9961 | 0.2286 |
| 28 | 1001 | 1 | 2 | A2 | TS03 | 0.6843 | 0.0033 | -3.7063 | 15 | 10.3694 | 2.0291 | 4.1173 | 0.9977 | 0.1957 |
| 28 | 1001 | 2 | 1 | BA* | BG** | 1.2394 | 0.4378 | -0.3516 | 15 | 40.4610 | 11.0430 | 121.9489 | 0.9964 | 0.2729 |
| 28 | 1001 | 2 | 2 | BA4 | BG** | 0.6769 | 0.7374 | -0.2764 | 15 | 55.9691 | 4.4790 | 20.0615 | 0.9991 | 0.0800 |
| 28 | 1016 | 1 | 1 | A1 | TS01 | 0.5635 | 0.8344 | -1.4185 | 15 | 15.1789 | 5.8728 | 34.4901 | 0.9887 | 0.3869 |
| 28 | 1016 | 1 | 2 | A2 | TS03 | 0.9632 | 0.4011 | -1.9807 | 15 | 14.5104 | 8.4931 | 72.1324 | 0.9887 | 0.5853 |
| 28 | 1016 | 2 | 1 | BA* | BG** | 0.7199 | 0.6171 | -0.1429 | 15 | 48.1306 | 4.3071 | 18.5509 | 0.9991 | 0.0895 |
| 28 | 1016 | 2 | 2 | TP1 | BG55 | 0.7488 | 0.5864 | -0.1679 | 15 | 45.5534 | 2.7471 | 7.5464 | 0.9996 | 0.0603 |
| 28 | 1802 | 1 | 1 | BA* | BS** | 0.8968 | 0.3915 | -0.4663 | 15 | 11.5882 | 3.4637 | 11.9969 | 0.9986 | 0.2989 |
| 28 | 1802 | 1 | 2 | A2 | TS03 | 0.7525 | 0.3040 | -0.0600 | 15 | 9.2941 | 4.4133 | 19.4774 | 0.9971 | 0.4749 |
| 28 | 1802 | 2 | 1 | BA* | BG** | 1.2030 | 0.4672 | -0.1977 | 15 | 49.0857 | 7.2767 | 52.9502 | 0.9986 | 0.1482 |
| 28 | 1802 | 2 | 2 | TP1 | BG55 | 0.9001 | 0.6394 | -0.1210 | 15 | 65.0943 | 6.6476 | 44.1907 | 0.9988 | 0.1021 |
| 28 | 2807 | 1 | 1 | A1 | TS01 | 0.3856 | 0.6519 | -3.2137 | 15 | 6.5407 | 1.7095 | 2.9225 | 0.9964 | 0.2614 |
| 28 | 2807 | 1 | 2 | A2 | TS03 | 0.9370 | 0.2147 | -2.8659 | 15 | 11.2559 | 1.9621 | 3.8497 | 0.9992 | 0.1743 |
| 28 | 3018 | 1 | 1 | A1 | TS01 | 0.7536 | 0.4199 | -1.3997 | 15 | 9.0963 | 2.0228 | 4.0918 | 0.9991 | 0.2224 |
| 28 | 3018 | 1 | 2 | A2 | TS03 | 0.9323 | 0.2198 | -1.7576 | 15 | 9.8522 | 4.9390 | 24.3937 | 0.9959 | 0.5013 |
| 28 | 3081 | 1 | 1 | A1 | TS01 | 0.7610 | 0.1258 | -1.0848 | 15 | 7.3569 | 5.7537 | 33.1050 | 0.9931 | 0.7821 |
| 28 | 3081 | 1 | 2 | A2 | TS03 | 0.7022 | 0.5815 | -1.3703 | 15 | 11.4155 | 1.8482 | 3.4158 | 0.9992 | 0.1619 |
| 28 | 3082 | 1 | 1 | A1 | TS01 | 0.9479 | 0.5542 | 0.0000 | 15 | 19.7653 | 2.3317 | 5.4368 | 0.9995 | 0.1180 |
| 28 | 3082 | 1 | 2 | A2 | TS03 | 0.8337 | 0.4984 | 0.0000 | 15 | 16.2211 | 5.4201 | 29.3771 | 0.9967 | 0.3341 |
| 28 | 3083 | 1 | 1 | A1 | TS01 | 0.6474 | 0.4511 | 0.0000 | 15 | 11.0247 | 2.2784 | 5.1912 | 0.9990 | 0.2067 |
| 28 | 3083 | 1 | 2 | A2 | TS03 | 0.6062 | 0.5550 | -0.1346 | 15 | 12.3327 | 1.5799 | 2.4960 | 0.9995 | 0.1281 |
| 28 | 3085 | 1 | 1 | BA* | BS** | 1.4489 | 0.2148 | -0.9126 | 15 | 10.5546 | 3.7374 | 13.9683 | 0.9992 | 0.3541 |
| 28 | 3087 | 1 | 1 | BA3 | BS03 | 0.8903 | 0.6372 | -0.8657 | 14 | 17.5893 | 2.3582 | 5.5609 | 0.9993 | 0.1341 |
| 28 | 3087 | 1 | 2 | BA* | BS** | 0.7258 | 0.3482 | 0.0000 | 13 | 10.4311 | 2.9281 | 8.5736 | 0.9987 | 0.2807 |
| 28 | 3089 | 1 | 1 | A1 | TS01 | 0.7743 | 0.4456 | -2.3509 | 15 | 10.3427 | 2.4650 | 6.0764 | 0.9984 | 0.2383 |
| 28 | 3089 | 1 | 2 | A2 | TS03 | 0.7370 | 0.3363 | -0.9617 | 15 | 8.6839 | 4.9681 | 24.6817 | 0.9950 | 0.5721 |
| 28 | 3090 | 1 | 1 | A1 | TS01 | 0.6065 | 0.2834 | -1.8594 | 15 | 8.2271 | 5.3669 | 28.8039 | 0.9885 | 0.6523 |
| 28 | 3090 | 1 | 2 | A2 | TS02 | 0.7514 | 0.4839 | -2.0114 | 15 | 10.2794 | 2.3089 | 5.3308 | 0.9986 | 0.2246 |
| 28 | 3090 | 2 | 1 | BA* | BG** | 0.9484 | 0.5388 | 0.0000 | 15 | 58.3285 | 9.8922 | 97.8550 | 0.9972 | 0.1696 |
| 28 | 3090 | 2 | 2 | BA* | BG** | 1.2587 | 0.6058 | -0.4254 | 15 | 65.0352 | 10.5074 | 110.4063 | 0.9978 | 0.1616 |
| 28 | 3090 | 3 | 1 | BA* | BG** | 0.7073 | 0.9193 | -0.0673 | 15 | 106.5282 | 7.6451 | 58.4479 | 0.9989 | 0.0718 |
| 28 | 3090 | 3 | 2 | BA* | BG** | 0.8222 | 0.6158 | 0.0000 | 15 | 81.5996 | 56.1786 | 3156.0310 | 0.9075 | 0.6885 |
| 28 | 3091 | 1 | 1 | A1 | TS01 | 0.9539 | 0.4315 | -0.7337 | 15 | 13.7137 | 6.0720 | 36.8695 | 0.9960 | 0.4428 |
| 28 | 3091 | 1 | 2 | A2 | TS03 | 0.6823 | 0.4351 | 0.0000 | 14 | 11.8952 | 2.9579 | 8.7491 | 0.9985 | 0.2487 |
| 28 | 3093 | 1 | 1 | BS* | BS** | 0.7523 | 0.5735 | -0.4220 | 15 | 14.3968 | 1.9019 | 3.6171 | 0.9995 | 0.1321 |
| 28 | 3093 | 1 | 2 | BA* | BS** | 0.8434 | 0.3937 | -0.8469 | 15 | 10.2153 | 3.1608 | 9.9909 | 0.9985 | 0.3094 |
| 28 | 3094 | 1 | 1 | A1 | TS01 | 1.5502 | 0.6160 | -4.2283 | 15 | 27.2839 | 9.6517 | 93.1548 | 0.9905 | 0.3538 |
| 28 | 3094 | 1 | 2 | A2 | TS02 | 0.7404 | 0.4200 | 0.0000 | 15 | 12.8719 | 5.7306 | 32.8400 | 0.9953 | 0.4452 |
| 28 | 3097 | 1 | 1 | A1 | TS01 | 0.5048 | 0.0000 | -0.0175 | 15 | 9.3960 | 9.3958 | 88.2817 | 0.9693 | 1.0000 |
| 28 | 3097 | 1 | 2 | A2 | TS03 | 0.5593 | 0.6087 | -3.1221 | 15 | 9.0685 | 1.9423 | 3.7724 | 0.9978 | 0.2142 |
| 28 | 3097 | 3 | 1 | BA* | BG** | 0.9806 | 0.7369 | -0.2088 | 15 | 86.7918 | 8.8876 | 78.9887 | 0.9985 | 0.1024 |
| 28 | 3097 | 3 | 2 | BA* | BG** | 0.9068 | 0.7638 | -0.1300 | 15 | 91.3346 | 7.5634 | 57.2049 | 0.9989 | 0.0828 |
| 28 | 3099 | 1 | 1 | A1 | TS01 | 0.5174 | 0.1286 | -0.4072 | 15 | 3.9182 | 3.2914 | 10.8335 | 0.9960 | 0.8400 |
| 28 | 3099 | 1 | 2 | A2 | TS03 | 0.5807 | 0.2052 | -2.6455 | 15 | 7.3937 | 3.0364 | 9.2196 | 0.9949 | 0.4107 |
| 28 | 4024 | 1 | 1 | BA* | BS** | 0.7762 | 0.1760 | 0.0000 | 15 | 9.6051 | 8.2256 | 67.6604 | 0.9904 | 0.8564 |
| 28 | 4024 | 1 | 2 | A2 | TS03 | 0.5100 | 0.3021 | -2.2208 | 15 | 6.0765 | 2.2798 | 5.1975 | 0.9967 | 0.3752 |
| 28 | 5006 | 1 | 1 | A1 | TS01 | 1.0949 | 0.2238 | -2.6408 | 15 | 12.9780 | 3.0408 | 9.2464 | 0.9986 | 0.2343 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | 5006 | 1 | 2 | A2 | TS03 | 0.8565 | 0.2252 | -3.6845 | 15 | 11.8816 | 2.4900 | 6.2003 | 0.9980 | 0.2096 |
| 28 | 5025 | 1 | 1 | BA* | BS** | 0.9304 | 0.4181 | -0.5371 | 15 | 12.6144 | 3.1695 | 10.0460 | 0.9989 | 0.2513 |
| 28 | 5025 | 1 | 2 | BA* | BS** | 0.9196 | 0.2927 | -0.5659 | 15 | 8.9272 | 3.9180 | 15.3509 | 0.9982 | 0.4389 |
| 28 | 5025 | 2 | 1 | BA* | BG** | 1.2468 | 0.5861 | 0.0000 | 15 | 87.0926 | 6.7758 | 45.9121 | 0.9993 | 0.0778 |
| 28 | 5025 | 2 | 2 | BA* | BG** | 1.1200 | 0.6862 | -0.1840 | 15 | 88.7097 | 9.4346 | 89.0116 | 0.9985 | 0.1064 |
| 28 | 5803 | 1 | 2 | BA* | BS** | 0.7222 | 0.3697 | 0.0000 | 15 | 11.3984 | 5.4634 | 29.8484 | 0.9954 | 0.4793 |
| 28 | 5805 | 1 | 1 | BA* | BS** | 0.6256 | 0.5485 | 0.0000 | 15 | 13.5636 | 4.3057 | 18.5387 | 0.9965 | 0.3174 |
| 28 | 5805 | 1 | 2 | BA* | BS** | 0.8535 | 0.2995 | -1.7143 | 15 | 9.4375 | 4.0607 | 16.4892 | 0.9968 | 0.4303 |
| 28 | 5805 | 2 | 1 | BA* | BG** | 0.7525 | 0.6732 | -0.2135 | 15 | 55.6776 | 3.6392 | 13.2441 | 0.9995 | 0.0654 |
| 28 | 5805 | 2 | 2 | BA* | BG** | 0.6319 | 0.7589 | -0.2775 | 15 | 55.0203 | 3.4368 | 11.8119 | 0.9995 | 0.0625 |
| 28 | 7012 | 1 | 1 | BA2 | BS02 | 0.9665 | 0.3616 | -1.6515 | 15 | 10.7051 | 2.7175 | 7.3847 | 0.9989 | 0.2538 |
| 28 | 7012 | 1 | 2 | A2 | TS03 | 0.4493 | 0.4766 | 0.0000 | 15 | 8.6674 | 3.8543 | 14.8555 | 0.9944 | 0.4447 |
| 28 | 7012 | 2 | 1 | BA* | BG** | 0.7754 | 0.5459 | 0.0000 | 15 | 48.1845 | 6.9962 | 48.9466 | 0.9979 | 0.1452 |
| 28 | 7012 | 2 | 2 | BA* | BG** | 0.6465 | 0.5989 | 0.0000 | 15 | 46.2632 | 3.2678 | 10.6787 | 0.9994 | 0.0706 |
| 28 | 7012 | 3 | 1 | BA* | BG** | 1.0775 | 0.6422 | -0.1267 | 15 | 79.6098 | 8.1694 | 66.7398 | 0.9987 | 0.1026 |
| 28 | 7012 | 3 | 2 | BA* | BG** | 0.6694 | 0.5714 | -0.0622 | 15 | 42.1163 | 5.1458 | 26.4788 | 0.9985 | 0.1222 |
| 28 | 9030 | 1 | 1 | A1 | TS01 | 0.5855 | 0.5830 | -1.6244 | 15 | 9.6100 | 3.0490 | 9.2965 | 0.9966 | 0.3173 |
| 28 | 9030 | 1 | 2 | A2 | TS03 | 0.9572 | 1.0500 | -2.5503 | 15 | 25.9545 | 11.6392 | 135.4719 | 0.9807 | 0.4484 |
| 29 | 0603 | 1 | 2 | TP7 | BS07 | 0.7049 | 0.4336 | -2.0065 | 15 | 8.8544 | 1.9018 | 3.6168 | 0.9989 | 0.2148 |
| 29 | 0605 | 1 | 2 | TP5 | BS05 | 1.1613 | 0.1806 | -1.9226 | 15 | 11.1343 | 1.4382 | 2.0683 | 0.9998 | 0.1292 |
| 29 | 0607 | 1 | 2 | TP1 | BS01 | 1.2712 | 0.1479 | -1.2551 | 15 | 8.9719 | 1.7118 | 2.9304 | 0.9998 | 0.1908 |
| 29 | 0608 | 1 | 2 | TP3 | BS03 | 0.9406 | 0.1876 | -1.5575 | 15 | 7.7907 | 1.0183 | 1.0369 | 0.9998 | 0.1307 |
| 29 | 0608 | 2 | 2 | TP3 | BG03 | 0.8897 | 0.4855 | 0.0000 | 14 | 45.7283 | 16.6274 | 276.4708 | 0.9888 | 0.3636 |
| 29 | 1002 | 1 | 1 | BA* | BS** | 2.2555 | 0.3205 | -1.0017 | 13 | 19.8262 | 2.5669 | 6.5889 | 0.9998 | 0.1295 |
| 29 | 1002 | 2 | 1 | BA* | BG** | 0.6787 | 0.7076 | 0.0000 | 15 | 63.1432 | 7.7860 | 60.6218 | 0.9978 | 0.1233 |
| 29 | 1002 | 2 | 2 | TP* | BG** | 0.6757 | 0.6406 | 0.0000 | 15 | 53.1658 | 6.9456 | 48.2409 | 0.9979 | 0.1306 |
| 29 | 1005 | 2 | 1 | BA* | BG** | 0.8208 | 0.6707 | 0.0000 | 15 | 69.5521 | 7.4657 | 55.7371 | 0.9985 | 0.1073 |
| 29 | 1005 | 2 | 2 | TP* | BG** | 0.6483 | 0.8938 | -0.0367 | 15 | 90.5061 | 8.1123 | 65.8088 | 0.9984 | 0.0896 |
| 29 | 1008 | 1 | 1 | A1 | TS02 | 1.2151 | 0.4634 | -3.2285 | 15 | 17.8213 | 2.9713 | 8.8286 | 0.9988 | 0.1667 |
| 29 | 1008 | 1 | 2 | A2 | TS04 | 1.3415 | 0.2402 | -2.4097 | 15 | 15.2300 | 1.5926 | 2.5363 | 0.9998 | 0.1046 |
| 29 | 1008 | 2 | 1 | BA* | BG** | 1.3623 | 0.4655 | 0.0000 | 15 | 66.4470 | 16.0703 | 258.2561 | 0.9956 | 0.2419 |
| 29 | 1010 | 1 | 1 | BA* | BS** | 2.3257 | 0.3104 | -0.4505 | 13 | 24.1425 | 5.5821 | 31.1604 | 0.9994 | 0.2312 |
| 29 | 1010 | 2 | 2 | TP* | BG** | 0.6512 | 0.7504 | 0.0000 | 15 | 67.2327 | 7.9067 | 62.5153 | 0.9979 | 0.1176 |
| 29 | 4036 | 1 | 1 | A1 | TS01 | 1.0374 | 0.2343 | -2.6844 | 15 | 12.4835 | 1.7344 | 3.0082 | 0.9995 | 0.1389 |
| 29 | 4036 | 1 | 2 | BA* | BS** | 1.3092 | 0.2385 | -1.1929 | 15 | 10.0560 | 0.7493 | 0.5614 | 1.0000 | 0.0745 |
| 29 | 4036 | 2 | 1 | BA* | BG** | 0.8372 | 0.6580 | 0.0000 | 15 | 69.4966 | 5.3582 | 28.7099 | 0.9992 | 0.0771 |
| 29 | 4036 | 2 | 2 | BA* | BG** | 0.9379 | 0.6573 | -0.1898 | 15 | 66.8932 | 4.0826 | 16.6680 | 0.9996 | 0.0610 |
| 29 | 4069 | 1 | 1 | BA* | BS** | 0.7065 | 0.6609 | -0.4527 | 15 | 15.5970 | 3.0304 | 9.1836 | 0.9985 | 0.1943 |
| 29 | 4069 | 1 | 2 | BA* | BS** | 0.6859 | 0.8918 | -0.9959 | 12 | 18.2657 | 3.5880 | 12.8736 | 0.9977 | 0.1964 |
| 29 | 4069 | 2 | 1 | BA* | BG** | 0.7332 | 0.6173 | -0.2456 | 15 | 44.9813 | 6.5533 | 42.9457 | 0.9979 | 0.1457 |
| 29 | 5000 | 1 | 1 | A1 | TS01 | 0.9256 | 0.1323 | -2.3526 | 15 | 10.3150 | 0.9680 | 0.9370 | 0.9998 | 0.0938 |
| 29 | 5000 | 2 | 1 | BA* | BG** | 0.8774 | 0.6656 | -0.0273 | 15 | 72.5356 | 5.8178 | 33.8464 | 0.9992 | 0.0802 |
| 29 | 5000 | 2 | 2 | BA* | BG** | 0.8525 | 0.7155 | 0.0000 | 15 | 81.5036 | 5.3840 | 28.9875 | 0.9994 | 0.0661 |
| 29 | 5047 | 1 | 1 | BA* | BS** | 0.6935 | 0.3517 | -1.9299 | 15 | 7.7724 | 1.3191 | 1.7402 | 0.9995 | 0.1697 |
| 29 | 5047 | 1 | 2 | BA* | BS** | 0.9456 | 0.3450 | -2.4405 | 15 | 11.3356 | 1.0444 | 1.0907 | 0.9998 | 0.0921 |
| 29 | 5058 | 1 | 2 | BA* | BS** | 0.7524 | 0.2320 | -2.9214 | 15 | 9.4557 | 0.9426 | 0.8886 | 0.9997 | 0.0997 |
| 29 | 5081 | 1 | 2 | A2 | TS04 | 1.1171 | 0.0606 | -0.9467 | 15 | 6.0906 | 0.7289 | 0.5312 | 0.9999 | 0.1197 |
| 29 | 5081 | 1 | 1 | BA* | BS** | 0.9644 | 0.1864 | -1.9737 | 15 | 9.4299 | 1.2547 | 1.5743 | 0.9997 | 0.1331 |
| 29 | 5091 | 1 | 1 | A1 | TS02 | 0.7057 | 0.1451 | -3.2496 | 15 | 9.6125 | 1.0902 | 1.1884 | 0.9995 | 0.1134 |
| 29 | 5091 | 1 | 2 | A2 | TS03 | 0.8396 | 0.2428 | -2.9690 | 15 | 10.6695 | 1.1016 | 1.2135 | 0.9996 | 0.1032 |
| 29 | 5393 | 1 | 1 | A1 | TS02 | 1.4920 | 0.2024 | -2.0448 | 15 | 15.0593 | 1.6159 | 2.6112 | 0.9998 | 0.1073 |
| 29 | 5393 | 2 | 1 | BA* | BG** | 0.7257 | 0.7392 | -0.3216 | 15 | 57.9131 | 6.7310 | 45.3067 | 0.9982 | 0.1162 |
| 29 | 5393 | 2 | 2 | TP* | BG** | 0.8813 | 0.6496 | -0.4566 | 15 | 50.5395 | 8.2776 | 68.5194 | 0.9974 | 0.1638 |
| 29 | 5403 | 1 | 1 | BA* | BS** | 0.3236 | 0.8099 | -1.1268 | 15 | 8.5646 | 3.8331 | 14.6930 | 0.9867 | 0.4476 |
| 29 | 5403 | 1 | 2 | TP* | BS** | 0.4875 | 0.8351 | -1.8453 | 15 | 10.8921 | 2.6887 | 7.2290 | 0.9964 | 0.2468 |
| 29 | 5413 | 1 | 1 | BA* | BS** | 0.1583 | 0.6566 | 0.0000 | 14 | 5.6276 | 4.3697 | 19.0940 | 0.9506 | 0.7765 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 5413 | 1 | 2 | BA* | BS** | 0.5343 | 0.7912 | -1.9114 | 15 | 11.0121 | 2.1423 | 4.5896 | 0.9980 | 0.1945 |
| 29 | 6067 | 1 | 1 | BA* | BS** | 0.8896 | 0.7517 | -3.5453 | 15 | 16.3716 | 4.8038 | 23.0761 | 0.9942 | 0.2934 |
| 29 | 6067 | 1 | 2 | TP* | BS** | 0.8678 | 0.7015 | -3.6541 | 15 | 15.3058 | 4.0251 | 16.2016 | 0.9955 | 0.2630 |
| 29 | 6067 | 2 | 1 | BA* | BG** | 0.8021 | 0.7135 | 0.0000 | 15 | 75.9444 | 5.1494 | 26.5163 | 0.9993 | 0.0678 |
| 29 | 6067 | 2 | 2 | TP* | BS** | 0.7277 | 0.7680 | 0.0000 | 15 | 78.0581 | 7.4258 | 55.1421 | 0.9985 | 0.0951 |
| 29 | 7054 | 1 | 1 | BA* | BS** | 1.4209 | 0.3180 | -2.1790 | 12 | 13.0802 | 0.7556 | 0.5709 | 1.0000 | 0.0578 |
| 29 | 7054 | 1 | 2 | BA* | BS** | 1.6696 | 0.2102 | -1.3860 | 15 | 13.3442 | 1.5837 | 2.5081 | 0.9999 | 0.1187 |
| 29 | 7054 | 2 | 2 | BA* | BG** | 1.0058 | 0.5377 | 0.0000 | 15 | 60.0267 | 10.1294 | 102.6042 | 0.9973 | 0.1687 |
| 29 | 7073 | 1 | 1 | A1 | TS01 | 0.7707 | 0.3347 | -5.1748 | 15 | 12.9541 | 1.3913 | 1.9359 | 0.9989 | 0.1074 |
| 29 | 7073 | 1 | 2 | A2 | TS03 | 1.1225 | 0.1654 | -2.2798 | 15 | 12.1784 | 1.3835 | 1.9142 | 0.9997 | 0.1136 |
| 29 | 7073 | 3 | 2 | BA* | BG** | 1.4402 | 0.4837 | -0.1764 | 15 | 63.3902 | 14.0779 | 198.1872 | 0.9966 | 0.2221 |
| 30 | 1001 | 1 | 1 | BA* | BS** | 0.8632 | 0.1528 | -0.9899 | 15 | 5.6627 | 2.2048 | 4.8611 | 0.9992 | 0.3894 |
| 30 | 6004 | 1 | 1 | BA* | BS** | 0.6669 | 0.2432 | -2.4667 | 15 | 7.7226 | 1.3104 | 1.7172 | 0.9993 | 0.1697 |
| 30 | 6004 | 1 | 2 | TP1 | BS93 | 0.8320 | 0.1334 | -1.6088 | 15 | 7.1760 | 1.4691 | 2.1583 | 0.9996 | 0.2047 |
| 30 | 6004 | 2 | 2 | TP1 | BG92 | 0.5146 | 0.5290 | -0.2255 | 15 | 24.9023 | 4.2754 | 18.2788 | 0.9977 | 0.1717 |
| 30 | 7066 | 1 | 1 | BA* | BS** | 0.6669 | 0.2432 | -2.4667 | 15 | 7.7226 | 1.3104 | 1.7172 | 0.9993 | 0.1697 |
| 30 | 7075 | 1 | 2 | TP1 | BS93 | 0.6023 | 0.2563 | -2.7520 | 15 | 7.4514 | 1.4447 | 2.0873 | 0.9989 | 0.1939 |
| 30 | 7076 | 2 | 1 | BA* | BG** | 0.4187 | 0.6012 | -0.4023 | 15 | 21.7755 | 4.3598 | 19.0076 | 0.9966 | 0.2002 |
| 30 | 7076 | 2 | 2 | TP1 | BG93 | 0.2809 | 0.8542 | -0.3448 | 15 | 29.2977 | 1.4241 | 2.0281 | 0.9996 | 0.0486 |
| 30 | 7088 | 1 | 1 | BA* | BS** | 0.7415 | 0.1513 | -1.2324 | 15 | 5.4493 | 1.7719 | 3.1395 | 0.9993 | 0.3252 |
| 30 | 7088 | 1 | 2 | TP1 | BS93 | 0.9762 | 0.1447 | -0.3559 | 15 | 4.9694 | 2.3714 | 5.6234 | 0.9994 | 0.4772 |
| 30 | 8129 | 1 | 1 | BA* | BS** | 1.0897 | 0.1394 | 0.0000 | 15 | 6.5625 | 3.5179 | 12.3759 | 0.9991 | 0.5361 |
| 31 | 0113 | 1 | 3 | A17 | TS33 | 0.9527 | 0.2803 | -1.0314 | 15 | 7.9180 | 0.6568 | 0.4314 | 0.9999 | 0.0830 |
| 31 | 0115 | 1 | 3 | A8 | TS16 | 0.7421 | 0.4491 | -2.4975 | 13 | 10.2100 | 1.2588 | 1.5846 | 0.9995 | 0.1233 |
| 31 | 0115 | 1 | 2 | B3 | BS03 | 0.9652 | 0.3697 | -0.8094 | 15 | 10.5198 | 1.2057 | 1.4537 | 0.9998 | 0.1146 |
| 31 | 0116 | 1 | 1 | B5 | BS05 | 1.0765 | 0.1833 | -0.8971 | 12 | 5.8672 | 0.6441 | 0.4148 | 1.0000 | 0.1098 |
| 31 | 0120 | 1 | 3 | A11 | TS22 | 0.7922 | 0.2468 | -1.8877 | 15 | 7.7078 | 0.9509 | 0.9043 | 0.9998 | 0.1234 |
| 31 | 0124 | 1 | 2 | B1 | BS01 | 0.7360 | 0.3377 | -2.7693 | 14 | 9.6077 | 0.7949 | 0.6319 | 0.9998 | 0.0827 |
| 31 | 3018 | 1 | 1 | BA* | BS** | 0.6827 | 0.8523 | -1.1184 | 15 | 17.2605 | 2.4041 | 5.7798 | 0.9988 | 0.1393 |
| 31 | 3018 | 1 | 2 | TP* | BS** | 0.7840 | 0.8169 | -1.2018 | 15 | 18.5336 | 2.1622 | 4.6752 | 0.9993 | 0.1167 |
| 31 | 3023 | 1 | 1 | BA* | BS** | 0.7441 | 0.7108 | -0.9261 | 15 | 15.6880 | 1.7926 | 3.2133 | 0.9995 | 0.1143 |
| 31 | 3023 | 1 | 2 | TP* | BS** | 0.6779 | 0.7220 | -0.4899 | 13 | 15.1514 | 1.2281 | 1.5081 | 0.9997 | 0.0811 |
| 31 | 3023 | 2 | 2 | TP* | BG** | 0.6834 | 0.6123 | -0.1004 | 15 | 46.9521 | 4.2287 | 17.8815 | 0.9991 | 0.0901 |
| 31 | 3024 | 1 | 1 | BA* | BS** | 1.1275 | 0.3020 | -1.5126 | 15 | 10.7282 | 1.6009 | 2.5629 | 0.9997 | 0.1492 |
| 31 | 3024 | 1 | 2 | TP* | BS** | 0.6338 | 0.4853 | -2.8514 | 15 | 9.1610 | 2.0618 | 4.2508 | 0.9981 | 0.2251 |
| 31 | 3028 | 1 | 1 | BA* | BS** | 1.0009 | 0.1676 | -2.2151 | 15 | 10.5388 | 1.1265 | 1.2690 | 0.9998 | 0.1069 |
| 31 | 3028 | 1 | 2 | A2 | TS03 | 0.9545 | 0.1654 | -2.4789 | 15 | 11.1995 | 0.7506 | 0.5634 | 0.9999 | 0.0670 |
| 31 | 3033 | 1 | 1 | BA* | BS** | 0.9545 | 0.5284 | -1.7917 | 12 | 12.3469 | 0.9881 | 0.9764 | 0.9999 | 0.0800 |
| 31 | 3033 | 1 | 2 | TP* | BS** | 0.6171 | 0.7665 | -1.1180 | 15 | 13.7834 | 2.8737 | 8.2582 | 0.9979 | 0.2085 |
| 31 | 4019 | 1 | 1 | A1 | TS01 | 0.9180 | 0.1886 | -1.7982 | 15 | 8.4177 | 0.7255 | 0.5263 | 0.9999 | 0.0862 |
| 31 | 4019 | 1 | 2 | A2 | TS04 | 0.5789 | 0.2259 | -3.1061 | 15 | 7.5423 | 0.8853 | 0.7837 | 0.9995 | 0.1174 |
| 31 | 5052 | 1 | 1 | A1 | TS02 | 1.2649 | 0.2288 | -1.3382 | 15 | 10.1099 | 0.9002 | 0.8103 | 0.9999 | 0.0890 |
| 31 | 5052 | 1 | 2 | TP1 | BS55 | 0.9413 | 0.2472 | -1.7577 | 15 | 8.8759 | 1.4139 | 1.9992 | 0.9997 | 0.1593 |
| 31 | 6700 | 1 | 1 | BA* | BS** | 0.5489 | 0.4015 | -2.4837 | 15 | 7.1214 | 1.6574 | 2.7470 | 0.9984 | 0.2327 |
| 31 | 6700 | 1 | 2 | TP1 | BS** | 0.3902 | 0.4593 | -2.7419 | 15 | 5.6543 | 1.7948 | 3.2212 | 0.9962 | 0.3174 |
| 31 | 6701 | 1 | 1 | BA* | BS** | 0.5232 | 1.0135 | -3.1041 | 15 | 12.3211 | 1.9729 | 3.8923 | 0.9977 | 0.1601 |
| 31 | 6701 | 1 | 2 | TP1 | BS55 | 0.7962 | 0.6268 | -0.6755 | 15 | 15.6783 | 1.5852 | 2.5127 | 0.9996 | 0.1011 |
| 31 | 6702 | 1 | 1 | BA* | BS** | 0.7452 | 0.7673 | -2.3411 | 15 | 14.4677 | 2.5028 | 6.2641 | 0.9984 | 0.1730 |
| 31 | 6702 | 1 | 2 | TP* | BS** | 0.6271 | 0.7658 | -2.2391 | 15 | 12.1624 | 2.3043 | 5.3097 | 0.9981 | 0.1895 |
| 31 | 7005 | 1 | 1 | BA* | BS** | 0.5740 | 0.5377 | -1.9149 | 15 | 8.5010 | 1.9488 | 3.7978 | 0.9984 | 0.2292 |
| 31 | 7005 | 1 | 2 | BA* | BS** | 0.6827 | 0.5896 | -1.8517 | 15 | 10.8422 | 2.0928 | 4.3798 | 0.9987 | 0.1930 |
| 31 | 7005 | 2 | 1 | BA* | BG** | 0.7557 | 0.7040 | -0.1716 | 15 | 61.9387 | 3.7489 | 14.0542 | 0.9995 | 0.0605 |
| 31 | 7005 | 2 | 2 | BA* | BG** | 0.6823 | 0.7349 | -0.2183 | 15 | 58.1916 | 3.5337 | 12.4867 | 0.9995 | 0.0607 |
| 31 | 7017 | 1 | 1 | BA* | BS** | 1.0963 | 0.2533 | -1.7314 | 15 | 10.3150 | 1.3966 | 1.9506 | 0.9998 | 0.1354 |
| 31 | 7017 | 1 | 2 | TP* | BS** | 0.8180 | 0.2451 | -2.8582 | 15 | 10.2167 | 0.9774 | 0.9553 | 0.9997 | 0.0957 |
| 31 | 7017 | 2 | 2 | TP* | BG** | 0.7653 | 0.5134 | -0.1536 | 15 | 37.8804 | 5.5099 | 30.3590 | 0.9983 | 0.1455 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 7040 | 1 | 1 | A1 | TS02 | 0.6558 | 0.1907 | -2.1733 | 15 | 6.7844 | 0.5449 | 0.2969 | 0.9999 | 0.0803 |
| 31 | 7040 | 1 | 2 | TP1 | BS** | 0.6510 | 0.1307 | -1.0998 | 13 | 4.0997 | 0.6884 | 0.4740 | 0.9999 | 0.1679 |
| 31 | 7040 | 2 | 1 | BA* | BG** | 0.7887 | 0.6180 | -0.0098 | 15 | 58.3264 | 4.4061 | 19.4138 | 0.9993 | 0.0755 |
| 31 | 7040 | 2 | 2 | TP* | BG** | 0.8222 | 0.5398 | -0.0242 | 15 | 48.6055 | 4.3531 | 18.9496 | 0.9992 | 0.0896 |
| 31 | 7050 | 1 | 1 | BA* | BS** | 0.6882 | 0.2449 | -2.8732 | 15 | 8.6509 | 1.3074 | 1.7092 | 0.9993 | 0.1511 |
| 31 | 7050 | 1 | 2 | TP* | BS** | 0.7362 | 0.1835 | -2.8416 | 15 | 9.1298 | 0.8446 | 0.7134 | 0.9997 | 0.0925 |
| 31 | 7050 | 2 | 2 | TP* | BG** | 0.5955 | 0.6446 | -0.2215 | 15 | 40.3730 | 5.9077 | 34.9003 | 0.9976 | 0.1463 |
| 32 | 0101 | 1 | 2 | B26 | BS01 | 0.5965 | 0.7717 | -1.9526 | 15 | 12.0147 | 2.5560 | 6.5330 | 0.9977 | 0.2127 |
| 32 | 0105 | 1 | 2 | B31 | BS06 | 0.5774 | 0.7375 | -1.9775 | 15 | 11.2470 | 2.2511 | 5.0675 | 0.9980 | 0.2002 |
| 32 | 0106 | 1 | 2 | B27 | BS02 | 1.2794 | 0.2343 | -1.5824 | 15 | 11.3339 | 1.7717 | 3.1388 | 0.9997 | 0.1563 |
| 32 | 0109 | 1 | 2 | B28 | BS03 | 0.7370 | 0.5980 | -2.1861 | 15 | 11.8912 | 3.1952 | 10.2093 | 0.9972 | 0.2687 |
| 32 | 0111 | 1 | 2 | B30 | BS05 | 1.2431 | 0.2367 | -1.4671 | 15 | 10.5573 | 1.3104 | 1.7171 | 0.9999 | 0.1241 |
| 32 | 1020 | 1 | 1 | BA* | BS** | 0.5320 | 0.6989 | -0.6981 | 15 | 11.7400 | 1.3112 | 1.7191 | 0.9995 | 0.1117 |
| 32 | 1020 | 1 | 2 | TP1 | BS92 | 0.6278 | 0.6056 | -1.2972 | 15 | 10.7296 | 2.3186 | 5.3759 | 0.9985 | 0.2161 |
| 32 | 1021 | 1 | 1 | BA* | BS** | 0.8756 | 0.1361 | -0.3087 | 15 | 4.2404 | 2.0614 | 4.2493 | 0.9995 | 0.4861 |
| 32 | 1021 | 1 | 2 | TP1 | BS93 | 0.4802 | 0.3284 | -2.1831 | 15 | 5.5222 | 1.3584 | 1.8452 | 0.9987 | 0.2460 |
| 32 | 1021 | 2 | 1 | BA* | BG** | 0.5125 | 0.5064 | -0.3604 | 15 | 20.9655 | 6.0519 | 36.6260 | 0.9946 | 0.2887 |
| 32 | 1030 | 1 | 1 | BA* | BS** | 1.1115 | 0.1956 | -0.0890 | 15 | 7.9144 | 2.4045 | 5.7818 | 0.9996 | 0.3038 |
| 32 | 1030 | 1 | 2 | TP1 | BS71 | 1.0128 | 0.2753 | -0.4842 | 15 | 9.0143 | 2.8766 | 8.2746 | 0.9992 | 0.3191 |
| 32 | 2027 | 1 | 1 | BA* | BS** | 0.6036 | 0.4453 | -1.6384 | 15 | 7.8090 | 2.3743 | 5.6373 | 0.9980 | 0.3040 |
| 32 | 2027 | 1 | 2 | TP1 | BS93 | 0.4681 | 0.5335 | -1.6621 | 15 | 7.0495 | 1.9534 | 3.8157 | 0.9978 | 0.2771 |
| 32 | 3010 | 1 | 2 | BA* | BS** | 0.4898 | 0.3852 | -1.1293 | 15 | 5.3940 | 0.8337 | 0.6951 | 0.9997 | 0.1546 |
| 32 | 7084 | 2 | 1 | BA* | BG** | 0.6450 | 0.4418 | -0.2098 | 15 | 23.9131 | 4.1919 | 17.5716 | 0.9983 | 0.1753 |
| 34 | 0503 | 1 | 2 | TP2 | BS56 | 0.7614 | 0.2402 | -0.5386 | 15 | 6.0828 | 2.5897 | 6.7068 | 0.9988 | 0.4258 |
| 34 | 0505 | 1 | 2 | TP1 | BS55 | 0.5751 | 0.5115 | -0.8372 | 15 | 8.9618 | 2.3731 | 5.6316 | 0.9983 | 0.2648 |
| 34 | 0505 | 2 | 2 | TP1 | BG55 | 0.9100 | 0.7671 | -0.3020 | 15 | 79.3859 | 4.7504 | 22.5663 | 0.9995 | 0.0598 |
| 34 | 0801 | 1 | 2 | B1 | BS01 | 0.4990 | 0.6526 | -0.4719 | 15 | 11.0871 | 3.0075 | 9.0452 | 0.9970 | 0.2713 |
| 34 | 0802 | 1 | 1 | B2 | BS02 | 0.5312 | 0.5392 | -0.1860 | 15 | 10.1831 | 1.8512 | 3.4268 | 0.9990 | 0.1818 |
| 34 | 1011 | 1 | 2 | TP | BS55 | 0.7084 | 0.5922 | -0.6944 | 15 | 13.0464 | 1.9333 | 3.7376 | 0.9993 | 0.1482 |
| 34 | 1031 | 1 | 1 | BA* | BS** | 0.7516 | 0.6361 | -1.0440 | 15 | 13.9755 | 1.9745 | 3.8986 | 0.9993 | 0.1413 |
| 34 | 1031 | 1 | 2 | TP | BS55 | 0.6511 | 0.4797 | -0.4137 | 15 | 10.4845 | 2.2398 | 5.0168 | 0.9990 | 0.2136 |
| 34 | 1033 | 1 | 1 | BA* | BS** | 0.8907 | 0.2220 | -0.3252 | 13 | 6.3063 | 3.3177 | 11.0073 | 0.9987 | 0.5261 |
| 34 | 1033 | 1 | 2 | TP | BS55 | 1.0464 | 0.2820 | -1.2799 | 15 | 10.7814 | 5.5022 | 30.2746 | 0.9965 | 0.5103 |
| 34 | 4042 | 2 | 1 | BA* | BG** | 0.6578 | 0.6752 | -0.1177 | 15 | 52.5478 | 4.1776 | 17.4526 | 0.9992 | 0.0795 |
| 35 | 0101 | 1 | 2 | B1 | BS01 | 0.8437 | 0.1740 | 0.0000 | 15 | 7.9791 | 5.8879 | 34.6669 | 0.9958 | 0.7379 |
| 35 | 0102 | 1 | 3 | A2 | TS03 | 0.5317 | 0.2421 | 0.0000 | 15 | 4.9971 | 1.7731 | 3.1439 | 0.9991 | 0.3548 |
| 35 | 0103 | 1 | 2 | B2 | BS02 | 0.7778 | 0.3042 | 0.0000 | 15 | 5.6753 | 3.8139 | 14.5455 | 0.9975 | 0.6720 |
| 35 | 0105 | 1 | 2 | B3 | BS03 | 0.7277 | 0.1732 | 0.0000 | 15 | 6.5538 | 4.6474 | 21.5980 | 0.9965 | 0.7091 |
| 35 | 0106 | 1 | 3 | A9 | TS17 | 0.3991 | 0.2297 | -1.2502 | 15 | 3.2704 | 1.0192 | 1.0388 | 0.9992 | 0.3116 |
| 35 | 0107 | 1 | 2 | B4 | BS04 | 0.6822 | 0.2334 | 0.0000 | 15 | 6.3042 | 2.3610 | 5.5744 | 0.9990 | 0.3745 |
| 35 | 0108 | 1 | 3 | A11 | TS21 | 0.4910 | 0.1442 | -1.0136 | 15 | 3.0907 | 0.9621 | 0.9256 | 0.9995 | 0.3113 |
| 35 | 0109 | 1 | 2 | B5 | BS05 | 0.6704 | 0.1364 | 0.0000 | 15 | 3.7696 | 1.7358 | 3.0130 | 0.9994 | 0.4605 |
| 35 | 0110 | 1 | 3 | A14 | TS27 | 0.7783 | 0.3229 | 0.0000 | 15 | 10.1957 | 4.3493 | 18.9161 | 0.9974 | 0.4266 |
| 35 | 0111 | 1 | 2 | B6 | BS06 | 0.6016 | 0.3769 | -0.6062 | 15 | 7.0933 | 1.8948 | 3.5904 | 0.9990 | 0.2671 |
| 35 | 0112 | 1 | 3 | A17 | TS33 | 0.5187 | 0.2317 | -0.7539 | 15 | 3.8545 | 1.3528 | 1.8300 | 0.9993 | 0.3510 |
| 35 | 1002 | 1 | 2 | TP1 | BS55 | 0.9051 | 0.4221 | -0.8276 | 15 | 11.2834 | 2.2779 | 5.1888 | 0.9993 | 0.2019 |
| 35 | 1002 | 2 | 2 | TP1 | BG55 | 0.9707 | 0.6487 | -0.0935 | 15 | 73.9881 | 5.9341 | 35.2135 | 0.9992 | 0.0802 |
| 35 | 1003 | 1 | 1 | BA* | BS** | 1.2015 | 0.4417 | -0.0646 | 15 | 19.8538 | 3.8564 | 14.8721 | 0.9992 | 0.1942 |
| 35 | 1003 | 2 | 1 | BA* | BG** | 0.7762 | 0.7697 | -0.1357 | 15 | 78.3228 | 4.2805 | 18.3231 | 0.9995 | 0.0547 |
| 35 | 1003 | 2 | 2 | TP1 | BG55 | 1.3095 | 0.3860 | 0.0000 | 15 | 49.8529 | 12.8881 | 166.1037 | 0.9963 | 0.2585 |
| 35 | 1005 | 1 | 2 | TP1 | BS55 | 1.0627 | 0.2438 | -1.0162 | 15 | 8.1912 | 1.7384 | 3.0222 | 0.9997 | 0.2122 |
| 35 | 1005 | 2 | 1 | BA* | BG** | 0.7366 | 0.7375 | 0.0000 | 15 | 75.4685 | 8.2614 | 68.2504 | 0.9981 | 0.1095 |
| 35 | 1005 | 2 | 2 | TP1 | BG55 | 0.8802 | 0.6531 | -0.0940 | 15 | 67.7448 | 5.1798 | 26.8300 | 0.9993 | 0.0765 |
| 35 | 1022 | 1 | 1 | A1 | TS01 | 0.9878 | 0.4068 | -2.2316 | 15 | 13.5446 | 5.9267 | 35.1262 | 0.9943 | 0.4376 |
| 35 | 1022 | 1 | 2 | A2 | TS03 | 0.8339 | 0.4387 | -1.8656 | 15 | 10.4348 | 2.3617 | 5.5776 | 0.9989 | 0.2263 |
| 35 | 1022 | 2 | 1 | BA* | BG** | 0.6392 | 0.8025 | 0.0000 | 15 | 77.4217 | 10.4941 | 110.1256 | 0.9966 | 0.1355 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | 1022 | 2 | 2 | TP1 | BG55 | 0.7352 | 0.7532 | 0.0000 | 15 | 78.5264 | 5.2192 | 27.2399 | 0.9993 | 0.0665 |
| 35 | 1112 | 1 | 1 | BA* | BS** | 0.8417 | 0.4699 | 0.0000 | 15 | 15.2222 | 4.4575 | 19.8690 | 0.9978 | 0.2928 |
| 35 | 1112 | 1 | 2 | TP1 | BS55 | 0.8456 | 0.5132 | -0.1217 | 15 | 15.7918 | 2.8769 | 8.2768 | 0.9991 | 0.1822 |
| 35 | 1112 | 2 | 1 | BA* | BG** | 0.9479 | 0.8044 | -0.5377 | 15 | 76.7049 | 4.8738 | 23.7542 | 0.9995 | 0.0635 |
| 35 | 1112 | 2 | 2 | TP1 | BG55 | 1.0553 | 0.6409 | -0.5854 | 15 | 54.3913 | 12.5249 | 156.8721 | 0.9953 | 0.2303 |
| 35 | 2006 | 1 | 1 | A1 | TS01 | 0.5038 | 0.6525 | -0.5448 | 15 | 10.9666 | 1.4940 | 2.2320 | 0.9992 | 0.1362 |
| 35 | 2006 | 1 | 2 | A2 | TS03 | 0.6805 | 0.6776 | -1.4607 | 15 | 12.8656 | 2.5914 | 6.7151 | 0.9983 | 0.2014 |
| 35 | 2006 | 2 | 1 | BA* | BG** | 0.5394 | 0.7011 | -0.2255 | 15 | 42.2135 | 3.7086 | 13.7537 | 0.9990 | 0.0879 |
| 35 | 2006 | 2 | 2 | TP1 | BG55 | 0.5955 | 0.6705 | -0.2082 | 15 | 43.6172 | 3.9785 | 15.8286 | 0.9990 | 0.0912 |
| 35 | 2007 | 2 | 1 | BA* | BS** | 0.8077 | 0.3957 | -1.6296 | 15 | 9.6288 | 2.7639 | 7.6391 | 0.9984 | 0.2870 |
| 35 | 2007 | 2 | 2 | TP1 | BS55 | 0.6662 | 0.4153 | -1.0251 | 15 | 8.5245 | 3.2107 | 10.3085 | 0.9974 | 0.3766 |
| 35 | 2118 | 1 | 1 | A1 | TS01 | 0.2731 | 0.1298 | 0.0000 | 15 | 2.5598 | 2.1970 | 4.8269 | 0.9944 | 0.8583 |
| 35 | 2118 | 1 | 2 | TP1 | BS55 | 0.5064 | 0.2923 | -0.2238 | 15 | 5.5136 | 2.4358 | 5.9334 | 0.9979 | 0.4418 |
| 35 | 2118 | 2 | 1 | BA* | BG** | 0.6992 | 0.6753 | -0.2370 | 15 | 51.0614 | 3.8876 | 15.1132 | 0.9993 | 0.0761 |
| 35 | 2118 | 2 | 2 | TP1 | BG56 | 0.6065 | 0.6786 | -0.1466 | 15 | 47.8181 | 2.3394 | 5.4728 | 0.9997 | 0.0489 |
| 35 | 2118 | 3 | 1 | BA* | BG** | 0.8368 | 0.6790 | 0.0000 | 15 | 74.9557 | 5.2642 | 27.7122 | 0.9993 | 0.0702 |
| 35 | 2118 | 3 | 2 | TP1 | BG55 | 0.9554 | 0.6672 | -0.1183 | 15 | 75.1762 | 4.7487 | 22.5504 | 0.9995 | 0.0632 |
| 35 | 3010 | 1 | 1 | A1 | TS01 | 0.7204 | 0.4099 | 0.0000 | 15 | 13.4100 | 7.8390 | 61.4499 | 0.9907 | 0.5846 |
| 35 | 3010 | 1 | 2 | A2 | TS03 | 0.6200 | 0.5703 | -1.0452 | 15 | 10.6650 | 3.9780 | 15.8242 | 0.9957 | 0.3730 |
| 35 | 3010 | 2 | 1 | BA* | BG** | 0.9575 | 0.6966 | -0.0228 | 15 | 87.5216 | 7.6745 | 58.8976 | 0.9989 | 0.0877 |
| 35 | 3010 | 2 | 2 | BA* | BG** | 0.6851 | 0.7610 | 0.0000 | 15 | 74.5450 | 12.4774 | 155.6846 | 0.9953 | 0.1674 |
| 35 | 6033 | 1 | 1 | BA* | BS** | 0.9073 | 0.3140 | -0.8156 | 15 | 9.0543 | 3.4644 | 12.0018 | 0.9984 | 0.3826 |
| 35 | 6033 | 1 | 2 | A2 | TS03 | 0.7294 | 0.8171 | -1.3477 | 15 | 17.4512 | 3.7982 | 14.4267 | 0.9972 | 0.2177 |
| 35 | 6033 | 2 | 1 | BA* | BG** | 0.6598 | 0.6857 | 0.0000 | 15 | 59.8510 | 8.0811 | 65.3044 | 0.9974 | 0.1350 |
| 35 | 6033 | 2 | 2 | TP1 | BG55 | 0.4777 | 0.7270 | 0.0000 | 15 | 47.3977 | 2.8824 | 8.3081 | 0.9994 | 0.0608 |
| 35 | 6035 | 1 | 1 | A1 | TS01 | 0.7396 | 0.1481 | -2.0998 | 15 | 8.3569 | 3.8169 | 14.5685 | 0.9956 | 0.4567 |
| 35 | 6035 | 1 | 2 | TP1 | BS55 | 1.0431 | 0.2668 | -1.5392 | 15 | 10.0157 | 3.3195 | 11.0192 | 0.9986 | 0.3314 |
| 35 | 6035 | 3 | 1 | BA3 | BG03 | 0.8740 | 0.5158 | -0.0205 | 15 | 48.6443 | 4.9770 | 24.7702 | 0.9991 | 0.1023 |
| 35 | 6035 | 3 | 2 | TP1 | BG55 | 0.3365 | 0.8375 | 0.0000 | 15 | 43.2443 | 6.3093 | 39.8069 | 0.9960 | 0.1459 |
| 35 | 6401 | 1 | 1 | A1 | TS01 | 1.0291 | 0.5537 | -2.8297 | 15 | 15.2862 | 3.4135 | 11.6521 | 0.9981 | 0.2233 |
| 35 | 6401 | 1 | 2 | A2 | TS03 | 0.8011 | 0.6618 | -1.5567 | 15 | 14.1495 | 0.9985 | 0.9970 | 0.9998 | 0.0706 |
| 35 | 6401 | 3 | 1 | BA* | BG** | 0.9800 | 0.6441 | 0.0000 | 15 | 80.7271 | 15.9003 | 252.8196 | 0.9948 | 0.1970 |
| 35 | 6401 | 3 | 2 | TP1 | BG** | 0.9800 | 0.6441 | 0.0000 | 15 | 80.7271 | 15.9003 | 252.8196 | 0.9948 | 0.1970 |
| 36 | 0801 | 1 | 2 | B1 | BS01 | 0.4623 | 0.5655 | -0.1668 | 15 | 9.3412 | 1.6278 | 2.6499 | 0.9990 | 0.1743 |
| 36 | 0802 | 1 | 2 | B2 | BS02 | 0.4891 | 0.6660 | -0.6244 | 15 | 10.5343 | 2.4175 | 5.8445 | 0.9979 | 0.2295 |
| 36 | 1008 | 1 | 1 | BA* | BS** | 0.8533 | 0.5917 | -1.5578 | 15 | 13.8609 | 3.4739 | 12.0682 | 0.9980 | 0.2506 |
| 36 | 1008 | 1 | 2 | TP | BS55 | 0.6464 | 0.4130 | -1.2083 | 15 | 8.2883 | 3.4294 | 11.7609 | 0.9967 | 0.4138 |
| 36 | 1011 | 1 | 1 | BA* | BS** | 1.2531 | 0.2721 | -1.8965 | 15 | 14.2170 | 6.1444 | 37.7537 | 0.9964 | 0.4322 |
| 36 | 1011 | 1 | 2 | TP | BS55 | 0.3868 | 0.0434 | -0.5088 | 14 | 5.0715 | 4.9699 | 24.6996 | 0.9828 | 0.9800 |
| 36 | 1644 | 1 | 1 | BA* | BS** | 0.7869 | 0.7098 | -1.1339 | 15 | 16.3051 | 2.3951 | 5.7367 | 0.9991 | 0.1469 |
| 36 | 4018 | 1 | 1 | BA* | BS** | 1.2293 | 0.4279 | -1.1935 | 15 | 15.2980 | 4.0828 | 16.6694 | 0.9987 | 0.2669 |
| 37 | 0201 | 1 | 3 | A2 | TS02 | 0.4533 | 0.3225 | -1.3388 | 15 | 4.9924 | 2.3729 | 5.6306 | 0.9966 | 0.4753 |
| 37 | 0206 | 1 | 3 | A8 | TS08 | 0.5075 | 0.2494 | -2.1239 | 15 | 5.5917 | 1.6271 | 2.6475 | 0.9983 | 0.2910 |
| 37 | 0207 | 1 | 3 | A11 | TS11 | 0.3071 | 0.5937 | -1.8885 | 15 | 4.9981 | 1.4187 | 2.0128 | 0.9971 | 0.2839 |
| 37 | 0210 | 1 | 3 | A5 | TS05 | 0.5609 | 0.2707 | -0.9501 | 15 | 5.0398 | 2.1611 | 4.6702 | 0.9983 | 0.4288 |
| 37 | 0212 | 1 | 1 | B5 | BS05 | 0.7789 | 0.1193 | 0.0000 | 15 | 4.3337 | 2.6932 | 7.2531 | 0.9989 | 0.6214 |
| 37 | 0212 | 1 | 3 | A14 | TS14 | 0.4674 | 0.2894 | -2.4036 | 15 | 5.6044 | 1.7037 | 2.9026 | 0.9977 | 0.3040 |
| 37 | 0801 | 1 | 2 | B1 | BS01 | 0.7232 | 0.6717 | -0.5640 | 15 | 15.8361 | 2.0406 | 4.1641 | 0.9993 | 0.1289 |
| 37 | 0802 | 1 | 2 | B2 | BS02 | 0.6942 | 0.7289 | -1.1240 | 15 | 15.0513 | 3.4940 | 12.2078 | 0.9975 | 0.2321 |
| 37 | 1006 | 1 | 1 | BA2 | BS02 | 0.9164 | 0.3319 | -3.1837 | 15 | 12.7709 | 4.0516 | 16.4157 | 0.9960 | 0.3173 |
| 37 | 1006 | 1 | 2 | TP | BS55 | 0.8226 | 0.2487 | -2.5525 | 15 | 10.6225 | 4.7713 | 22.7656 | 0.9939 | 0.4492 |
| 37 | 1006 | 2 | 1 | BA1 | BG01 | 0.9826 | 0.6171 | -0.1741 | 15 | 63.9775 | 9.1950 | 84.5476 | 0.9978 | 0.1437 |
| 37 | 1006 | 2 | 2 | TP1 | BG55 | 1.0125 | 0.6169 | -0.1279 | 15 | 69.1116 | 4.5007 | 20.2563 | 0.9995 | 0.0651 |
| 37 | 1024 | 1 | 2 | TP | BS55 | 0.3320 | 0.2857 | -3.2671 | 14 | 4.9725 | 2.5609 | 6.5584 | 0.9874 | 0.5150 |
| 37 | 1024 | 2 | 1 | BA* | BG** | 0.7243 | 0.7045 | -0.2415 | 15 | 56.4088 | 7.4521 | 55.5338 | 0.9978 | 0.1321 |
| 37 | 1028 | 1 | 2 | TP | BS55 | 0.5957 | 0.5871 | 0.0000 | 14 | 13.8604 | 2.8360 | 8.0429 | 0.9984 | 0.2046 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 37 | 1030 | 1 | 2 | TP | BS55 | 0.5776 | 0.5130 | 0.0000 | 15 | 11.7039 | 4.0470 | 16.3786 | 0.9963 | 0.3458 |
| 37 | 1040 | 2 | 1 | BA* | BG** | 0.6688 | 0.6185 | -0.0045 | 15 | 50.1581 | 5.3333 | 28.4436 | 0.9987 | 0.1063 |
| 37 | 1040 | 2 | 2 | TP | BG55 | 0.8254 | 0.6915 | -0.2682 | 15 | 60.5673 | 8.3977 | 70.5219 | 0.9977 | 0.1387 |
| 37 | 1352 | 1 | 2 | TP | BS55 | 0.6910 | 0.0000 | 0.0000 | 15 | 6.2336 | 6.2335 | 38.8571 | 0.9927 | 1.0000 |
| 37 | 1801 | 1 | 2 | TP | BS55 | 0.8054 | 0.2202 | -2.9237 | 15 | 10.5320 | 3.3995 | 11.5569 | 0.9964 | 0.3228 |
| 37 | 1803 | 1 | 2 | TP | BS55 | 0.8492 | 0.2879 | -1.4407 | 15 | 9.1823 | 4.7054 | 22.1410 | 0.9960 | 0.5124 |
| 37 | 1803 | 2 | 1 | BA* | BG** | 0.6012 | 0.6739 | 0.0000 | 15 | 52.1425 | 12.4341 | 154.6067 | 0.9923 | 0.2385 |
| 37 | 1803 | 2 | 2 | TP | BG55 | 0.7949 | 0.7390 | -0.4169 | 15 | 59.3161 | 7.6911 | 59.1527 | 0.9979 | 0.1297 |
| 37 | 1817 | 1 | 1 | BA* | BS** | 0.9124 | 0.3333 | -3.4651 | 15 | 13.2190 | 4.0068 | 16.0547 | 0.9956 | 0.3031 |
| 37 | 1817 | 1 | 2 | TP | BS55 | 0.9654 | 0.1769 | -2.5638 | 15 | 11.9084 | 4.0678 | 16.5471 | 0.9967 | 0.3416 |
| 37 | 1992 | 1 | 1 | BA* | BS** | 0.8120 | 0.2192 | -0.9444 | 15 | 6.5814 | 3.3311 | 11.0965 | 0.9981 | 0.5061 |
| 37 | 2819 | 1 | 1 | BA* | BS** | 0.5632 | 0.2011 | -2.2567 | 15 | 6.3456 | 1.9793 | 3.9177 | 0.9979 | 0.3119 |
| 37 | 2819 | 1 | 2 | TP | BS55 | 0.7508 | 0.0614 | -1.7706 | 15 | 7.5939 | 3.4340 | 11.7925 | 0.9968 | 0.4522 |
| 37 | 2825 | 1 | 2 | TP | BS55 | 0.5958 | 0.1375 | -0.2998 | 15 | 4.4379 | 3.6210 | 13.1116 | 0.9964 | 0.8159 |
| 37 | 3008 | 1 | 1 | BA* | BS** | 0.6223 | 0.3402 | -2.8894 | 15 | 8.7603 | 3.6009 | 12.9661 | 0.9935 | 0.4110 |
| 37 | 3008 | 1 | 2 | BA* | BS** | 0.6704 | 0.4799 | -2.2577 | 15 | 9.8624 | 3.8740 | 15.0077 | 0.9948 | 0.3928 |
| 37 | 3011 | 1 | 1 | BA* | BS** | 0.9754 | 0.2170 | -0.4908 | 15 | 8.8436 | 6.0037 | 36.0446 | 0.9962 | 0.6789 |
| 37 | 3011 | 1 | 2 | TP | BS55 | 1.2689 | 0.2668 | -1.9342 | 15 | 13.4837 | 4.6206 | 21.3501 | 0.9980 | 0.3427 |
| 37 | 3044 | 2 | 1 | BA* | BG** | 0.7047 | 0.5818 | -0.3382 | 15 | 36.6513 | 8.7532 | 76.6182 | 0.9952 | 0.2388 |
| 37 | 3044 | 2 | 2 | BA* | BG** | 0.8331 | 0.5646 | -0.3174 | 15 | 41.5713 | 7.4481 | 55.4742 | 0.9974 | 0.1792 |
| 37 | 3807 | 1 | 1 | BA* | BS** | 0.7188 | 0.4839 | -2.9830 | 15 | 11.3129 | 4.6917 | 22.0120 | 0.9919 | 0.4147 |
| 37 | 3807 | 1 | 2 | TP | BS55 | 0.7263 | 0.4405 | -3.2208 | 15 | 10.9731 | 3.9086 | 15.2769 | 0.9940 | 0.3562 |
| 37 | 5037 | 1 | 1 | BA* | BS** | 0.6293 | 0.3403 | -2.3543 | 15 | 9.3646 | 5.6625 | 32.0642 | 0.9865 | 0.6047 |
| 37 | 5037 | 1 | 2 | BA* | BS** | 0.8095 | 0.1422 | -2.6958 | 15 | 10.5456 | 4.1501 | 17.2232 | 0.9949 | 0.3935 |
| 37 | 5827 | 1 | 1 | BA* | BS** | 0.6703 | 0.4708 | -2.8276 | 15 | 10.0631 | 3.8618 | 14.9137 | 0.9938 | 0.3838 |
| 37 | 5827 | 1 | 2 | TP | BS55 | 0.6923 | 0.2928 | -2.4503 | 15 | 9.2849 | 4.4524 | 19.8240 | 0.9928 | 0.4795 |
| 38 | 0219 | 1 | 3 | A14 | TS27 | 0.7657 | 0.1591 | -1.6992 | 15 | 6.5843 | 0.5169 | 0.2671 | 0.9999 | 0.0785 |
| 38 | 0219 | 1 | 3 | A14 | TS28 | 0.5685 | 0.1507 | -2.8057 | 13 | 6.5594 | 0.4256 | 0.1811 | 0.9999 | 0.0649 |
| 38 | 0221 | 1 | 3 | A20 | TS40 | 0.7199 | 0.1386 | -1.8029 | 13 | 5.1078 | 0.5500 | 0.3025 | 0.9999 | 0.1077 |
| 38 | 0221 | 1 | 3 | A21 | TS42 | 0.7785 | 0.2271 | -2.2288 | 15 | 8.2173 | 0.4454 | 0.1983 | 0.9999 | 0.0542 |
| 38 | 0221 | 3 | 3 | B13 | BG12 | 1.0296 | 0.5450 | 0.0000 | 14 | 59.1369 | 6.0983 | 37.1893 | 0.9990 | 0.1031 |
| 38 | 0223 | 3 | 3 | B12 | BG11 | 1.0719 | 0.6569 | -0.0664 | 14 | 78.4702 | 4.4137 | 19.4806 | 0.9996 | 0.0562 |
| 38 | 3005 | 2 | 1 | BA* | BG** | 0.9006 | 0.3575 | -0.7161 | 15 | 16.3261 | 6.2887 | 39.5482 | 0.9964 | 0.3852 |
| 38 | 3006 | 1 | 1 | BA* | BS** | 0.6977 | 0.6230 | -3.1469 | 15 | 11.4280 | 2.4777 | 6.1392 | 0.9976 | 0.2168 |
| 38 | 3006 | 1 | 2 | TP* | BS** | 0.6985 | 0.5303 | -2.2198 | 15 | 10.0854 | 1.7994 | 3.2379 | 0.9990 | 0.1784 |
| 38 | 3006 | 2 | 1 | BA* | BG** | 0.6527 | 0.6024 | -0.0942 | 15 | 43.1805 | 6.8477 | 46.8905 | 0.9973 | 0.1586 |
| 38 | 3006 | 2 | 2 | TP* | BG** | 0.3656 | 0.8232 | -0.0286 | 15 | 43.6899 | 5.1463 | 26.4848 | 0.9976 | 0.1178 |
| 39 | 0101 | 2 | 2 | B16 | BG16 | 1.3235 | 0.6547 | 0.0000 | 14 | 101.9413 | 9.9099 | 98.2065 | 0.9988 | 0.0972 |
| 39 | 0102 | 2 | 2 | B18 | BG18 | 1.3342 | 0.6330 | 0.0000 | 14 | 95.7167 | 5.3768 | 28.9097 | 0.9996 | 0.0562 |
| 39 | 0106 | 1 | 2 | B2 | BS02 | 1.5063 | 0.3014 | -0.9646 | 14 | 12.3440 | 1.8809 | 3.5379 | 0.9998 | 0.1524 |
| 39 | 0107 | 1 | 1 | B3 | BS03 | 1.1437 | 0.2312 | -2.5223 | 15 | 13.2773 | 1.6224 | 2.6320 | 0.9996 | 0.1222 |
| 39 | 0108 | 1 | 1 | B5 | BS05 | 1.0460 | 0.2559 | -1.6620 | 15 | 9.7165 | 1.2973 | 1.6829 | 0.9998 | 0.1335 |
| 39 | 0108 | 2 | 2 | B19 | BG19 | 0.9477 | 0.5841 | -0.0283 | 14 | 58.5248 | 4.9704 | 24.7051 | 0.9993 | 0.0849 |
| 39 | 0203 | 2 | 2 | B23 | BG23 | 1.3221 | 0.5554 | -0.0436 | 14 | 76.0211 | 5.9199 | 35.0458 | 0.9994 | 0.0779 |
| 39 | 0204 | 3 | 1 | B19 | BG19 | 1.2464 | 0.5372 | 0.0000 | 14 | 70.0611 | 5.6160 | 31.5398 | 0.9994 | 0.0802 |
| 39 | 0209 | 2 | 1 | B22 | BG22 | 1.2262 | 0.6116 | 0.0000 | 13 | 78.9295 | 5.7591 | 33.1673 | 0.9995 | 0.0730 |
| 39 | 0210 | 2 | 1 | B20 | BG20 | 0.7285 | 0.8353 | 0.0000 | 14 | 83.3119 | 4.4737 | 20.0137 | 0.9995 | 0.0537 |
| 39 | 0211 | 1 | 2 | B6 | BS06 | 1.3626 | 0.3090 | -0.2987 | 15 | 13.9226 | 2.9887 | 8.9323 | 0.9996 | 0.2147 |
| 39 | 0803 | 1 | 3 | A4 | TS07 | 1.8490 | 0.2425 | -1.3345 | 15 | 15.1620 | 1.7963 | 3.2267 | 0.9999 | 0.1185 |
| 39 | 0804 | 1 | 3 | A1 | TS13 | 1.3505 | 0.2300 | -1.9049 | 15 | 13.1974 | 1.9383 | 3.7568 | 0.9997 | 0.1469 |
| 39 | 0804 | 3 | 1 | B6 | BG06 | 1.0810 | 0.6542 | -0.0182 | 13 | 76.6177 | 4.2136 | 17.7548 | 0.9997 | 0.0550 |
| 39 | 0809 | 3 | 2 | B7 | BG07 | 1.1805 | 0.5990 | 0.0000 | 14 | 78.2695 | 4.3249 | 18.7047 | 0.9997 | 0.0553 |
| 39 | 0810 | 1 | 2 | B4 | BS04 | 1.0565 | 0.2802 | -3.9932 | 15 | 15.7864 | 2.1498 | 4.6215 | 0.9989 | 0.1362 |
| 39 | 0810 | 3 | 2 | B8 | BG08 | 1.0751 | 0.6261 | -0.0474 | 14 | 73.1927 | 6.4980 | 42.2246 | 0.9991 | 0.0888 |
| 39 | 3013 | 1 | 1 | A1 | TS02 | 0.5991 | 0.3751 | -4.0511 | 15 | 9.6988 | 4.1732 | 17.4159 | 0.9876 | 0.4303 |
| 39 | 3013 | 1 | 2 | A2 | TS03 | 0.8795 | 0.3858 | -5.8718 | 15 | 15.3849 | 3.1500 | 9.9227 | 0.9949 | 0.2047 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | 3801 | 1 | 1 | BA* | BS** | 1.5905 | 0.2845 | -2.3499 | 15 | 18.1764 | 1.4295 | 2.0435 | 0.9999 | 0.0786 |
| 39 | 3801 | 1 | 2 | BA* | BS** | 1.3816 | 0.4328 | -1.4045 | 14 | 15.2036 | 1.2717 | 1.6172 | 0.9999 | 0.0836 |
| 39 | 4031 | 1 | 1 | BA* | BS** | 1.8391 | 0.2655 | -2.0338 | 15 | 19.1379 | 1.7028 | 2.8994 | 0.9999 | 0.0890 |
| 39 | 4031 | 1 | 2 | B* | BS** | 1.5370 | 0.3557 | -1.6368 | 14 | 14.1414 | 1.3570 | 1.8416 | 0.9999 | 0.0960 |
| 39 | 4031 | 2 | 1 | BA* | BG** | 0.9639 | 0.5048 | -0.1818 | 15 | 45.3001 | 10.8097 | 116.8488 | 0.9958 | 0.2386 |
| 39 | 4031 | 2 | 2 | BA* | BG** | 0.7575 | 0.6792 | 0.0000 | 15 | 65.7124 | 6.2888 | 39.5489 | 0.9988 | 0.0957 |
| 39 | 5003 | 1 | 1 | BA* | BS** | 1.2735 | 0.2940 | -3.2631 | 14 | 14.7829 | 1.5177 | 2.3035 | 0.9997 | 0.1027 |
| 39 | 5003 | 1 | 2 | BA* | BG** | 1.3413 | 0.2548 | -2.8297 | 15 | 16.8755 | 1.7787 | 3.1639 | 0.9997 | 0.1054 |
| 39 | 5003 | 2 | 1 | BA* | BG** | 1.1465 | 0.4724 | 0.0000 | 15 | 56.8831 | 8.3130 | 69.1059 | 0.9984 | 0.1461 |
| 39 | 5003 | 2 | 2 | BA* | BG** | 0.7158 | 0.7927 | -0.1822 | 15 | 72.2603 | 3.7138 | 13.7924 | 0.9996 | 0.0514 |
| 39 | 5010 | 1 | 2 | BA* | BS** | 0.9527 | 0.4270 | -2.8889 | 15 | 13.4263 | 3.7567 | 14.1131 | 0.9970 | 0.2798 |
| 39 | 7021 | 1 | 1 | BA* | BS** | 1.0532 | 0.4167 | -4.3618 | 15 | 16.5995 | 1.2925 | 1.6707 | 0.9996 | 0.0779 |
| 39 | 7021 | 1 | 2 | BA* | BS** | 1.2614 | 0.1805 | -2.4099 | 15 | 14.3301 | 1.8556 | 3.4432 | 0.9996 | 0.1295 |
| 39 | 7021 | 2 | 1 | BA* | BG** | 0.7853 | 0.5365 | 0.0000 | 15 | 46.8231 | 6.0738 | 36.8907 | 0.9984 | 0.1297 |
| 39 | 7021 | 2 | 2 | BA* | BG** | 0.6546 | 0.7917 | -0.2778 | 15 | 61.4396 | 3.4390 | 11.8264 | 0.9995 | 0.0560 |
| 39 | 9006 | 1 | 1 | A1 | TS02 | 0.7979 | 0.1969 | -4.7725 | 15 | 12.9144 | 1.5188 | 2.3068 | 0.9988 | 0.1176 |
| 39 | 9006 | 1 | 2 | BA* | BS** | 1.1796 | 0.2895 | -1.3390 | 14 | 10.6948 | 1.0943 | 1.1974 | 0.9999 | 0.1023 |
| 39 | 9006 | 2 | 1 | BA* | BG** | 0.6696 | 0.7168 | -0.1912 | 15 | 55.2714 | 5.6925 | 32.4043 | 0.9986 | 0.1030 |
| 39 | 9006 | 2 | 2 | BA* | BG** | 0.7314 | 0.6309 | -0.0579 | 15 | 53.6655 | 5.3642 | 28.7742 | 0.9988 | 0.1000 |
| 39 | 9022 | 1 | 1 | BA* | BS** | 0.9700 | 0.2885 | -2.2142 | 15 | 10.7029 | 1.6258 | 2.6431 | 0.9995 | 0.1519 |
| 39 | 9022 | 1 | 2 | BA* | BS** | 1.2538 | 0.2363 | -1.3040 | 14 | 8.8109 | 1.5731 | 2.4748 | 0.9998 | 0.1785 |
| 40 | 0114 | 1 | 2 | B1 | BS01 | 0.6288 | 0.2585 | -0.3183 | 15 | 5.6036 | 2.1666 | 4.6943 | 0.9989 | 0.3867 |
| 40 | 0116 | 1 | 2 | B2 | BS02 | 0.7489 | 0.1739 | 0.0000 | 15 | 5.5532 | 2.8508 | 8.1271 | 0.9987 | 0.5134 |
| 40 | 0117 | 1 | 2 | B3 | BS03 | 0.8804 | 0.2326 | 0.0000 | 15 | 9.4557 | 5.7176 | 32.6911 | 0.9964 | 0.6047 |
| 40 | 0120 | 1 | 2 | B5 | BS05 | 0.8234 | 0.2199 | 0.0000 | 15 | 8.2045 | 4.8307 | 23.3353 | 0.9971 | 0.5888 |
| 40 | 0121 | 1 | 3 | A14 | TS27 | 0.5877 | 0.0915 | -1.7329 | 15 | 5.5403 | 1.8775 | 3.5251 | 0.9985 | 0.3389 |
| 40 | 0122 | 1 | 2 | B4 | BS04 | 0.7352 | 0.2144 | -0.0206 | 15 | 6.2618 | 2.5809 | 6.6610 | 0.9989 | 0.4122 |
| 40 | 0123 | 1 | 2 | B6 | BS06 | 1.0303 | 0.2341 | 0.0000 | 15 | 13.1087 | 9.6699 | 93.5063 | 0.9926 | 0.7377 |
| 40 | 0124 | 1 | 3 | A17 | TS33 | 0.5897 | 0.0185 | -1.1002 | 15 | 4.3894 | 2.0908 | 4.3715 | 0.9984 | 0.4763 |
| 40 | 1015 | 1 | 1 | A1 | TS01 | 1.0432 | 0.1972 | -1.7187 | 15 | 9.2633 | 1.3513 | 1.8261 | 0.9998 | 0.1459 |
| 40 | 1015 | 1 | 2 | A2 | TS03 | 0.5881 | 0.3653 | -0.1026 | 15 | 8.6658 | 4.0718 | 16.5793 | 0.9960 | 0.4699 |
| 40 | 1017 | 1 | 1 | A1 | TS01 | 1.7708 | 0.4159 | -1.3840 | 15 | 23.2895 | 11.2262 | 126.0274 | 0.9951 | 0.4820 |
| 40 | 1017 | 1 | 2 | A2 | TS03 | 0.7012 | 0.6516 | -1.5159 | 15 | 12.5003 | 2.0748 | 4.3050 | 0.9990 | 0.1660 |
| 40 | 3018 | 1 | 1 | A1 | TS01 | 0.5833 | 0.5169 | -4.2692 | 15 | 9.3121 | 2.2222 | 4.9381 | 0.9963 | 0.2386 |
| 40 | 3018 | 1 | 2 | A2 | TS03 | 0.2960 | 0.0000 | -2.1828 | 15 | 3.5950 | 1.9737 | 3.8954 | 0.9928 | 0.5490 |
| 40 | 4086 | 1 | 1 | A1 | TS01 | 0.5422 | 0.6520 | -4.0088 | 15 | 8.9576 | 2.6429 | 6.9847 | 0.9946 | 0.2950 |
| 40 | 4086 | 1 | 2 | A2 | TS03 | 0.5464 | 0.5555 | -2.6984 | 15 | 8.3427 | 1.9925 | 3.9701 | 0.9978 | 0.2388 |
| 40 | 4087 | 1 | 1 | A1 | TS01 | 1.7265 | 0.2555 | -0.6188 | 15 | 13.4423 | 1.6242 | 2.6379 | 0.9999 | 0.1208 |
| 40 | 4087 | 1 | 2 | BA* | BS** | 0.5161 | 0.2697 | 0.0000 | 15 | 16.0911 | 15.2534 | 232.6666 | 0.9319 | 0.9479 |
| 40 | 4088 | 1 | 2 | BA* | BS** | 0.5991 | 0.2581 | -1.9140 | 15 | 6.3004 | 2.2542 | 5.0814 | 0.9978 | 0.3578 |
| 40 | 4155 | 1 | 1 | A1 | TS01 | 0.7895 | 0.5631 | -3.6829 | 15 | 12.2987 | 2.4675 | 6.0887 | 0.9980 | 0.2006 |
| 40 | 4155 | 1 | 2 | BA* | BS** | 0.9793 | 0.4536 | -2.3316 | 15 | 13.0311 | 3.0449 | 9.2715 | 0.9985 | 0.2337 |
| 40 | 4157 | 1 | 1 | BA* | BS** | 0.6765 | 0.5117 | -0.6596 | 15 | 11.3167 | 3.7357 | 13.9554 | 0.9971 | 0.3301 |
| 40 | 4157 | 1 | 2 | BA* | BS** | 0.6748 | 0.6605 | -1.3037 | 15 | 12.5993 | 2.2571 | 5.0945 | 0.9988 | 0.1791 |
| 40 | 4158 | 1 | 1 | BA* | BS** | 0.6912 | 0.5342 | -1.9908 | 15 | 10.6815 | 3.6615 | 13.4066 | 0.9961 | 0.3428 |
| 40 | 4158 | 1 | 2 | BA* | BS** | 0.6080 | 0.3899 | -1.3724 | 15 | 7.5637 | 3.3252 | 11.0572 | 0.9963 | 0.4396 |
| 40 | 4160 | 1 | 1 | A1 | TS01 | 0.5848 | 0.3835 | -5.9611 | 15 | 9.3646 | 3.3566 | 11.2667 | 0.9885 | 0.3584 |
| 40 | 4160 | 1 | 2 | A2 | TS02 | 1.0501 | 0.4262 | -1.7440 | 15 | 13.0136 | 3.2212 | 10.3762 | 0.9987 | 0.2475 |
| 40 | 4160 | 2 | 1 | BA* | BG** | 0.9827 | 0.3492 | -0.0154 | 15 | 32.0665 | 7.2453 | 52.4938 | 0.9977 | 0.2259 |
| 40 | 4160 | 2 | 2 | BA* | BG** | 0.9216 | 0.5836 | -0.0393 | 15 | 61.3965 | 9.6157 | 92.4612 | 0.9973 | 0.1566 |
| 40 | 4161 | 1 | 1 | A1 | TS01 | 0.6876 | 0.1714 | 0.0000 | 15 | 11.0000 | 10.1482 | 102.9855 | 0.9814 | 0.9226 |
| 40 | 4161 | 1 | 2 | A2 | TS03 | 0.5642 | 0.1977 | -0.0065 | 15 | 8.8452 | 7.8870 | 62.2048 | 0.9833 | 0.8917 |
| 40 | 4162 | 1 | 1 | A1 | TS01 | 1.2183 | 0.5652 | -1.8572 | 15 | 18.4623 | 2.9331 | 8.6030 | 0.9992 | 0.1589 |
| 40 | 4162 | 1 | 2 | A2 | TS03 | 0.7156 | 0.2577 | -1.8255 | 15 | 7.3988 | 2.8343 | 8.0331 | 0.9977 | 0.3831 |
| 40 | 4164 | 1 | 1 | BA* | BS** | 0.7598 | 0.5080 | -0.8089 | 15 | 12.1212 | 3.8623 | 14.9177 | 0.9974 | 0.3186 |
| 40 | 4164 | 1 | 2 | A2 | TS03 | 0.7977 | 0.6125 | -1.1781 | 15 | 14.0655 | 2.1484 | 4.6156 | 0.9992 | 0.1527 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 4166 | 1 | 1 | BA* | BS** | 0.6403 | 0.1545 | 0.0000 | 15 | 7.2230 | 6.2647 | 39.2470 | 0.9917 | 0.8673 |
| 40 | 4166 | 1 | 2 | A2 | TS03 | 0.7740 | 0.1165 | -2.2322 | 15 | 8.4046 | 4.0599 | 16.4826 | 0.9957 | 0.4831 |
| 40 | 5021 | 1 | 2 | A2 | TS01 | 0.5350 | 0.0000 | -0.6667 | 15 | 6.6961 | 6.3165 | 39.8978 | 0.9848 | 0.9433 |
| 40 | 6010 | 1 | 1 | BA* | BS** | 1.1617 | 0.2813 | -1.0623 | 15 | 10.2850 | 3.1847 | 10.1424 | 0.9991 | 0.3096 |
| 40 | 6010 | 1 | 2 | BA* | BS** | 1.0072 | 0.2751 | -0.6287 | 15 | 9.8899 | 5.3661 | 28.7954 | 0.9971 | 0.5426 |
| 40 | 7024 | 1 | 1 | A1 | TS01 | 0.6482 | 0.4314 | -2.7779 | 15 | 9.1781 | 3.3174 | 11.0053 | 0.9953 | 0.3614 |
| 40 | 7024 | 1 | 2 | A2 | TS03 | 0.7882 | 0.1866 | -1.5423 | 15 | 9.4466 | 6.8567 | 47.0143 | 0.9897 | 0.7258 |
| 41 | 2002 | 1 | 1 | A1 | TS01 | 0.1994 | 0.5385 | -2.2799 | 15 | 3.1045 | 1.3327 | 1.7760 | 0.9932 | 0.4293 |
| 41 | 2002 | 1 | 2 | A2 | TS03 | 0.3939 | 0.4940 | -2.0941 | 15 | 5.5609 | 1.7347 | 3.0092 | 0.9971 | 0.3119 |
| 41 | 5005 | 1 | 1 | A1 | TS01 | 0.4772 | 0.2917 | -2.2655 | 15 | 5.3426 | 1.1851 | 1.4045 | 0.9990 | 0.2218 |
| 41 | 5005 | 1 | 2 | A2 | TS03 | 0.5785 | 0.1770 | -2.9179 | 15 | 7.1401 | 0.9754 | 0.9513 | 0.9994 | 0.1366 |
| 41 | 5006 | 1 | 1 | A1 | TS01 | 0.5503 | 0.2553 | -2.4153 | 15 | 6.2731 | 1.1852 | 1.4048 | 0.9992 | 0.1889 |
| 41 | 5006 | 1 | 1 | BA* | BS** | 0.6064 | 0.1979 | -0.8382 | 15 | 3.9976 | 1.2551 | 1.5752 | 0.9995 | 0.3140 |
| 41 | 5006 | 1 | 2 | BA* | BS** | 0.2850 | 0.7409 | -2.7081 | 15 | 5.3247 | 1.4871 | 2.2114 | 0.9956 | 0.2793 |
| 41 | 5006 | 2 | 1 | BA* | BG** | 1.0135 | 0.1741 | 0.0000 | 15 | 14.1320 | 1.6635 | 2.7673 | 0.9998 | 0.1177 |
| 41 | 5006 | 2 | 2 | BA* | BG** | 1.0411 | 0.1936 | 0.0000 | 15 | 16.4050 | 1.2461 | 1.5528 | 0.9999 | 0.0760 |
| 41 | 5006 | 3 | 2 | BA* | BG** | 0.5314 | 0.5185 | -0.1905 | 15 | 25.6261 | 4.5654 | 20.8425 | 0.9976 | 0.1782 |
| 41 | 5008 | 1 | 1 | BA* | BS** | 0.8025 | 0.2465 | -0.8242 | 15 | 6.1389 | 1.6796 | 2.8210 | 0.9995 | 0.2736 |
| 41 | 5008 | 1 | 2 | BA* | BS** | 1.0517 | 0.1759 | -0.1054 | 15 | 6.4417 | 1.1887 | 1.4129 | 0.9999 | 0.1845 |
| 41 | 5022 | 1 | 2 | BA6 | BS16 | 0.9010 | 0.2600 | -1.0831 | 15 | 7.3860 | 1.5785 | 2.4915 | 0.9996 | 0.2137 |
| 41 | 6011 | 1 | 1 | A1 | TS01 | 0.5741 | 0.2144 | -1.1075 | 15 | 4.1952 | 0.7865 | 0.6185 | 0.9998 | 0.1875 |
| 41 | 6011 | 1 | 2 | A2 | TS03 | 0.4429 | 0.2012 | -2.0200 | 15 | 4.3665 | 0.6748 | 0.4554 | 0.9996 | 0.1545 |
| 41 | 7018 | 1 | 1 | BA* | BS** | 0.6390 | 0.1580 | -2.3917 | 15 | 7.1201 | 0.7665 | 0.5875 | 0.9997 | 0.1076 |
| 41 | 7018 | 1 | 2 | BA* | BS** | 0.9140 | 0.1529 | -0.0717 | 15 | 5.1195 | 1.5882 | 2.5225 | 0.9997 | 0.3102 |
| 41 | 7019 | 1 | 1 | BA* | BS** | 0.8883 | 0.1998 | 0.0000 | 15 | 8.9560 | 6.1635 | 37.9882 | 0.9959 | 0.6882 |
| 41 | 7019 | 1 | 2 | BA* | BS** | 1.0430 | 0.2763 | 0.0000 | 15 | 11.7100 | 4.9578 | 24.5801 | 0.9981 | 0.4234 |
| 41 | 7025 | 1 | 2 | A2 | TS05 | 0.7142 | 0.2945 | -4.7190 | 15 | 11.2517 | 2.2405 | 5.0198 | 0.9970 | 0.1991 |
| 42 | 0603 | 1 | 2 | B5 | BS05 | 0.8429 | 0.2252 | 0.0000 | 15 | 7.9144 | 3.8112 | 14.5250 | 0.9983 | 0.4815 |
| 42 | 0608 | 1 | 2 | BA6 | BS06 | 0.7779 | 0.2264 | -0.5420 | 15 | 5.8285 | 2.4156 | 5.8350 | 0.9990 | 0.4144 |
| 42 | 1597 | 1 | 1 | BA1 | BS01 | 1.2179 | 0.2240 | -1.3571 | 15 | 11.1283 | 5.2052 | 27.0944 | 0.9976 | 0.4677 |
| 42 | 1597 | 1 | 2 | TP | BS55 | 0.9290 | 0.2135 | 0.0000 | 15 | 16.1797 | 14.4547 | 208.9396 | 0.9797 | 0.8934 |
| 42 | 1598 | 1 | 2 | BA6 | BS06 | 0.8814 | 0.2810 | 0.0000 | 15 | 30.5068 | 29.1444 | 849.3943 | 0.9162 | 0.9553 |
| 42 | 1599 | 1 | 1 | BA* | BS** | 1.1976 | 0.2726 | -1.4671 | 15 | 11.2610 | 3.5947 | 12.9217 | 0.9988 | 0.3192 |
| 42 | 1599 | 1 | 2 | TP | BS55 | 0.8779 | 0.3119 | -1.6200 | 15 | 9.2788 | 3.2764 | 10.7350 | 0.9981 | 0.3531 |
| 42 | 1605 | 1 | 1 | BA2 | BS02 | 1.1296 | 0.2423 | -2.7411 | 15 | 14.5193 | 4.8309 | 23.3378 | 0.9965 | 0.3327 |
| 42 | 1605 | 1 | 2 | TP | BS55 | 0.7416 | 0.1876 | -3.6869 | 14 | 11.3205 | 4.9672 | 24.6734 | 0.9889 | 0.4388 |
| 42 | 1606 | 1 | 1 | BA2 | BS02 | 1.0593 | 0.0861 | -0.1187 | 15 | 8.2531 | 7.7058 | 59.3792 | 0.9951 | 0.9337 |
| 42 | 1606 | 1 | 2 | BA5 | BS04 | 1.3631 | 0.2563 | 0.0000 | 15 | 13.9993 | 5.7341 | 32.8805 | 0.9985 | 0.4096 |
| 42 | 1608 | 1 | 1 | BA1 | BS01 | 1.1241 | 0.2083 | -0.5573 | 15 | 8.1766 | 4.0561 | 16.4521 | 0.9987 | 0.4961 |
| 42 | 1613 | 1 | 1 | BA* | BS** | 0.6696 | 0.6107 | -2.6245 | 15 | 11.0678 | 3.2580 | 10.6148 | 0.9961 | 0.2944 |
| 42 | 1613 | 1 | 2 | BA* | BS** | 0.7219 | 0.4706 | -2.2170 | 14 | 10.8923 | 4.4822 | 20.0902 | 0.9940 | 0.4115 |
| 42 | 1613 | 2 | 1 | BA1 | BG01 | 0.8608 | 0.7675 | -0.4527 | 15 | 67.4814 | 8.4253 | 70.9859 | 0.9980 | 0.1249 |
| 42 | 1614 | 1 | 1 | BA* | BS** | 1.1678 | 0.3567 | -1.9054 | 14 | 14.4923 | 5.3291 | 28.3991 | 0.9970 | 0.3677 |
| 42 | 1614 | 1 | 2 | BA* | BS** | 1.4264 | 0.2147 | -1.4519 | 15 | 12.0917 | 3.1325 | 9.8123 | 0.9993 | 0.2591 |
| 42 | 1614 | 2 | 1 | BA* | BG** | 0.6597 | 0.6437 | -0.2470 | 15 | 43.8404 | 3.1860 | 10.1506 | 0.9994 | 0.0727 |
| 42 | 1617 | 1 | 1 | BA* | BS** | 1.7221 | 0.4466 | -2.7154 | 15 | 24.0327 | 4.9292 | 24.2971 | 0.9985 | 0.2051 |
| 42 | 1617 | 1 | 2 | BA* | BS** | 1.0380 | 0.3248 | -3.0124 | 15 | 14.5857 | 5.1336 | 26.3537 | 0.9950 | 0.3520 |
| 42 | 1618 | 1 | 1 | BA* | BS** | 0.8466 | 0.0940 | 0.0000 | 15 | 15.7954 | 15.5357 | 241.3591 | 0.9710 | 0.9836 |
| 42 | 1618 | 2 | 1 | BA* | BG** | 0.7340 | 0.7223 | -0.4796 | 14 | 51.9994 | 6.8455 | 46.8612 | 0.9979 | 0.1316 |
| 42 | 1623 | 1 | 1 | BA* | BS** | 1.1494 | 0.3166 | -1.3721 | 15 | 11.2787 | 2.9156 | 8.5008 | 0.9992 | 0.2585 |
| 42 | 1623 | 1 | 2 | BA5 | BS05 | 0.8315 | 0.4185 | -2.4920 | 15 | 11.2998 | 3.8210 | 14.5999 | 0.9964 | 0.3381 |
| 42 | 1627 | 1 | 1 | BA* | BS** | 1.1344 | 0.2458 | -0.7043 | 15 | 9.5244 | 4.5863 | 21.0340 | 0.9983 | 0.4815 |
| 42 | 1627 | 1 | 2 | BA* | BS** | 1.0536 | 0.4409 | -2.0805 | 15 | 14.1108 | 4.6979 | 22.0705 | 0.9970 | 0.3329 |
| 42 | 1690 | 1 | 1 | BA* | BS** | 1.1688 | 0.2724 | 0.0000 | 15 | 14.9389 | 9.5433 | 91.0754 | 0.9944 | 0.6388 |
| 42 | 1690 | 1 | 2 | BA* | BS** | 0.7380 | 0.3412 | -0.9247 | 15 | 7.9361 | 3.3480 | 11.2092 | 0.9977 | 0.4219 |
| 42 | 3044 | 1 | 1 | BA1 | BS01 | 1.4695 | 0.4205 | -3.1776 | 15 | 21.3035 | 4.6973 | 22.0645 | 0.9979 | 0.2205 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 42 | 5020 | 1 | 2 | BA5 | BS04 | 0.8639 | 0.5063 | -1.0841 | 15 | 12.5725 | 2.1072 | 4.4404 | 0.9994 | 0.1676 |
| 42 | 7025 | 1 | 1 | BA* | BS** | 0.8528 | 0.4199 | -2.2559 | 15 | 12.2311 | 5.5955 | 31.3100 | 0.9931 | 0.4575 |
| 42 | 7025 | 1 | 2 | BA* | BS** | 0.8620 | 0.6210 | -2.3223 | 15 | 14.6346 | 5.3154 | 28.2534 | 0.9942 | 0.3632 |
| 42 | 7025 | 2 | 2 | BA* | BG** | 1.2372 | 0.5122 | -0.4399 | 15 | 47.7571 | 9.7326 | 94.7229 | 0.9975 | 0.2038 |
| 42 | 7037 | 1 | 1 | BA* | BS** | 1.2869 | 0.2822 | -1.3211 | 15 | 12.1342 | 4.1306 | 17.0618 | 0.9987 | 0.3404 |
| 42 | 7037 | 1 | 2 | BA* | BS** | 1.0692 | 0.2131 | -0.8617 | 15 | 8.6850 | 4.8633 | 23.6512 | 0.9977 | 0.5600 |
| 42 | 7037 | 2 | 1 | BA3 | BG03 | 0.8159 | 0.5241 | 0.0000 | 15 | 47.6005 | 7.7802 | 60.5310 | 0.9975 | 0.1634 |
| 42 | 7037 | 2 | 2 | BA5 | BG05 | 1.3511 | 0.4294 | -0.4827 | 15 | 38.1261 | 10.7165 | 114.8433 | 0.9967 | 0.2811 |
| 42 | 9027 | 1 | 2 | BA* | BS** | 1.1214 | 0.1738 | -0.7099 | 15 | 7.8782 | 4.8097 | 23.1334 | 0.9980 | 0.6105 |
| 45 | 1008 | 1 | 1 | A1 | TS01 | 0.9584 | 0.5623 | -2.6292 | 15 | 14.5498 | 2.1731 | 4.7222 | 0.9991 | 0.1494 |
| 45 | 1008 | 1 | 2 | A2 | TS03 | 0.6119 | 0.2568 | 0.0000 | 15 | 10.4462 | 8.7071 | 75.8142 | 0.9829 | 0.8335 |
| 45 | 1008 | 2 | 1 | BA* | BG** | 0.5487 | 0.7521 | -0.1001 | 15 | 53.7453 | 3.4792 | 12.1046 | 0.9994 | 0.0647 |
| 45 | 1008 | 2 | 2 | TP1 | BG55 | 0.8435 | 0.7367 | -0.2961 | 15 | 69.2724 | 4.6863 | 21.9612 | 0.9994 | 0.0677 |
| 45 | 1011 | 1 | 1 | BA* | BS** | 0.8791 | 0.5004 | -0.7119 | 15 | 13.6214 | 2.7876 | 7.7706 | 0.9990 | 0.2046 |
| 45 | 1011 | 1 | 2 | BA* | BS** | 0.8041 | 0.4662 | -0.4398 | 15 | 12.4319 | 2.7275 | 7.4393 | 0.9990 | 0.2194 |
| 45 | 1011 | 2 | 1 | BA* | BG** | 0.8686 | 0.6486 | 0.0000 | 15 | 74.1676 | 23.4012 | 547.6161 | 0.9862 | 0.3155 |
| 45 | 1011 | 2 | 2 | BA* | BG** | 1.2357 | 0.5509 | 0.0000 | 15 | 77.7528 | 15.0246 | 225.7375 | 0.9963 | 0.1932 |
| 45 | 1024 | 1 | 1 | A1 | TS01 | 0.9860 | 0.3844 | -2.0542 | 15 | 12.5254 | 4.7007 | 22.0968 | 0.9966 | 0.3753 |
| 45 | 1024 | 1 | 2 | TP1 | BS55 | 1.0778 | 0.2189 | -2.2483 | 15 | 12.5007 | 5.0386 | 25.3870 | 0.9963 | 0.4031 |
| 45 | 1024 | 2 | 1 | BA* | BG** | 0.5058 | 0.7978 | -0.0066 | 15 | 59.2241 | 4.5845 | 21.0178 | 0.9989 | 0.0774 |
| 45 | 1024 | 2 | 2 | TP1 | BG55 | 0.4304 | 0.8535 | -0.0496 | 15 | 56.2340 | 2.7222 | 7.4102 | 0.9995 | 0.0484 |
| 45 | 1025 | 1 | 1 | A1 | TS01 | 0.6298 | 0.4025 | 0.0000 | 15 | 9.8305 | 3.0734 | 9.4456 | 0.9981 | 0.3126 |
| 45 | 1025 | 1 | 2 | A2 | TS03 | 0.8716 | 0.4924 | -5.2213 | 15 | 14.2812 | 3.3376 | 11.1398 | 0.9954 | 0.2337 |
| 45 | 1025 | 2 | 1 | BA* | BG** | 0.6765 | 0.6035 | -0.0609 | 15 | 46.7493 | 2.7040 | 7.3115 | 0.9996 | 0.0578 |
| 45 | 1025 | 2 | 2 | TP1 | BG** | 0.8929 | 0.6805 | -0.1293 | 15 | 71.4322 | 4.1134 | 16.9201 | 0.9996 | 0.0576 |
| 45 | 3012 | 1 | 1 | A1 | TS01 | 0.5775 | 0.3749 | -3.0666 | 15 | 8.2779 | 2.7739 | 7.6948 | 0.9953 | 0.3351 |
| 45 | 3012 | 1 | 2 | A2 | TS03 | 0.5603 | 0.4095 | -4.3981 | 15 | 9.0701 | 3.0086 | 9.0518 | 0.9921 | 0.3317 |
| 45 | 5017 | 1 | 1 | A1 | TS01 | 0.8494 | 0.4346 | -0.7402 | 15 | 11.7830 | 3.8878 | 15.1153 | 0.9979 | 0.3300 |
| 45 | 5017 | 1 | 2 | BA* | BS** | 0.7194 | 0.5896 | 0.0000 | 14 | 16.9997 | 5.2463 | 27.5236 | 0.9961 | 0.3086 |
| 45 | 5034 | 1 | 1 | A1 | TS01 | 0.9504 | 0.5001 | -1.5595 | 15 | 13.9786 | 5.3898 | 29.0500 | 0.9959 | 0.3856 |
| 45 | 5034 | 1 | 2 | A2 | TS03 | 0.7599 | 0.4244 | -1.8524 | 15 | 9.7174 | 2.9941 | 8.9644 | 0.9978 | 0.3081 |
| 45 | 5035 | 1 | 1 | A1 | TS01 | 0.6324 | 0.7250 | -1.3138 | 15 | 13.1283 | 2.5475 | 6.4899 | 0.9983 | 0.1940 |
| 45 | 5035 | 1 | 2 | A2 | TS03 | 0.8516 | 0.3949 | -0.4930 | 15 | 11.6157 | 4.5648 | 20.8377 | 0.9973 | 0.3930 |
| 45 | 7019 | 1 | 1 | A1 | TS01 | 0.8309 | 0.3925 | -1.7864 | 15 | 10.6064 | 4.5556 | 20.7534 | 0.9958 | 0.4295 |
| 45 | 7019 | 1 | 2 | A2 | TS03 | 0.4102 | 0.6064 | -1.0110 | 15 | 7.4814 | 1.8731 | 3.5086 | 0.9979 | 0.2504 |
| 46 | 0804 | 1 | 3 | A5 | TS10 | 1.0014 | 0.1792 | -0.5826 | 15 | 5.6290 | 1.2340 | 1.5228 | 0.9998 | 0.2192 |
| 46 | 0804 | 1 | 3 | A6 | TS12 | 1.0125 | 0.2113 | -1.1664 | 14 | 7.4543 | 1.4291 | 2.0425 | 0.9998 | 0.1917 |
| 46 | 3009 | 1 | 1 | A1 | TS02 | 1.5606 | 0.2006 | -1.1031 | 15 | 10.9052 | 1.2399 | 1.5373 | 0.9999 | 0.1137 |
| 46 | 3009 | 2 | 1 | BA* | BG** | 0.8673 | 0.5690 | -0.2010 | 15 | 49.3638 | 16.8450 | 283.7539 | 0.9892 | 0.3412 |
| 46 | 3009 | 2 | 2 | TP* | BG** | 0.6031 | 0.7497 | -0.0289 | 15 | 60.9481 | 5.8817 | 34.5944 | 0.9986 | 0.0965 |
| 46 | 3010 | 1 | 1 | BA* | BS** | 0.9322 | 0.3758 | -2.7217 | 15 | 12.0752 | 2.3515 | 5.5293 | 0.9988 | 0.1947 |
| 46 | 3010 | 1 | 2 | TP* | BS** | 1.0380 | 0.4275 | -3.1172 | 15 | 14.6385 | 2.8377 | 8.0523 | 0.9985 | 0.1938 |
| 46 | 3010 | 2 | 1 | BA* | BG** | 0.5338 | 0.7779 | -0.1845 | 15 | 51.6920 | 5.5391 | 30.6814 | 0.9983 | 0.1072 |
| 46 | 3010 | 2 | 2 | TP* | BG** | 0.5876 | 0.6184 | -0.0587 | 15 | 41.9237 | 8.9799 | 80.6390 | 0.9948 | 0.2142 |
| 46 | 3012 | 1 | 2 | TP* | BS** | 1.2348 | 0.2422 | -2.5427 | 15 | 14.5183 | 1.8950 | 3.5911 | 0.9996 | 0.1305 |
| 46 | 3012 | 2 | 2 | TP* | BG** | 0.8957 | 0.5861 | 0.0000 | 15 | 61.4029 | 8.3851 | 70.3101 | 0.9980 | 0.1366 |
| 46 | 3013 | 1 | 1 | BA* | BS** | 0.8050 | 0.4527 | -2.8605 | 15 | 11.3293 | 2.3970 | 5.7457 | 0.9983 | 0.2116 |
| 46 | 3013 | 1 | 2 | TP* | BS** | 0.4566 | 0.9315 | -2.9497 | 15 | 10.2363 | 3.2072 | 10.2859 | 0.9923 | 0.3133 |
| 46 | 3013 | 2 | 1 | BA* | BG** | 0.8500 | 0.5165 | 0.0000 | 15 | 48.3228 | 9.9216 | 98.4390 | 0.9962 | 0.2053 |
| 46 | 3013 | 2 | 2 | TP* | BG** | 0.8512 | 0.5507 | -0.0674 | 15 | 50.3168 | 11.1993 | 125.4248 | 0.9954 | 0.2226 |
| 46 | 3052 | 1 | 1 | A1 | TS01 | 0.8446 | 0.1040 | -1.6726 | 15 | 7.2552 | 0.3888 | 0.1512 | 1.0000 | 0.0536 |
| 46 | 3052 | 1 | 2 | A2 | TS03 | 0.9241 | 0.2112 | -1.8830 | 15 | 8.9443 | 1.6171 | 2.6149 | 0.9995 | 0.1808 |
| 46 | 3052 | 2 | 1 | BA* | BG** | 0.7146 | 0.7893 | -0.4298 | 15 | 59.4961 | 12.6767 | 160.6987 | 0.9939 | 0.2131 |
| 46 | 3052 | 2 | 2 | TP* | BG** | 0.6374 | 0.8206 | -0.3821 | 15 | 59.1952 | 11.2968 | 127.6171 | 0.9946 | 0.1908 |
| 46 | 3053 | 1 | 1 | TP* | BS56 | 1.7962 | 0.3681 | 0.0000 | 15 | 25.0367 | 6.0484 | 36.5830 | 0.9991 | 0.2416 |
| 46 | 3053 | 1 | 2 | TP* | BS55 | 1.2268 | 0.4501 | -2.1052 | 14 | 15.7522 | 1.4936 | 2.2308 | 0.9998 | 0.0948 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | 3053 | 2 | 1 | TP* | BG** | 0.8185 | 0.7113 | 0.0000 | 15 | 77.8152 | 3.4433 | 11.8566 | 0.9997 | 0.0443 |
| 46 | 3053 | 2 | 2 | TP* | BG55 | 1.1884 | 0.5823 | -0.2036 | 14 | 64.9293 | 6.3667 | 40.5343 | 0.9991 | 0.0981 |
| 46 | 5020 | 1 | 1 | BA* | BS** | 2.7055 | 0.4640 | -0.8565 | 12 | 35.1499 | 3.1575 | 9.9701 | 0.9999 | 0.0898 |
| 46 | 5020 | 1 | 2 | TP* | BS** | 1.5206 | 0.6009 | -1.0997 | 12 | 23.2240 | 3.4530 | 11.9230 | 0.9995 | 0.1487 |
| 46 | 5025 | 1 | 1 | A1 | TS01 | 0.8830 | 0.1689 | -2.5597 | 15 | 10.2432 | 0.6086 | 0.3704 | 0.9999 | 0.0594 |
| 46 | 5025 | 1 | 2 | A2 | TS03 | 0.5766 | 0.1952 | -1.9920 | 15 | 5.6501 | 0.7813 | 0.6104 | 0.9997 | 0.1383 |
| 46 | 5025 | 2 | 1 | BA* | BG** | 0.9986 | 0.5352 | -0.1822 | 14 | 48.4778 | 5.0833 | 25.8399 | 0.9991 | 0.1049 |
| 46 | 5025 | 2 | 2 | TP* | BG** | 0.5190 | 0.7112 | -0.1280 | 15 | 44.2861 | 6.6796 | 44.6170 | 0.9969 | 0.1508 |
| 46 | 5040 | 1 | 1 | A1 | TS01 | 0.7909 | 0.2828 | -3.0264 | 15 | 10.2181 | 0.8014 | 0.6423 | 0.9998 | 0.0784 |
| 46 | 5040 | 1 | 2 | TP* | BS** | 0.7266 | 0.3868 | -2.9324 | 15 | 9.8406 | 1.8869 | 3.5602 | 0.9987 | 0.1917 |
| 46 | 5040 | 2 | 1 | BA* | BG** | 0.6632 | 0.6993 | 0.0000 | 15 | 60.6216 | 5.1603 | 26.6284 | 0.9990 | 0.0851 |
| 46 | 5040 | 2 | 2 | TP* | BG** | 0.5935 | 0.7513 | -0.0979 | 15 | 57.3438 | 4.4212 | 19.5467 | 0.9991 | 0.0771 |
| 46 | 5040 | 3 | 1 | BA* | BG** | 0.6328 | 0.7042 | 0.0000 | 15 | 58.7378 | 3.1279 | 9.7837 | 0.9996 | 0.0533 |
| 46 | 5040 | 3 | 2 | TP* | BG** | 0.5499 | 0.7878 | -0.2430 | 14 | 48.8398 | 5.3293 | 28.4011 | 0.9983 | 0.1091 |
| 46 | 6600 | 1 | 1 | TP1 | BS55 | 1.1863 | 0.2317 | -0.5790 | 15 | 8.3740 | 0.9404 | 0.8844 | 0.9999 | 0.1123 |
| 46 | 6600 | 1 | 2 | TP2 | BS56 | 1.0023 | 0.1514 | -1.3986 | 14 | 7.8296 | 1.0442 | 1.0904 | 0.9999 | 0.1334 |
| 46 | 7049 | 1 | 1 | A1 | TS01 | 1.5136 | 0.1861 | -1.2292 | 15 | 10.9340 | 1.3506 | 1.8242 | 0.9999 | 0.1235 |
| 46 | 7049 | 1 | 2 | TP1 | BS** | 0.8353 | 0.1960 | -1.7720 | 15 | 7.5593 | 0.7829 | 0.6129 | 0.9999 | 0.1036 |
| 46 | 7049 | 2 | 1 | BA* | BG** | 0.5622 | 0.6946 | -0.1306 | 15 | 45.9112 | 8.3765 | 70.1656 | 0.9957 | 0.1825 |
| 46 | 7049 | 2 | 2 | TP* | BG** | 0.6955 | 0.6255 | -0.3226 | 15 | 41.5335 | 7.9110 | 62.5833 | 0.9964 | 0.1905 |
| 46 | 9106 | 1 | 1 | BA* | BS** | 1.1870 | 0.2524 | -0.6165 | 15 | 9.0984 | 1.9959 | 3.9837 | 0.9997 | 0.2194 |
| 46 | 9106 | 1 | 2 | A2 | TS04 | 1.0458 | 0.1937 | -1.6813 | 15 | 9.1558 | 0.9413 | 0.8860 | 0.9999 | 0.1028 |
| 46 | 9106 | 2 | 2 | TP* | BG** | 0.5238 | 0.7802 | -0.1904 | 14 | 51.4747 | 6.8047 | 46.3046 | 0.9974 | 0.1322 |
| 46 | 9106 | 2 | 1 | BA* | BG** | 1.8358 | 0.3683 | -0.5697 | 15 | 36.7206 | 4.5272 | 20.4955 | 0.9996 | 0.1233 |
| 46 | 9197 | 1 | 1 | BA* | BS** | 1.4855 | 0.2598 | -0.7724 | 15 | 11.5107 | 1.0718 | 1.1488 | 0.9999 | 0.0931 |
| 46 | 9197 | 2 | 1 | BA* | BG** | 0.7879 | 0.6616 | -0.0875 | 15 | 61.4780 | 4.2921 | 18.4225 | 0.9994 | 0.0698 |
| 46 | 9197 | 2 | 2 | TP* | BG** | 1.0141 | 0.5245 | -0.1141 | 15 | 53.3287 | 3.6552 | 13.3603 | 0.9996 | 0.0685 |
| 46 | 9197 | 3 | 1 | BA* | BG** | 0.9735 | 0.5689 | -0.2246 | 15 | 53.2131 | 5.0722 | 25.7276 | 0.9992 | 0.0953 |
| 46 | 9197 | 3 | 2 | TP* | BG** | 0.8925 | 0.5091 | 0.0000 | 15 | 49.3730 | 4.7788 | 22.8370 | 0.9992 | 0.0968 |
| 47 | 1023 | 1 | 1 | A1 | TS01 | 1.0786 | 0.2218 | -3.0252 | 15 | 13.8537 | 2.1721 | 4.7179 | 0.9992 | 0.1568 |
| 47 | 1023 | 1 | 2 | A2 | TS03 | 1.2949 | 0.3683 | -3.3139 | 15 | 18.9807 | 6.8685 | 47.1759 | 0.9939 | 0.3619 |
| 47 | 1023 | 2 | 2 | BA* | BG** | 0.8648 | 0.6731 | 0.0000 | 15 | 77.8210 | 24.1529 | 583.3605 | 0.9860 | 0.3104 |
| 47 | 1028 | 1 | 1 | A1 | TS01 | 1.2481 | 0.2578 | -1.5370 | 15 | 12.3083 | 5.3024 | 28.1152 | 0.9976 | 0.4308 |
| 47 | 1028 | 1 | 2 | A2 | TS03 | 0.8043 | 0.0949 | -2.3105 | 15 | 9.0333 | 2.7403 | 7.5091 | 0.9980 | 0.3034 |
| 47 | 1028 | 2 | 1 | BA* | BG** | 1.1137 | 0.6494 | 0.0000 | 15 | 91.8633 | 10.7345 | 115.2304 | 0.9982 | 0.1169 |
| 47 | 1028 | 2 | 2 | TP1 | BG55 | 0.9327 | 0.7073 | 0.0000 | 15 | 88.5205 | 6.8098 | 46.3732 | 0.9991 | 0.0769 |
| 47 | 1029 | 1 | 1 | BA* | BS** | 0.8849 | 0.4230 | -2.1874 | 15 | 11.8374 | 4.9107 | 24.1146 | 0.9952 | 0.4148 |
| 47 | 1029 | 1 | 2 | TP1 | BS55 | 1.4501 | 0.2150 | -1.2842 | 15 | 14.3676 | 8.7824 | 77.1311 | 0.9953 | 0.6113 |
| 47 | 1029 | 2 | 1 | BA* | BG** | 0.7273 | 0.8019 | -0.0465 | 15 | 84.0687 | 5.7557 | 33.1284 | 0.9992 | 0.0685 |
| 47 | 1029 | 2 | 2 | TP1 | BG55 | 1.0711 | 0.5600 | -0.0865 | 15 | 63.9161 | 10.5702 | 111.7286 | 0.9974 | 0.1654 |
| 47 | 2001 | 1 | 1 | A1 | TS01 | 0.7135 | 0.3533 | -3.6649 | 15 | 10.2850 | 1.9889 | 3.9558 | 0.9982 | 0.1934 |
| 47 | 2001 | 1 | 2 | A2 | TS03 | 0.9409 | 0.3478 | -3.0080 | 15 | 12.7809 | 3.8818 | 15.0685 | 0.9966 | 0.3037 |
| 47 | 2008 | 1 | 1 | A1 | TS01 | 0.8779 | 0.5949 | -3.0326 | 15 | 14.5350 | 4.7821 | 22.8686 | 0.9945 | 0.3290 |
| 47 | 2008 | 1 | 2 | A2 | TS03 | 0.7039 | 0.1426 | -1.4181 | 15 | 7.5574 | 5.3151 | 28.2505 | 0.9924 | 0.7033 |
| 47 | 3075 | 1 | 2 | TP1 | BS55 | 0.8884 | 0.3764 | -1.6948 | 15 | 10.2725 | 2.9924 | 8.9542 | 0.9984 | 0.2913 |
| 47 | 3075 | 2 | 2 | TP1 | BG55 | 0.6575 | 0.8543 | 0.0000 | 15 | 87.4282 | 6.0281 | 36.3380 | 0.9991 | 0.0689 |
| 47 | 3101 | 1 | 1 | A1 | TS01 | 0.7853 | 0.1677 | 0.0000 | 15 | 12.8767 | 11.9530 | 142.8747 | 0.9803 | 0.9283 |
| 47 | 3101 | 1 | 2 | A2 | TS03 | 0.9733 | 0.0706 | -3.1421 | 15 | 14.5104 | 5.9779 | 35.7349 | 0.9917 | 0.4120 |
| 47 | 3101 | 2 | 1 | BA* | BG** | 1.2076 | 0.5647 | -0.1090 | 15 | 71.6649 | 7.9968 | 63.9488 | 0.9988 | 0.1116 |
| 47 | 3101 | 2 | 2 | TP1 | BG55 | 1.8474 | 0.5231 | -0.2039 | 15 | 90.9057 | 24.5441 | 602.4151 | 0.9943 | 0.2700 |
| 47 | 3104 | 1 | 1 | A1 | TS01 | 0.8583 | 0.3951 | -2.5626 | 15 | 11.4247 | 3.5042 | 12.2792 | 0.9971 | 0.3067 |
| 47 | 3104 | 1 | 2 | A2 | TS03 | 1.0671 | 0.7672 | -3.6486 | 15 | 19.6622 | 3.4665 | 12.0164 | 0.9979 | 0.1763 |
| 47 | 3104 | 2 | 1 | BA* | BG** | 1.0306 | 0.6849 | 0.0000 | 15 | 118.1427 | 78.0074 | 6085.1500 | 0.9052 | 0.6603 |
| 47 | 3104 | 2 | 2 | TP1 | BG55 | 0.7363 | 0.7146 | 0.0000 | 15 | 70.9373 | 10.2498 | 105.0592 | 0.9969 | 0.1445 |
| 47 | 3108 | 1 | 1 | A1 | TS01 | 0.6470 | 0.4496 | -2.0586 | 15 | 8.7325 | 2.7688 | 7.6660 | 0.9973 | 0.3171 |
| 47 | 3108 | 1 | 2 | TP1 | BS55 | 0.7829 | 0.0000 | -3.3939 | 15 | 12.4377 | 5.1447 | 26.4681 | 0.9899 | 0.4136 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 47 | 3108 | 2 | 1 | BA* | BG** | 0.7518 | 0.8033 | -0.1174 | 15 | 82.3921 | 3.3388 | 11.1474 | 0.9997 | 0.0405 |
| 47 | 3108 | 2 | 2 | TP1 | BG** | 1.1590 | 0.6200 | 0.0000 | 15 | 87.5784 | 8.8720 | 78.7129 | 0.9988 | 0.1013 |
| 47 | 3109 | 1 | 1 | A1 | TS01 | 0.8278 | 0.3696 | -3.5625 | 15 | 11.8201 | 2.9844 | 8.9068 | 0.9971 | 0.2525 |
| 47 | 3109 | 1 | 2 | TP1 | BS55 | 0.8609 | 0.0000 | -1.9870 | 15 | 11.6292 | 7.3989 | 54.7442 | 0.9880 | 0.6362 |
| 47 | 3109 | 2 | 2 | TP1 | BG55 | 0.7034 | 0.9260 | -0.1367 | 15 | 100.6816 | 3.0394 | 9.2379 | 0.9998 | 0.0302 |
| 47 | 3110 | 1 | 1 | A1 | TS01 | 1.0502 | 0.1794 | -3.1042 | 15 | 14.4364 | 5.4579 | 29.7884 | 0.9943 | 0.3781 |
| 47 | 3110 | 2 | 2 | TP1 | BG55 | 0.9401 | 0.7373 | -0.0074 | 15 | 95.8770 | 6.5525 | 42.9347 | 0.9993 | 0.0683 |
| 47 | 6015 | 1 | 1 | A1 | TS01 | 0.6318 | 0.5032 | -3.4845 | 15 | 9.6273 | 2.6672 | 7.1137 | 0.9963 | 0.2770 |
| 47 | 6015 | 1 | 2 | A2 | TS03 | 0.5653 | 0.4175 | -2.0241 | 15 | 7.4948 | 2.9248 | 8.5545 | 0.9960 | 0.3902 |
| 47 | 6015 | 2 | 1 | BA* | BG** | 0.8159 | 0.7663 | -0.1549 | 15 | 79.6900 | 5.2476 | 27.5375 | 0.9993 | 0.0659 |
| 47 | 6015 | 2 | 2 | TP1 | BG55 | 1.1750 | 0.5796 | 0.0000 | 15 | 81.5816 | 8.9494 | 80.0916 | 0.9986 | 0.1097 |
| 47 | 6022 | 1 | 1 | A1 | TS01 | 0.8717 | 0.3258 | -1.6146 | 15 | 10.0830 | 4.8007 | 23.0465 | 0.9959 | 0.4761 |
| 47 | 6022 | 1 | 2 | A2 | TS03 | 0.7641 | 0.4143 | -2.3112 | 15 | 10.0105 | 3.2069 | 10.2841 | 0.9971 | 0.3204 |
| 47 | 6022 | 2 | 2 | TP1 | BG55 | 1.1636 | 0.6405 | 0.0000 | 15 | 93.6808 | 8.1064 | 65.7136 | 0.9990 | 0.0865 |
| 47 | 9024 | 1 | 1 | BA* | BG** | 0.7471 | 0.9837 | -0.3424 | 15 | 107.1057 | 7.8765 | 62.0396 | 0.9988 | 0.0735 |
| 47 | 9024 | 1 | 2 | TP1 | BG55 | 1.1186 | 0.5635 | 0.0000 | 15 | 73.0364 | 6.8620 | 47.0864 | 0.9991 | 0.0940 |
| 47 | 9025 | 2 | 1 | BA* | BG** | 0.6103 | 0.6752 | 0.0000 | 15 | 54.4923 | 14.4041 | 207.4771 | 0.9900 | 0.2643 |
| 47 | 9025 | 2 | 2 | TP1 | BG55 | 1.2069 | 0.5885 | -0.0494 | 15 | 81.7582 | 9.9364 | 98.7320 | 0.9984 | 0.1215 |
| 48 | 0001 | 1 | 1 | BA* | BS** | 1.1825 | 0.1390 | -0.7944 | 15 | 6.3343 | 1.8259 | 3.3341 | 0.9997 | 0.2883 |
| 48 | 0001 | 1 | 2 | TP1 | BS55 | 2.4171 | 0.4522 | -2.1555 | 15 | 36.0592 | 18.5955 | 345.7918 | 0.9909 | 0.5157 |
| 48 | 0001 | 2 | 1 | BA* | BG** | 1.2829 | 0.5166 | 0.0000 | 15 | 73.5065 | 13.5510 | 183.6289 | 0.9969 | 0.1844 |
| 48 | 0001 | 2 | 2 | TP1 | BG55 | 1.5222 | 0.6143 | -0.1842 | 15 | 97.9238 | 14.9166 | 222.5048 | 0.9976 | 0.1523 |
| 48 | 0113 | 1 | 2 | B7 | BS07 | 0.5169 | 0.5114 | 0.0000 | 15 | 10.0631 | 2.6437 | 6.9890 | 0.9980 | 0.2627 |
| 48 | 0116 | 1 | 2 | B10 | BS10 | 0.5240 | 0.5196 | 0.0000 | 15 | 10.4722 | 3.0734 | 9.4456 | 0.9974 | 0.2935 |
| 48 | 0117 | 1 | 2 | B8 | BS08 | 0.5169 | 0.5384 | 0.0000 | 15 | 10.5978 | 2.4509 | 6.0069 | 0.9983 | 0.2313 |
| 48 | 0119 | 1 | 2 | B3 | BS03 | 0.5116 | 0.5199 | 0.0000 | 15 | 10.1840 | 2.6951 | 7.2636 | 0.9979 | 0.2646 |
| 48 | 0121 | 1 | 2 | B4 | BS04 | 0.4944 | 0.5622 | 0.0000 | 15 | 10.6762 | 2.8146 | 7.9218 | 0.9976 | 0.2636 |
| 48 | 0123 | 1 | 2 | B9 | BS09 | 0.5120 | 0.4813 | 0.0000 | 15 | 9.2633 | 1.7556 | 3.0822 | 0.9991 | 0.1895 |
| 48 | 0801 | 1 | 1 | B2 | BS02 | 0.8722 | 0.1827 | 0.0000 | 15 | 6.9158 | 3.6900 | 13.6163 | 0.9985 | 0.5336 |
| 48 | 0801 | 1 | 2 | B3 | BS03 | 0.7152 | 0.1898 | -0.1431 | 15 | 5.1111 | 2.3524 | 5.5338 | 0.9990 | 0.4603 |
| 48 | 0801 | 1 | 3 | A5 | TS09 | 0.6076 | 0.1794 | -0.4282 | 15 | 4.1610 | 2.4970 | 6.2349 | 0.9983 | 0.6001 |
| 48 | 0801 | 3 | 2 | B5 | BG02 | 0.7867 | 0.2624 | -0.5323 | 15 | 6.6812 | 2.4791 | 6.1460 | 0.9990 | 0.3711 |
| 48 | 0801 | 3 | 3 | B6 | BG03 | 0.8143 | 0.2526 | -0.5981 | 15 | 6.6102 | 2.4686 | 6.0938 | 0.9991 | 0.3734 |
| 48 | 0802 | 1 | 1 | B1 | BS01 | 0.9765 | 0.2118 | 0.0000 | 15 | 10.5884 | 7.4231 | 55.1028 | 0.9951 | 0.7011 |
| 48 | 0802 | 1 | 3 | A1 | TS01 | 0.5835 | 0.1785 | -0.9326 | 15 | 4.0036 | 1.7313 | 2.9974 | 0.9990 | 0.4324 |
| 48 | 0802 | 3 | 2 | B4 | BG01 | 0.7746 | 0.0000 | 0.0000 | 15 | 7.1301 | 7.1301 | 50.8381 | 0.9924 | 1.0000 |
| 48 | 1039 | 1 | 1 | BA* | BS** | 0.6196 | 0.2150 | -1.8082 | 15 | 5.7130 | 1.1450 | 1.3111 | 0.9995 | 0.2004 |
| 48 | 1039 | 1 | 2 | A2 | TS03 | 0.8759 | 0.3008 | -1.4755 | 15 | 8.3049 | 1.6820 | 2.8292 | 0.9995 | 0.2025 |
| 48 | 1039 | 3 | 1 | BA* | BG** | 0.8631 | 0.5002 | -0.3710 | 15 | 33.7749 | 4.9935 | 24.9346 | 0.9987 | 0.1478 |
| 48 | 1046 | 1 | 1 | A1 | TS01 | 0.2690 | 0.4162 | 0.0000 | 15 | 4.7580 | 2.3261 | 5.4108 | 0.9941 | 0.4889 |
| 48 | 1046 | 1 | 2 | TP1 | BS55 | 0.9175 | 0.1621 | -1.5803 | 15 | 7.5706 | 1.1793 | 1.3908 | 0.9998 | 0.1558 |
| 48 | 1046 | 2 | 1 | BA* | BG** | 0.5926 | 0.6244 | 0.0000 | 13 | 42.0988 | 16.6814 | 278.2681 | 0.9832 | 0.3962 |
| 48 | 1046 | 2 | 2 | TP1 | BG56 | 0.9471 | 0.4889 | -0.8175 | 15 | 26.5594 | 10.2416 | 104.8895 | 0.9931 | 0.3856 |
| 48 | 1046 | 3 | 2 | TP1 | BG55 | 0.9946 | 0.6148 | 0.0000 | 15 | 75.0062 | 8.4506 | 71.4128 | 0.9985 | 0.1127 |
| 48 | 1047 | 1 | 1 | A1 | TS01 | 0.1957 | 0.5812 | -1.0967 | 15 | 3.9545 | 2.3003 | 5.2916 | 0.9855 | 0.5817 |
| 48 | 1047 | 1 | 2 | A2 | TS03 | 0.7547 | 0.0755 | -1.0669 | 15 | 5.6753 | 3.4096 | 11.6253 | 0.9975 | 0.6008 |
| 48 | 1048 | 1 | 1 | A1 | TS01 | 0.5724 | 0.3698 | -1.4262 | 15 | 6.2640 | 1.4335 | 2.0549 | 0.9992 | 0.2288 |
| 48 | 1048 | 1 | 2 | A2 | TS03 | 0.5912 | 0.1241 | -1.3962 | 15 | 4.7759 | 2.1736 | 4.7244 | 0.9982 | 0.4551 |
| 48 | 1049 | 1 | 1 | A1 | TS01 | 1.0273 | 0.1630 | -1.6539 | 15 | 8.9400 | 2.2006 | 4.8426 | 0.9993 | 0.2462 |
| 48 | 1049 | 1 | 2 | BA* | BS** | 0.9918 | 0.2778 | 0.0000 | 15 | 11.1612 | 4.5471 | 20.6765 | 0.9982 | 0.4074 |
| 48 | 1050 | 1 | 1 | A1 | TS01 | 1.5581 | 0.2048 | -1.6032 | 15 | 13.8254 | 2.5861 | 6.6878 | 0.9996 | 0.1871 |
| 48 | 1050 | 1 | 2 | A2 | TS04 | 1.4249 | 0.2317 | -1.3411 | 15 | 11.8615 | 3.3286 | 11.0797 | 0.9993 | 0.2806 |
| 48 | 1050 | 3 | 2 | TP1 | BG55 | 1.1191 | 0.6722 | 0.0000 | 15 | 97.1308 | 10.5492 | 111.2865 | 0.9984 | 0.1086 |
| 48 | 1056 | 1 | 1 | A1 | TS02 | 0.7251 | 0.1003 | -0.6057 | 15 | 3.6029 | 2.2711 | 5.1577 | 0.9990 | 0.6303 |
| 48 | 1056 | 1 | 2 | A2 | TS03 | 0.6485 | 0.1412 | -2.2270 | 15 | 5.9666 | 1.6549 | 2.7388 | 0.9990 | 0.2774 |
| 48 | 1056 | 2 | 1 | BA* | BG** | 0.4747 | 0.7532 | 0.0000 | 15 | 50.1248 | 6.6977 | 44.8590 | 0.9971 | 0.1336 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 1056 | 2 | 2 | TP1 | BG55 | 0.8513 | 0.4880 | -0.4002 | 15 | 35.8626 | 15.4161 | 237.6548 | 0.9863 | 0.4299 |
| 48 | 1056 | 2 | 2 | TP1 | BG56 | 0.7956 | 0.4463 | -0.6084 | 15 | 23.5245 | 11.2791 | 127.2175 | 0.9890 | 0.4795 |
| 48 | 1060 | 1 | 1 | A1 | TS01 | 0.6443 | 0.3365 | -2.3882 | 15 | 7.7133 | 2.0621 | 4.2522 | 0.9983 | 0.2673 |
| 48 | 1060 | 1 | 2 | A2 | TS03 | 0.7981 | 0.1751 | 0.0000 | 15 | 5.6172 | 2.3073 | 5.3238 | 0.9993 | 0.4108 |
| 48 | 1060 | 3 | 1 | BA* | BG** | 0.4672 | 0.9551 | -0.0712 | 15 | 74.4472 | 4.3246 | 18.7024 | 0.9993 | 0.0581 |
| 48 | 1061 | 1 | 1 | A1 | TS02 | 0.8909 | 0.4123 | -1.3360 | 15 | 10.8153 | 2.6377 | 6.9574 | 0.9989 | 0.2439 |
| 48 | 1061 | 1 | 2 | A2 | TS04 | 0.8356 | 0.1845 | -1.0435 | 15 | 6.4016 | 3.3320 | 11.1023 | 0.9981 | 0.5205 |
| 48 | 1061 | 2 | 1 | BA* | BG** | 0.8527 | 0.5775 | 0.0000 | 15 | 57.9665 | 7.5989 | 57.7437 | 0.9981 | 0.1311 |
| 48 | 1061 | 2 | 2 | TP1 | BG55 | 1.0719 | 0.5824 | -0.4320 | 15 | 51.7045 | 10.9626 | 120.1779 | 0.9964 | 0.2120 |
| 48 | 1065 | 1 | 1 | A1 | TS01 | 0.5213 | 0.5976 | -1.6932 | 15 | 8.5312 | 1.6362 | 2.6770 | 0.9988 | 0.1918 |
| 48 | 1065 | 1 | 2 | A2 | TS03 | 0.4962 | 0.2820 | -2.2360 | 15 | 5.7801 | 1.8836 | 3.5480 | 0.9977 | 0.3259 |
| 48 | 1065 | 2 | 1 | BA* | BG** | 0.7229 | 0.7348 | -0.5081 | 15 | 50.2397 | 7.6681 | 58.7990 | 0.9973 | 0.1526 |
| 48 | 1068 | 1 | 1 | BA2 | BS02 | 0.8729 | 0.1775 | -1.6186 | 15 | 7.3374 | 1.2804 | 1.6394 | 0.9997 | 0.1745 |
| 48 | 1068 | 1 | 2 | TP1 | BS55 | 0.6051 | 0.0593 | -1.8845 | 15 | 5.6804 | 1.0365 | 1.0744 | 0.9995 | 0.1825 |
| 48 | 1068 | 3 | 1 | BA* | BG** | 0.6203 | 0.6740 | -0.0205 | 15 | 53.5868 | 3.6333 | 13.2006 | 0.9994 | 0.0678 |
| 48 | 1068 | 3 | 2 | TP1 | BG55 | 0.5156 | 0.8304 | -0.0221 | 15 | 64.2182 | 5.0362 | 25.3634 | 0.9989 | 0.0784 |
| 48 | 1069 | 1 | 1 | BA* | BS** | 0.7532 | 0.0771 | 0.0000 | 15 | 3.0000 | 2.1279 | 4.5279 | 0.9993 | 0.7093 |
| 48 | 1069 | 1 | 2 | A2 | TS03 | 0.4375 | 0.1681 | -0.2736 | 15 | 2.9681 | 1.8376 | 3.3768 | 0.9983 | 0.6191 |
| 48 | 1069 | 1 | 2 | TP1 | BS55 | 1.0704 | 0.1992 | -0.9432 | 15 | 7.2355 | 1.9804 | 3.9220 | 0.9996 | 0.2737 |
| 48 | 1070 | 1 | 1 | BA* | BS** | 0.8122 | 0.1334 | -0.9318 | 15 | 4.5743 | 0.8297 | 0.6885 | 0.9999 | 0.1814 |
| 48 | 1070 | 1 | 2 | A2 | TS03 | 0.5886 | 0.1441 | -2.6538 | 15 | 7.5826 | 2.9387 | 8.6362 | 0.9952 | 0.3876 |
| 48 | 1076 | 1 | 1 | A1 | TS01 | 0.8602 | 0.4952 | -1.1453 | 15 | 12.4281 | 3.8649 | 14.9375 | 0.9978 | 0.3110 |
| 48 | 1076 | 1 | 2 | A2 | TS03 | 0.8243 | 0.5250 | -1.6402 | 15 | 12.0704 | 2.5359 | 6.4308 | 0.9988 | 0.2101 |
| 48 | 1077 | 1 | 1 | A1 | TS03 | 0.7623 | 0.4403 | -1.0167 | 15 | 10.6064 | 4.7174 | 22.2535 | 0.9958 | 0.4448 |
| 48 | 1077 | 1 | 2 | TP1 | BS55 | 0.6875 | 0.4037 | -0.8742 | 15 | 8.4515 | 2.6379 | 6.9586 | 0.9984 | 0.3121 |
| 48 | 1077 | 2 | 2 | TP1 | BG55 | 1.1532 | 0.6336 | -0.0656 | 15 | 86.5221 | 5.9036 | 34.8525 | 0.9994 | 0.0682 |
| 48 | 1087 | 1 | 1 | A1 | TS02 | 1.0534 | 0.5543 | -2.1209 | 15 | 16.5135 | 5.2940 | 28.0269 | 0.9963 | 0.3206 |
| 48 | 1087 | 1 | 2 | A2 | TS04 | 0.9902 | 0.4640 | -1.8606 | 15 | 12.9144 | 2.5636 | 6.5719 | 0.9991 | 0.1985 |
| 48 | 1087 | 2 | 1 | BA* | BG** | 1.0699 | 0.4313 | -0.0371 | 15 | 45.4053 | 9.7455 | 94.9744 | 0.9971 | 0.2146 |
| 48 | 1087 | 2 | 2 | TP1 | BG55 | 0.8091 | 0.6580 | -0.1574 | 15 | 60.5297 | 5.1602 | 26.6275 | 0.9991 | 0.0853 |
| 48 | 1092 | 1 | 1 | BA* | BS** | 0.6858 | 0.0000 | 0.0000 | 15 | 6.8958 | 6.8958 | 47.5524 | 0.9909 | 1.0000 |
| 48 | 1092 | 1 | 2 | A2 | TS03 | 0.5586 | 0.1308 | -1.3361 | 15 | 4.4110 | 2.1759 | 4.7348 | 0.9980 | 0.4933 |
| 48 | 1092 | 2 | 1 | BA* | BG** | 1.2075 | 0.6778 | -0.1562 | 15 | 95.8562 | 11.6279 | 135.2075 | 0.9981 | 0.1213 |
| 48 | 1092 | 2 | 2 | TP1 | BG56 | 1.0069 | 0.7279 | -0.1513 | 15 | 90.0656 | 7.9083 | 62.5408 | 0.9989 | 0.0878 |
| 48 | 1092 | 3 | 2 | TP1 | BG55 | 0.8162 | 0.9196 | -0.1491 | 15 | 113.9006 | 5.2890 | 27.9736 | 0.9996 | 0.0464 |
| 48 | 1093 | 1 | 1 | BA* | BS** | 0.8755 | 0.5979 | -1.6241 | 15 | 14.1202 | 2.5389 | 6.4461 | 0.9990 | 0.1798 |
| 48 | 1093 | 1 | 2 | A2 | TS03 | 0.8456 | 0.2368 | -2.8365 | 15 | 9.9976 | 1.2405 | 1.5390 | 0.9996 | 0.1241 |
| 48 | 1093 | 2 | 1 | BA* | BG** | 0.4777 | 0.8992 | 0.0000 | 15 | 70.9626 | 3.8067 | 14.4906 | 0.9994 | 0.0536 |
| 48 | 1094 | 1 | 1 | BA* | BS** | 1.6352 | 0.1700 | -1.2629 | 15 | 12.5691 | 4.8236 | 23.2669 | 0.9989 | 0.3838 |
| 48 | 1094 | 1 | 2 | TP1 | BS55 | 1.3982 | 0.3655 | 0.0000 | 15 | 23.0356 | 13.1342 | 172.5080 | 0.9929 | 0.5702 |
| 48 | 1094 | 2 | 1 | BA* | BG** | 1.5853 | 0.6592 | -0.2348 | 15 | 110.3281 | 11.0771 | 122.7017 | 0.9989 | 0.1004 |
| 48 | 1094 | 2 | 2 | TP1 | BG55 | 1.4927 | 0.7425 | -0.5738 | 15 | 101.3282 | 21.6068 | 466.8531 | 0.9947 | 0.2132 |
| 48 | 1096 | 1 | 1 | A1 | TS01 | 0.6131 | 0.3404 | -2.4188 | 15 | 7.3179 | 1.8548 | 3.4402 | 0.9985 | 0.2535 |
| 48 | 1096 | 1 | 2 | A2 | TS03 | 0.7918 | 0.1782 | 0.0000 | 15 | 5.6172 | 2.2089 | 4.8791 | 0.9993 | 0.3932 |
| 48 | 1096 | 2 | 1 | BA* | BG** | 1.1299 | 0.6115 | -0.0809 | 15 | 78.6232 | 9.6798 | 93.6992 | 0.9983 | 0.1231 |
| 48 | 1096 | 2 | 2 | TP1 | BG55 | 1.4170 | 0.6724 | 0.0000 | 15 | 131.5498 | 47.2433 | 2231.9330 | 0.9802 | 0.3591 |
| 48 | 1109 | 1 | 1 | A1 | TS01 | 0.8706 | 0.0230 | -2.1721 | 15 | 9.5529 | 1.7616 | 3.1032 | 0.9993 | 0.1844 |
| 48 | 1109 | 1 | 2 | A2 | TS03 | 0.7174 | 0.2844 | -2.2452 | 15 | 7.7410 | 1.5772 | 2.4875 | 0.9992 | 0.2037 |
| 48 | 1111 | 1 | 1 | A1 | TS01 | 0.5797 | 0.0165 | -0.1335 | 15 | 5.7046 | 5.6809 | 32.2726 | 0.9910 | 0.9958 |
| 48 | 1111 | 1 | 2 | A2 | TS03 | 0.5305 | 0.1816 | 0.0000 | 15 | 8.1504 | 7.3507 | 54.0324 | 0.9837 | 0.9019 |
| 48 | 1111 | 2 | 1 | BA* | BG** | 0.8135 | 0.6991 | -0.6209 | 15 | 47.2577 | 6.7876 | 46.0711 | 0.9979 | 0.1436 |
| 48 | 1111 | 2 | 2 | TP1 | BG55 | 0.9247 | 0.6744 | -0.5227 | 15 | 54.4180 | 5.4616 | 29.8294 | 0.9990 | 0.1004 |
| 48 | 1113 | 1 | 1 | A1 | TS01 | 1.4862 | 0.5646 | -0.4100 | 15 | 27.9782 | 2.8598 | 8.1783 | 0.9997 | 0.1022 |
| 48 | 1113 | 1 | 2 | A2 | TS03 | 0.6508 | 0.0979 | 0.0000 | 15 | 15.7788 | 15.6134 | 243.7787 | 0.9513 | 0.9895 |
| 48 | 1113 | 2 | 1 | BA* | BG** | 0.6822 | 0.6823 | -0.0883 | 15 | 56.8836 | 3.4954 | 12.2182 | 0.9995 | 0.0614 |
| 48 | 1113 | 2 | 2 | BA* | BG** | 0.5870 | 0.6988 | -0.3355 | 15 | 42.5607 | 4.2733 | 18.2612 | 0.9988 | 0.1004 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 1116 | 1 | 1 | A1 | TS01 | 0.6600 | 0.0845 | 0.0000 | 15 | 5.0124 | 4.5751 | 20.9316 | 0.9957 | 0.9128 |
| 48 | 1116 | 1 | 2 | A2 | TS03 | 1.0212 | 0.1796 | -1.6503 | 15 | 9.4903 | 3.8936 | 15.1599 | 0.9979 | 0.4103 |
| 48 | 1116 | 1 | 2 | BA* | BS** | 0.9684 | 0.6387 | -2.3171 | 15 | 16.0083 | 3.5275 | 12.4434 | 0.9980 | 0.2204 |
| 48 | 1116 | 2 | 1 | BA* | BG** | 0.8627 | 0.6446 | -0.3105 | 15 | 54.3408 | 7.4961 | 56.1922 | 0.9980 | 0.1379 |
| 48 | 1116 | 2 | 2 | BA* | BG** | 0.7072 | 0.7099 | -0.2427 | 15 | 56.0598 | 2.7298 | 7.4521 | 0.9997 | 0.0487 |
| 48 | 1119 | 1 | 1 | A1 | TS01 | 0.6123 | 0.5002 | -4.4764 | 15 | 10.1831 | 3.6670 | 13.4472 | 0.9906 | 0.3601 |
| 48 | 1119 | 1 | 2 | A2 | TS03 | 0.9051 | 0.3711 | -2.2878 | 15 | 11.6729 | 4.6384 | 21.5149 | 0.9957 | 0.3974 |
| 48 | 1119 | 2 | 1 | BA* | BG** | 0.8611 | 0.5342 | -0.2475 | 15 | 41.6198 | 5.8457 | 34.1727 | 0.9985 | 0.1405 |
| 48 | 1119 | 2 | 2 | BA* | BG** | 0.9342 | 0.6529 | -0.4263 | 15 | 55.0876 | 7.1734 | 51.4578 | 0.9983 | 0.1302 |
| 48 | 1122 | 1 | 1 | BA* | BS** | 0.7429 | 0.6981 | -0.7939 | 13 | 16.2678 | 2.8990 | 8.4044 | 0.9987 | 0.1782 |
| 48 | 1122 | 1 | 2 | A2 | TS03 | 1.3591 | 0.3205 | -1.2279 | 15 | 14.2210 | 6.5101 | 42.3815 | 0.9972 | 0.4578 |
| 48 | 1122 | 2 | 1 | BA* | BG** | 0.6373 | 0.7066 | -0.2534 | 15 | 49.2421 | 5.2154 | 27.2003 | 0.9986 | 0.1059 |
| 48 | 1122 | 2 | 2 | TP1 | BG56 | 0.7464 | 0.6473 | -0.2806 | 15 | 48.5090 | 5.2748 | 27.8238 | 0.9987 | 0.1087 |
| 48 | 1122 | 3 | 1 | BA* | BG** | 1.5637 | 0.4818 | -0.0042 | 15 | 80.6908 | 14.5067 | 210.4451 | 0.9974 | 0.1798 |
| 48 | 1122 | 3 | 2 | TP1 | BG55 | 1.3659 | 0.4999 | 0.0000 | 15 | 74.0008 | 7.4202 | 55.0590 | 0.9991 | 0.1003 |
| 48 | 1123 | 2 | 1 | BA* | BG** | 0.9039 | 0.6133 | 0.0000 | 15 | 67.8677 | 8.7063 | 75.7992 | 0.9980 | 0.1283 |
| 48 | 1123 | 2 | 2 | TP1 | BG55 | 1.3586 | 0.7716 | -0.1586 | 15 | 142.7129 | 38.9888 | 1520.1290 | 0.9870 | 0.2732 |
| 48 | 1130 | 1 | 1 | A1 | TS01 | 0.8339 | 0.3785 | -3.0166 | 15 | 11.0970 | 2.6387 | 6.9628 | 0.9981 | 0.2378 |
| 48 | 1130 | 1 | 2 | A2 | TS03 | 0.4708 | 0.1461 | 0.0000 | 15 | 7.6420 | 7.2012 | 51.8574 | 0.9798 | 0.9423 |
| 48 | 1168 | 1 | 1 | BA* | BS** | 0.5363 | 0.5224 | -0.6130 | 13 | 9.0128 | 1.4398 | 2.0731 | 0.9994 | 0.1598 |
| 48 | 1168 | 1 | 2 | TP1 | BS55 | 0.7643 | 0.3016 | -2.4930 | 15 | 9.8188 | 3.6417 | 13.2619 | 0.9960 | 0.3709 |
| 48 | 1168 | 2 | 1 | BA* | BG** | 0.8288 | 0.6750 | 0.0000 | 15 | 75.9349 | 18.8174 | 354.0960 | 0.9908 | 0.2478 |
| 48 | 1168 | 2 | 2 | TP1 | BG55 | 0.8960 | 0.7159 | -0.6894 | 15 | 51.9649 | 8.8914 | 79.0570 | 0.9970 | 0.1711 |
| 48 | 1169 | 1 | 1 | A1 | TS01 | 0.5189 | 0.3640 | 0.0000 | 15 | 7.2526 | 1.8333 | 3.3610 | 0.9990 | 0.2528 |
| 48 | 1169 | 1 | 2 | BA* | BS** | 0.5656 | 0.4104 | 0.0000 | 15 | 9.8431 | 4.6508 | 21.6300 | 0.9947 | 0.4725 |
| 48 | 1169 | 2 | 1 | BA* | BG** | 0.9740 | 0.6142 | -0.2792 | 15 | 57.9787 | 7.3459 | 53.9626 | 0.9984 | 0.1267 |
| 48 | 1169 | 2 | 2 | BA* | BG** | 0.8358 | 0.5874 | 0.0000 | 15 | 57.8642 | 6.9788 | 48.7036 | 0.9984 | 0.1206 |
| 48 | 1174 | 1 | 1 | BA* | BS** | 0.8932 | 0.1124 | -0.6738 | 15 | 4.0297 | 1.0964 | 1.2021 | 0.9998 | 0.2721 |
| 48 | 1174 | 1 | 2 | TP1 | BS55 | 0.7137 | 0.1437 | -1.3846 | 15 | 5.3914 | 1.2550 | 1.5751 | 0.9996 | 0.2328 |
| 48 | 1174 | 2 | 1 | BA* | BG** | 1.6799 | 0.5421 | -0.4016 | 15 | 73.7977 | 13.3790 | 178.9982 | 0.9977 | 0.1813 |
| 48 | 1174 | 2 | 2 | TP1 | BG55 | 0.3661 | 0.5938 | 0.0000 | 15 | 25.9945 | 3.2338 | 10.4575 | 0.9982 | 0.1244 |
| 48 | 1178 | 1 | 1 | A1 | TS02 | 0.7560 | 0.6120 | -2.1811 | 15 | 12.1655 | 2.9447 | 8.6714 | 0.9978 | 0.2421 |
| 48 | 1178 | 1 | 2 | TP1 | BS55 | 0.4893 | 0.0709 | -4.1166 | 15 | 6.4859 | 0.6759 | 0.4568 | 0.9995 | 0.1042 |
| 48 | 1178 | 3 | 1 | BA* | BG** | 1.0965 | 0.6769 | -0.1937 | 15 | 82.2865 | 10.3738 | 107.6152 | 0.9981 | 0.1261 |
| 48 | 1178 | 3 | 2 | TP1 | BG55 | 1.2110 | 0.5944 | 0.0000 | 15 | 87.1282 | 16.2582 | 264.3297 | 0.9960 | 0.1866 |
| 48 | 1181 | 1 | 1 | BA* | BS** | 0.5584 | 0.0584 | -0.9664 | 15 | 3.2042 | 0.7428 | 0.5518 | 0.9998 | 0.2318 |
| 48 | 1181 | 1 | 2 | BA* | BS** | 0.7741 | 0.3088 | 0.0000 | 15 | 14.3172 | 11.2218 | 125.9298 | 0.9829 | 0.7838 |
| 48 | 1181 | 3 | 1 | BA* | BG** | 0.5263 | 0.5941 | -0.1956 | 15 | 32.0852 | 8.4562 | 71.5068 | 0.9931 | 0.2636 |
| 48 | 1181 | 3 | 2 | BA* | BG** | 0.5965 | 0.4934 | -0.0726 | 15 | 29.6996 | 6.4603 | 41.7353 | 0.9963 | 0.2175 |
| 48 | 1183 | 1 | 1 | A1 | TS01 | 1.1153 | 0.5611 | -2.5662 | 15 | 16.7838 | 3.4547 | 11.9353 | 0.9984 | 0.2058 |
| 48 | 1183 | 1 | 2 | A2 | TS03 | 0.5369 | 0.1391 | -0.5341 | 15 | 4.7789 | 4.0887 | 16.7172 | 0.9940 | 0.8556 |
| 48 | 1183 | 2 | 1 | BA* | BG** | 0.9761 | 0.5845 | -0.4770 | 15 | 45.8192 | 10.2230 | 104.5105 | 0.9961 | 0.2231 |
| 48 | 1183 | 2 | 2 | TP1 | BG55 | 1.1945 | 0.4834 | -0.4498 | 15 | 41.8088 | 10.4902 | 110.0445 | 0.9966 | 0.2509 |
| 48 | 2133 | 1 | 1 | A1 | TS01 | 0.8825 | 0.2062 | -0.5692 | 15 | 6.4940 | 3.4616 | 11.9824 | 0.9984 | 0.5330 |
| 48 | 2133 | 2 | 1 | BA* | BG** | 0.8670 | 0.3555 | 0.0000 | 15 | 29.4880 | 7.0663 | 49.9333 | 0.9972 | 0.2396 |
| 48 | 2133 | 2 | 2 | TP1 | BG56 | 0.9124 | 0.5934 | -0.2994 | 15 | 50.4702 | 7.3042 | 53.3512 | 0.9981 | 0.1447 |
| 48 | 2133 | 3 | 1 | BA* | BG** | 1.2008 | 0.5362 | -0.0825 | 15 | 67.2307 | 8.3571 | 69.8419 | 0.9986 | 0.1243 |
| 48 | 2172 | 1 | 1 | BA* | BS** | 1.2787 | 0.3241 | -2.0671 | 15 | 13.9130 | 2.0103 | 4.0414 | 0.9996 | 0.1445 |
| 48 | 2172 | 1 | 2 | A2 | TS03 | 1.0860 | 0.4669 | -1.3617 | 15 | 15.8198 | 6.9894 | 48.8520 | 0.9950 | 0.4418 |
| 48 | 2172 | 2 | 1 | BA* | BG** | 0.9072 | 0.5018 | -0.3122 | 15 | 37.5204 | 3.2859 | 10.7969 | 0.9995 | 0.0876 |
| 48 | 2172 | 2 | 2 | TP1 | BG55 | 0.3511 | 0.7418 | 0.0000 | 15 | 36.8771 | 6.5394 | 42.7638 | 0.9948 | 0.1773 |
| 48 | 2176 | 1 | 1 | A1 | TS01 | 1.0513 | 0.3217 | -1.1322 | 15 | 10.0617 | 2.5702 | 6.6062 | 0.9993 | 0.2554 |
| 48 | 2176 | 1 | 2 | A2 | TS03 | 0.5881 | 0.5567 | -1.7206 | 15 | 8.8641 | 1.5623 | 2.4407 | 0.9991 | 0.1762 |
| 48 | 3003 | 1 | 1 | A1 | TS01 | 0.6192 | 0.0679 | 0.0000 | 15 | 4.4593 | 4.1960 | 17.6067 | 0.9959 | 0.9410 |
| 48 | 3003 | 1 | 2 | A2 | TS03 | 0.7775 | 0.1964 | -1.8579 | 15 | 7.6780 | 1.3521 | 1.8281 | 0.9995 | 0.1761 |
| 48 | 3003 | 1 | 2 | BA* | BS** | 0.7511 | 0.3068 | -1.1866 | 15 | 7.9343 | 3.8754 | 15.0188 | 0.9968 | 0.4884 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 3010 | 1 | 1 | BA* | BS** | 1.3216 | 0.4319 | -0.8315 | 15 | 16.9910 | 3.3028 | 10.9087 | 0.9994 | 0.1944 |
| 48 | 3010 | 1 | 2 | BA* | BS** | 1.2018 | 0.0371 | -0.4498 | 15 | 5.2572 | 4.1184 | 16.9613 | 0.9988 | 0.7834 |
| 48 | 3559 | 1 | 1 | BA* | BS** | 0.5283 | 0.4441 | -1.1081 | 15 | 7.5731 | 3.8451 | 14.7847 | 0.9941 | 0.5077 |
| 48 | 3559 | 1 | 2 | A2 | TS04 | 1.8621 | 0.3327 | -2.3088 | 15 | 21.8811 | 5.7345 | 32.8850 | 0.9984 | 0.2621 |
| 48 | 3559 | 2 | 2 | BA* | BG** | 0.6777 | 0.7088 | -0.1040 | 15 | 59.9317 | 2.8371 | 8.0489 | 0.9997 | 0.0473 |
| 48 | 3569 | 1 | 1 | A1 | TS01 | 1.0267 | 0.2027 | -3.5340 | 15 | 13.3962 | 2.1068 | 4.4387 | 0.9991 | 0.1573 |
| 48 | 3569 | 1 | 2 | A2 | TS03 | 1.0925 | 0.2743 | -2.7706 | 15 | 13.1595 | 1.7139 | 2.9374 | 0.9995 | 0.1302 |
| 48 | 3579 | 1 | 1 | A1 | TS01 | 0.9075 | 0.1757 | -0.1934 | 15 | 6.3830 | 3.6998 | 13.6882 | 0.9985 | 0.5796 |
| 48 | 3579 | 1 | 2 | TP1 | BS55 | 1.3686 | 0.2137 | -1.0404 | 15 | 10.1803 | 3.5574 | 12.6550 | 0.9992 | 0.3494 |
| 48 | 3579 | 3 | 1 | BA2 | BG02 | 0.8486 | 0.7206 | -0.2323 | 15 | 70.5724 | 8.6469 | 74.7693 | 0.9979 | 0.1225 |
| 48 | 3579 | 3 | 2 | TP1 | BG55 | 0.9795 | 0.5958 | -0.3799 | 15 | 51.1478 | 10.7036 | 114.5670 | 0.9962 | 0.2093 |
| 48 | 3589 | 1 | 1 | BA* | BS** | 0.8255 | 0.4347 | -0.9027 | 15 | 10.6293 | 1.8368 | 3.3739 | 0.9995 | 0.1728 |
| 48 | 3589 | 1 | 2 | A2 | TS03 | 0.6124 | 0.2298 | 0.0000 | 15 | 7.6426 | 5.6974 | 32.4601 | 0.9927 | 0.7455 |
| 48 | 3589 | 2 | 1 | BA* | BG** | 0.7018 | 0.5286 | -0.3641 | 15 | 30.9365 | 9.6662 | 93.4358 | 0.9930 | 0.3125 |
| 48 | 3589 | 2 | 2 | BA* | BG** | 0.6064 | 0.6015 | -0.2226 | 15 | 36.3433 | 4.8411 | 23.4359 | 0.9983 | 0.1332 |
| 48 | 3609 | 1 | 1 | A1 | TS01 | 1.0019 | 0.1553 | -1.1059 | 15 | 7.6613 | 3.9094 | 15.2833 | 0.9981 | 0.5103 |
| 48 | 3609 | 1 | 2 | A2 | TS03 | 1.1427 | 0.2088 | 0.0000 | 15 | 19.8825 | 17.8032 | 316.9555 | 0.9797 | 0.8954 |
| 48 | 3609 | 2 | 1 | BA* | BG** | 0.9874 | 0.6889 | -0.2357 | 15 | 74.1827 | 7.3598 | 54.1660 | 0.9988 | 0.0992 |
| 48 | 3609 | 2 | 2 | TP1 | BG55 | 0.9310 | 0.6618 | -0.1583 | 15 | 69.3289 | 7.6087 | 57.8930 | 0.9986 | 0.1097 |
| 48 | 3629 | 1 | 1 | A1 | TS01 | 0.5051 | 0.4218 | 0.0000 | 15 | 8.5373 | 3.1936 | 10.1990 | 0.9968 | 0.3741 |
| 48 | 3629 | 1 | 2 | A2 | TS03 | 0.6260 | 0.6250 | -0.7440 | 15 | 12.2638 | 1.8072 | 3.2658 | 0.9992 | 0.1474 |
| 48 | 3669 | 1 | 1 | A1 | TS01 | 0.5386 | 0.5690 | -0.4213 | 15 | 10.3680 | 1.7830 | 3.1792 | 0.9991 | 0.1720 |
| 48 | 3679 | 1 | 1 | A1 | TS01 | 0.8181 | 0.2984 | -5.9348 | 15 | 12.6878 | 2.0251 | 4.1010 | 0.9979 | 0.1596 |
| 48 | 3679 | 1 | 2 | A2 | TS03 | 0.9106 | 0.0806 | -2.0818 | 15 | 9.2618 | 2.8048 | 7.8668 | 0.9985 | 0.3028 |
| 48 | 3689 | 1 | 1 | A1 | TS01 | 0.7872 | 0.5902 | -0.8875 | 15 | 14.7206 | 3.6583 | 13.3831 | 0.9979 | 0.2485 |
| 48 | 3689 | 1 | 2 | A2 | TS03 | 0.8658 | 0.2941 | 0.0000 | 15 | 17.2743 | 14.7415 | 217.3108 | 0.9766 | 0.8534 |
| 48 | 3699 | 1 | 1 | A1 | TS01 | 0.7258 | 0.2840 | -2.2718 | 15 | 8.2451 | 1.9560 | 3.8260 | 0.9988 | 0.2372 |
| 48 | 3699 | 1 | 2 | A2 | TS3 | 0.5171 | 0.1171 | -1.6449 | 15 | 4.8727 | 2.1237 | 4.5101 | 0.9976 | 0.4358 |
| 48 | 3719 | 1 | 1 | BA* | BS** | 1.0874 | 0.2352 | -1.6164 | 15 | 9.7238 | 1.2773 | 1.6314 | 0.9998 | 0.1314 |
| 48 | 3719 | 1 | 2 | A2 | TS03 | 0.8553 | 0.0000 | -2.3761 | 15 | 11.2364 | 4.6756 | 21.8614 | 0.9946 | 0.4161 |
| 48 | 3729 | 1 | 1 | A1 | TS01 | 0.6161 | 0.2844 | -0.9449 | 15 | 6.9741 | 4.4894 | 20.1548 | 0.9941 | 0.6437 |
| 48 | 3729 | 1 | 2 | A2 | TS03 | 0.8793 | 0.3458 | -2.7438 | 15 | 11.0419 | 2.2294 | 4.9704 | 0.9988 | 0.2019 |
| 48 | 3729 | 3 | 1 | BA* | BG** | 0.4983 | 0.3616 | 0.0000 | 15 | 18.3633 | 7.5055 | 56.3321 | 0.9907 | 0.4087 |
| 48 | 3729 | 3 | 2 | TP1 | BG55 | 0.3628 | 0.6231 | -0.3130 | 15 | 22.0396 | 5.0054 | 25.0537 | 0.9947 | 0.2271 |
| 48 | 3739 | 1 | 1 | BA* | BS** | 0.7775 | 0.6480 | -0.2105 | 14 | 18.6712 | 4.3894 | 19.2671 | 0.9976 | 0.2351 |
| 48 | 3739 | 1 | 2 | TP1 | BS55 | 0.7142 | 0.5147 | -0.0185 | 14 | 14.4747 | 2.9015 | 8.4188 | 0.9988 | 0.2005 |
| 48 | 3749 | 1 | 1 | A1 | TS02 | 0.5443 | 0.0767 | 0.0000 | 15 | 3.3566 | 2.9886 | 8.9315 | 0.9973 | 0.8904 |
| 48 | 3749 | 1 | 2 | A2 | TS03 | 0.7364 | 0.0000 | 0.0000 | 15 | 8.1574 | 8.1574 | 66.5429 | 0.9890 | 1.0000 |
| 48 | 3749 | 3 | 1 | BA* | BG** | 0.7245 | 0.6321 | -0.4749 | 15 | 39.0022 | 8.3789 | 70.2067 | 0.9958 | 0.2148 |
| 48 | 3749 | 3 | 2 | TP1 | BG55 | 0.7531 | 0.6258 | -0.3916 | 15 | 42.5085 | 4.6821 | 21.9224 | 0.9989 | 0.1101 |
| 48 | 3769 | 1 | 1 | BA* | BS** | 0.7304 | 0.1785 | -0.5835 | 15 | 5.3515 | 3.5912 | 12.8970 | 0.9975 | 0.6711 |
| 48 | 3769 | 1 | 2 | A2 | TS02 | 0.6608 | 0.4072 | -1.4669 | 15 | 7.9952 | 2.4608 | 6.0555 | 0.9982 | 0.3078 |
| 48 | 3769 | 2 | 1 | BA* | BG** | 0.7405 | 0.7234 | -0.0184 | 15 | 72.6001 | 6.5095 | 42.3737 | 0.9988 | 0.0897 |
| 48 | 3769 | 2 | 2 | TP1 | BG55 | 1.0551 | 0.6975 | 0.0000 | 15 | 98.6007 | 7.6388 | 58.3509 | 0.9991 | 0.0775 |
| 48 | 3779 | 1 | 1 | A1 | TS01 | 0.4182 | 0.0991 | -1.9067 | 15 | 4.7729 | 2.8088 | 7.8896 | 0.9931 | 0.5885 |
| 48 | 3779 | 1 | 2 | A2 | TS03 | 0.5474 | 0.8711 | -3.6300 | 15 | 11.2935 | 3.8440 | 14.7762 | 0.9904 | 0.3404 |
| 48 | 3779 | 2 | 1 | BA* | BG** | 0.8962 | 0.8037 | -0.2238 | 15 | 91.0029 | 6.4221 | 41.2429 | 0.9992 | 0.0706 |
| 48 | 3779 | 2 | 2 | BA* | BG** | 1.3180 | 0.6415 | -0.3775 | 15 | 78.4383 | 10.7225 | 114.9721 | 0.9982 | 0.1367 |
| 48 | 3845 | 1 | 1 | A1 | TS01 | 0.7689 | 0.0902 | -1.8058 | 15 | 6.9577 | 1.4250 | 2.0307 | 0.9995 | 0.2048 |
| 48 | 3845 | 1 | 2 | A2 | TS03 | 0.9610 | 0.1262 | -1.4659 | 15 | 7.5391 | 1.9179 | 3.6784 | 0.9995 | 0.2544 |
| 48 | 3855 | 1 | 2 | BA* | BS** | 0.6657 | 0.3326 | 0.0000 | 15 | 11.0182 | 7.4470 | 55.4572 | 0.9898 | 0.6759 |
| 48 | 3855 | 3 | 1 | BA* | BG** | 1.1692 | 0.6775 | -0.1114 | 15 | 93.7113 | 10.6134 | 112.6450 | 0.9984 | 0.1133 |
| 48 | 3855 | 3 | 2 | BA* | BG** | 1.0912 | 0.5608 | -0.1954 | 15 | 59.6986 | 11.0639 | 122.4101 | 0.9970 | 0.1853 |
| 48 | 3865 | 1 | 1 | BA* | BS** | 1.2225 | 0.5115 | 0.0000 | 15 | 38.0167 | 24.3138 | 591.1616 | 0.9695 | 0.6396 |
| 48 | 3865 | 1 | 2 | BA* | BS** | 1.0770 | 0.2217 | -0.1799 | 15 | 8.8436 | 3.8086 | 14.5056 | 0.9989 | 0.4307 |
| 48 | 3865 | 2 | 1 | BA* | BG** | 1.2664 | 0.5259 | 0.0000 | 15 | 75.0102 | 12.9163 | 166.8304 | 0.9972 | 0.1722 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 3865 | 3 | 1 | BA* | BG** | 1.3101 | 0.4971 | 0.0000 | 15 | 72.1820 | 16.8039 | 282.3720 | 0.9952 | 0.2328 |
| 48 | 3865 | 3 | 2 | BA* | BG** | 1.4621 | 0.4890 | 0.0000 | 15 | 79.7790 | 24.1432 | 582.8943 | 0.9920 | 0.3026 |
| 48 | 3875 | 1 | 1 | A1 | TS02 | 0.8909 | 0.4123 | -1.3360 | 15 | 10.8153 | 2.6377 | 6.9574 | 0.9989 | 0.2439 |
| 48 | 3875 | 1 | 2 | A2 | TS04 | 0.8356 | 0.1845 | -1.0435 | 15 | 6.4016 | 3.3320 | 11.1023 | 0.9981 | 0.5205 |
| 48 | 3875 | 2 | 1 | BA* | BG** | 0.8527 | 0.5775 | 0.0000 | 15 | 57.9665 | 7.5989 | 57.7437 | 0.9981 | 0.1311 |
| 48 | 3875 | 2 | 2 | TP1 | BG55 | 1.0719 | 0.5824 | -0.4320 | 15 | 51.7045 | 10.9626 | 120.1779 | 0.9964 | 0.2120 |
| 48 | 4142 | 1 | 1 | A1 | TS01 | 1.1171 | 0.1876 | 0.0000 | 15 | 11.8491 | 9.0519 | 81.9362 | 0.9943 | 0.7639 |
| 48 | 4142 | 1 | 2 | A2 | TS03 | 0.8534 | 0.5502 | -2.7885 | 15 | 13.0377 | 2.7326 | 7.4672 | 0.9982 | 0.2096 |
| 48 | 4142 | 2 | 1 | BA* | BG** | 0.6898 | 0.6644 | -0.1726 | 15 | 51.6384 | 3.8000 | 14.4396 | 0.9993 | 0.0736 |
| 48 | 4143 | 1 | 1 | A1 | TS01 | 0.5192 | 0.1006 | -3.3748 | 15 | 6.4991 | 0.9771 | 0.9546 | 0.9992 | 0.1503 |
| 48 | 4143 | 1 | 2 | A2 | TS03 | 0.6944 | 0.0709 | -3.7478 | 15 | 9.4466 | 0.6026 | 0.3632 | 0.9998 | 0.0638 |
| 48 | 4146 | 1 | 1 | A1 | TS01 | 0.8967 | 0.0960 | -2.6418 | 15 | 10.2804 | 1.0173 | 1.0349 | 0.9998 | 0.0990 |
| 48 | 4146 | 1 | 2 | BA* | BS** | 0.7922 | 0.1042 | -1.4312 | 15 | 6.1179 | 1.3984 | 1.9555 | 0.9996 | 0.2286 |
| 48 | 4152 | 1 | 1 | A1 | TS01 | 1.0009 | 0.4958 | -3.4883 | 15 | 15.7918 | 4.4307 | 19.6312 | 0.9957 | 0.2806 |
| 48 | 4152 | 1 | 2 | A2 | TS03 | 0.5188 | 0.7056 | -3.9887 | 15 | 9.1376 | 2.2527 | 5.0747 | 0.9956 | 0.2465 |
| 48 | 5024 | 1 | 1 | A1 | TS01 | 0.7839 | 0.6234 | -1.0216 | 15 | 14.4133 | 1.5606 | 2.4356 | 0.9996 | 0.1083 |
| 48 | 5024 | 1 | 2 | A2 | TS03 | 0.6295 | 0.5079 | -1.2612 | 15 | 9.1610 | 1.8537 | 3.4360 | 0.9990 | 0.2023 |
| 48 | 5026 | 1 | 1 | A1 | TS01 | 0.4942 | 0.0000 | 0.0000 | 15 | 3.3267 | 3.3267 | 11.0667 | 0.9959 | 1.0000 |
| 48 | 5026 | 1 | 2 | A2 | TS03 | 0.6330 | 0.0982 | -1.8711 | 15 | 6.1513 | 2.6269 | 6.9004 | 0.9974 | 0.4270 |
| 48 | 5035 | 1 | 1 | BA* | BS** | 1.4983 | 0.2332 | -1.6172 | 15 | 15.0545 | 7.3138 | 53.4921 | 0.9966 | 0.4858 |
| 48 | 5035 | 1 | 2 | A2 | TS01 | 0.6420 | 0.5294 | -1.2696 | 15 | 10.3418 | 3.7580 | 14.1228 | 0.9961 | 0.3634 |
| 48 | 5154 | 1 | 1 | A1 | TS02 | 0.6028 | 0.0000 | 0.0000 | 15 | 9.0196 | 9.0196 | 81.3524 | 0.9800 | 1.0000 |
| 48 | 5154 | 1 | 2 | A2 | TS03 | 1.3451 | 0.4239 | -1.0231 | 15 | 17.2232 | 5.1358 | 26.3760 | 0.9984 | 0.2982 |
| 48 | 5274 | 1 | 1 | A1 | TS01 | 0.8072 | 0.3649 | -0.4367 | 15 | 9.6249 | 2.2282 | 4.9648 | 0.9993 | 0.2315 |
| 48 | 5274 | 1 | 2 | BA* | BS** | 0.6108 | 0.0003 | -4.9793 | 15 | 9.8764 | 1.4840 | 2.2021 | 0.9981 | 0.1503 |
| 48 | 5278 | 1 | 1 | BA* | BS** | 0.7006 | 0.2426 | -0.5890 | 15 | 6.6940 | 4.2286 | 17.8809 | 0.9963 | 0.6317 |
| 48 | 5278 | 1 | 2 | BA* | BS** | 1.0431 | 0.3908 | -0.7118 | 15 | 12.5634 | 3.1848 | 10.1428 | 0.9991 | 0.2535 |
| 48 | 5283 | 1 | 1 | BA* | BS** | 1.1492 | 0.2770 | -2.1357 | 15 | 12.6201 | 2.4808 | 6.1543 | 0.9992 | 0.1966 |
| 48 | 5283 | 1 | 2 | A2 | TS03 | 1.0381 | 0.2403 | -2.2314 | 15 | 11.5478 | 3.0142 | 9.0856 | 0.9986 | 0.2610 |
| 48 | 5284 | 1 | 1 | BA* | BS** | 0.8908 | 0.4057 | -1.8433 | 15 | 11.9032 | 6.3418 | 40.2184 | 0.9928 | 0.5328 |
| 48 | 5284 | 1 | 2 | BA* | BS** | 1.2864 | 0.2540 | -1.5777 | 15 | 11.8048 | 2.8857 | 8.3275 | 0.9993 | 0.2445 |
| 48 | 5287 | 1 | 1 | A1 | TS01 | 1.0870 | 0.5970 | -1.0263 | 15 | 20.7876 | 7.9700 | 63.5210 | 0.9945 | 0.3834 |
| 48 | 5287 | 1 | 2 | A2 | TS03 | 1.0347 | 0.1660 | -1.2314 | 15 | 7.2651 | 1.4041 | 1.9716 | 0.9998 | 0.1933 |
| 48 | 5301 | 1 | 1 | BA* | BS** | 1.5556 | 0.2404 | -1.8881 | 15 | 16.1372 | 5.2772 | 27.8490 | 0.9982 | 0.3270 |
| 48 | 5310 | 1 | 1 | BA* | BS** | 1.5817 | 0.2623 | -0.9995 | 15 | 13.4953 | 5.0810 | 25.8164 | 0.9988 | 0.3765 |
| 48 | 5310 | 1 | 2 | BA* | BS** | 1.1585 | 0.3833 | 0.0000 | 15 | 21.3370 | 13.7334 | 188.6076 | 0.9888 | 0.6436 |
| 48 | 5317 | 1 | 2 | BA* | BS** | 1.1854 | 0.1472 | -0.1649 | 15 | 6.1860 | 2.4602 | 6.0524 | 0.9996 | 0.3977 |
| 48 | 5323 | 1 | 1 | A1 | TS01 | 0.7712 | 0.2614 | -1.7482 | 15 | 7.9144 | 2.9943 | 8.9661 | 0.9978 | 0.3783 |
| 48 | 5323 | 1 | 2 | A2 | TS03 | 0.5231 | 0.1702 | 0.0000 | 15 | 10.5978 | 10.0911 | 101.8306 | 0.9688 | 0.9522 |
| 48 | 5328 | 1 | 1 | BA* | BS** | 0.6195 | 0.2964 | 0.0000 | 15 | 7.7533 | 3.5977 | 12.9435 | 0.9972 | 0.4640 |
| 48 | 5328 | 1 | 2 | BA* | BS** | 0.9400 | 0.2737 | -0.7221 | 15 | 7.9325 | 2.4006 | 5.7631 | 0.9993 | 0.3026 |
| 48 | 5328 | 2 | 1 | BA* | BG** | 1.2057 | 0.6678 | -0.5053 | 15 | 70.0284 | 15.2927 | 233.8654 | 0.9953 | 0.2184 |
| 48 | 5328 | 2 | 2 | BA* | BG** | 1.3066 | 0.6749 | -0.3716 | 15 | 84.9276 | 13.1606 | 173.2012 | 0.9974 | 0.1550 |
| 48 | 5334 | 1 | 1 | A1 | TS01 | 1.1230 | 0.3507 | -2.1864 | 15 | 13.0760 | 2.3668 | 5.6017 | 0.9993 | 0.1810 |
| 48 | 5334 | 1 | 2 | A2 | TS03 | 0.4436 | 0.2779 | -2.0031 | 15 | 5.3032 | 2.7747 | 7.6991 | 0.9940 | 0.5232 |
| 48 | 5334 | 2 | 1 | BA* | BG** | 0.8673 | 0.6713 | -0.2076 | 15 | 63.3952 | 7.6303 | 58.2211 | 0.9983 | 0.1204 |
| 48 | 5334 | 2 | 2 | BA* | BG** | 0.6408 | 0.8223 | -0.4483 | 15 | 57.1899 | 6.5150 | 42.4458 | 0.9981 | 0.1139 |
| 48 | 5335 | 1 | 1 | A1 | TS01 | 1.0870 | 0.2442 | -1.9767 | 15 | 11.3167 | 3.8455 | 14.7879 | 0.9981 | 0.3398 |
| 48 | 5335 | 1 | 2 | BA* | BS** | 0.8031 | 0.2092 | 0.0000 | 15 | 15.6510 | 14.3869 | 206.9826 | 0.9733 | 0.9192 |
| 48 | 5336 | 1 | 1 | A1 | TS02 | 0.6660 | 0.7842 | -1.1332 | 15 | 15.8601 | 3.0139 | 9.0838 | 0.9980 | 0.1900 |
| 48 | 5336 | 1 | 2 | A2 | TS03 | 0.5993 | 0.0394 | 0.0000 | 15 | 10.9870 | 10.9548 | 120.0075 | 0.9708 | 0.9971 |
| 48 | 6079 | 1 | 1 | A1 | TS01 | 0.6642 | 0.2998 | -1.5951 | 15 | 7.1534 | 3.0129 | 9.0776 | 0.9972 | 0.4212 |
| 48 | 6079 | 1 | 2 | A2 | TS03 | 0.6024 | 0.6458 | -0.2059 | 15 | 15.2447 | 4.9298 | 24.3025 | 0.9948 | 0.3234 |
| 48 | 6079 | 2 | 1 | BA* | BG** | 0.8312 | 0.6924 | -0.2645 | 15 | 63.3301 | 7.1331 | 50.8813 | 0.9984 | 0.1126 |
| 48 | 6079 | 2 | 2 | TP1 | BG55 | 1.0314 | 0.6060 | -0.1234 | 15 | 68.9553 | 6.7147 | 45.0871 | 0.9990 | 0.0974 |
| 48 | 6086 | 1 | 1 | BA* | BS** | 1.0420 | 0.2928 | -0.4239 | 15 | 9.7160 | 2.2405 | 5.0197 | 0.9996 | 0.2306 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 6086 | 1 | 2 | BA* | BS** | 1.2088 | 0.4265 | -0.9874 | 15 | 15.2431 | 4.6335 | 21.4689 | 0.9984 | 0.3040 |
| 48 | 6086 | 3 | 1 | BA* | BG** | 0.5267 | 0.8172 | -0.4793 | 15 | 45.8608 | 3.8488 | 14.8132 | 0.9990 | 0.0839 |
| 48 | 6086 | 3 | 2 | BA* | BG** | 0.3105 | 0.6743 | 0.0000 | 15 | 26.6508 | 8.7508 | 76.5773 | 0.9849 | 0.3284 |
| 48 | 6160 | 1 | 1 | A1 | TS01 | 0.8030 | 0.5282 | -1.5959 | 15 | 11.7100 | 2.4616 | 6.0595 | 0.9988 | 0.2102 |
| 48 | 6160 | 1 | 2 | A2 | TS03 | 0.7838 | 0.3104 | -1.8914 | 15 | 8.8307 | 3.1643 | 10.0130 | 0.9975 | 0.3583 |
| 48 | 6160 | 2 | 1 | BA* | BG** | 0.8726 | 0.5779 | -0.4339 | 15 | 41.4319 | 8.9644 | 80.3599 | 0.9964 | 0.2164 |
| 48 | 6160 | 2 | 2 | TP1 | BG56 | 0.9748 | 0.5737 | -0.6729 | 15 | 38.2874 | 8.8441 | 78.2183 | 0.9965 | 0.2310 |
| 48 | 6160 | 3 | 2 | TP1 | BG55 | 0.6736 | 0.7802 | -0.4673 | 15 | 54.0436 | 9.6652 | 93.4165 | 0.9957 | 0.1788 |
| 48 | 6179 | 1 | 1 | A1 | TS01 | 0.4822 | 0.2125 | -1.0385 | 15 | 5.2490 | 4.1291 | 17.0495 | 0.9913 | 0.7866 |
| 48 | 6179 | 1 | 2 | TP1 | BS55 | 0.8004 | 0.4316 | -0.9298 | 15 | 10.1009 | 2.2976 | 5.2789 | 0.9991 | 0.2275 |
| 48 | 6179 | 2 | 1 | BA* | BG** | 0.8907 | 0.4659 | -0.3075 | 15 | 33.4070 | 9.2941 | 86.3811 | 0.9955 | 0.2782 |
| 48 | 6179 | 2 | 2 | TP1 | BG56 | 1.3590 | 0.4119 | -0.0515 | 15 | 52.8315 | 6.4993 | 42.2415 | 0.9991 | 0.1230 |
| 48 | 6179 | 3 | 1 | BA* | BG** | 0.6677 | 0.8267 | -0.3630 | 15 | 64.4824 | 4.9904 | 24.9042 | 0.9991 | 0.0774 |
| 48 | 6179 | 3 | 2 | TP1 | BG55 | 0.9588 | 0.5936 | -0.4588 | 15 | 46.6597 | 8.1894 | 67.0668 | 0.9975 | 0.1755 |
| 48 | 7165 | 1 | 1 | BA* | BS** | 1.1862 | 0.1231 | -0.7905 | 15 | 5.9936 | 1.6291 | 2.6540 | 0.9998 | 0.2718 |
| 48 | 7165 | 1 | 2 | BA* | BS** | 0.9013 | 0.0985 | -0.6833 | 15 | 4.1748 | 1.8001 | 3.2403 | 0.9996 | 0.4312 |
| 48 | 9005 | 1 | 1 | A1 | TS01 | 0.3172 | 0.0000 | -0.4635 | 15 | 2.6241 | 2.4190 | 5.8515 | 0.9939 | 0.9218 |
| 48 | 9005 | 1 | 2 | A2 | TS02 | 0.7919 | 0.1162 | 0.0000 | 15 | 5.8039 | 4.7482 | 22.5456 | 0.9968 | 0.8181 |
| 48 | 9005 | 2 | 1 | BA* | BG** | 1.3612 | 0.4785 | -0.3394 | 15 | 51.6156 | 9.7545 | 95.1502 | 0.9979 | 0.1890 |
| 48 | 9005 | 2 | 2 | TP1 | BG55 | 1.0147 | 0.5039 | -0.1886 | 15 | 47.5197 | 11.7760 | 138.6751 | 0.9955 | 0.2478 |
| 48 | 9167 | 1 | 1 | A1 | TS02 | 0.8812 | 0.1315 | -1.8578 | 15 | 7.9180 | 1.4721 | 2.1670 | 0.9996 | 0.1859 |
| 48 | 9167 | 1 | 2 | A2 | TS04 | 0.4121 | 0.1762 | -3.8694 | 15 | 5.5274 | 2.1224 | 4.5044 | 0.9942 | 0.3840 |
| 48 | 9167 | 3 | 1 | BA* | BG** | 0.5166 | 0.7905 | -0.3504 | 15 | 45.8396 | 5.2235 | 27.2846 | 0.9981 | 0.1140 |
| 48 | 9167 | 3 | 2 | BA4 | BG04 | 0.6355 | 0.6545 | 0.0000 | 15 | 68.4114 | 46.7841 | 2188.7500 | 0.9032 | 0.6839 |
| 48 | 9355 | 1 | 1 | A1 | TS01 | 0.8326 | 0.9215 | -6.5304 | 15 | 16.5550 | 4.2824 | 18.3393 | 0.9903 | 0.2587 |
| 48 | 9355 | 1 | 2 | A2 | TS03 | 0.9827 | 0.3819 | -2.7108 | 15 | 12.5098 | 2.4174 | 5.8439 | 0.9989 | 0.1932 |
| 48 | 9355 | 2 | 1 | BA* | BG** | 1.1978 | 0.5980 | -0.5399 | 15 | 55.4975 | 9.5098 | 90.4357 | 0.9977 | 0.1714 |
| 48 | 9355 | 2 | 2 | BA* | BG** | 1.0700 | 0.5730 | -0.1388 | 15 | 63.6345 | 10.0938 | 101.8849 | 0.9976 | 0.1586 |
| 49 | 1001 | 1 | 2 | TP1 | BS92 | 0.6573 | 0.2997 | -0.6944 | 15 | 6.1875 | 2.1911 | 4.8007 | 0.9988 | 0.3541 |
| 49 | 1004 | 1 | 2 | TP1 | BS92 | 0.5560 | 0.4624 | -1.7032 | 15 | 7.3666 | 2.1936 | 4.8120 | 0.9979 | 0.2978 |
| 49 | 1004 | 2 | 1 | BA* | BG** | 0.5228 | 0.4641 | -0.0590 | 15 | 23.9394 | 4.1392 | 17.1331 | 0.9979 | 0.1729 |
| 49 | 1005 | 1 | 2 | TP1 | BS92 | 0.4435 | 0.5445 | -0.1073 | 15 | 8.7788 | 1.4289 | 2.0416 | 0.9992 | 0.1628 |
| 49 | 1005 | 2 | 1 | BA* | BS** | 0.4553 | 0.6050 | -0.3851 | 15 | 24.1858 | 4.2698 | 18.2313 | 0.9973 | 0.1765 |
| 49 | 1006 | 1 | 1 | BA* | BS** | 0.4898 | 0.3852 | -1.1293 | 15 | 5.3940 | 0.8337 | 0.6951 | 0.9997 | 0.1546 |
| 49 | 1006 | 1 | 2 | TP1 | BS92 | 1.2204 | 0.2152 | 0.0000 | 15 | 11.4642 | 6.2059 | 38.5127 | 0.9978 | 0.5413 |
| 49 | 1007 | 1 | 1 | BA* | BS** | 0.7531 | 0.2743 | -0.9425 | 15 | 6.4528 | 1.9615 | 3.8473 | 0.9992 | 0.3040 |
| 49 | 1007 | 1 | 2 | TP1 | BS92 | 0.4903 | 0.5820 | -2.3478 | 15 | 7.7337 | 2.2605 | 5.1101 | 0.9967 | 0.2923 |
| 49 | 1007 | 2 | 1 | BA* | BG** | 0.8246 | 0.3053 | -0.2227 | 15 | 17.7555 | 4.4907 | 20.1663 | 0.9983 | 0.2529 |
| 49 | 1008 | 1 | 1 | BA* | BS** | 0.8006 | 0.2097 | -1.6247 | 15 | 7.1481 | 1.5569 | 2.4239 | 0.9995 | 0.2178 |
| 49 | 1008 | 1 | 2 | TP1 | BS92 | 0.1806 | 0.0191 | 0.0000 | 15 | 1.9881 | 1.9842 | 3.9369 | 0.9892 | 0.9980 |
| 49 | 1017 | 1 | 2 | TP1 | BS93 | 0.4876 | 0.5832 | -2.4639 | 15 | 7.7355 | 2.5250 | 6.3758 | 0.9957 | 0.3264 |
| 49 | 1017 | 2 | 2 | TP1 | BG92 | 0.3212 | 0.6559 | -0.3865 | 15 | 19.7441 | 4.1297 | 17.0541 | 0.9955 | 0.2092 |
| 49 | 3010 | 1 | 1 | BA* | BS** | 0.7527 | 0.1979 | -0.9158 | 15 | 5.1501 | 1.6498 | 2.7218 | 0.9994 | 0.3203 |
| 49 | 3010 | 1 | 2 | BA* | BS** | 1.0737 | 0.2270 | 0.0000 | 15 | 10.8790 | 6.2007 | 38.4482 | 0.9972 | 0.5700 |
| 49 | 3010 | 2 | 1 | BA* | BG** | 1.4775 | 0.1875 | 0.0000 | 15 | 23.0145 | 5.0178 | 25.1778 | 0.9993 | 0.2180 |
| 49 | 3011 | 1 | 1 | BA* | BS** | 0.5780 | 0.5443 | -1.6765 | 15 | 8.6261 | 2.1050 | 4.4310 | 0.9983 | 0.2440 |
| 49 | 3011 | 1 | 2 | BA* | BS** | 0.8525 | 0.1971 | -0.4863 | 15 | 5.6753 | 2.5078 | 6.2888 | 0.9991 | 0.4419 |
| 49 | 3015 | 1 | 1 | BA* | BS** | 0.4704 | 0.6380 | -0.3831 | 15 | 10.1686 | 1.5138 | 2.2915 | 0.9992 | 0.1489 |
| 49 | 3015 | 1 | 2 | BA* | BS** | 0.5093 | 0.6040 | -0.7390 | 15 | 9.4783 | 1.6176 | 2.6166 | 0.9991 | 0.1707 |
| 49 | 7083 | 1 | 1 | BA* | BS** | 0.8152 | 0.2173 | -1.3587 | 15 | 6.7485 | 1.7632 | 3.1087 | 0.9994 | 0.2613 |
| 49 | 7083 | 1 | 2 | BA* | BS** | 0.6113 | 0.3619 | -1.2624 | 15 | 6.6246 | 1.8816 | 3.5404 | 0.9988 | 0.2840 |
| 49 | 7083 | 2 | 1 | BA* | BG** | 0.8260 | 0.3036 | -0.4199 | 15 | 14.9736 | 6.2237 | 38.7348 | 0.9962 | 0.4156 |
| 49 | 7083 | 2 | 2 | BA* | BG** | 0.6247 | 0.4793 | -0.2354 | 15 | 25.6539 | 4.6513 | 21.6346 | 0.9979 | 0.1813 |
| 49 | 7086 | 1 | 2 | TP1 | BS91 | 0.9678 | 0.1569 | -0.0136 | 15 | 6.1582 | 2.7988 | 7.8336 | 0.9993 | 0.4545 |
| 50 | 1004 | 1 | 1 | BA* | BS** | 1.1439 | 0.4125 | -1.4476 | 13 | 14.0060 | 4.2195 | 17.8039 | 0.9984 | 0.3013 |
| 50 | 1004 | 1 | 2 | TP | BS55 | 0.3943 | 0.3176 | -4.0953 | 15 | 5.5317 | 1.1752 | 1.3810 | 0.9977 | 0.2124 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 1004 | 2 | 2 | TP | BG56 | 0.5635 | 0.7474 | -0.3827 | 15 | 44.2032 | 4.5135 | 20.3718 | 0.9987 | 0.1021 |
| 50 | 1681 | 1 | 1 | BA* | BS** | 1.2213 | 0.6279 | -3.0230 | 15 | 20.1830 | 3.5260 | 12.4327 | 0.9984 | 0.1747 |
| 50 | 1681 | 1 | 2 | TP | BS55 | 1.4159 | 0.3008 | -2.1457 | 15 | 17.2902 | 7.9334 | 62.9395 | 0.9949 | 0.4588 |
| 50 | 1681 | 2 | 2 | TP | BG56 | 0.6066 | 0.7146 | -0.1734 | 15 | 51.2471 | 2.9838 | 8.9030 | 0.9995 | 0.0582 |
| 50 | 1682 | 1 | 1 | BA* | BS** | 1.0957 | 0.5284 | -2.6105 | 15 | 16.5170 | 4.4261 | 19.5906 | 0.9972 | 0.2680 |
| 50 | 1682 | 1 | 2 | BA* | BS** | 1.1282 | 0.6013 | -2.0879 | 15 | 18.1732 | 4.3784 | 19.1706 | 0.9979 | 0.2409 |
| 50 | 1682 | 2 | 2 | BA* | BG** | 0.6875 | 0.6992 | -0.1642 | 15 | 56.1181 | 3.9118 | 15.3021 | 0.9994 | 0.0697 |
| 50 | 1683 | 2 | 1 | BA1 | BG02 | 0.8640 | 0.6675 | -0.2055 | 14 | 65.0169 | 5.9241 | 35.0952 | 0.9989 | 0.0911 |
| 50 | 1683 | 2 | 2 | TP | BG56 | 0.4986 | 0.7137 | -0.0464 | 15 | 46.3476 | 2.9376 | 8.6295 | 0.9994 | 0.0634 |
| 51 | 0114 | 1 | 3 | A2 | TS03 | 0.5144 | 0.3259 | -1.9594 | 15 | 5.7196 | 1.4357 | 2.0612 | 0.9988 | 0.2510 |
| 51 | 0115 | 1 | 3 | B5 | BS05 | 0.6203 | 0.3835 | -2.0731 | 15 | 7.6737 | 2.3918 | 5.7206 | 0.9977 | 0.3117 |
| 51 | 0118 | 1 | 2 | B6 | BS06 | 0.5953 | 0.2372 | -1.4975 | 15 | 5.4362 | 1.7564 | 3.0851 | 0.9988 | 0.3231 |
| 51 | 0118 | 1 | 3 | A17 | TS33 | 0.4442 | 0.4700 | -1.3420 | 15 | 6.0616 | 1.8732 | 3.5087 | 0.9979 | 0.3090 |
| 51 | 0119 | 1 | 3 | A9 | TS17 | 0.3658 | 0.4482 | -2.2999 | 15 | 5.2081 | 2.1489 | 4.6177 | 0.9945 | 0.4126 |
| 51 | 0120 | 1 | 3 | A5 | TS09 | 0.4780 | 0.4066 | -1.5428 | 15 | 5.7628 | 1.7531 | 3.0733 | 0.9982 | 0.3042 |
| 51 | 0121 | 1 | 2 | B1 | BS01 | 0.6608 | 0.2973 | -1.4822 | 15 | 6.6167 | 2.2443 | 5.0370 | 0.9985 | 0.3392 |
| 51 | 0122 | 1 | 2 | B3 | BS03 | 0.5062 | 0.4662 | -1.5953 | 15 | 6.9680 | 2.4886 | 6.1930 | 0.9969 | 0.3571 |
| 51 | 0124 | 1 | 2 | B4 | BS04 | 0.5206 | 0.4808 | -1.3342 | 15 | 7.3950 | 2.6712 | 7.1354 | 0.9969 | 0.3612 |
| 51 | 0124 | 1 | 3 | A11 | TS21 | 0.3912 | 0.4619 | -1.9888 | 15 | 5.5015 | 2.1684 | 4.7021 | 0.9955 | 0.3942 |
| 51 | 1002 | 1 | 1 | BA* | BS** | 0.9203 | 0.5978 | -2.4904 | 15 | 14.7400 | 3.6876 | 13.5984 | 0.9974 | 0.2502 |
| 51 | 1023 | 3 | 1 | BA3 | BG03 | 0.7583 | 0.6550 | -0.0802 | 15 | 58.9732 | 5.5108 | 30.3684 | 0.9989 | 0.0934 |
| 51 | 1023 | 3 | 2 | TP | BG55 | 0.7582 | 0.6091 | 0.0000 | 15 | 56.2160 | 6.1123 | 37.3603 | 0.9986 | 0.1087 |
| 51 | 1417 | 1 | 1 | BA* | BS** | 1.4674 | 0.2978 | -0.6854 | 15 | 13.4313 | 3.7213 | 13.8477 | 0.9993 | 0.2771 |
| 51 | 1423 | 1 | 1 | BA* | BS** | 0.9465 | 0.3992 | -1.7951 | 15 | 11.4842 | 3.5444 | 12.5626 | 0.9980 | 0.3086 |
| 51 | 1423 | 1 | 2 | TP | BS55 | 0.9345 | 0.3388 | -2.3778 | 15 | 11.4447 | 2.8925 | 8.3665 | 0.9984 | 0.2527 |
| 51 | 1464 | 1 | 1 | BA* | BS** | 0.7885 | 0.1180 | 0.0000 | 15 | 11.0324 | 10.4828 | 109.8897 | 0.9846 | 0.9502 |
| 51 | 1464 | 1 | 2 | TP | BS55 | 0.8938 | 0.0218 | -2.0860 | 15 | 9.8377 | 2.6124 | 6.8246 | 0.9986 | 0.2655 |
| 51 | 2004 | 1 | 1 | BA* | BS** | 0.5652 | 0.3826 | -3.7069 | 15 | 8.3990 | 2.1311 | 4.5417 | 0.9966 | 0.2537 |
| 51 | 2021 | 2 | 1 | BA* | BG** | 0.9107 | 0.5696 | -0.2606 | 15 | 48.4904 | 10.3851 | 107.8510 | 0.9961 | 0.2142 |
| 51 | 2021 | 2 | 2 | TP | BG55 | 0.7662 | 0.6289 | -0.0855 | 15 | 55.0742 | 8.6415 | 74.6758 | 0.9972 | 0.1569 |
| 51 | 2564 | 1 | 1 | BA* | BS** | 0.7350 | 0.6367 | -0.4893 | 15 | 15.3849 | 2.2126 | 4.8956 | 0.9992 | 0.1438 |
| 51 | 2564 | 1 | 2 | BA* | BS** | 0.6886 | 0.5831 | -0.3640 | 15 | 13.5671 | 1.7357 | 3.0127 | 0.9995 | 0.1279 |
| 51 | 5008 | 1 | 1 | BA* | BS** | 0.6460 | 0.4407 | -0.0251 | 15 | 10.8417 | 3.2677 | 10.6778 | 0.9980 | 0.3014 |
| 51 | 5008 | 1 | 2 | BA* | BS** | 0.5809 | 0.5441 | 0.0000 | 15 | 11.9929 | 2.5340 | 6.4212 | 0.9986 | 0.2113 |
| 51 | 5009 | 1 | 1 | BA* | BS** | 0.9052 | 0.1870 | -1.9295 | 15 | 9.5678 | 4.0459 | 16.3695 | 0.9969 | 0.4229 |
| 51 | 5009 | 1 | 2 | BA* | BS** | 1.0325 | 0.1803 | 0.0000 | 15 | 8.3449 | 4.8225 | 23.2565 | 0.9981 | 0.5779 |
| 53 | 1002 | 1 | 2 | TP1 | BS92 | 1.0332 | 0.2614 | -0.6515 | 15 | 8.2445 | 1.8047 | 3.2571 | 0.9997 | 0.2189 |
| 53 | 1002 | 2 | 1 | BA* | BG** | 1.1580 | 0.2142 | -0.0474 | 15 | 19.2927 | 2.3819 | 5.6735 | 0.9997 | 0.1235 |
| 53 | 1005 | 1 | 1 | BA* | BS** | 0.9097 | 0.2515 | -0.3079 | 15 | 7.5763 | 2.0665 | 4.2702 | 0.9995 | 0.2728 |
| 53 | 1005 | 1 | 2 | TP1 | BS93 | 0.6142 | 0.4763 | -1.7276 | 15 | 8.1492 | 1.6934 | 2.8676 | 0.9990 | 0.2078 |
| 53 | 1007 | 1 | 1 | BA* | BS** | 0.5906 | 0.3952 | -1.6754 | 15 | 7.1094 | 2.2198 | 4.9276 | 0.9981 | 0.3122 |
| 53 | 1007 | 1 | 2 | TP1 | BS92 | 0.7145 | 0.3614 | -1.6793 | 15 | 7.8891 | 1.8544 | 3.4389 | 0.9991 | 0.2351 |
| 53 | 1501 | 1 | 2 | TP1 | BS94 | 0.7335 | 0.3038 | -1.1522 | 15 | 6.7167 | 1.2622 | 1.5933 | 0.9996 | 0.1879 |
| 53 | 1801 | 1 | 1 | BA* | BS** | 0.7999 | 0.1773 | -0.5271 | 15 | 5.0029 | 2.4732 | 6.1169 | 0.9990 | 0.4944 |
| 53 | 3011 | 1 | 1 | BA* | BS** | 0.4274 | 0.7691 | -1.1216 | 15 | 9.6249 | 1.2419 | 1.5424 | 0.9992 | 0.1290 |
| 53 | 3011 | 1 | 2 | BA* | BS** | 0.4703 | 0.6519 | -1.0354 | 15 | 9.0069 | 1.5076 | 2.2727 | 0.9990 | 0.1674 |
| 53 | 3013 | 1 | 1 | BA* | BS** | 0.5114 | 0.4146 | -0.9199 | 15 | 6.5647 | 2.4144 | 5.8295 | 0.9976 | 0.3678 |
| 53 | 3013 | 3 | 2 | BA* | BG** | 0.4448 | 0.6515 | -0.1487 | 15 | 32.3363 | 2.1804 | 4.7541 | 0.9995 | 0.0674 |
| 53 | 3014 | 1 | 1 | BA* | BS** | 0.4594 | 0.7331 | -1.5977 | 15 | 9.2464 | 2.0269 | 4.1083 | 0.9977 | 0.2192 |
| 53 | 3019 | 1 | 1 | BA* | BS** | 0.5597 | 0.4670 | -1.6887 | 15 | 7.5258 | 2.2056 | 4.8646 | 0.9979 | 0.2931 |
| 53 | 3019 | 2 | 1 | BA* | BG** | 1.1767 | 0.2875 | 0.0000 | 15 | 30.6498 | 5.1271 | 26.2876 | 0.9991 | 0.1673 |
| 53 | 3812 | 1 | 1 | BA* | BS** | 0.5340 | 0.6305 | -1.2078 | 15 | 9.6026 | 1.9926 | 3.9705 | 0.9985 | 0.2075 |
| 53 | 3813 | 1 | 1 | BA* | BS** | 0.3829 | 0.6385 | -1.0895 | 15 | 7.1634 | 1.4574 | 2.1240 | 0.9985 | 0.2034 |
| 53 | 3813 | 1 | 2 | BA* | BS** | 0.4382 | 0.7987 | -1.5788 | 15 | 9.4793 | 1.0563 | 1.1157 | 0.9994 | 0.1114 |
| 53 | 3813 | 3 | 1 | BA* | BG** | 1.1284 | 0.3111 | -0.0801 | 15 | 29.9844 | 6.1666 | 38.0271 | 0.9985 | 0.2057 |
| 53 | 3813 | 3 | 2 | BA* | BG** | 1.0159 | 0.1915 | -0.1497 | 15 | 12.4308 | 1.8367 | 3.3736 | 0.9998 | 0.1478 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | 6020 | 1 | 1 | BA* | BS** | 0.7318 | 0.2985 | -1.2997 | 15 | 7.0020 | 2.2530 | 5.0762 | 0.9988 | 0.3218 |
| 53 | 6020 | 1 | 2 | TP1 | BS93 | 0.8172 | 0.1737 | -0.5986 | 15 | 5.0634 | 2.4790 | 6.1455 | 0.9990 | 0.4896 |
| 53 | 6048 | 1 | 1 | BA* | BS** | 0.4495 | 0.5742 | -2.3301 | 15 | 7.1434 | 2.2914 | 5.2506 | 0.9960 | 0.3208 |
| 53 | 6048 | 1 | 2 | TP1 | BS93 | 0.2750 | 0.6909 | -1.3540 | 15 | 5.4755 | 1.5383 | 2.3664 | 0.9966 | 0.2809 |
| 53 | 6056 | 1 | 1 | BA* | BS** | 0.5908 | 0.2718 | -2.1214 | 15 | 6.4461 | 1.3607 | 1.8514 | 0.9991 | 0.2111 |
| 53 | 7322 | 1 | 1 | A1 | TS01 | 0.4421 | 0.3624 | -3.0458 | 15 | 6.0222 | 1.4826 | 2.1981 | 0.9977 | 0.2462 |
| 53 | 7322 | 1 | 2 | A2 | TS03 | 0.6621 | 0.1988 | -1.6438 | 15 | 5.8611 | 1.1943 | 1.4263 | 0.9995 | 0.2038 |
| 54 | 1640 | 1 | 2 | TP | BS55 | 0.5410 | 0.0700 | -4.9047 | 15 | 8.6932 | 4.1059 | 16.8585 | 0.9827 | 0.4723 |
| 54 | 1640 | 2 | 2 | TP | BG55 | 0.9178 | 0.4477 | -0.5587 | 15 | 27.5491 | 12.1551 | 147.7459 | 0.9908 | 0.4412 |
| 54 | 4003 | 1 | 1 | BA* | BS** | 1.0716 | 0.2435 | -1.1424 | 15 | 10.0702 | 5.4886 | 30.1248 | 0.9968 | 0.5450 |
| 54 | 4003 | 1 | 2 | BA* | BS** | 0.8170 | 0.4793 | -1.4548 | 15 | 11.5214 | 4.2115 | 17.7367 | 0.9967 | 0.3655 |
| 54 | 4004 | 1 | 2 | BA* | BS** | 1.4203 | 0.3066 | -1.5908 | 15 | 14.7593 | 5.1961 | 26.9992 | 0.9982 | 0.3521 |
| 54 | 5007 | 1 | 1 | BA* | BS** | 1.1742 | 0.2740 | -1.4721 | 15 | 10.8803 | 2.6045 | 6.7836 | 0.9993 | 0.2394 |
| 54 | 5007 | 1 | 2 | BA* | BS** | 0.9846 | 0.2224 | -1.2891 | 15 | 8.8048 | 4.1543 | 17.2580 | 0.9977 | 0.4718 |
| 54 | 7008 | 1 | 1 | BA* | BS** | 1.0362 | 0.2487 | -1.1386 | 15 | 9.8261 | 5.2988 | 28.0776 | 0.9968 | 0.5393 |
| 54 | 7008 | 1 | 2 | BA* | BS** | 0.8841 | 0.2236 | -0.8756 | 15 | 7.8667 | 4.8688 | 23.7053 | 0.9966 | 0.6189 |
| 54 | 7008 | 2 | 1 | BA* | BG** | 0.9816 | 0.5243 | -0.5753 | 14 | 34.2041 | 5.5294 | 30.5744 | 0.9986 | 0.1617 |
| 54 | 7008 | 2 | 2 | BA* | BG** | 1.1749 | 0.4853 | -0.7702 | 15 | 32.2399 | 8.3627 | 69.9350 | 0.9971 | 0.2594 |
| 55 | 3008 | 1 | 1 | A1 | TS01 | 1.0364 | 0.2578 | -3.0994 | 15 | 13.6887 | 1.6237 | 2.6364 | 0.9995 | 0.1186 |
| 55 | 3008 | 1 | 2 | A2 | TS03 | 1.5196 | 0.1800 | -1.5251 | 15 | 12.4453 | 1.1405 | 1.3007 | 0.9999 | 0.0916 |
| 55 | 3008 | 2 | 1 | BA* | BG** | 0.8042 | 0.6120 | 0.0000 | 15 | 58.8891 | 7.7725 | 60.4117 | 0.9980 | 0.1320 |
| 55 | 3008 | 2 | 2 | BA* | BG** | 0.7533 | 0.6921 | 0.0000 | 15 | 67.7589 | 11.4098 | 130.1831 | 0.9960 | 0.1684 |
| 55 | 3009 | 1 | 1 | A1 | TS01 | 1.4634 | 0.1653 | -1.8229 | 15 | 13.4996 | 0.9171 | 0.8411 | 0.9999 | 0.0679 |
| 55 | 3009 | 1 | 2 | A2 | TS03 | 1.2469 | 0.1538 | -2.1802 | 15 | 13.2927 | 1.4383 | 2.0686 | 0.9998 | 0.1082 |
| 55 | 3009 | 2 | 1 | BA* | BG** | 0.5777 | 0.6857 | 0.0000 | 15 | 51.4322 | 13.4270 | 180.2853 | 0.9906 | 0.2611 |
| 55 | 3009 | 2 | 2 | BA* | BG** | 0.6681 | 0.6862 | 0.0000 | 15 | 58.9962 | 7.1587 | 51.2468 | 0.9980 | 0.1213 |
| 55 | 3010 | 1 | 1 | BA* | BS** | 1.2473 | 0.5325 | -1.8301 | 15 | 17.8904 | 2.6231 | 6.8807 | 0.9994 | 0.1466 |
| 55 | 3010 | 1 | 2 | BA* | BS** | 1.5658 | 0.5045 | -2.1686 | 15 | 21.7573 | 4.2054 | 17.6852 | 0.9989 | 0.1933 |
| 55 | 3010 | 2 | 1 | BA* | BG** | 0.6437 | 0.6906 | -0.0160 | 14 | 52.1159 | 4.4055 | 19.4084 | 0.9991 | 0.0845 |
| 55 | 3010 | 2 | 2 | BA* | BG** | 0.8599 | 0.6231 | -0.0681 | 15 | 61.9789 | 4.5754 | 20.9343 | 0.9994 | 0.0738 |
| 55 | 3012 | 1 | 2 | BA* | BS** | 0.8230 | 0.2729 | -2.8097 | 15 | 10.3003 | 2.0583 | 4.2367 | 0.9988 | 0.1998 |
| 55 | 3012 | 2 | 2 | BA* | BG** | 0.6331 | 0.7364 | -0.3018 | 15 | 51.1471 | 6.0547 | 36.6597 | 0.9982 | 0.1184 |
| 55 | 3014 | 2 | 1 | BA* | BG** | 0.7819 | 0.6045 | -0.0046 | 15 | 55.9243 | 7.2832 | 53.0456 | 0.9981 | 0.1302 |
| 55 | 3014 | 2 | 2 | BA* | BG** | 0.7512 | 0.5633 | 0.0000 | 15 | 48.6824 | 8.6258 | 74.4042 | 0.9968 | 0.1772 |
| 55 | 3015 | 1 | 1 | BA* | BS** | 0.7631 | 0.7279 | -0.9364 | 15 | 17.0665 | 4.5660 | 20.8484 | 0.9967 | 0.2675 |
| 55 | 3015 | 1 | 2 | BA* | BS** | 0.6826 | 0.7608 | -0.7822 | 14 | 17.7151 | 6.2238 | 38.7362 | 0.9929 | 0.3513 |
| 55 | 3015 | 2 | 1 | BA* | BG** | 0.9702 | 0.5662 | -0.1432 | 15 | 55.9959 | 8.9043 | 79.2863 | 0.9977 | 0.1590 |
| 55 | 3015 | 2 | 2 | BA* | BG** | 1.1878 | 0.4978 | -0.0056 | 14 | 64.6290 | 6.6199 | 43.8224 | 0.9991 | 0.1024 |
| 55 | 3016 | 1 | 1 | BA* | BS** | 0.6840 | 0.7019 | -0.8075 | 15 | 15.2628 | 4.1441 | 17.1737 | 0.9967 | 0.2715 |
| 55 | 3016 | 1 | 2 | BA* | BS** | 0.6764 | 0.7193 | -0.7304 | 15 | 15.4155 | 2.8375 | 8.0514 | 0.9985 | 0.1841 |
| 55 | 3016 | 2 | 2 | BA* | BG** | 0.7246 | 0.6876 | -0.1759 | 15 | 56.2122 | 8.0877 | 65.4113 | 0.9974 | 0.1439 |
| 55 | 3019 | 1 | 1 | BA* | BS** | 0.5193 | 0.8105 | -1.2897 | 15 | 12.1459 | 2.5929 | 6.7230 | 0.9975 | 0.2135 |
| 55 | 3019 | 1 | 2 | BA* | BS** | 0.6382 | 0.7629 | -1.0202 | 15 | 14.6164 | 2.3123 | 5.3466 | 0.9988 | 0.1582 |
| 55 | 3019 | 2 | 1 | BA* | BG** | 0.4696 | 0.8899 | -0.2831 | 14 | 51.4534 | 3.3349 | 11.1218 | 0.9993 | 0.0648 |
| 55 | 3019 | 2 | 2 | BA* | BG** | 0.5305 | 0.8181 | -0.3522 | 14 | 47.6593 | 4.0321 | 16.2575 | 0.9989 | 0.0846 |
| 55 | 5037 | 1 | 1 | BA* | BS** | 0.8135 | 0.7130 | -0.9439 | 15 | 17.6856 | 3.9672 | 15.7389 | 0.9978 | 0.2243 |
| 55 | 5037 | 1 | 2 | BA* | BS** | 0.7853 | 0.7247 | -0.7567 | 14 | 18.7183 | 4.5417 | 20.6273 | 0.9971 | 0.2426 |
| 55 | 5037 | 2 | 1 | BA* | BG** | 0.7356 | 0.6899 | -0.1476 | 15 | 59.9553 | 5.0251 | 25.2513 | 0.9991 | 0.0838 |
| 55 | 5037 | 2 | 2 | BA* | BG** | 1.0646 | 0.4485 | -0.0399 | 15 | 47.6517 | 8.7476 | 76.5197 | 0.9977 | 0.1836 |
| 55 | 5037 | 3 | 1 | BA* | BG** | 0.7199 | 0.6375 | -0.1297 | 15 | 50.9659 | 8.0997 | 65.6049 | 0.9971 | 0.1589 |
| 55 | 5037 | 3 | 2 | BA* | BG** | 0.8673 | 0.6144 | -0.0728 | 15 | 60.2130 | 9.7125 | 94.3333 | 0.9971 | 0.1613 |
| 55 | 5040 | 1 | 1 | A1 | TS01 | 0.7496 | 0.1026 | -2.8290 | 15 | 9.5857 | 0.9551 | 0.9121 | 0.9997 | 0.0996 |
| 55 | 5040 | 1 | 2 | A2 | TS03 | 0.8517 | 0.2111 | -1.7295 | 15 | 7.7257 | 0.8908 | 0.7935 | 0.9998 | 0.1153 |
| 55 | 5040 | 2 | 1 | BA* | BG** | 1.0359 | 0.5645 | 0.0000 | 15 | 66.9965 | 4.4413 | 19.7249 | 0.9995 | 0.0663 |
| 55 | 5040 | 2 | 2 | BA* | BG** | 1.1836 | 0.5859 | -0.0435 | 14 | 73.1520 | 4.2972 | 18.4657 | 0.9997 | 0.0587 |
| 55 | 6351 | 1 | 1 | BA* | BS** | 1.0151 | 0.6627 | -2.0042 | 15 | 17.6230 | 3.2109 | 10.3098 | 0.9987 | 0.1822 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55 | 6351 | 1 | 2 | BA* | BS** | 1.2305 | 0.2870 | -2.6085 | 15 | 14.8346 | 1.5503 | 2.4034 | 0.9997 | 0.1045 |
| 55 | 6351 | 2 | 1 | BA* | BG** | 0.6835 | 0.7305 | 0.0000 | 15 | 66.6113 | 9.1991 | 84.6238 | 0.9972 | 0.1381 |
| 55 | 6351 | 2 | 2 | BA* | BG** | 0.9798 | 0.5101 | -0.0698 | 15 | 51.2385 | 9.9352 | 98.7080 | 0.9969 | 0.1939 |
| 55 | 6352 | 2 | 1 | BA* | BG** | 0.8347 | 0.5834 | 0.0000 | 15 | 56.4563 | 8.2268 | 67.6804 | 0.9977 | 0.1457 |
| 55 | 6352 | 2 | 2 | BA* | BG** | 0.9457 | 0.5664 | -0.0925 | 15 | 56.7607 | 8.0662 | 65.0632 | 0.9981 | 0.1421 |
| 55 | 6352 | 3 | 2 | BA* | BG** | 1.1559 | 0.5722 | -0.1505 | 15 | 67.3348 | 12.7446 | 162.4252 | 0.9967 | 0.1893 |
| 55 | 6353 | 2 | 1 | BA* | BG** | 0.9507 | 0.5942 | 0.0000 | 15 | 66.3937 | 5.2340 | 27.3943 | 0.9993 | 0.0788 |
| 55 | 6353 | 2 | 2 | BA* | BG** | 1.0573 | 0.5146 | 0.0000 | 15 | 59.2497 | 6.9840 | 48.7768 | 0.9988 | 0.1179 |
| 55 | 6353 | 3 | 1 | BA* | BG** | 0.8055 | 0.6693 | -0.0362 | 14 | 61.0869 | 7.2402 | 52.4203 | 0.9983 | 0.1185 |
| 55 | 6353 | 3 | 2 | BA* | BG** | 1.1817 | 0.6066 | -0.0133 | 15 | 84.8340 | 6.0394 | 36.4741 | 0.9994 | 0.0712 |
| 55 | 6354 | 2 | 1 | BA* | BG** | 1.0734 | 0.4901 | -0.1456 | 15 | 49.3421 | 9.0026 | 81.0461 | 0.9976 | 0.1825 |
| 55 | 6354 | 2 | 2 | BA* | BG** | 0.7629 | 0.7229 | -0.0283 | 15 | 72.0614 | 6.5750 | 43.2305 | 0.9988 | 0.0912 |
| 55 | 6354 | 3 | 1 | BA* | BG** | 0.7439 | 0.6535 | 0.0000 | 15 | 60.2026 | 8.2956 | 68.8174 | 0.9976 | 0.1378 |
| 55 | 6354 | 3 | 2 | BA* | BG** | 0.8589 | 0.6627 | -0.0457 | 14 | 63.8479 | 5.7972 | 33.6070 | 0.9990 | 0.0908 |
| 55 | 6355 | 2 | 1 | BA* | BG** | 1.0170 | 0.5238 | 0.0000 | 15 | 58.5945 | 6.7882 | 46.0799 | 0.9988 | 0.1159 |
| 55 | 6355 | 3 | 1 | BA* | BG** | 1.0764 | 0.5262 | 0.0000 | 15 | 62.2665 | 11.2502 | 126.5672 | 0.9970 | 0.1807 |
| 55 | 6355 | 3 | 2 | BA* | BG** | 0.8631 | 0.6657 | -0.2543 | 14 | 57.0610 | 8.0976 | 65.5706 | 0.9978 | 0.1419 |
| 56 | 1007 | 1 | 1 | BA* | BS** | 0.5267 | 0.6435 | -1.6153 | 15 | 9.1626 | 1.9697 | 3.8797 | 0.9983 | 0.2150 |
| 56 | 1007 | 1 | 2 | TP1 | BS92 | 0.3757 | 0.6902 | -1.1476 | 15 | 7.6799 | 2.2477 | 5.0520 | 0.9963 | 0.2927 |
| 56 | 2015 | 1 | 1 | BA* | BS** | 0.7355 | 0.2501 | -0.7573 | 15 | 5.9785 | 2.4038 | 5.7781 | 0.9988 | 0.4021 |
| 56 | 2015 | 2 | 1 | BA* | BS** | 0.8038 | 0.3029 | -0.2500 | 15 | 16.8254 | 5.2887 | 27.9698 | 0.9975 | 0.3143 |
| 56 | 2015 | 2 | 2 | TP1 | BS91 | 0.5109 | 0.6047 | -0.3357 | 15 | 28.2256 | 5.2655 | 27.7260 | 0.9969 | 0.1866 |
| 56 | 2017 | 1 | 1 | BA* | BS** | 0.9145 | 0.1653 | -0.6342 | 15 | 5.0124 | 1.4839 | 2.2019 | 0.9997 | 0.2960 |
| 56 | 2017 | 1 | 2 | A2 | TS03 | 0.8373 | 0.1439 | -1.0321 | 15 | 5.2626 | 1.3780 | 1.8988 | 0.9997 | 0.2618 |
| 56 | 2017 | 1 | 2 | TP1 | BS91 | 0.9368 | 0.1288 | -1.2572 | 15 | 6.6783 | 1.5417 | 2.3767 | 0.9996 | 0.2308 |
| 56 | 2018 | 1 | 1 | BA* | BS** | 0.6951 | 0.2164 | -0.4344 | 15 | 5.0266 | 2.0530 | 4.2150 | 0.9991 | 0.4084 |
| 56 | 2018 | 1 | 2 | A2 | TS03 | 0.6300 | 0.3023 | -2.6856 | 15 | 7.8510 | 1.5721 | 2.4716 | 0.9988 | 0.2002 |
| 56 | 2018 | 1 | 2 | TP1 | BS92 | 0.8120 | 0.1932 | -1.5868 | 15 | 7.0122 | 1.1781 | 1.3879 | 0.9997 | 0.1680 |
| 56 | 2019 | 1 | 1 | A1 | TS01 | 0.5839 | 0.2582 | -3.4133 | 15 | 8.0166 | 1.4579 | 2.1256 | 0.9986 | 0.1819 |
| 56 | 2019 | 1 | 1 | BA* | BS** | 0.8127 | 0.1588 | -0.0702 | 15 | 4.7809 | 1.5786 | 2.4921 | 0.9997 | 0.3302 |
| 56 | 2019 | 3 | 1 | BA* | BG** | 0.7843 | 0.3780 | -0.3117 | 15 | 20.9982 | 4.7261 | 22.3361 | 0.9981 | 0.2251 |
| 56 | 2019 | 3 | 2 | TP1 | BG91 | 0.4929 | 0.6218 | -0.4144 | 15 | 26.9970 | 5.1264 | 26.2801 | 0.9967 | 0.1899 |
| 56 | 2020 | 1 | 1 | BA* | BS** | 0.9256 | 0.1478 | 0.0000 | 15 | 5.6044 | 2.5155 | 6.3276 | 0.9994 | 0.4488 |
| 56 | 2020 | 1 | 2 | TP1 | BS91 | 0.8684 | 0.1470 | -1.0685 | 15 | 5.7998 | 1.9816 | 3.9266 | 0.9994 | 0.3417 |
| 56 | 2037 | 1 | 1 | BA* | BS** | 0.7543 | 0.1982 | -1.1134 | 15 | 5.7998 | 2.3292 | 5.4254 | 0.9988 | 0.4016 |
| 56 | 2037 | 1 | 2 | TP1 | BS91 | 0.6440 | 0.3430 | -2.1612 | 15 | 7.7016 | 2.3682 | 5.6084 | 0.9979 | 0.3075 |
| 56 | 6031 | 1 | 1 | BA* | BS** | 0.9141 | 0.1899 | 0.0000 | 15 | 8.5038 | 5.6761 | 32.2186 | 0.9967 | 0.6675 |
| 56 | 6031 | 1 | 2 | TP1 | BS91 | 0.9185 | 0.1802 | 0.0000 | 15 | 7.2493 | 3.9686 | 15.7501 | 0.9984 | 0.5475 |
| 56 | 7772 | 1 | 1 | BA* | BS** | 0.8610 | 0.1257 | -0.5661 | 15 | 4.0708 | 1.8172 | 3.3022 | 0.9995 | 0.4464 |
| 56 | 7772 | 1 | 2 | TP1 | BS91 | 0.8466 | 0.1469 | -0.5322 | 15 | 4.6823 | 2.5486 | 6.4954 | 0.9991 | 0.5443 |
| 56 | 7773 | 1 | 1 | BA* | BS** | 0.5958 | 0.5748 | -1.2315 | 15 | 9.6870 | 2.0090 | 4.0363 | 0.9987 | 0.2074 |
| 56 | 7773 | 1 | 2 | TP1 | BS92 | 0.7844 | 0.2339 | -0.5387 | 15 | 5.8538 | 1.9482 | 3.7953 | 0.9994 | 0.3328 |
| 56 | 7773 | 2 | 2 | TP1 | BG91 | 0.7720 | 0.4443 | -0.2661 | 15 | 27.6469 | 4.2579 | 18.1297 | 0.9987 | 0.1540 |
| 56 | 7775 | 1 | 1 | BA* | BS** | 0.4821 | 0.4984 | -1.8745 | 15 | 6.8917 | 2.2835 | 5.2143 | 0.9969 | 0.3313 |
| 56 | 7775 | 1 | 2 | TP1 | BS92 | 0.6113 | 0.4254 | -1.7583 | 15 | 7.6295 | 2.0629 | 4.2556 | 0.9984 | 0.2704 |
| 72 | 1003 | 1 | 1 | A1 | TS01 | 0.7677 | 0.1314 | -2.0330 | 15 | 8.1141 | 3.5550 | 12.6377 | 0.9966 | 0.4381 |
| 72 | 1003 | 2 | 2 | BA* | BG** | 0.7733 | 0.6425 | -0.1222 | 15 | 56.5290 | 5.9619 | 35.5445 | 0.9987 | 0.1055 |
| 72 | 3008 | 2 | 1 | BA* | BG** | 1.0268 | 0.5676 | -0.0038 | 15 | 67.1298 | 7.3403 | 53.8794 | 0.9988 | 0.1093 |
| 72 | 3008 | 2 | 2 | BA* | BG** | 0.5267 | 0.7757 | 0.0000 | 15 | 58.6135 | 12.4299 | 154.5012 | 0.9925 | 0.2121 |
| 72 | 4121 | 1 | 1 | BA* | BS** | 1.9106 | 0.5216 | -2.5055 | 15 | 27.2654 | 4.8949 | 23.9605 | 0.9989 | 0.1795 |
| 72 | 4121 | 1 | 2 | BA* | BS** | 1.2027 | 0.4161 | -0.8498 | 15 | 15.8685 | 6.5074 | 42.3464 | 0.9969 | 0.4101 |
| 72 | 4121 | 2 | 2 | BA* | BG** | 1.5485 | 0.5749 | -0.5376 | 15 | 67.3378 | 12.7083 | 161.5020 | 0.9974 | 0.1887 |
| 72 | 4122 | 1 | 1 | BA* | BS** | 1.2098 | 0.2621 | -0.4862 | 15 | 12.2397 | 7.2895 | 53.1373 | 0.9964 | 0.5956 |
| 72 | 4122 | 1 | 2 | BA* | BS** | 1.0992 | 0.3283 | 0.0000 | 15 | 19.1528 | 13.7886 | 190.1261 | 0.9872 | 0.7199 |
| 72 | 4122 | 2 | 1 | BA* | BG** | 1.1082 | 0.5559 | -0.2774 | 15 | 55.8261 | 5.9029 | 34.8440 | 0.9991 | 0.1057 |
| 72 | 4122 | 2 | 2 | BA* | BG** | 1.4196 | 0.3703 | 0.0000 | 15 | 52.0171 | 16.3563 | 267.5274 | 0.9947 | 0.3144 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 | 0502 | 1 | 1 | B* | BS** | 1.3128 | 0.2273 | -1.4959 | 14 | 9.5791 | 1.4157 | 2.0043 | 0.9998 | 0.1478 |
| 81 | 0503 | 1 | 1 | TP1 | BS92 | 0.8891 | 0.2260 | -2.2604 | 15 | 9.5907 | 1.2887 | 1.6609 | 0.9996 | 0.1344 |
| 81 | 1803 | 1 | 1 | BA* | BS** | 0.5780 | 0.6098 | -1.0072 | 15 | 10.3845 | 1.7088 | 2.9199 | 0.9991 | 0.1645 |
| 81 | 1803 | 1 | 2 | TP1 | BS92 | 0.9559 | 0.1613 | -0.6140 | 15 | 5.2327 | 1.8642 | 3.4754 | 0.9996 | 0.3563 |
| 81 | 1804 | 1 | 2 | A2 | TS01 | 0.7127 | 0.1848 | -2.3735 | 15 | 7.8891 | 0.9652 | 0.9317 | 0.9997 | 0.1224 |
| 81 | 1805 | 1 | 1 | BA* | BS** | 0.8268 | 0.1422 | -0.6674 | 15 | 4.4955 | 2.0442 | 4.1789 | 0.9993 | 0.4547 |
| 81 | 1805 | 1 | 2 | A2 | TS01 | 0.8676 | 0.1668 | -1.4833 | 15 | 6.9864 | 1.3319 | 1.7740 | 0.9997 | 0.1906 |
| 81 | 2812 | 1 | 2 | A2 | TS01 | 0.6117 | 0.1241 | -0.1113 | 15 | 3.6095 | 2.5915 | 6.7159 | 0.9984 | 0.7180 |
| 82 | 1005 | 1 | 2 | TP1 | BS93 | 0.4579 | 0.7072 | -0.9901 | 15 | 9.6545 | 1.6413 | 2.6940 | 0.9988 | 0.1700 |
| 82 | 6006 | 1 | 1 | BA* | BS** | 0.4297 | 0.7591 | -1.0445 | 15 | 9.6644 | 1.1709 | 1.3711 | 0.9993 | 0.1212 |
| 82 | 6006 | 2 | 2 | TP1 | BS91 | 0.3899 | 0.6125 | -0.0975 | 15 | 26.6723 | 1.4002 | 1.9605 | 0.9997 | 0.0525 |
| 83 | 3802 | 3 | 1 | TP* | BG** | 0.6763 | 0.6963 | 0.0000 | 15 | 61.2728 | 4.4651 | 19.9374 | 0.9993 | 0.0729 |
| 83 | 3802 | 3 | 2 | TP* | BG** | 0.5925 | 0.7617 | -0.0055 | 15 | 62.6748 | 4.6906 | 22.0020 | 0.9991 | 0.0748 |
| 83 | 6452 | 2 | 1 | TP* | BG** | 0.8337 | 0.6163 | 0.0000 | 15 | 61.4362 | 7.8370 | 61.4187 | 0.9981 | 0.1276 |
| 83 | 6452 | 2 | 2 | TP* | BG** | 0.8576 | 0.5819 | 0.0000 | 15 | 57.9362 | 7.7898 | 60.6808 | 0.9981 | 0.1345 |
| 84 | 1684 | 1 | 1 | BA* | BS** | 0.5179 | 0.5416 | -0.7282 | 15 | 9.0528 | 2.5916 | 6.7165 | 0.9976 | 0.2863 |
| 84 | 1684 | 1 | 2 | TP | BS55 | 0.7465 | 0.5157 | -1.6855 | 15 | 11.0143 | 3.5974 | 12.9413 | 0.9970 | 0.3266 |
| 84 | 1684 | 2 | 1 | BA* | BG** | 0.4921 | 0.7761 | -0.2031 | 14 | 48.7783 | 4.3794 | 19.1794 | 0.9987 | 0.0898 |
| 84 | 1802 | 1 | 1 | BA* | BS** | 0.9406 | 0.5042 | -2.4537 | 15 | 13.8554 | 4.2982 | 18.4745 | 0.9965 | 0.3102 |
| 84 | 3803 | 1 | 1 | BA* | BS** | 1.0566 | 0.6190 | -2.6651 | 15 | 17.7074 | 4.8586 | 23.6060 | 0.9964 | 0.2744 |
| 84 | 3803 | 1 | 2 | BA* | BS** | 1.5316 | 0.2817 | -2.8357 | 15 | 19.1254 | 2.9740 | 8.8446 | 0.9993 | 0.1555 |
| 84 | 6804 | 1 | 1 | BA* | BS** | 2.3059 | 0.5146 | -4.3315 | 15 | 38.5662 | 10.4900 | 110.0405 | 0.9943 | 0.2720 |
| 87 | 1620 | 1 | 1 | BA* | BS** | 1.0184 | 0.1279 | -1.2565 | 15 | 8.3666 | 4.5074 | 20.3167 | 0.9975 | 0.5387 |
| 87 | 1622 | 1 | 1 | BA* | BS** | 1.0448 | 0.5029 | -1.5132 | 15 | 14.4799 | 2.4721 | 6.1114 | 0.9993 | 0.1707 |
| 87 | 1622 | 1 | 2 | TP | BS55 | 0.8343 | 0.3742 | -0.9775 | 15 | 9.6323 | 3.4832 | 12.1327 | 0.9981 | 0.3616 |
| 87 | 1622 | 2 | 1 | BA* | BG** | 0.7437 | 0.6665 | -0.3225 | 15 | 49.6466 | 3.0995 | 9.6069 | 0.9996 | 0.0624 |
| 87 | 1680 | 1 | 1 | BA* | BS** | 0.8394 | 0.6361 | -1.4016 | 14 | 14.9122 | 2.4080 | 5.7984 | 0.9990 | 0.1615 |
| 87 | 1680 | 1 | 2 | TP | BS55 | 1.0324 | 0.3501 | -1.2024 | 15 | 11.0510 | 3.9020 | 15.2256 | 0.9983 | 0.3531 |
| 87 | 1680 | 2 | 2 | TP | BG56 | 0.6671 | 0.7649 | -0.2925 | 15 | 58.0769 | 4.8198 | 23.2306 | 0.9990 | 0.0830 |
| 87 | 1806 | 1 | 1 | BA* | BS** | 0.8891 | 0.6522 | -1.8377 | 15 | 15.4689 | 3.0128 | 9.0770 | 0.9985 | 0.1948 |
| 87 | 2811 | 1 | 1 | BA* | BS** | 0.7644 | 0.0000 | -1.2744 | 15 | 8.4420 | 6.0481 | 36.5792 | 0.9917 | 0.7164 |
| 87 | 2811 | 1 | 2 | BA4 | BS04 | 1.0321 | 0.2468 | -3.7740 | 15 | 15.1510 | 3.7047 | 13.7249 | 0.9967 | 0.2445 |
| 87 | 2812 | 1 | 1 | BA* | BS** | 0.7722 | 0.3124 | -5.6702 | 15 | 11.7951 | 2.4417 | 5.9619 | 0.9963 | 0.2070 |
| 87 | 2812 | 1 | 2 | BA* | BS** | 0.8875 | 0.2427 | -5.1568 | 15 | 14.4166 | 1.7407 | 3.0301 | 0.9986 | 0.1207 |
| 88 | 1645 | 1 | 1 | BA* | BS** | 0.5575 | 0.5673 | -1.8587 | 14 | 9.1378 | 3.0354 | 9.2136 | 0.9960 | 0.3322 |
| 88 | 1645 | 1 | 2 | TP | BS55 | 1.0514 | 0.3470 | -2.4734 | 15 | 13.5024 | 4.2005 | 17.6442 | 0.9972 | 0.3111 |
| 88 | 1646 | 1 | 1 | BA* | BS** | 0.8683 | 0.3856 | -2.8835 | 15 | 12.1859 | 4.4038 | 19.3934 | 0.9950 | 0.3614 |
| 88 | 1646 | 1 | 2 | TP | BS55 | 0.6209 | 0.4368 | -1.5422 | 15 | 8.1105 | 2.9942 | 8.9652 | 0.9970 | 0.3692 |
| 88 | 1647 | 1 | 2 | TP | BS55 | 0.9317 | 0.2328 | -1.5853 | 15 | 9.1251 | 4.0036 | 16.0289 | 0.9974 | 0.4387 |
| 89 | 1021 | 1 | 1 | BA* | BS** | 0.8247 | 0.5784 | -1.0241 | 15 | 13.8763 | 2.0789 | 4.3216 | 0.9993 | 0.1498 |
| 89 | 1021 | 1 | 2 | TP | BS55 | 0.6993 | 0.5953 | -0.7918 | 15 | 12.7025 | 1.9984 | 3.9934 | 0.9992 | 0.1573 |
| 89 | 1125 | 1 | 1 | BA* | BS** | 0.8009 | 0.7689 | -1.3846 | 15 | 17.2552 | 2.4522 | 6.0135 | 0.9990 | 0.1421 |
| 89 | 1125 | 1 | 2 | TP | BS55 | 0.6521 | 0.6448 | -0.7963 | 15 | 12.8612 | 1.9143 | 3.6646 | 0.9992 | 0.1488 |
| 89 | 1125 | 2 | 1 | BA* | BG** | 0.6902 | 0.6806 | -0.0818 | 15 | 57.3803 | 3.4760 | 12.0829 | 0.9995 | 0.0606 |
| 89 | 1125 | 2 | 2 | TP | BG57 | 0.7417 | 0.6761 | -0.2235 | 15 | 54.7011 | 2.9181 | 8.5151 | 0.9997 | 0.0533 |
| 89 | 1127 | 1 | 1 | BA* | BS** | 0.7183 | 0.5634 | -0.9276 | 15 | 12.1000 | 2.8263 | 7.9878 | 0.9984 | 0.2336 |
| 89 | 1127 | 2 | 1 | BA3 | BG03 | 0.5767 | 0.7112 | -0.3218 | 15 | 43.4476 | 2.6671 | 7.1134 | 0.9995 | 0.0614 |
| 89 | 1127 | 2 | 2 | TP | BG56 | 0.5373 | 0.7512 | -0.3205 | 15 | 44.5018 | 4.0575 | 16.4632 | 0.9989 | 0.0912 |
| 89 | 3001 | 1 | 1 | BA* | BS** | 0.5224 | 0.6329 | -0.7970 | 15 | 10.2711 | 1.5581 | 2.4276 | 0.9992 | 0.1517 |
| 89 | 3001 | 1 | 2 | BA* | BS** | 0.6467 | 0.6037 | -0.8812 | 15 | 11.7830 | 2.2201 | 4.9289 | 0.9988 | 0.1884 |
| 89 | 3001 | 2 | 2 | BA* | BG** | 0.5924 | 0.6600 | -0.2148 | 15 | 42.3901 | 3.9292 | 15.4384 | 0.9990 | 0.0927 |
| 89 | 3002 | 1 | 1 | BA* | BS** | 0.8047 | 0.5151 | -1.4386 | 15 | 12.1800 | 4.3839 | 19.2183 | 0.9964 | 0.3599 |
| 89 | 3015 | 1 | 1 | BA* | BS** | 0.6002 | 0.6961 | -0.6166 | 15 | 13.5366 | 2.4707 | 6.1042 | 0.9986 | 0.1825 |
| 89 | 3015 | 1 | 2 | BA* | BS** | 0.8164 | 0.5880 | -1.0565 | 15 | 14.0635 | 2.8041 | 7.8629 | 0.9988 | 0.1994 |
| 89 | 9018 | 1 | 1 | BA* | BS** | 0.7245 | 0.4851 | -0.5827 | 15 | 11.1663 | 2.1725 | 4.7198 | 0.9992 | 0.1946 |
| 89 | 9018 | 1 | 2 | BA* | BS** | 0.7180 | 0.4582 | -0.7045 | 15 | 10.6077 | 3.8728 | 14.9983 | 0.9972 | 0.3651 |

Table 16. k-values determined from nonlinear regression analyses of LTPP resilient modulus test of unbound materials (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | k1 | k2 | k3 | No. Points | Std Dev($M_R$) | RMSE | MSE | $R^2$ | $S_e/S_y$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 | 6400 | 1 | 1 | TP* | BS** | 0.9157 | 0.6394 | -1.1130 | 15 | 16.6942 | 2.6427 | 6.9841 | 0.9991 | 0.1583 |
| 90 | 6400 | 1 | 2 | TP* | BS** | 0.8282 | 0.5789 | -1.1381 | 15 | 13.6706 | 2.4851 | 6.1757 | 0.9990 | 0.1818 |
| 90 | 6405 | 3 | 1 | TP* | BG** | 0.7461 | 0.7024 | -0.0178 | 15 | 68.1338 | 3.8397 | 14.7434 | 0.9995 | 0.0564 |
| 90 | 6405 | 3 | 2 | TP* | BG** | 1.4688 | 0.5246 | -0.2743 | 15 | 68.1394 | 16.7181 | 279.4952 | 0.9955 | 0.2454 |
| 90 | 6801 | 1 | 1 | TP* | BS** | 1.5200 | 0.2122 | -1.2996 | 15 | 11.7380 | 1.4006 | 1.9617 | 0.9999 | 0.1193 |
| 90 | 6801 | 1 | 2 | TP* | BS** | 0.9887 | 0.3140 | 0.0000 | 15 | 11.9575 | 3.6365 | 13.2241 | 0.9989 | 0.3041 |

* - Reference to LTPP Database Code List

** - Reference to LTPP Database Code List

# APPENDIX B.

## GRAPHICAL EXAMPLES OF THE DIFFERENT TYPES OF ANOMALIES IDENTIFIED IN THE RESILIENT MODULUS TEST DATA

Appendix B provides graphical examples of the different types of anomalies identified in the resilient modulus test data. The following gives a brief description of the graphical examples included in this appendix:

- Figures 34 through 37 show excess softening or potential disturbance of the test specimen for the higher vertical loads. These resilient modulus tests could be "good" data, but the universal constitutive equation does not fit the test data.

- Figures 38 through 41 provide graphical examples of the resilient modulus tests with a significant effect of the confining pressure that varies with the vertical loads used in the test program. These tests could be "good" data, but the universal constitutive equation does not represent a good fit to the test data.

- Figures 42 through 45 provide graphical examples of the resilient modulus tests with a sudden drop and then an increase in the resilient modulus measured at increasing vertical loads.

- Figures 46 through 49 provide graphical examples of the resilient modulus tests with relationships between resilient modulus and vertical loads for different confining pressures that intersect or have completely different stress sensitivity effects.

- Figures 50 through 53 provide graphical examples of the resilient modulus tests where the higher confining pressures result in a lower resilient modulus.

- Figures 54 through 57 provide graphical examples of the resilient modulus tests where the resilient modulus is independent of the confining pressure at the lowest vertical load used in the test program.

- Figures 58 through 61 provide graphical examples of the resilient modulus tests with possible data entry errors.

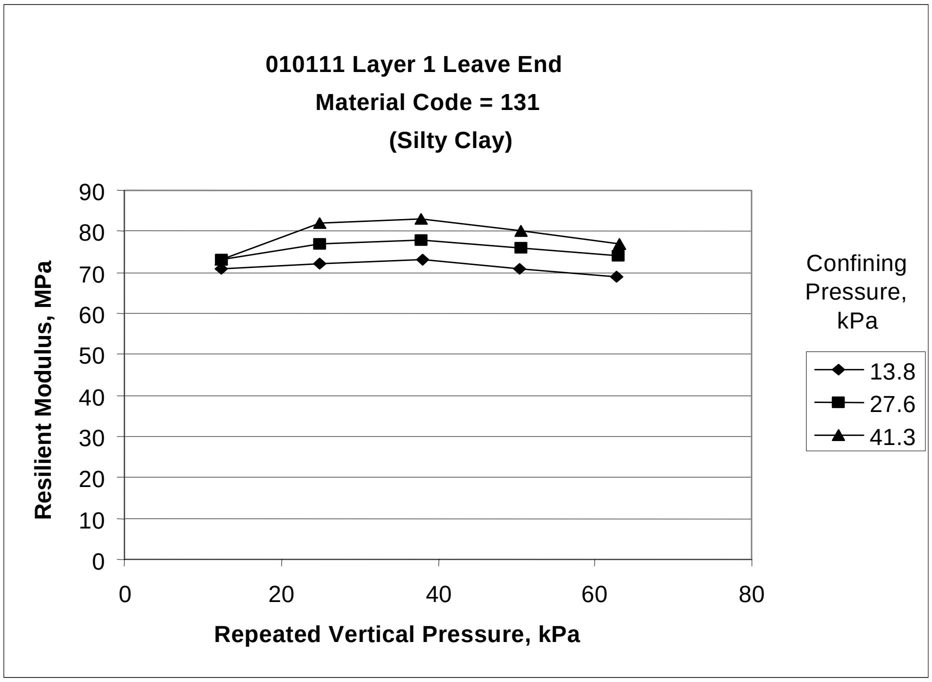



Figure 34. Sample from test section 010111, layer 1, at the leave end exhibits specimen distortion or excess softening.

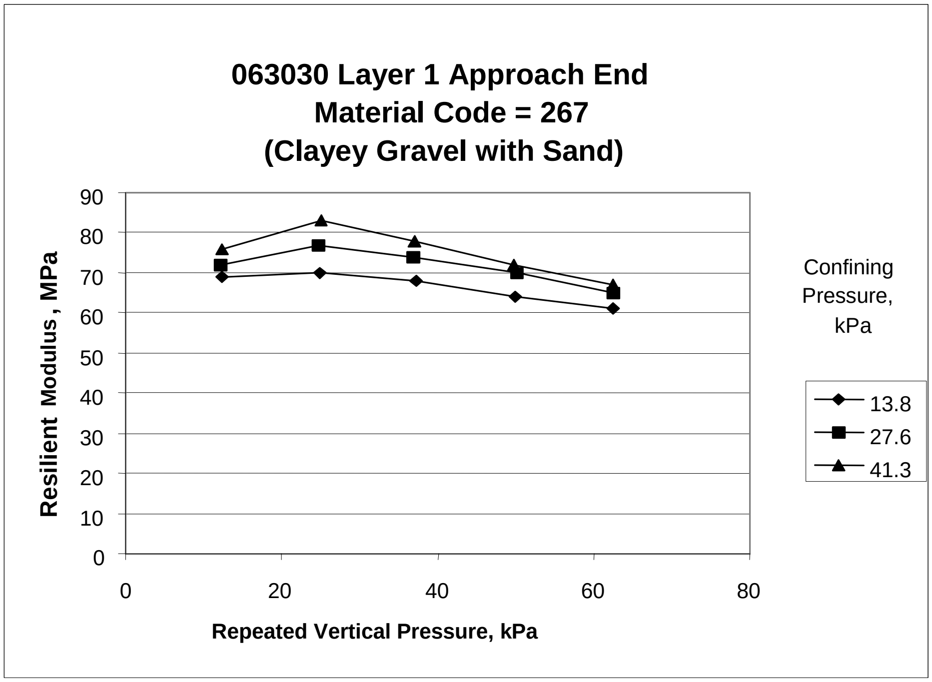



Figure 35. Sample from test section 063030, layer 1, at the approach end exhibits specimen distortion or excess softening.

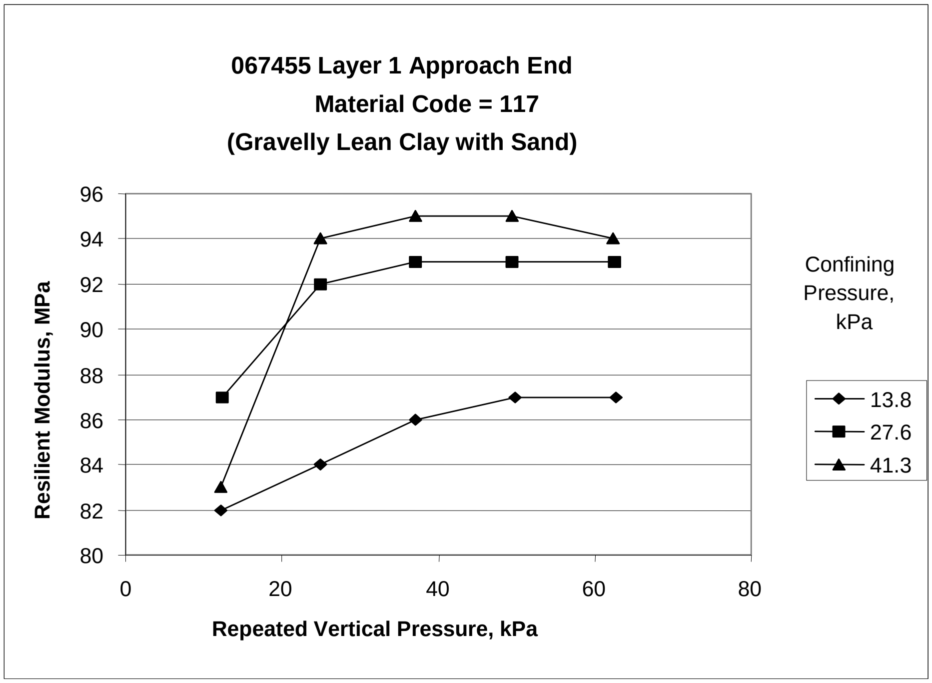



Figure 36. Sample from test section 067455, layer 1, at the approach end exhibits specimen distortion or excess softening.

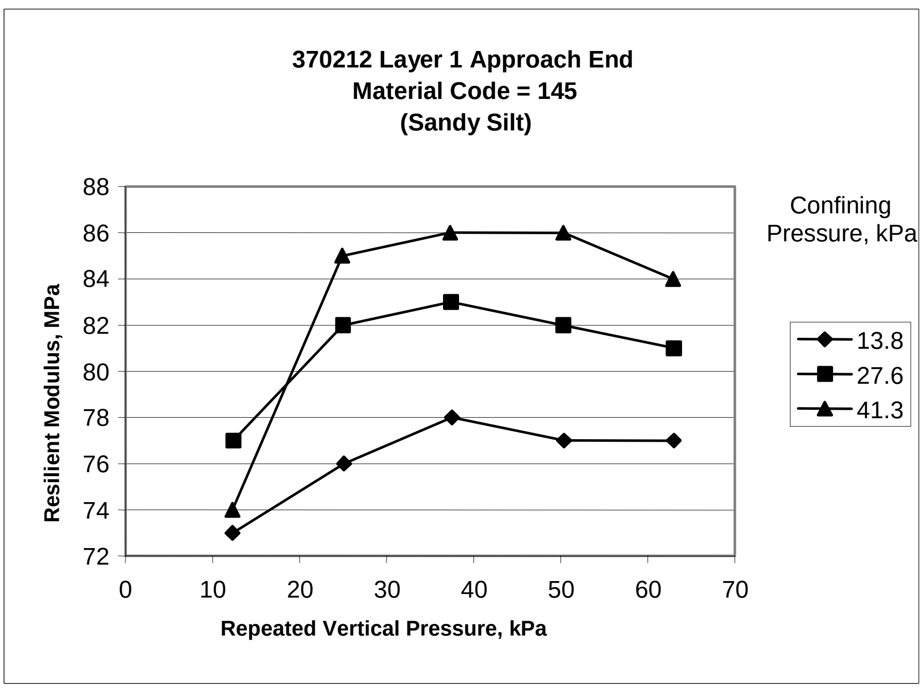



Figure 37. Sample from test section 370212, layer 1, at the approach end exhibits specimen distortion or excess softening.

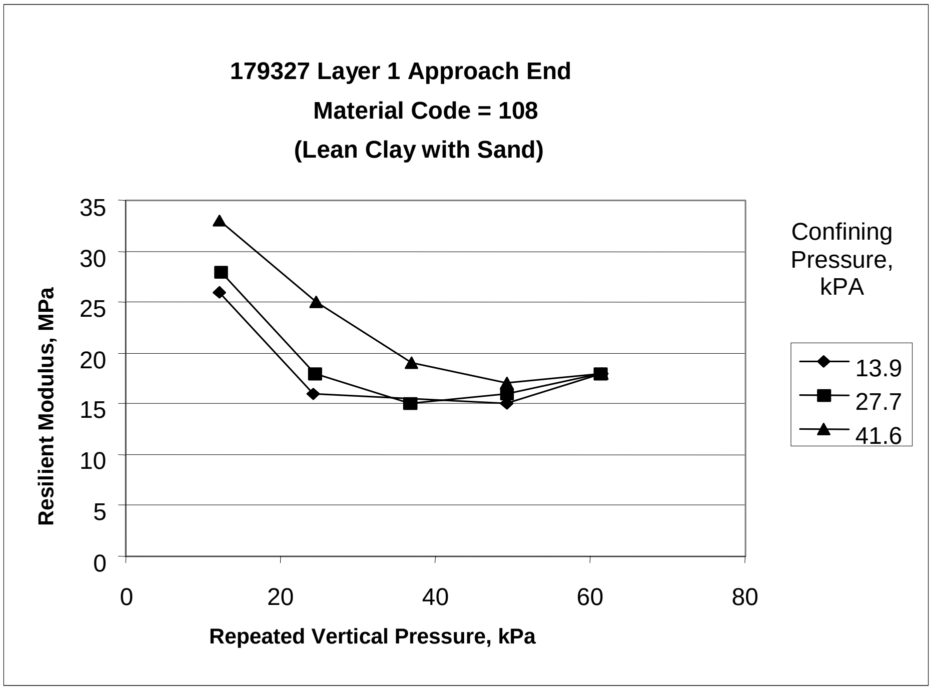



Figure 38. Sample from test section 179327, layer 1, at the approach end shows significant effect of confining pressure on resilient modulus.

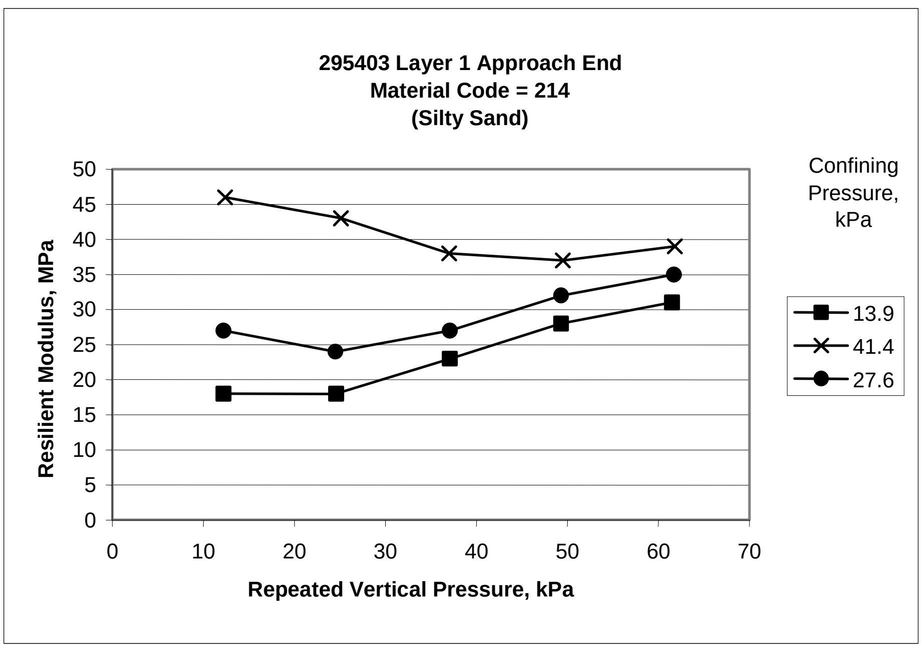



Figure 39. Sample from test section 295403, layer 1, at the approach end shows significant effect of confining pressure on resilient modulus.

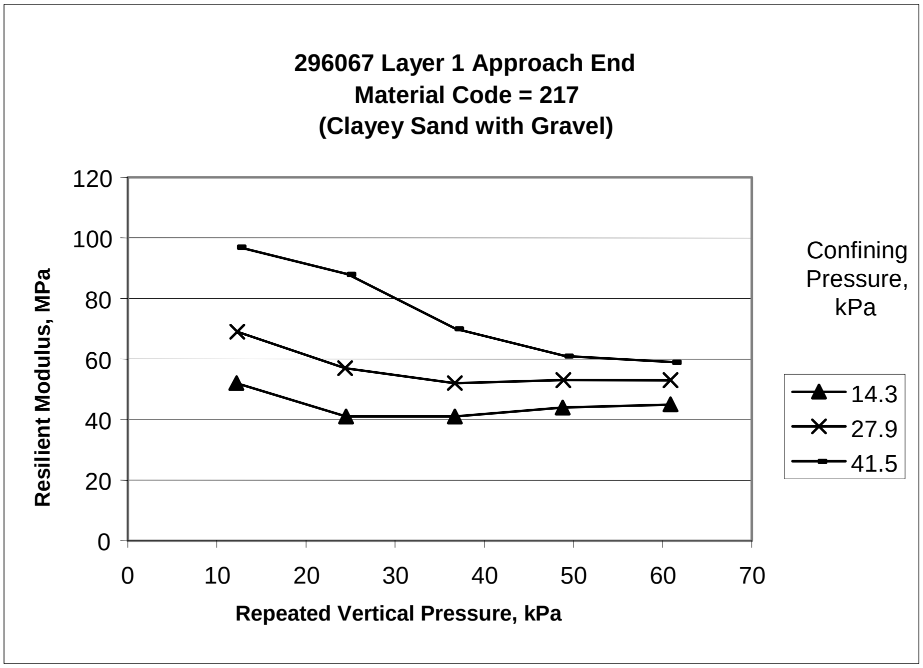



Figure 40. Sample from test section 296067, layer 1, at the approach end shows significant effect of confining pressure on resilient modulus.

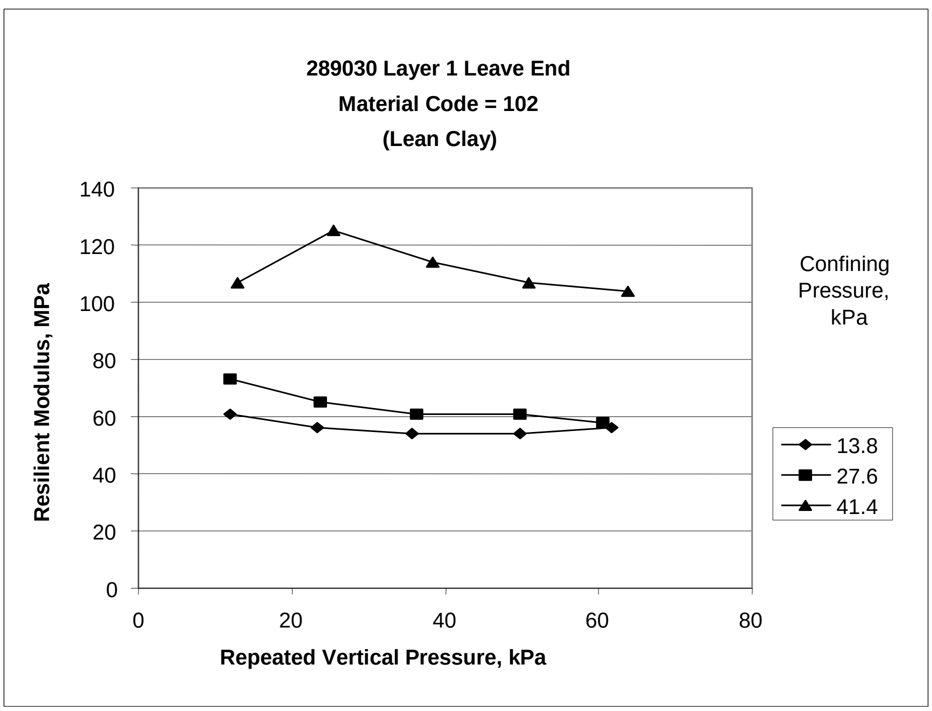



Figure 41. Sample from test section 289030, layer 1, at the leave end shows significant effect of confining pressure on resilient modulus.

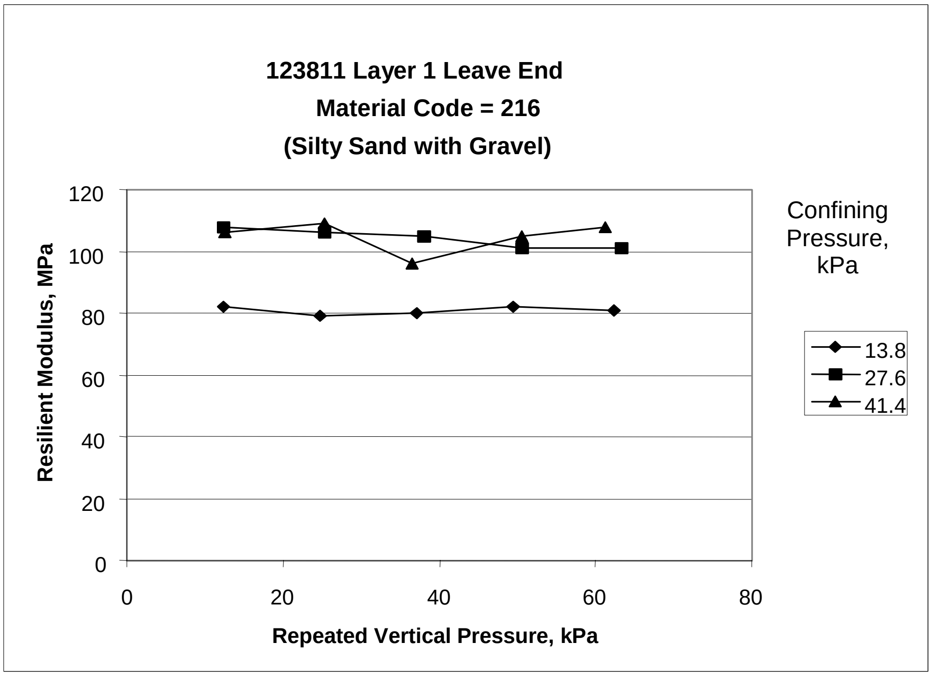



Figure 42. Sample from test section 123811, layer 1, at the leave end shows sudden drop and then increase in resilient modulus.

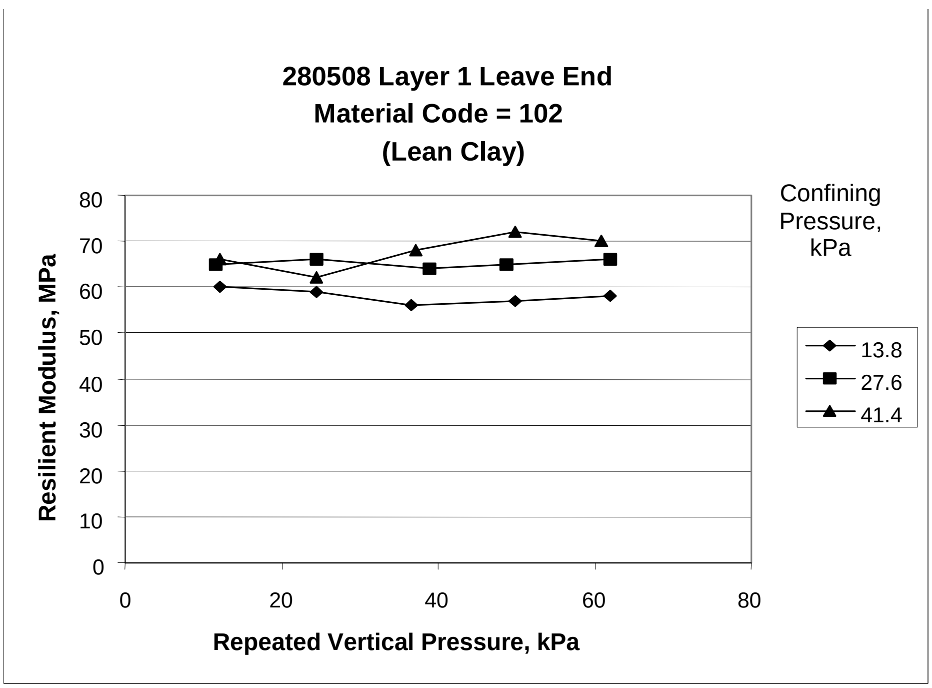



Figure 43. Sample from test section 280508, layer 1, at the leave end shows sudden drop and then increase in resilient modulus.

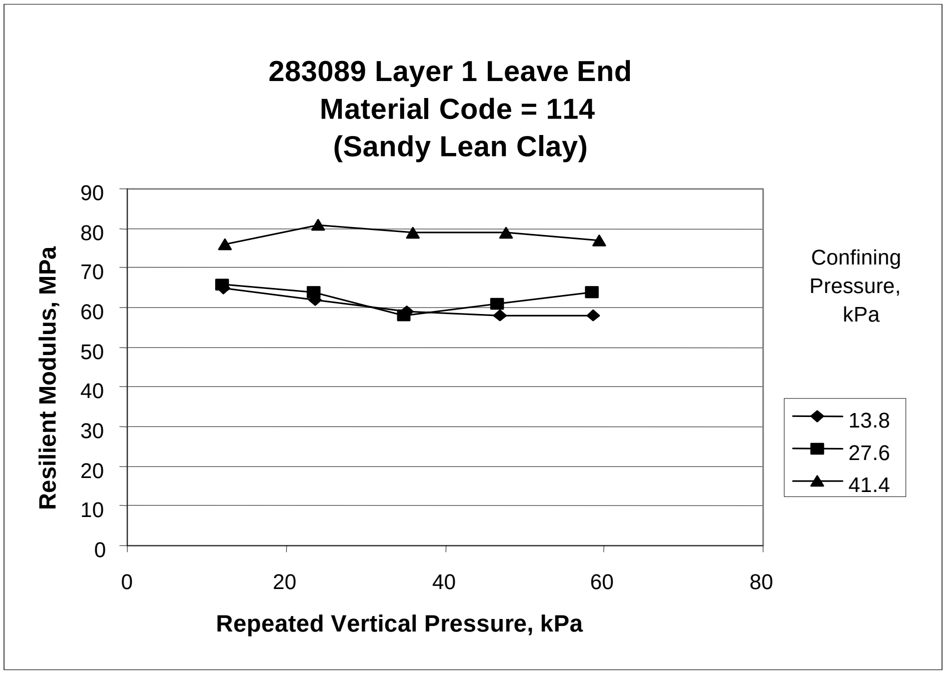



Figure 44. Sample from test section 283089, layer 1, at the leave end shows sudden drop and then increase in resilient modulus.

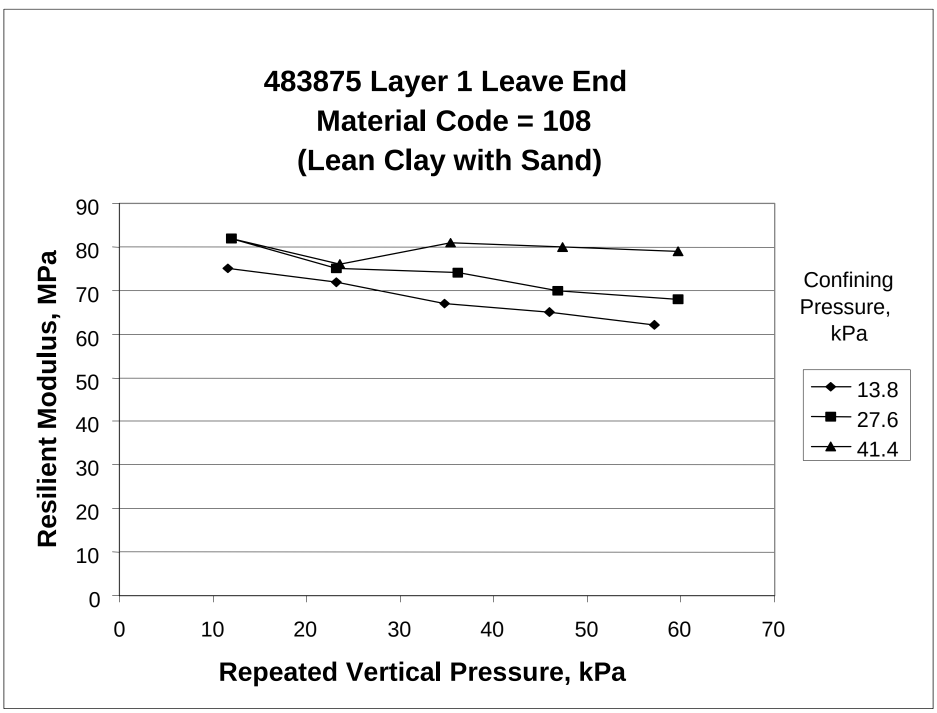



Figure 45. Sample from test section 483875, layer 1, at the leave end shows sudden drop and then increase in resilient modulus.

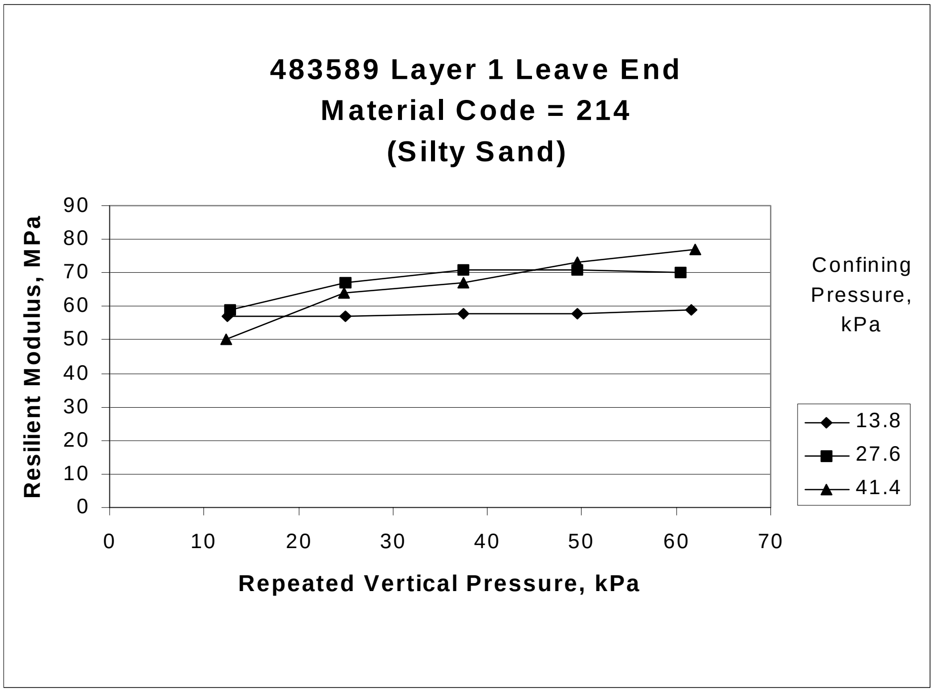



Figure 46. Sample from test section 483589, layer 1, at the leave end exhibiting localized softening or disturbance of the specimen during the test or LVDT movement.

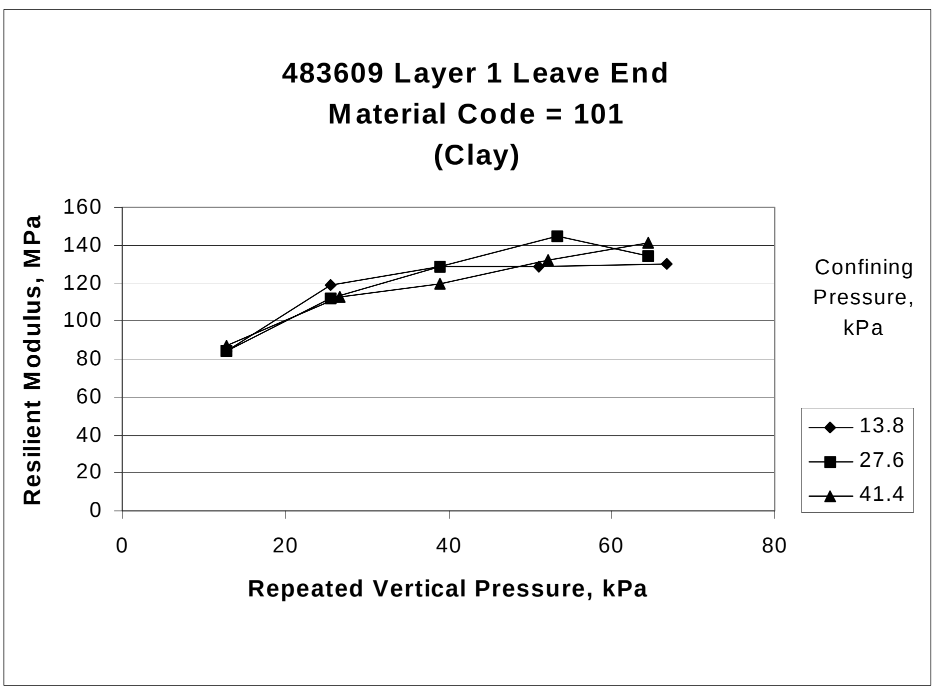



Figure 47. Sample from test section 483609, layer 1, at the leave end exhibiting localized softening or disturbance of the specimen during the test or LVDT movement.

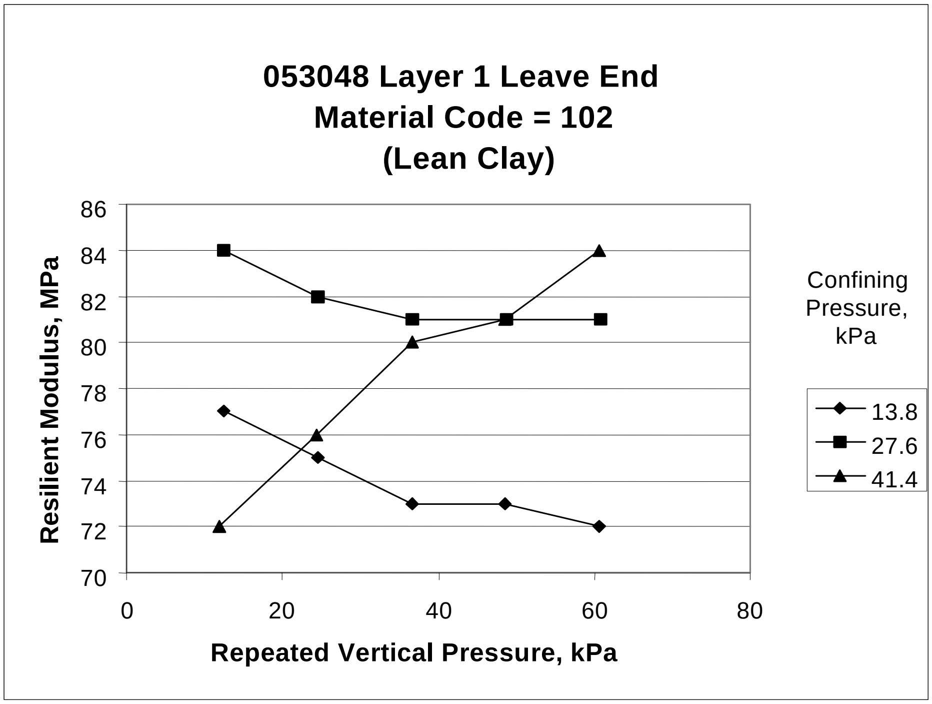



Figure 48. Sample from test section 053048, layer 1, at the leave end exhibiting localized softening or disturbance of the specimen during the test or LVDT movement.

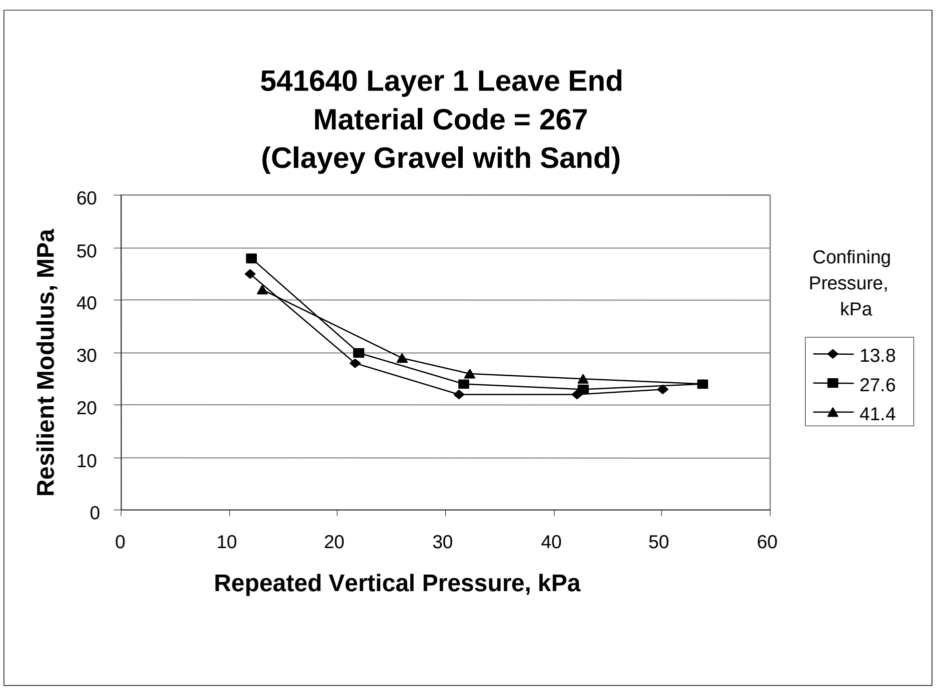



Figure 49. Sample from test section 541640, layer 1, at the leave end exhibiting localized softening or disturbance of the specimen during the test or LVDT movement.

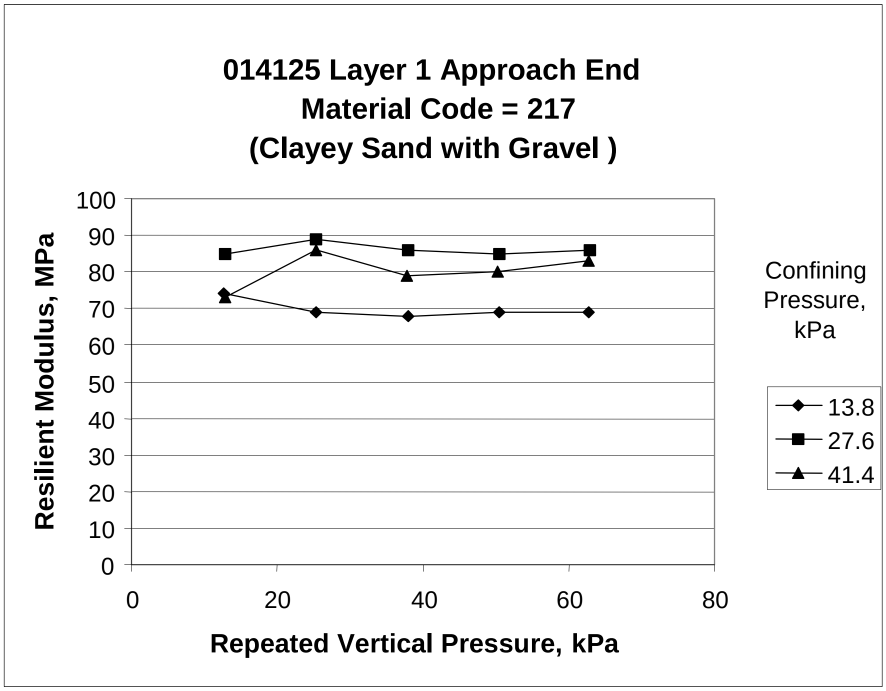



Figure 50. Sample from test section 014125, layer 1, at the approach end shows higher confining pressures result in lower resilient modulus.

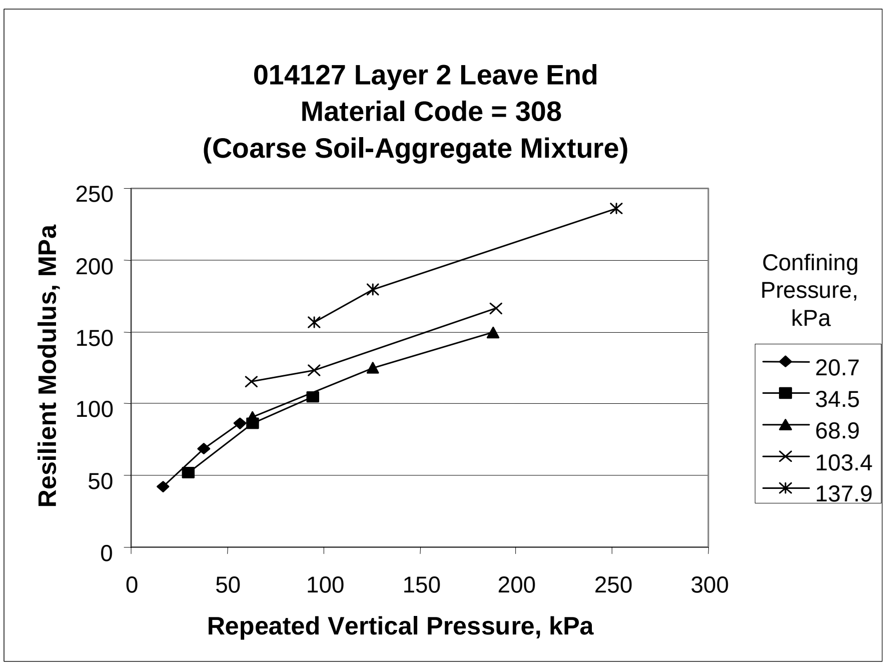



Figure 51. Sample from test section 014127, layer 1, at the leave end shows higher confining pressures result in lower resilient modulus.

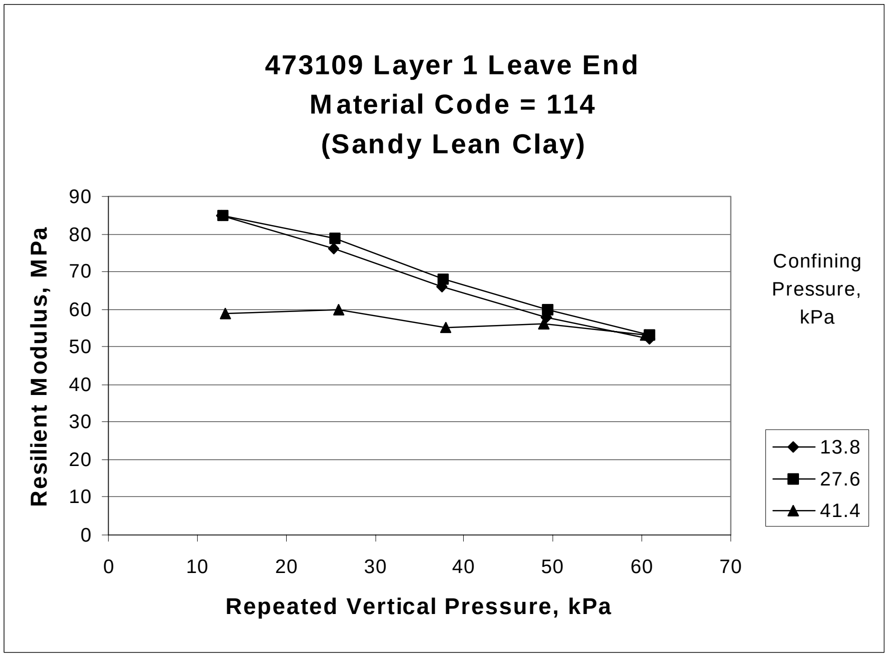



Figure 52. Sample from test section 473109, layer 1, at the leave end shows higher confining pressures result in lower resilient modulus.

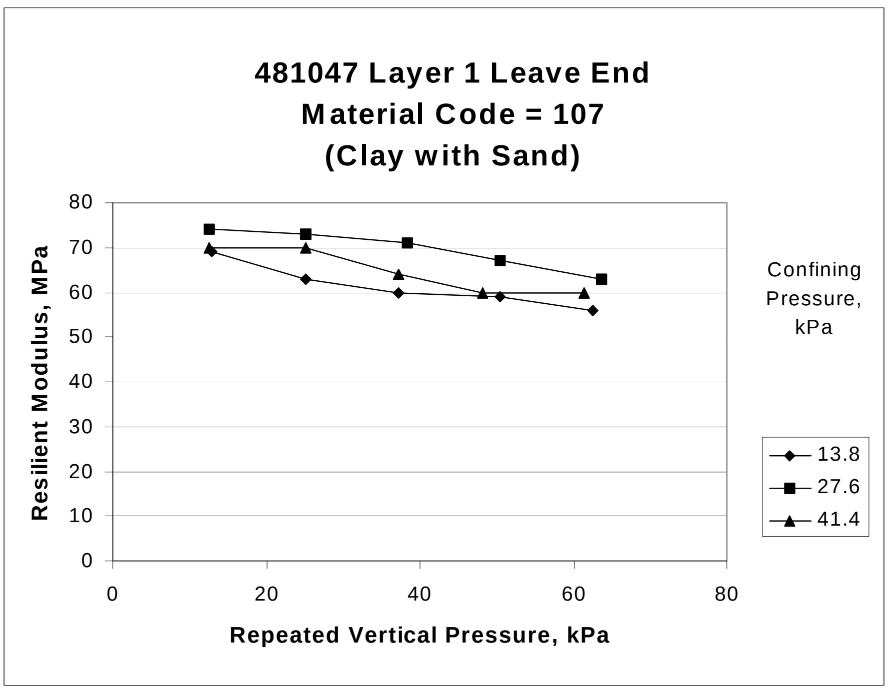



Figure 53. Sample from test section 481047, layer 1, at the leave end shows higher confining pressures result in lower resilient modulus.

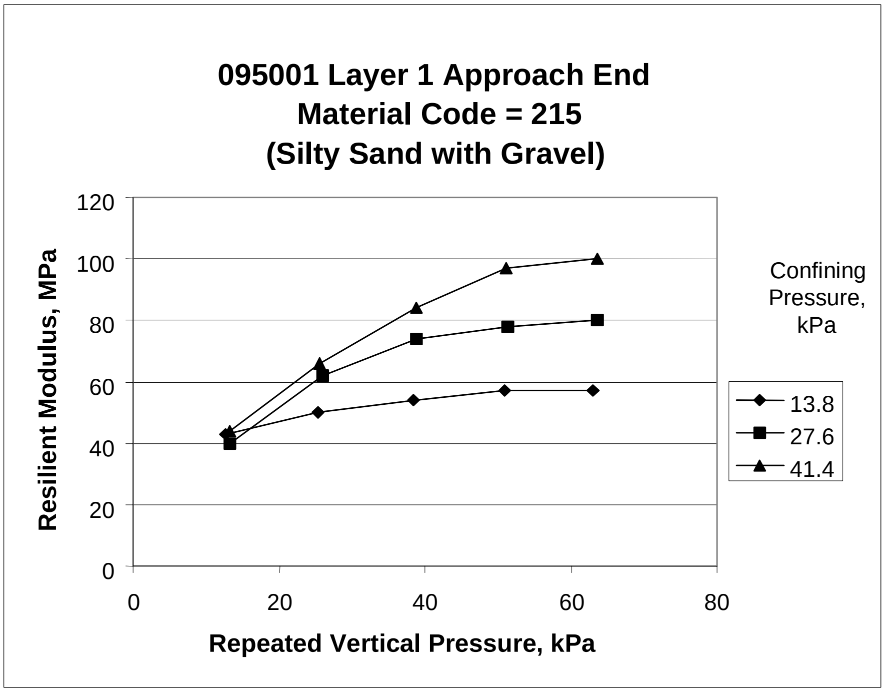



Figure 54. Sample from test section 095001, layer 1, at the approach end shows that resilient modulus is independent of confining pressure at the lowest vertical stress.

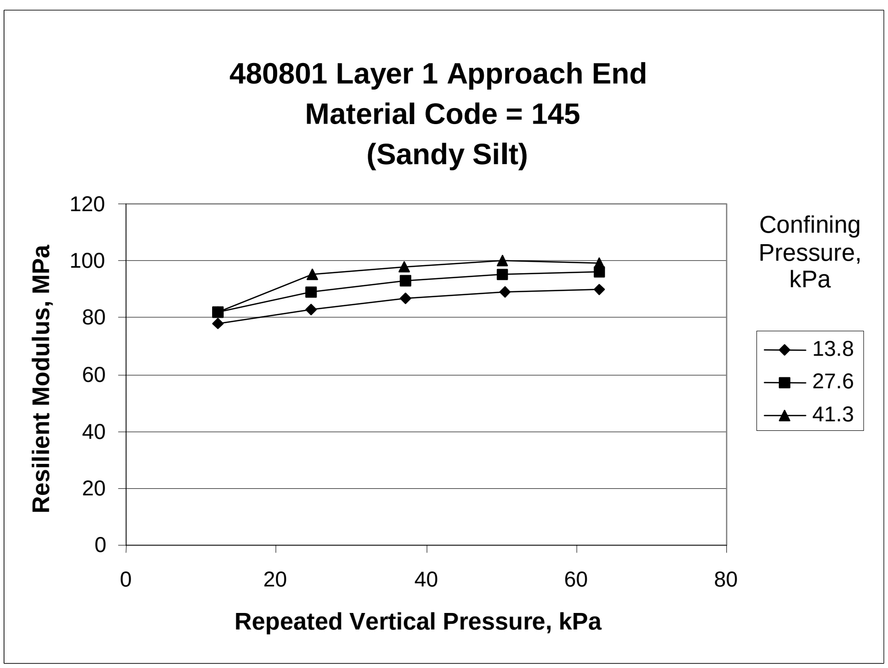



Figure 55. Sample from test section 480801, layer 1, at the approach end shows that resilient modulus is independent of confining pressure at the lowest vertical stress.

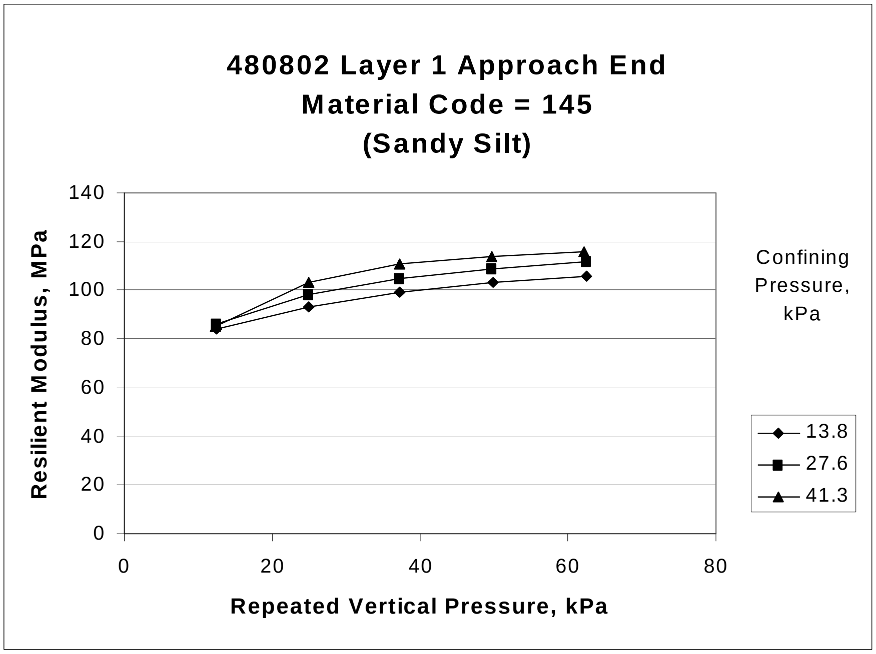



Figure 56. Sample from test section 480802, layer 1, at the approach end shows that resilient modulus is independent of confining pressure at the lowest vertical stress.

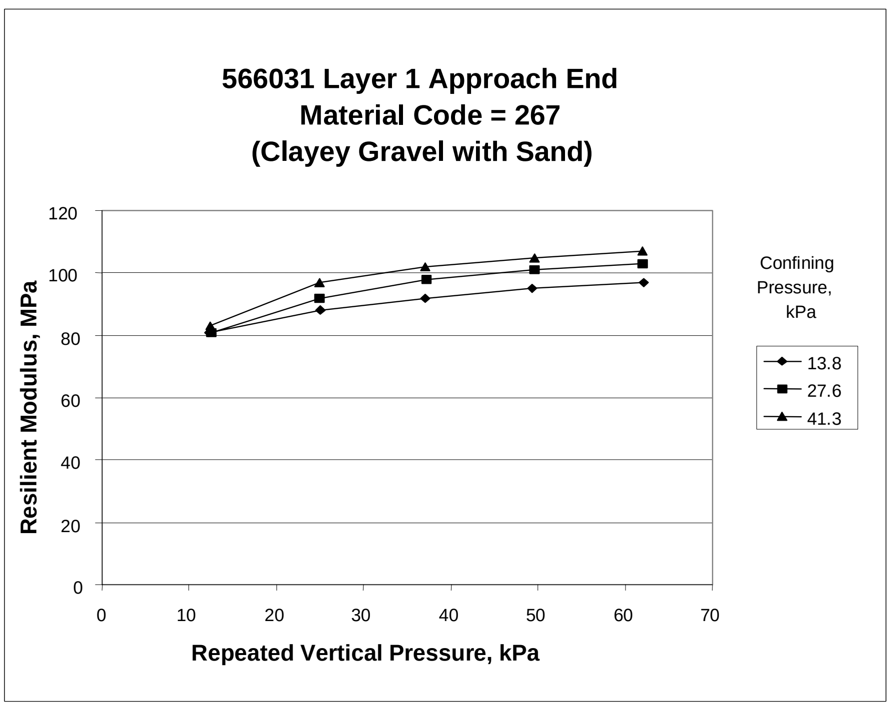



Figure 57. Sample from test section 566031, layer 1, at the approach end shows that resilient modulus is independent of confining pressure at the lowest vertical stress.

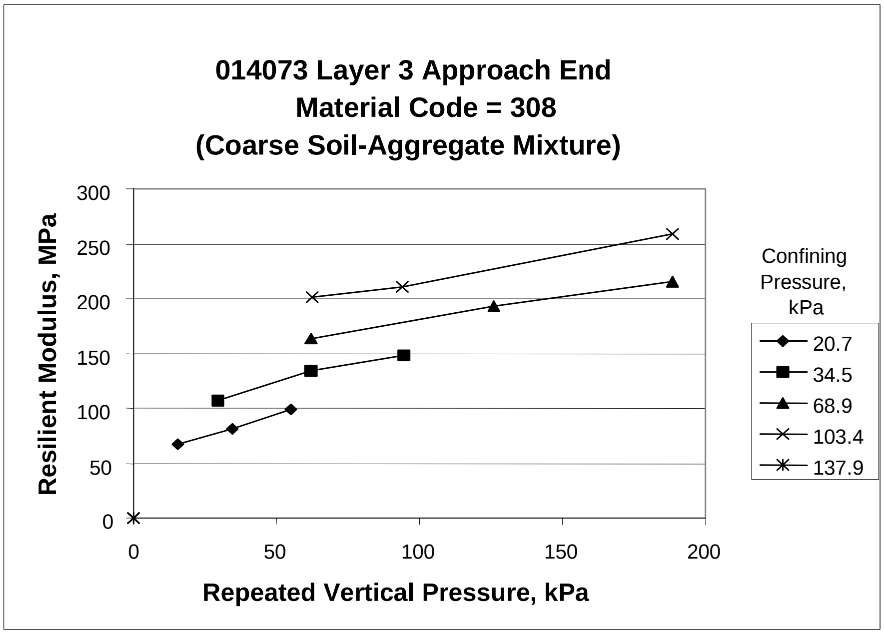



Figure 58. Sample from test section 014073, layer 3, at the approach end shows possible data entry error.

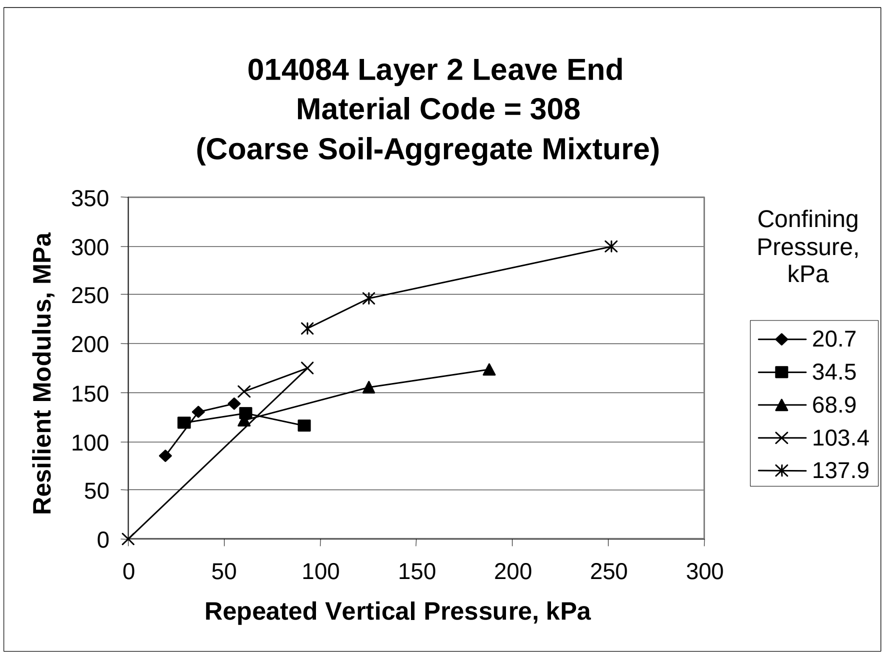



Figure 59. Sample from test section 014084, layer 2, at the leave end shows possible data entry error.

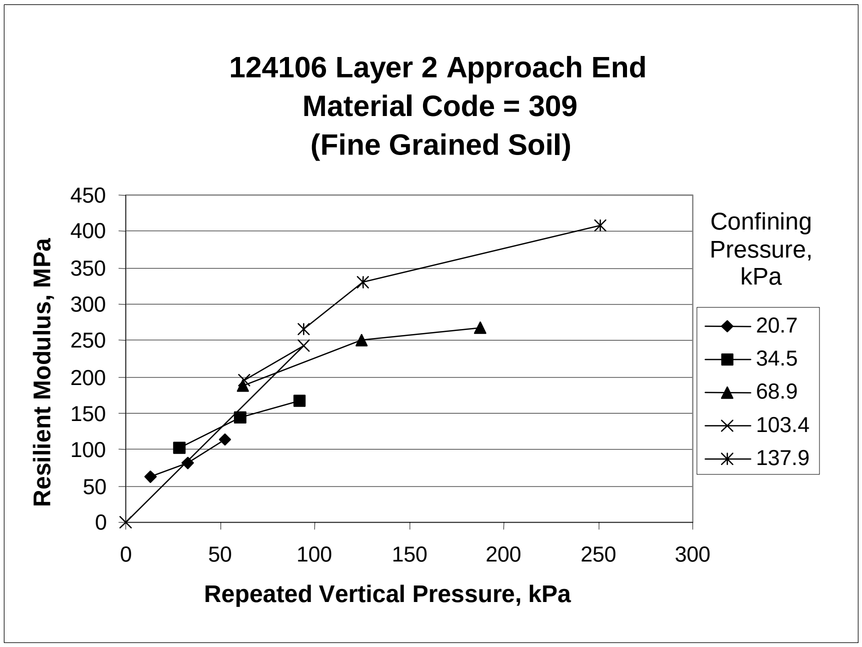



Figure 60. Sample from test section 124106, layer 2, at the approach end shows possible data entry error.

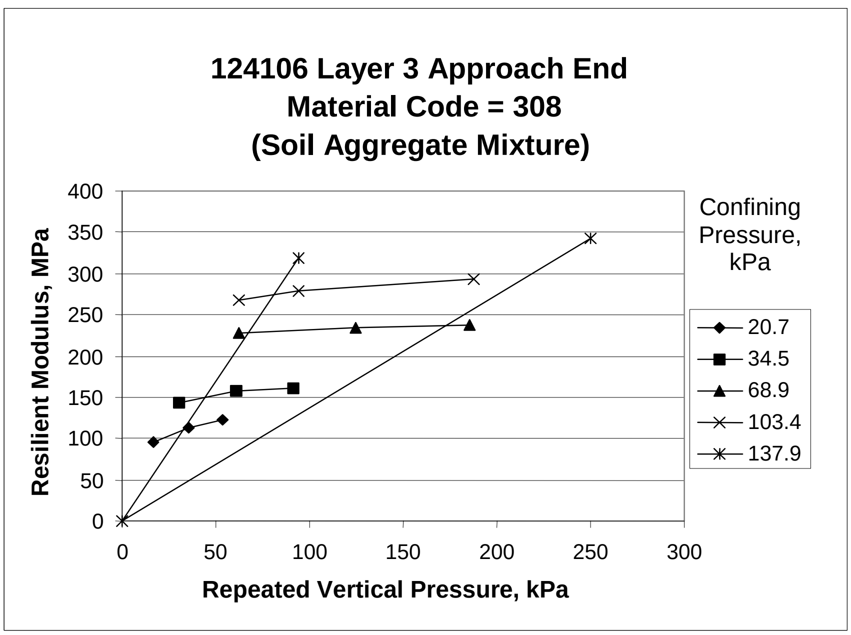



Figure 61. Sample from test section 124106, layer 3, at the approach end shows possible data entry error.

# APPENDIX C.

## SUMMARY OF THE FLAGGED RESILIENT MODULUS TESTS BY ANOMALY TYPE

Appendix C, tables 17 through 23, provides listings of all the resilient modulus tests that were flagged with the potential anomalies graphically presented in appendix B.

Table 17. Resilient modulus tests showing characteristics of exhibiting test specimen distortion or excessive softening.

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 1 | 0102 | 1 | 2 | B7 | BS07 | 0.9990 | 0.5558 | 131 | 15 | 0.6274 | -0.1670 | 1 | Failure |
| 1 | 0111 | 1 | 2 | B3 | BS03 | 0.9988 | 0.6470 | 131 | 15 | 0.7076 | 0.0259 | 1 | Failure |
| 1 | 4073 | 1 | 1 | BA* | BS** | 0.9968 | 0.8106 | 215 | 15 | 0.5578 | 0.0058 | 1 | Failure |
| 1 | 4155 | 1 | 1 | BA* | BS** | 0.9799 | 0.5513 | 214 | 15 | 0.8244 | 0.1524 | 1 | Lowest confining pressure curve behaves (concaves up) totally different from the other two (concave down). |
| 6 | 6044 | 1 | 1 | BA* | BS** | 0.9990 | 0.5689 | 145 | 15 | 0.8265 | 0.5620 | 1 | Failure |
| 6 | 7455 | 1 | 1 | BA1 | BS01 | 0.9991 | 0.5840 | 117 | 15 | 0.8015 | 0.5104 | 1 | Failure |
| 10 | 0103 | 1 | 1 | B3 | BS03 | 0.9991 | 0.6256 | 202 | 15 | 0.7127 | -0.0037 | 1 | Failure, first point of highest and mid confinement coincide. |
| 30 | 8129 | 1 | 1 | BA* | BS** | 0.9991 | 0.5361 | 117 | 15 | 0.8556 | 0.6380 | 1 | Failure at confining pressure of 41.4 kPa. |
| 37 | 0212 | 1 | 1 | B5 | BS05 | 0.9989 | 0.6214 | 145 | 15 | 0.7859 | 0.4244 | 1 | Failure |
| 42 | 1606 | 1 | 1 | BA2 | BS02 | 0.9951 | 0.9337 | 117 | 15 | 0.3327 | 0.0507 | 1 | Failure with interweaving pattern. |
| 42 | 1618 | 1 | 1 | BA* | BS** | 0.9710 | 0.9836 | 120 | 15 | 0.2168 | 0.6799 | 1 | Failure with interweaving pattern. Possible seating problem at initial stages for 41.4-kPa and 27.6-kPa confining pressure. |
| 51 | 1464 | 1 | 1 | BA* | BS** | 0.9846 | 0.9502 | 135 | 15 | 0.2958 | 0.5469 | 1 | Failure, first point on the 41.4-kPa curve lies below the other two curves. This could be due to a seating problem with the sample at 41.4 kPa. |
| 81 | 2812 | 1 | 2 | A2 | TS01 | 0.9984 | 0.7180 | 108 | 15 | 0.7314 | 0.1891 | 1 | Failure |

* - Reference to LTPP Database Code List

** - Reference to LTPP Database Code List

Table 18. Resilient modulus tests showing significant effect of confining pressure.

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 17 | 1003 | 1 | 2 | TP* | BS** | 0.9872 | 0.3804 | 102 | 15 | 0.3379 | -0.5564 | 2 | All seem to merge at end. |
| 17 | 9327 | 1 | 1 | BA* | BS** | 0.9787 | 0.5676 | 108 | 14 | -0.0863 | -0.6986 | 2 | All merged at end. |
| 18 | 3003 | 1 | 1 | BA* | BS** | 0.9807 | 0.5508 | 216 | 15 | 0.7481 | 0.1058 | 2 | |
| 18 | 5528 | 1 | 1 | BA* | BS** | 0.9792 | 0.3648 | 217 | 15 | 0.5770 | -0.2747 | 2 | |
| 27 | 4082 | 1 | 2 | TP* | BS** | 0.9814 | 0.5051 | 217 | 14 | 0.7976 | 0.0651 | 2 | Highest confining pressure curve/shape is a mirror image of the other two confining pressures. |
| 28 | 9030 | 1 | 2 | A2 | TS03 | 0.9807 | 0.4484 | 102 | 15 | 0.7436 | -0.0835 | 2 | Highest confining pressure shows failure, big gap between it and the other two curves. |
| 29 | 5403 | 1 | 1 | BA* | BS** | 0.9867 | 0.4476 | 214 | 15 | 0.8494 | 0.2330 | 2 | Failure at highest confining pressure (41.4 kPa). |
| 29 | 5413 | 1 | 1 | BA* | BS** | 0.9506 | 0.7765 | 145 | 14 | 0.6310 | 0.9024 | 2 | Points on 27.6 kPa and 41.4 kPa seem to merge at the end. |
| 29 | 6067 | 1 | 1 | BA* | BS** | 0.9942 | 0.2934 | 217 | 15 | 0.4942 | -0.4435 | 2 | |
| 36 | 1011 | 1 | 2 | TP | BS55 | 0.9828 | 0.9800 | 265 | 14 | 0.0196 | -0.1406 | 2 | All merged at end. |
| 39 | 3013 | 1 | 1 | A1 | TS02 | 0.9876 | 0.4303 | 108 | 15 | 0.0386 | -0.7283 | 2 | Highest and mid confining pressure merged at end. |
| 48 | 1047 | 1 | 1 | A1 | TS01 | 0.9855 | 0.5817 | 107 | 15 | 0.7413 | 0.1683 | 2 | Weaving of 13.8-kPa and 27.6-kPa confining pressure curves. |
| 48 | 1056 | 2 | 2 | TP1 | BG56 | 0.9890 | 0.4795 | 308 | 15 | 0.8462 | 0.4455 | 2 | Highest confining pressure concave down and all others concave up. |
| 48 | 3559 | 1 | 1 | BA* | BS** | 0.9941 | 0.5077 | 214 | 15 | 0.7649 | -0.0547 | 2 | Big gap between highest confining pressure (concave down) and the other two (concave up). |
| 48 | 5284 | 1 | 1 | BA* | BS** | 0.9928 | 0.5328 | 216 | 15 | 0.4744 | -0.3790 | 2 | First and last points of curves 13.8 kPa and 27.6 kPa coincide. |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

Table 19. Resilient modulus tests with a sudden drop and then an increase in resilient modulus.

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 1 | 4129 | 1 | 2 | TP1 | BS55 | 0.9951 | 0.7299 | 215 | 15 | 0.2770 | -0.4128 | 3 | Leak in membrane suspected for highest confining pressure. |
| 12 | 3811 | 1 | 2 | A2 | TS03 | 0.9964 | 0.5001 | 216 | 15 | 0.7180 | -0.0632 | 3 | Highest confining pressure went down and up, the other two not very stress-sensitive. |
| 28 | 0508 | 1 | 2 | A9 | TS03 | 0.9983 | 0.5757 | 102 | 15 | 0.8119 | 0.1305 | 3 | 2nd point of highest confining pressure plot below mid confining pressure. |
| 28 | 3089 | 1 | 2 | A2 | TS03 | 0.9950 | 0.5721 | 114 | 15 | 0.7298 | -0.1215 | 3 | Mid confining pressure very close to lowest confining pressure; 3rd point actually went below. |
| 45 | 1024 | 1 | 1 | A1 | TS01 | 0.9966 | 0.3753 | 217 | 15 | 0.4722 | -0.4943 | 3 | There is a sudden dip in the data at 41.4-kPa confining pressure after which the curve becomes normal; also there might be some initial seating problem at a confining pressure of 41.4 kPa. |
| 48 | 1056 | 1 | 1 | A1 | TS02 | 0.9990 | 0.6303 | 108 | 15 | 0.3895 | -0.4717 | 3 | Curve 41.4 kPa dips suddenly and also has an initial seating problem. |
| 48 | 1056 | 2 | 2 | TP1 | BG55 | 0.9863 | 0.4299 | 308 | 15 | 0.8215 | 0.6161 | 3 | Curve 137.9 kPa suddenly dips, probably due to membrane rupture. |
| 48 | 1061 | 1 | 2 | A2 | TS04 | 0.9981 | 0.5205 | 108 | 15 | 0.4530 | -0.4930 | 3 | 1st two points of highest confining pressure coincide with the mid confining pressure. |
| 48 | 1069 | 1 | 2 | A2 | TS03 | 0.9983 | 0.6191 | 103 | 15 | 0.7259 | 0.0983 | 3 | Highest confining pressure very close to mid confining pressure; 2nd point actually went below. |
| 48 | 3875 | 1 | 2 | A2 | TS04 | 0.9981 | 0.5205 | 108 | 15 | 0.4530 | -0.4930 | 3 | Highest confining pressure has a sudden dip in the middle; probably due to defective sample (air voids ?). |

* - Reference to LTPP Database Code List

** - Reference to LTPP Database Code List

Table 20. Resilient modulus tests exhibiting localized softening or disturbance of the specimen during the test or LVDT movement.

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R- Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 01 | 3028 | 1 | 1 | BA* | BS** | 0.9750 | 0.8727 | 216 | 15 | 0.4830 | 0.8360 | 4 | Highest confining pressure test plot below other two tests at beginning, possible problem with seating of specimen; all show failure at end. |
| 01 | 4073 | 1 | 2 | A2 | TS03 | 0.9618 | 0.9473 | 215 | 15 | 0.3334 | 0.9081 | 4 | Higher confining pressure test plot below lower confining pressure test at beginning, possible problem with seating of specimen. |
| 01 | 4084 | 1 | 1 | A1 | TS01 | 0.9991 | 0.5145 | 216 | 15 | 0.7123 | -0.1511 | 4 | Lowest and highest confining pressure show failure, mid confining pressure not sensitive to stress. |
| 01 | 4126 | 1 | 1 | A1 | TS01 | 0.9951 | 0.5137 | 214 | 15 | 0.4255 | -0.4975 | 4 | Highest confining pressure test plot below mid confining pressure test at beginning, possible problem with seating of specimen. |
| 04 | 1015 | 1 | 2 | TP1 | BS92 | 0.9981 | 0.6582 | 267 | 15 | 0.7576 | 0.7586 | 4 | First point of highest confining pressure plot below lowest confining pressure, seating problem suspected for specimen. |
| 04 | 1017 | 1 | 1 | BA* | BS** | 0.9945 | 0.8660 | 267 | 15 | 0.5015 | 0.9538 | 4 | Highest confining pressure test plot below other two tests at beginning, possible problem with seating of specimen. |
| 05 | 3011 | 1 | 2 | A2 | TS03 | 0.9972 | 0.6716 | 133 | 15 | 0.4038 | -0.4237 | 4 | Failure at highest confining pressure. |
| 05 | 3048 | 1 | 2 | A2 | TS03 | 0.9977 | 0.8997 | 102 | 15 | 0.4530 | 0.1170 | 4 | 1st point of highest confining pressure plot below lowest confining pressure test. |
| 05 | 3073 | 1 | 1 | BA* | BS** | 0.9945 | 0.7465 | 265 | 15 | 0.2842 | -0.4630 | 4 | Highest confining pressure test went wild! |
| 05 | 4021 | 1 | 1 | A1 | TS01 | 0.9841 | 0.9319 | 265 | 15 | -0.1699 | -0.3471 | 4 | Highest confining pressure test went wild! |
| 05 | 5803 | 1 | 1 | BA* | BS** | 0.9964 | 0.7366 | 217 | 15 | 0.7201 | 0.4326 | 4 | Each confining test weaves in and out with the others. |
| 05 | 5805 | 1 | 2 | BA* | BS** | 0.9958 | 0.6178 | 282 | 15 | 0.7947 | 0.5935 | 4 | Mid confining pressure behaves (concaves down) totally different from the other two (concave up). |
| 08 | 7783 | 1 | 2 | TP1 | BS93 | 0.9876 | 0.5139 | 216 | 15 | -0.2180 | -0.7920 | 4 | Three confining pressures close to each other. |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

Table 20. Resilient modulus tests exhibiting localized softening or disturbance of the specimen during the test or LVDT movement (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R- Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 12 | 4000 | 1 | 1 | A1 | TS01 | 0.9723 | 0.9658 | 214 | 15 | 0.1921 | 0.4881 | 4 | Leak in membrane for highest confining pressure, it almost coincides with the lowest confining pressure. |
| 12 | 4059 | 1 | 2 | BA* | BS** | 0.9948 | 0.5249 | 202 | 15 | 0.8610 | 0.2460 | 4 | Mid confining pressure behaves differently from the other two, possible rupture of membrane in the middle of the test. |
| 12 | 4102 | 1 | 1 | A1 | TS02 | 0.9713 | 0.7394 | 204 | 15 | 0.6884 | 0.8606 | 4 | Beginning of highest confining pressure plot below the other two, Seating problem? |
| 12 | 4103 | 1 | 1 | BA* | BS** | 0.8766 | 0.8768 | 214 | 15 | 0.4853 | 0.9543 | 4 | Each confining test weaves in and out with the others. |
| 15 | 1003 | 1 | 1 | BA* | BS** | 0.9964 | 0.5461 | 145 | 15 | 0.8346 | 0.8442 | 4 | 1st point of highest confining pressure plot below mid confining pressure test. |
| 16 | 6027 | 1 | 2 | TP1 | BS93 | 0.9937 | 0.7566 | 255 | 15 | 0.6592 | 0.9273 | 4 | 1st point of all confining pressures are out of order, possible problem with seating of sample. |
| 17 | 5854 | 1 | 1 | BA* | BS** | 0.9856 | 0.6732 | 108 | 15 | -0.2648 | -0.6812 | 4 | All merged at end. |
| 21 | 6040 | 1 | 1 | BA* | BS** | 0.9957 | 0.7271 | 108 | 15 | 0.6858 | 0.9062 | 4 | 1st half of highest confining pressure plot below mid confining pressure. |
| 22 | 0118 | 1 | 2 | B4 | BS04 | 0.9978 | 0.5966 | 101 | 15 | 0.7986 | 0.8203 | 4 | 1st point of highest confining pressure plot below mid confining pressure test. |
| 28 | 1016 | 1 | 1 | A1 | TS01 | 0.9887 | 0.3869 | 214 | 15 | 0.8582 | 0.1640 | 4 | 1st point of highest confining pressure plot below mid confining pressure, big gap between the lowest and the other two curves. |
| 28 | 3018 | 1 | 2 | A2 | TS03 | 0.9959 | 0.5013 | 214 | 15 | 0.1695 | -0.6590 | 4 | Highest confining pressure below mid confining pressure except last point. |
| 28 | 3081 | 1 | 1 | A1 | TS01 | 0.9931 | 0.7821 | 216 | 15 | 0.1502 | -0.4899 | 4 | Highest confining pressure crossing the other two curves. |
| 28 | 3090 | 1 | 1 | A1 | TS01 | 0.9885 | 0.6523 | 143 | 15 | 0.2925 | -0.5250 | 4 | 1st point of highest confining pressure plot below lowest confining pressure test. |
| 28 | 3097 | 1 | 1 | A1 | TS01 | 0.9693 | 1.0000 | 141 | 15 | -0.2393 | -0.0113 | 4 | Highest confining pressure crossing the other two curves. |
| 28 | 3099 | 1 | 1 | A1 | TS01 | 0.9960 | 0.8400 | 103 | 15 | 0.4192 | -0.1249 | 4 | Highest confining pressure crossing the other two curves. |

Table 20. Resilient modulus tests exhibiting localized softening or disturbance of the specimen during the test or LVDT movement (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 34 | 1033 | 1 | 2 | TP | BS55 | 0.9965 | 0.5103 | 267 | 15 | 0.5167 | -0.4152 | 4 | 1st point of highest confining pressure plot below mid confining pressure test. |
| 35 | 1022 | 1 | 1 | A1 | TS01 | 0.9943 | 0.4376 | 204 | 15 | 0.4313 | -0.4923 | 4 | 1st point of highest confining pressure plot below mid confining pressure test. |
| 35 | 2118 | 1 | 1 | A1 | TS01 | 0.9944 | 0.8583 | 214 | 15 | 0.4930 | 0.7739 | 4 | Data points at different confining pressures form a weaving pattern. |
| 35 | 3010 | 1 | 1 | A1 | TS01 | 0.9907 | 0.5846 | 202 | 15 | 0.8301 | 0.6993 | 4 | 1st point of highest confining pressure plots below mid & lowest confining pressure test. |
| 37 | 1024 | 1 | 2 | TP | BS55 | 0.9874 | 0.5150 | 214 | 14 | 0.0140 | -0.7077 | 4 | Data points of confining pressures 13.8 kPa and 27.6 kPa form a weaving pattern. |
| 37 | 1352 | 1 | 2 | TP | BS55 | 0.9927 | 1.0000 | 141 | 15 | 0.0570 | 0.0980 | 4 | Data points at different confining pressures form a weaving pattern. |
| 37 | 1803 | 1 | 2 | TP | BS55 | 0.9960 | 0.5124 | 144 | 15 | 0.4728 | -0.4673 | 4 | 1st point of highest confining pressure plot below mid confining pressure test. |
| 37 | 1992 | 1 | 1 | BA* | BS** | 0.9981 | 0.5061 | 215 | 15 | 0.5541 | -0.3762 | 4 | Data points of confining pressures 41.4 kPa and 27.6 kPa form a weaving pattern. |
| 37 | 2825 | 1 | 2 | TP | BS55 | 0.9964 | 0.8159 | 204 | 15 | 0.5545 | -0.0093 | 4 | Data points of confining pressures 41.4 kPa and 27.6 kPa form a weaving pattern. |
| 37 | 3011 | 1 | 1 | BA* | BS** | 0.9962 | 0.6789 | 216 | 15 | 0.6536 | -0.0090 | 4 | Data points of confining pressures 41.4 kPa and 27.6 kPa form a weaving pattern. |
| 37 | 5037 | 1 | 1 | BA* | BS** | 0.9865 | 0.6047 | 215 | 15 | 0.2836 | -0.5465 | 4 | 1st point of highest confining pressure plot below mid confining pressure test. |
| 40 | 0116 | 1 | 2 | B2 | BS02 | 0.9987 | 0.5134 | 113 | 15 | 0.8543 | 0.6704 | 4 | 1st point of highest confining pressure plot below mid confining pressure test. |
| 40 | 4087 | 1 | 2 | BA* | BS** | 0.9319 | 0.9479 | 108 | 15 | 0.3259 | 0.9272 | 4 | Weaving pattern seen. |
| 40 | 4161 | 1 | 1 | A1 | TS01 | 0.9814 | 0.9226 | 214 | 15 | 0.4172 | 0.8217 | 4 | Weaving pattern seen. |
| 40 | 4161 | 1 | 2 | A2 | TS03 | 0.9833 | 0.8917 | 214 | 15 | 0.4912 | 0.1678 | 4 | Weaving pattern seen and soil seems to be stress-insensitive. |
| 40 | 4166 | 1 | 1 | BA* | BS** | 0.9917 | 0.8673 | 114 | 15 | 0.5024 | 0.8040 | 4 | Data at confining pressure of 41.4 kPa weaves through the data at the other two confining pressures. |
| 40 | 5021 | 1 | 2 | A2 | TS01 | 0.9848 | 0.9433 | 265 | 15 | -0.3253 | -0.3316 | 4 | Data at confining pressure of 41.4 kPa weaves through the data at the other two confining pressures. |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

Table 20. Resilient modulus tests exhibiting localized softening or disturbance of the specimen during the test or LVDT movement (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 40 | 6010 | 1 | 2 | BA* | BS** | 0.9971 | 0.5426 | 217 | 15 | 0.7421 | -0.0317 | 4 | Data points at confining pressure of 41.4 kPa weave through the data points at a confining pressure of 27.6 kPa. |
| 40 | 7024 | 1 | 2 | A2 | TS03 | 0.9897 | 0.7258 | 214 | 15 | 0.1761 | -0.5484 | 4 | First point of highest confining pressure plot below lowest confining pressure, seating problem suspected for specimen. |
| 42 | 1597 | 1 | 2 | TP | BS55 | 0.9797 | 0.8934 | 111 | 15 | 0.4510 | 0.8784 | 4 | Curves 41.4 kPa and 27.6 kPa lower than the curve at 13.8 kPa during initial stages of the test. Could be a seating problem or leak in pressure during the initial stages of the test. |
| 42 | 1598 | 1 | 2 | BA6 | BS06 | 0.9162 | 0.9553 | 217 | 15 | 0.3077 | 0.9222 | 4 | Curves 41.4 kPa and 27.6 kPa lower than the curve at 13.8 kPa during initial stages of the test. Could be a seating problem or leak in pressure during the initial stages of the test. |
| 42 | 1605 | 1 | 2 | TP | BS55 | 0.9889 | 0.4388 | 267 | 14 | -0.1774 | -0.8089 | 4 | First point on the 41.4-kPa curve which is slightly below the first point on the 27.6 kPa curve. Initial seating problem for 41.4 kPa? |
| 42 | 1690 | 1 | 1 | BA* | BS** | 0.9944 | 0.6388 | 146 | 15 | 0.8085 | 0.3473 | 4 | Weaving pattern, with seating problem for a pressure of 27.6 kPa. Also the soil seems to stress-insensitive. |
| 42 | 7037 | 1 | 2 | BA* | BS** | 0.9977 | 0.5600 | 267 | 15 | 0.5678 | -0.3326 | 4 | Weaving pattern, with seating problem for a pressure of 41.1. Also, the soil seems stress-insensitive. |
| 42 | 9027 | 1 | 2 | BA* | BS** | 0.9980 | 0.6105 | 267 | 15 | 0.5527 | -0.3264 | 4 | Weaving pattern, with seating problem for a pressure of 27.6 kPa. Also, the soil seems stress-insensitive. |
| 45 | 1008 | 1 | 2 | A2 | TS03 | 0.9829 | 0.8335 | 214 | 15 | 0.5816 | 0.6383 | 4 | Weaving pattern, with seating problem for a pressure of 41.4 kPa. Also, the soil seems stress-insensitive during the latter part of the test. |
| 45 | 1011 | 2 | 1 | BA* | BG** | 0.9862 | 0.3155 | 308 | 15 | 0.9521 | 0.8993 | 4 | Weaving pattern. The first point at every pressure is below the curve at an immediately lower pressure. Probably seating problems at the initial stages of the test. |
| 47 | 1029 | 1 | 2 | TP1 | BS55 | 0.9953 | 0.6113 | 217 | 15 | 0.3157 | -0.5409 | 4 | Seating problem with 41.4 kPa. |
| 47 | 2008 | 1 | 2 | A2 | TS03 | 0.9924 | 0.7033 | 131 | 15 | 0.1024 | -0.6179 | 4 | Seating problem with 41.4 kPa. |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

Table 20. Resilient modulus tests exhibiting localized softening or disturbance of the specimen during the test or LVDT movement (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 47 | 3101 | 1 | 1 | A1 | TS01 | 0.9803 | 0.9283 | 109 | 15 | 0.3780 | 0.5898 | 4 | Weaving pattern with the 41.4-kPa curve lower than that of 27.6 kPa. Probable initial seating problems and also a leak in pressure at 41.4 kPa. |
| 47 | 6022 | 1 | 1 | A1 | TS01 | 0.9959 | 0.4761 | 114 | 15 | 0.4705 | -0.4557 | 4 | Curves at pressure 41.4 kPa and 27.6 kPa weave through each other. Leak in pressure at level 41.4 kPa? |
| 48 | 0801 | 1 | 3 | A5 | TS09 | 0.9983 | 0.6001 | 145 | 15 | 0.7146 | -0.0544 | 4 | Failure with seating problem at 41.4 kPa? |
| 48 | 1046 | 2 | 1 | BA* | BG** | 0.9832 | 0.3962 | 309 | 13 | 0.9336 | 0.8257 | 4 | Seating problem with 34.5 and 68.9 kPa? |
| 48 | 1069 | 1 | 1 | BA* | BS** | 0.9993 | 0.7093 | 103 | 15 | 0.7223 | 0.3748 | 4 | 1st point of highest and lowest confining pressure coincide. |
| 48 | 1092 | 1 | 1 | BA* | BS** | 0.9909 | 1.0000 | 143 | 15 | -0.1710 | 0.1423 | 4 | All three curves cross each other. |
| 48 | 1094 | 1 | 2 | TP1 | BS55 | 0.9929 | 0.5702 | 217 | 15 | 0.8159 | 0.7139 | 4 | Mid confining pressure crosses the other two curves. |
| 48 | 1111 | 1 | 2 | A2 | TS03 | 0.9837 | 0.9019 | 216 | 15 | 0.4419 | 0.8732 | 4 | All three curves cross each other. |
| 48 | 1111 | 1 | 1 | A1 | TS01 | 0.9910 | 0.9958 | 216 | 15 | 0.0569 | -0.0743 | 4 | Highest confining pressure crosses the other two curves. |
| 48 | 1113 | 1 | 2 | A2 | TS03 | 0.9513 | 0.9895 | 114 | 15 | 0.1790 | 0.7852 | 4 | All three curves cross each other. |
| 48 | 1116 | 1 | 1 | A1 | TS01 | 0.9957 | 0.9128 | 114 | 15 | 0.4004 | 0.2941 | 4 | All three curves cross each other. |
| 48 | 1130 | 1 | 2 | A2 | TS03 | 0.9798 | 0.9423 | 109 | 15 | 0.3352 | 0.9155 | 4 | Highest confining pressure below mid confining pressure and crosses the lowest confining pressure curve. |
| 48 | 1181 | 1 | 2 | BA* | BS** | 0.9829 | 0.7838 | 114 | 15 | 0.6034 | 0.7567 | 4 | Mid confining pressure crosses the other two curves. |
| 48 | 1183 | 1 | 2 | A2 | TS03 | 0.9940 | 0.8556 | 114 | 15 | 0.3563 | -0.1881 | 4 | Highest confining pressure below mid confining pressure and crosses the lowest confining pressure curve. |
| 48 | 3003 | 1 | 1 | A1 | TS01 | 0.9959 | 0.9410 | 103 | 15 | 0.4018 | 0.5168 | 4 | All three curves cross each other. |
| 48 | 3010 | 1 | 2 | BA* | BS** | 0.9988 | 0.7834 | 102 | 15 | -0.0756 | -0.5581 | 4 | All three curves are very close and cross each other. |
| 48 | 3579 | 1 | 1 | A1 | TS01 | 0.9985 | 0.5796 | 114 | 15 | 0.7667 | 0.2049 | 4 | Highest confining pressure crosses mid confining pressure. |
| 48 | 3589 | 1 | 2 | A2 | TS03 | 0.9927 | 0.7455 | 214 | 15 | 0.6881 | 0.6033 | 4 | Highest confining pressure crosses the other two curves. |

* - Reference to LTPP Database Code List

** - Reference to LTPP Database Code List

Table 20. Resilient modulus tests exhibiting localized softening or disturbance of the specimen during the test or LVDT movement (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 48 | 3609 | 1 | 1 | A1 | TS01 | 0.9981 | 0.5103 | 101 | 15 | 0.1417 | -0.6404 | 4 | Highest confining pressure crosses the other two curves. |
| 48 | 3609 | 1 | 2 | A2 | TS03 | 0.9797 | 0.8954 | 101 | 15 | 0.4350 | 0.8887 | 4 | All three curves are very close and cross each other. |
| 48 | 3689 | 1 | 2 | A2 | TS03 | 0.9766 | 0.8534 | 113 | 15 | 0.5666 | 0.7254 | 4 | Lowest confining pressure crosses the other two curves and data entry error for mid confining pressure. |
| 48 | 3729 | 1 | 1 | A1 | TS01 | 0.9941 | 0.6437 | 102 | 15 | 0.6323 | -0.1869 | 4 | Highest confining pressure (concave down) crossed the other two (concave up). |
| 48 | 3749 | 1 | 1 | A1 | TS02 | 0.9973 | 0.8904 | 216 | 15 | 0.4979 | 0.5238 | 4 | All three curves cross each other. |
| 48 | 3749 | 1 | 2 | A2 | TS03 | 0.9890 | 1.0000 | 216 | 15 | -0.0034 | 0.1366 | 4 | Highest confining pressure (concave down) crossed the other two (concave up). |
| 48 | 3769 | 1 | 1 | BA* | BS** | 0.9975 | 0.6711 | 215 | 15 | 0.6232 | -0.1880 | 4 | Highest confining pressure (concave down) crossed the other two (concave up). |
| 48 | 3779 | 1 | 1 | A1 | TS01 | 0.9931 | 0.5885 | 109 | 15 | -0.1265 | -0.7517 | 4 | Lowest confining pressure crosses mid confining pressure. |
| 48 | 4142 | 1 | 1 | A1 | TS01 | 0.9943 | 0.7639 | 216 | 15 | 0.6560 | 0.5129 | 4 | First point of highest confining pressure plot below lowest confining pressure, seating problem suspected for specimen. |
| 48 | 5026 | 1 | 1 | A1 | TS01 | 0.9959 | 1.0000 | 103 | 15 | -0.1073 | 0.3915 | 4 | All three curves cross each other. |
| 48 | 5154 | 1 | 1 | A1 | TS02 | 0.9800 | 1.0000 | 216 | 15 | -0.3015 | 0.2044 | 4 | Leak in pressure for the highest confining pressure, hence it crosses the other two curves. |
| 48 | 5278 | 1 | 1 | BA* | BS** | 0.9963 | 0.6317 | 217 | 15 | 0.6168 | -0.0005 | 4 | Leak in pressure for 41.4-kPa sample, hence it falls below the 27.6-kPa curve. Could be due to rupture in membrane. |
| 48 | 5310 | 1 | 2 | BA* | BS** | 0.9888 | 0.6436 | 214 | 15 | 0.7688 | 0.8089 | 4 | First point of 27.6 kPa falls below that of 13.8 kPa. This could be due to a seating problem for the sample at 27.6 kPa. |
| 48 | 5323 | 1 | 2 | A2 | TS03 | 0.9688 | 0.9522 | 108 | 15 | 0.3180 | 0.8322 | 4 | Curves 27.6 kPa and 41.4 kPa fall below curve 13.8 kPa for the first half of the test and during the second half, curve 41.4 kPa is below curve 27.6 kPa. This could be due to seating problems or leak in pressure. |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

Table 20. Resilient modulus tests exhibiting localized softening or disturbance of the specimen during the test or LVDT movement (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 48 | 5334 | 1 | 2 | A2 | TS03 | 0.9940 | 0.5232 | 114 | 15 | 0.2214 | -0.6071 | 4 | First point of 27.6 kPa falls below that of 13.8 kPa. This could be due to a seating problem for the sample at 27.6 kPa. Also, the last points on the 13.8-kPa and 27.6-kPa curves coincide. |
| 48 | 5335 | 1 | 2 | BA* | BS** | 0.9733 | 0.9192 | 108 | 15 | 0.3890 | 0.7325 | 4 | Curves 27.6 kPa and 41.4 kPa fall below curve 13.8 kPa for the first half of the test and during the second half, curve 41.4 kPa is below curve 27.6 kPa. This could be due to seating problems or leak in pressure. |
| 48 | 5336 | 1 | 2 | A2 | TS03 | 0.9708 | 0.9971 | 108 | 15 | 0.1334 | 0.4812 | 4 | All three curves cross each other. The material is also stress-insensitive. |
| 48 | 6179 | 1 | 1 | A1 | TS01 | 0.9913 | 0.7866 | 216 | 15 | 0.3214 | -0.3123 | 4 | Curve 27.6 kPa falls below curve 13.8 kPa during the latter part of the test. This could be due to membrane rupture or leak in pressure. |
| 48 | 9005 | 1 | 2 | A2 | TS02 | 0.9968 | 0.8181 | 118 | 15 | 0.6201 | 0.6909 | 4 | Seating problems with samples at 27.6 kPa and 41.4 kPa. |
| 49 | 1008 | 1 | 2 | TP1 | BS92 | 0.9892 | 0.9980 | 114 | 15 | 0.1121 | 0.0801 | 4 | Curves 27.6 kPa and 13.8 kPa seem to be almost the same. All the curves cross each other. |
| 51 | 5009 | 1 | 2 | BA* | BS** | 0.9981 | 0.5779 | 267 | 15 | 0.8143 | 0.7293 | 4 | Highest confining pressure crosses mid confining pressure. |
| 54 | 1640 | 1 | 2 | TP | BS55 | 0.9827 | 0.4723 | 267 | 15 | -0.2536 | -0.8097 | 4 | First point on curve 41.4 kPa lies below the other two curves. This is probably due to a seating problem. The last points on the middle and high confining pressures coincide with each other. |
| 54 | 4003 | 1 | 1 | BA* | BS** | 0.9968 | 0.5450 | 265 | 15 | 0.5032 | -0.4247 | 4 | First point on the highest confinement curve is below that on the mid confining pressure curve. Due to a seating problem? Soil is stress insensitive. |
| 54 | 7008 | 1 | 2 | BA* | BS** | 0.9966 | 0.6189 | 108 | 15 | 0.5514 | -0.3145 | 4 | First point on the highest confinement curve is below that on the mid confining pressure curve. Due to a seating problem? Soil is stress insensitive. |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

Table 20. Resilient modulus tests exhibiting localized softening or disturbance of the specimen during the test or LVDT movement (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 54 | 7008 | 1 | 1 | BA* | BS** | 0.9968 | 0.5393 | 108 | 15 | 0.5152 | -0.4178 | 4 | First point on the highest confinement curve is below that on the mid confining pressure curve. Due to a seating problem Soil is stress insensitive. |
| 72 | 4122 | 1 | 1 | BA* | BS** | 0.9964 | 0.5956 | 267 | 15 | 0.7028 | 0.0797 | 4 | The 41.4-kPa curve falls below the 27.6-kPa curve during the second half of the test. Could be due to membrane rupture. |
| 87 | 1620 | 1 | 1 | BA* | BS** | 0.9975 | 0.5387 | 102 | 15 | 0.0715 | -0.7134 | 4 | First point on the highest confinement curve is below that on the mid & low confining pressure curves. Due to a seating problem? |
| 87 | 2811 | 1 | 1 | BA* | BS** | 0.9917 | 0.7164 | 131 | 15 | -0.4051 | -0.7092 | 4 | First point on the highest confinement curve is below that on the mid & low confining pressure curves. Due to a seating problem? |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

Table 21. Resilient modulus tests that result in lower resilient moduli for the higher confining pressures.

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 1 | 4125 | 1 | 1 | BA* | BS** | 0.9944 | 0.8035 | 217 | 15 | 0.5165 | 0.0141 | 5 | Leak in membrane suspected for highest confining pressure, not sensitive to stress for the other two. |
| 1 | 4127 | 2 | 2 | BA* | BG** | 0.9845 | 0.3184 | 308 | 15 | 0.9579 | 0.9118 | 5 | Leak in membrane suspected for 34.5-kPa and 68.9-kPa confining pressure. |
| 12 | 3995 | 3 | 1 | BA* | BG** | 0.9800 | 0.3448 | 308 | 15 | 0.9551 | 0.8834 | 5 | 20.7-kPa confining pressure above 34.5-kPa confining pressure and behaves differently from all confining pressures. |
| 28 | 1016 | 1 | 2 | A2 | TS03 | 0.9887 | 0.5853 | 214 | 15 | 0.4356 | -0.4020 | 5 | Highest confining pressure below mid confining pressure. |
| 28 | 4024 | 1 | 1 | BA* | BS** | 0.9904 | 0.8564 | 108 | 15 | 0.5351 | 0.7370 | 5 | Highest confining pressure below mid confining pressure, 2nd point of all three curves coincide. |
| 40 | 3018 | 1 | 2 | A2 | TS03 | 0.9928 | 0.5490 | 102 | 15 | -0.5167 | -0.7962 | 5 | Out of order and some weaving seen. |
| 47 | 3108 | 1 | 2 | TP1 | BS55 | 0.9899 | 0.4136 | 114 | 15 | -0.6332 | -0.8891 | 5 | Curve at pressure of 41.4 kPa is lower than the curve at 13.8 kPa. |
| 47 | 3109 | 1 | 2 | TP1 | BS55 | 0.9880 | 0.6362 | 114 | 15 | -0.6952 | -0.7730 | 5 | Curve at pressure of 41.4 kPa is lower than the curve at 13.8 kPa. Also the last points of all curves merge at one single point. |
| 48 | 0802 | 3 | 2 | B4 | BG01 | 0.9924 | 1.0000 | 302 | 15 | -0.4163 | 0.0445 | 5 | Curve at pressure 41.4 kPa is lower than the curves at 13.8 kPa and 27.6 kPa. The soil is stress-insensitive. |
| 48 | 1047 | 1 | 2 | A2 | TS03 | 0.9975 | 0.6008 | 107 | 15 | -0.1202 | -0.7463 | 5 | Curve 41.4 kPa below curve 26.7 kPa |
| 48 | 9005 | 1 | 1 | A1 | TS01 | 0.9939 | 0.9218 | 118 | 15 | -0.6583 | -0.3640 | 5 | Curve 41.4 kPa is below the curves at 13.8 kPa and 27.6 kPa. Also, the curves at 13.8 kPa and 27.6 kPa cross each other, which may be due to seating problems with the sample at 27.6 kPa. |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

Table 22. Resilient modulus tests showing resilient modulus is independent of confining pressure at the lowest vertical stress.

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 6 | 1253 | 1 | 1 | BA* | BS** | 0.9972 | 0.6037 | 267 | 15 | 0.8209 | 0.7423 | 6 | 1st points of all confining pressures are about the same. |
| 9 | 5001 | 1 | 1 | BA2 | BS02 | 0.9767 | 0.5652 | 215 | 15 | 0.8353 | 0.7068 | 6 | 1st points of all confining pressures are about the same. |
| 12 | 3811 | 1 | 1 | BA* | BS** | 0.9937 | 0.6869 | 216 | 15 | 0.7299 | 0.7225 | 6 | 1st points of all confining pressures are about the same. |
| 22 | 0113 | 1 | 1 | B6 | BS06 | 0.9966 | 0.6632 | 101 | 15 | 0.7409 | 0.8622 | 6 | 1st points of highest confining pressure plot coincide with mid confining pressure test. |
| 22 | 0117 | 1 | 2 | B5 | BS05 | 0.9991 | 0.5231 | 101 | 15 | 0.8566 | 0.5662 | 6 | 1st points of highest confining pressure plot coincide with mid confining pressure test. |
| 22 | 0124 | 1 | 1 | B3 | BS03 | 0.9988 | 0.6005 | 101 | 15 | 0.7928 | 0.8236 | 6 | 1st points of highest confining pressure plot coincide with mid confining pressure test. |
| 35 | 0101 | 1 | 2 | B1 | BS01 | 0.9958 | 0.7379 | 114 | 15 | 0.6699 | 0.8883 | 6 | 1st points of highest confining pressure plot below mid & lowest confining pressure test. |
| 35 | 0105 | 1 | 2 | B3 | BS03 | 0.9965 | 0.7091 | 103 | 15 | 0.7000 | 0.8837 | 6 | 1st points of highest confining pressure plot below mid confining pressure test (the first points at all confining pressures. Start at almost the same point). |
| 40 | 0117 | 1 | 2 | B3 | BS03 | 0.9964 | 0.6047 | 113 | 15 | 0.7927 | 0.8499 | 6 | 1st points of highest and mid confining pressure test coincide. |
| 40 | 0120 | 1 | 2 | B5 | BS05 | 0.9971 | 0.5888 | 113 | 15 | 0.8066 | 0.7704 | 6 | 1st points of highest and mid confining pressure test coincide. |
| 40 | 0123 | 1 | 2 | B6 | BS06 | 0.9926 | 0.7377 | 113 | 15 | 0.6792 | 0.9140 | 6 | The first points at all confining pressure start at almost the same point. |
| 48 | 0801 | 1 | 1 | B2 | BS02 | 0.9985 | 0.5336 | 145 | 15 | 0.8479 | 0.7235 | 6 | First and the last points of confining pressures 27.6 kPa and 41.3 kPa coincide. |
| 48 | 0802 | 1 | 1 | B1 | BS01 | 0.9951 | 0.7011 | 145 | 15 | 0.7176 | 0.8737 | 6 | Initial point is the same for all three curves. |

Table 22. Resilient modulus tests showing resilient modulus is independent of confining pressure at the lowest vertical stress (continued).

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 48 | 2133 | 1 | 1 | A1 | TS01 | 0.9984 | 0.5330 | 103 | 15 | 0.7112 | -0.1237 | 6 | 1st points of highest and mid confining pressure coincide. |
| 49 | 1006 | 1 | 2 | TP1 | BS92 | 0.9978 | 0.5413 | 267 | 15 | 0.8344 | 0.6160 | 6 | Initial points on curves 13.8 kPa and 27.6 kPa coincide. Also, the second point on the 41.4-kPa curve looks like a data entry error. |
| 56 | 6031 | 1 | 1 | BA* | BS** | 0.9967 | 0.6675 | 267 | 15 | 0.7533 | 0.8494 | 6 | First point on all three curves coincide. |
| 56 | 6031 | 1 | 1 | BA* | BS** | 0.9967 | 0.6675 | 267 | 15 | 0.7533 | 0.8494 | 6 | First point on all three curves coincide. |
| 56 | 6031 | 1 | 2 | TP1 | BS91 | 0.9984 | 0.5475 | 267 | 15 | 0.8397 | 0.7415 | 6 | First points on the mid and high confining pressures coincide. |
| 56 | 7772 | 1 | 2 | TP1 | BS91 | 0.9991 | 0.5443 | 267 | 15 | 0.6069 | -0.2731 | 6 | First points on the mid and high confining pressures coincide. First point on the low curve does not exactly coincide with the other two, but is very close. |
| 72 | 4122 | 1 | 2 | BA* | BS** | 0.9872 | 0.7199 | 267 | 15 | 0.6964 | 0.8196 | 6 | First point on all three curves coincide. |
| 81 | 1805 | 1 | 1 | BA* | BS** | 0.9993 | 0.4547 | 137 | 15 | 0.4926 | -0.4517 | 6 | First points on the mid and high confining pressures coincide. Failure? |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

Table 23. Resilient modulus tests with potential data entry error.

| State Code | SHRP ID | Layer No. | Test No. | Loc. No. | Sample No. | R-Squared | $S_E/S_Y$ | Matl Code | No. of Cycles | Correlations with $M_R$ | | Flag | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $\theta$ | $\tau_{oct}$ | | |
| 1 | 4073 | 3 | 1 | BA* | BG** | 0.7186 | 0.9743 | 308 | 15 | 0.2039 | 0.8829 | 7 | Both *Mr* and stress at zero for highest confining pressure, data entry error?! But it's at Level E!!?? |
| 1 | 4084 | 2 | 2 | BA* | BG** | 0.9121 | 0.7272 | 308 | 15 | 0.7395 | 0.8240 | 7 | Leak in membrane suspected for 34.5-kPa and 68.9-kPa confining pressure, zero data point for 103.4-kPa confining pressure. |
| 12 | 3997 | 3 | 1 | BA* | BG** | 0.9313 | 0.6430 | 308 | 15 | 0.7856 | 0.7503 | 7 | Zero data point for 103.4-kPa confining pressure. |
| 12 | 4106 | 3 | 1 | BA* | BG** | 0.9070 | 0.7260 | 308 | 15 | 0.6918 | 0.7711 | 7 | Zero data point for 137.9-kPa confining pressure. |
| 12 | 4106 | 2 | 1 | BA* | BG** | 0.9310 | 0.5385 | 309 | 15 | 0.8489 | 0.9126 | 7 | Zero data point for 103.4-kPa confining pressure. |
| 28 | 3090 | 3 | 2 | BA* | BG** | 0.9075 | 0.6885 | 308 | 15 | 0.7319 | 0.8265 | 7 | Zero point for highest confining pressure. |
| 47 | 3104 | 2 | 1 | BA* | BG** | 0.9052 | 0.6603 | 303 | 15 | 0.7507 | 0.8214 | 7 | Zero point for a pressure of 137.9 kPa. |
| 48 | 3865 | 1 | 1 | BA* | BS** | 0.9695 | 0.6396 | 114 | 15 | 0.7238 | 0.5862 | 7 | Zero point for lowest confining pressure. |
| 48 | 9167 | 3 | 2 | BA4 | BG04 | 0.9032 | 0.6839 | 308 | 15 | 0.7396 | 0.9023 | 7 | Initial zero point for curve 137.9 kPa. |

* - Reference to LTPP Database Code List
** - Reference to LTPP Database Code List

# APPENDIX D.

## PARAMETERS AND THEIR VALUES INCLUDED IN THE NONLINEAR REGRESSION RELATING RESILIENT MODULUS TO PHYSICAL PROPERTIES

Appendix D, tables 24 through 39, provides a summary of the minimum, maximum, mean, and median values for each parameter included in the nonlinear optimization regression study to determine the relationship and effect between resilient modulus and physical properties. Tables 24 through 31 include the data sets for the base and subbase materials, while tables 31 through 36 include the data sets for the subgrade soils. The following defines the parameters used in these tables.

| | | |
|---|---|---|
| $P_{3/8}$ | – | Percent passing the 3/8-in [9.5-mm] sieve. |
| $P_{No.\ 4}$ | – | Percent passing the No. 4 sieve. |
| $P_{No.\ 40}$ | – | Percent passing the No. 40 sieve. |
| $P_{No.\ 200}$ | – | Percent passing the No. 200 sieve. |
| LL | – | Liquid limit. |
| PI | – | Plasticity index. |
| $W_{opt}$ | – | Optimum water content of material. |
| $\delta_{d,opt}$ | – | Maximum dry unit weight of material. |
| $W_s$ | – | Water content of test specimen. |
| $\delta_s$ | – | Dry unit weight of test specimen. |
| %Silt | – | Percent by weight of silt in the material. |
| %Clay | – | Percent by weight of clay in the material. |

Table 24. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for all granular base and subbase material data set.

LTPP BASE MATL. CODE: All Granular Base & Subbase Materials
No. of Resilient Modulus Tests: 423

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 39.0 | 100.0 | 79.0 | 78.9 |
| $P_{No. 4}$ | 21.0 | 100.0 | 65.0 | 67.6 |
| $P_{No. 40}$ | 8.0 | 98.0 | 38.0 | 42.4 |
| $P_{No. 200}$ | 1.7 | 96.1 | 14.1 | 17.5 |
| LL | 0.0 | 60.0 | 0.0 | 7.5 |
| PI | 0.0 | 37.0 | 0.0 | 1.9 |
| $w_{opt}$% | 4.0 | 19.0 | 8.0 | 8.2 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1666.1 | 2467.1 | 2114.6 | 2097.0 |
| $w_s$% | 3.1 | 20.5 | 7.6 | 8.0 |
| $\gamma_s$ (kg/m$^3$) | 1557.0 | 2391.6 | 2000.0 | 1978.8 |
| $\gamma_s/\gamma_{d,opt}$ | 0.80 | 1.06 | 0.95 | 0.94 |
| $w_s/w_{opt}$ | 0.36 | 1.46 | 0.98 | 0.98 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 30172.0 | 665211.9 | 117421.0 | 140388.9 |

Table 25. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for LTPP base and subbase material code 302 data set – uncrushed gravel.

LTPP BASE MATL. CODE: 302 – Uncrushed Gravel
No. of Resilient Modulus Tests: 31

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 60.0 | 90.0 | 76.0 | 76.6 |
| $P_{No. 4}$ | 32.0 | 81.0 | 59.0 | 61.2 |
| $P_{No. 40}$ | 9.0 | 45.0 | 25.0 | 25.6 |
| $P_{No. 200}$ | 3.5 | 18.1 | 6.9 | 8.5 |
| LL | 0.0 | 23.0 | 0.0 | 3.0 |
| PI | 0.0 | 8.0 | 0.0 | 0.7 |
| $w_{opt}$% | 5.0 | 10.0 | 6.0 | 6.7 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 2018.5 | 2371.0 | 2194.7 | 2190.1 |
| $w_s$% | 3.7 | 13.8 | 6.0 | 6.4 |
| $\gamma_s$ (kg/m$^3$) | 1882.1 | 2215.5 | 2057.0 | 2049.9 |
| $\gamma_s/\gamma_{d,opt}$ | 0.89 | 1.00 | 0.94 | 0.94 |
| $w_s/w_{opt}$ | 0.62 | 1.38 | 0.98 | 0.95 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 93439.9 | 535209.3 | 193843.1 | 215727.5 |

Table 26. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for LTPP base and subbase material code 303 data set – crushed stone.

LTPP BASE MATL. CODE: 303 – Crushed Stone
No. of Resilient Modulus Tests: 57

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 39.0 | 90.0 | 64.0 | 63.5 |
| $P_{No. 4}$ | 21.0 | 77.0 | 49.0 | 46.9 |
| $P_{No. 40}$ | 8.0 | 47.0 | 25.0 | 25.6 |
| $P_{No. 200}$ | 3.0 | 32.4 | 12.2 | 13.4 |
| LL | 0.0 | 27.0 | 0.0 | 6.1 |
| PI | 0.0 | 8.0 | 0.0 | 1.3 |
| $w_{opt}$% | 4.0 | 11.0 | 6.0 | 6.4 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1874.3 | 2354.9 | 2242.8 | 2218.6 |
| $w_s$% | 3.1 | 12.9 | 6.3 | 6.6 |
| $\gamma_s$ (kg/m$^3$) | 1723.6 | 2236.2 | 2095.2 | 2082.3 |
| $\gamma_s/\gamma_{d,opt}$ | 0.80 | 1.00 | 0.94 | 0.94 |
| $w_s/w_{opt}$ | 0.52 | 1.42 | 1.00 | 1.03 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 74747.9 | 665211.9 | 198342.0 | 220732.2 |

Table 27. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for LTPP base and subbase material code 304 data set – crushed gravel.

LTPP BASE MATL. CODE: 304 – Crushed Gravel
No. of Resilient Modulus Tests: 27

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 49.0 | 98.0 | 69.0 | 69.5 |
| $P_{No. 4}$ | 30.0 | 91.0 | 53.0 | 53.7 |
| $P_{No. 40}$ | 8.0 | 69.0 | 28.0 | 28.2 |
| $P_{No. 200}$ | 3.5 | 59.9 | 12.3 | 16.3 |
| LL | 0.0 | 33.0 | 0.0 | 9.7 |
| PI | 0.0 | 16.0 | 0.0 | 2.1 |
| $w_{opt}$% | 5.0 | 11.0 | 6.0 | 7.2 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1986.5 | 2419.0 | 2194.7 | 2195.3 |
| $w_s$% | 4.3 | 11.3 | 5.9 | 6.9 |
| $\gamma_s$ (kg/m$^3$) | 1875.8 | 2285.8 | 2061.6 | 2072.8 |
| $\gamma_s/\gamma_{d,opt}$ | 0.92 | 0.96 | 0.94 | 0.94 |
| $w_s/w_{opt}$ | 0.69 | 1.30 | 0.95 | 0.96 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 57189.9 | 584658.9 | 172031.6 | 210196.2 |

Table 28. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for LTPP base and subbase material code 306 data set – sand.

LTPP BASE MATL. CODE: 306 – Sand
No. of Resilient Modulus Tests: 35

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 80.0 | 100.0 | 98.0 | 94.6 |
| $P_{No. 4}$ | 69.0 | 100.0 | 95.0 | 91.1 |
| $P_{No. 40}$ | 28.0 | 97.0 | 59.0 | 60.9 |
| $P_{No. 200}$ | 1.7 | 32.3 | 9.4 | 10.5 |
| LL | 0.0 | 26.0 | 0.0 | 2.0 |
| PI | 0.0 | 4.0 | 0.0 | 0.1 |
| $w_{opt}$% | 5.0 | 16.0 | 10.0 | 9.5 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1666.1 | 2226.8 | 1906.4 | 1943.0 |
| $w_s$% | 5.0 | 14.7 | 9.1 | 8.9 |
| $\gamma_s$ (kg/m$^3$) | 1574.6 | 2108.9 | 1797.3 | 1831.5 |
| $\gamma_s/\gamma_{d,opt}$ | 0.90 | 0.97 | 0.95 | 0.94 |
| $w_s/w_{opt}$ | 0.55 | 1.21 | 0.96 | 0.95 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 30172.0 | 151323.7 | 64972.0 | 78238.9 |

Table 29. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for LTPP base and subbase material code 307 data set – fine-grained soil-aggregate mixture.

LTPP BASE MATL. CODE: 307 – Fine-Grained Soil-Aggregate Mixture
No. of Resilient Modulus Tests: 26

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 59.0 | 100.0 | 92.0 | 89.0 |
| $P_{No. 4}$ | 47.0 | 99.0 | 85.5 | 83.0 |
| $P_{No. 40}$ | 32.0 | 80.0 | 50.5 | 51.4 |
| $P_{No. 200}$ | 7.2 | 64.8 | 32.5 | 29.3 |
| LL | 0.0 | 60.0 | 0.0 | 12.8 |
| PI | 0.0 | 37.0 | 0.0 | 4.5 |
| $w_{opt}$% | 4.0 | 17.0 | 8.0 | 8.5 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1794.2 | 2226.8 | 2082.6 | 2065.3 |
| $w_s$% | 3.7 | 16.6 | 7.7 | 8.1 |
| $\gamma_s$ (kg/m$^3$) | 1726.4 | 2096.8 | 1968.7 | 1962.3 |
| $\gamma_s/\gamma_{d,opt}$ | 0.92 | 0.97 | 0.96 | 0.95 |
| $w_s/w_{opt}$ | 0.87 | 1.10 | 0.94 | 0.95 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 43914.4 | 139740.7 | 84267.3 | 87798.8 |

Table 30. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for LTPP base and subbase material code 308 data set – coarse-grained soil-aggregate mixture.

LTPP BASE MATL. CODE: 308 – Coarse-Grained Soil-Aggregate Mixture
No. of Resilient Modulus Tests: 155

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8''}$ | 45.0 | 100.0 | 75.0 | 75.3 |
| $P_{No. 4}$ | 34.0 | 99.0 | 61.0 | 62.1 |
| $P_{No. 40}$ | 13.0 | 90.0 | 36.0 | 37.3 |
| $P_{No. 200}$ | 1.9 | 37.0 | 15.9 | 17.4 |
| LL | 0.0 | 44.0 | 0.0 | 10.4 |
| PI | 0.0 | 18.0 | 0.0 | 2.7 |
| $w_{opt}$% | 4.0 | 19.0 | 8.0 | 8.5 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1682.1 | 2451.1 | 2114.6 | 2099.8 |
| $w_s$% | 3.5 | 20.5 | 7.9 | 8.5 |
| $\gamma_s$ (kg/m$^3$) | 1557.0 | 2332.0 | 2005.5 | 1985.3 |
| $\gamma_s/\gamma_{d,opt}$ | 0.85 | 1.06 | 0.95 | 0.95 |
| $w_s/w_{opt}$ | 0.36 | 1.46 | 0.99 | 1.01 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 37058.9 | 412457.8 | 117658.0 | 141567.2 |

Table 31. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for LTPP base and subbase material code 309 data set – fine-grained soil.

LTPP BASE MATL. CODE: 309 – Fine-Grained Soil
No. of Resilient Modulus Tests: 72

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8''}$ | 58.0 | 100.0 | 94.5 | 92.3 |
| $P_{No. 4}$ | 36.0 | 100.0 | 89.5 | 87.4 |
| $P_{No. 40}$ | 20.0 | 98.0 | 66.0 | 67.2 |
| $P_{No. 200}$ | 4.1 | 96.1 | 18.0 | 23.9 |
| LL | 0.0 | 30.0 | 0.0 | 5.4 |
| PI | 0.0 | 12.0 | 0.0 | 1.6 |
| $w_{opt}$% | 5.0 | 13.0 | 9.0 | 9.0 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1746.2 | 2467.1 | 1986.5 | 2001.8 |
| $w_s$% | 4.7 | 14.2 | 8.3 | 8.5 |
| $\gamma_s$ (kg/m$^3$) | 1608.3 | 2391.6 | 1871.0 | 1889.8 |
| $\gamma_s/\gamma_{d,opt}$ | 0.86 | 1.01 | 0.94 | 0.94 |
| $w_s/w_{opt}$ | 0.45 | 1.29 | 0.96 | 0.95 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 33188.6 | 304324.2 | 58296.3 | 69574.2 |

Table 32. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for all subgrade soils data set.

SOIL TYPE: All Subgrade Soils
No. of Resilient Modulus Tests: 404

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8''}$ | 53.0 | 100.0 | 96.0 | 92.3 |
| $P_{No. 4}$ | 30.0 | 100.0 | 92.0 | 87.4 |
| $P_{No. 40}$ | 18.0 | 99.0 | 71.0 | 69.3 |
| $P_{No. 200}$ | 1.0 | 99.0 | 35.0 | 40.2 |
| % Silt | 0.0 | 92.7 | 23.2 | 26.6 |
| % Clay | 0.0 | 75.5 | 10.3 | 13.5 |
| LL | 0.0 | 73.0 | 22.0 | 19.7 |
| PI | 0.0 | 46.0 | 5.0 | 7.9 |
| $w_{opt}$% | 6.0 | 95.0 | 12.0 | 13.2 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 352.4 | 2226.8 | 1890.4 | 1865.5 |
| $w_s$% | 3.0 | 33.2 | 11.6 | 12.7 |
| $\gamma_s$ (kg/m$^3$) | 1215.8 | 2160.0 | 1804.5 | 1790.3 |
| $\gamma_s/\gamma_{d,opt}$ | 0.816 | 4.231 | 0.957 | 0.966 |
| $w_s/w_{opt}$ | 0.239 | 1.357 | 0.973 | 0.964 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 1380.2 | 275475.0 | 49524.3 | 58883.4 |

Table 33. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for the gravel subgrade soils data set.

SOIL TYPE: Gravel
No. of Resilient Modulus Tests: 64

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 53.0 | 99.0 | 79.0 | 78.7 |
| $P_{No. 4}$ | 30.0 | 99.0 | 65.0 | 66.5 |
| $P_{No. 40}$ | 18.0 | 97.0 | 47.0 | 48.3 |
| $P_{No. 200}$ | 9.5 | 61.1 | 29.4 | 31.8 |
| % Silt | 4.1 | 55.5 | 20.9 | 22.2 |
| % Clay | 0.7 | 32.8 | 8.7 | 9.8 |
| LL | 0.0 | 50.0 | 26.0 | 23.7 |
| PI | 0.0 | 27.0 | 7.0 | 8.2 |
| $w_{opt}$% | 7.0 | 26.0 | 11.0 | 12.6 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1457.8 | 2226.8 | 1978.5 | 1921.9 |
| $w_s$% | 6.8 | 25.5 | 11.4 | 12.3 |
| $\gamma_s$ (kg/m$^3$) | 1377.6 | 2160.0 | 1869.6 | 1838.3 |
| $\gamma_s/\gamma_{d,opt}$ | 0.864 | 1.030 | 0.958 | 0.957 |
| $w_s/w_{opt}$ | 0.746 | 1.244 | 0.971 | 0.977 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 36839.8 | 275475.0 | 76995.7 | 89477.2 |

Table 34. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for the sand subgrade soils data set.

SOIL TYPE: Sand
No. of Resilient Modulus Tests: 209

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 65.0 | 100.0 | 96.0 | 93.7 |
| $P_{No. 4}$ | 45.0 | 100.0 | 92.0 | 89.4 |
| $P_{No. 40}$ | 26.0 | 99.0 | 65.0 | 66.0 |
| $P_{No. 200}$ | 1.0 | 74.0 | 24.3 | 25.4 |
| % Silt | 0.0 | 55.0 | 15.9 | 17.1 |
| % Clay | 0.0 | 28.0 | 7.1 | 8.3 |
| LL | 0.0 | 65.0 | 0.0 | 10.7 |
| PI | 0.0 | 26.0 | 0.0 | 3.4 |
| $w_{opt}$% | 6.0 | 33.0 | 11.0 | 11.3 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1361.7 | 2194.7 | 1922.4 | 1913.3 |
| $w_s$% | 3.0 | 33.2 | 10.4 | 10.6 |
| $\gamma_s$ (kg/m$^3$) | 1249.4 | 2141.4 | 1839.5 | 1831.9 |
| $\gamma_s/\gamma_{d,opt}$ | 0.865 | 1.056 | 0.957 | 0.957 |
| $w_s/w_{opt}$ | 0.250 | 1.167 | 0.960 | 0.938 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 22074.1 | 151773.2 | 57600.0 | 62402.6 |

Table 35. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for the silt subgrade soils data set.

SOIL TYPE: Silt
No. of Resilient Modulus Tests: 31

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 85.0 | 100.0 | 97.0 | 94.6 |
| $P_{No. 4}$ | 64.0 | 100.0 | 94.0 | 90.8 |
| $P_{No. 40}$ | 50.0 | 99.0 | 82.0 | 81.5 |
| $P_{No. 200}$ | 34.7 | 99.0 | 61.2 | 65.6 |
| % Silt | 28.0 | 92.7 | 48.9 | 55.6 |
| % Clay | 2.8 | 19.0 | 8.8 | 9.8 |
| LL | 0.0 | 52.0 | 18.0 | 15.3 |
| PI | 0.0 | 15.0 | 0.0 | 2.6 |
| $w_{opt}$% | 7.0 | 32.0 | 13.0 | 14.1 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 1409.8 | 2210.8 | 1842.3 | 1845.2 |
| $w_s$% | 6.6 | 33.1 | 12.3 | 14.0 |
| $\gamma_s$ (kg/m$^3$) | 1366.5 | 2098.3 | 1778.1 | 1775.0 |
| $\gamma_s/\gamma_{d,opt}$ | 0.926 | 1.048 | 0.953 | 0.962 |
| $w_s/w_{opt}$ | 0.771 | 1.182 | 0.985 | 0.983 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 22165.4 | 70263.0 | 40329.2 | 43567.6 |

Table 36. Summary of the LTPP data used in the nonlinear regression study of resilient modulus for the clay subgrade soils data set.

SOIL TYPE: Clay
No. of Resilient Modulus Tests: 100

| Parameters | Min | Max | Median | Mean |
|---|---|---|---|---|
| $P_{3/8"}$ | 74.0 | 100.0 | 99.0 | 97.5 |
| $P_{No. 4}$ | 54.0 | 100.0 | 98.0 | 95.3 |
| $P_{No. 40}$ | 38.0 | 99.0 | 88.0 | 85.9 |
| $P_{No. 200}$ | 7.0 | 98.4 | 66.6 | 68.5 |
| % Silt | 3.3 | 71.2 | 39.4 | 40.1 |
| % Clay | 3.1 | 75.5 | 26.0 | 28.0 |
| LL | 0.0 | 73.0 | 35.0 | 37.1 |
| PI | 0.0 | 46.0 | 15.5 | 18.7 |
| $w_{opt}$% | 8.0 | 95.0 | 16.0 | 17.5 |
| $\gamma_{d, opt}$ (kg/m$^3$) | 352.4 | 2114.6 | 1730.2 | 1735.7 |
| $w_s$% | 7.9 | 28.7 | 16.8 | 16.9 |
| $\gamma_s$ (kg/m$^3$) | 1215.8 | 2027.9 | 1666.7 | 1677.3 |
| $\gamma_s/\gamma_{d,opt}$ | 0.816 | 4.231 | 0.957 | 0.993 |
| $w_s/w_{opt}$ | 0.239 | 1.357 | 1.000 | 1.003 |
| $(\gamma_{d,opt})^2/P_{No. 40}$ | 1380.2 | 63686.0 | 35848.6 | 36696.0 |

# APPENDIX E.

## RESULTS FROM NONLINEAR OPTIMIZATION REGRESSION STUDY RELATING RESILIENT MODULUS TO PHYSICAL PROPERTIES

Appendix E provides a summary from the nonlinear regression study that was used to identify the relationship or effect of physical properties of the materials on the resilient modulus by material type. Tables 37 through 49 identify the physical properties considered to be important and list the coefficients for each parameter, along with resulting statistics from the regression study for each base material and soil type.

Figures 62 through 74 provide a graphical comparison of the residuals ($M_R$[Predicted]-$M_R$[Observed]) by base material and soil type. As shown by the models, there is a modulus-dependent bias. Determining the cause of the bias was beyond the scope of work for this study. Thus, the residuals and their resilient modulus dependence are presented for the consideration of future users of the LTPP resilient modulus database and computed parameters from this study.

Table 37. Results from the nonlinear optimization regression study for all base and subbase material types combined.

| Material | | All Base and Subbase Materials Combined | | |
|---|---|---|---|---|
| Model | | Coefficient | θ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | 12.8140 | -8.9652 | -2.7735 |
| | $P_{3/8"}$ | 0.0083 | -- | -- |
| | $P_{No. 4}$ | -0.0139 | 0.0023 | 0.0007 |
| | $P_{No. 40}$ | -- | -- | -- |
| | $P_{No. 200}$ | 0.0036 | -0.0019 | -0.0054 |
| | % Silt | -- | -- | -- |
| | % Clay | -- | -- | -- |
| | LL | -0.0055 | 0.0041 | 0.0007 |
| | PI | 0.0206 | -0.0168 | -- |
| | $w_{opt}$% | -- | -- | -- |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -0.0056 | 0.0042 | 0.0010 |
| | $w_s$% | -0.0431 | -- | -- |
| | $\gamma_s$ (kg/m$^3$) | 0.0054 | -0.0045 | -0.0005 |
| | $\gamma_s/\gamma_{d,opt}$ | -10.9427 | 9.7625 | 1.7644 |
| | $w_s/w_{opt}$ | 0.1150 | 0.1251 | -0.0969 |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -8.14E-07 | 4.29E-07 | -- |
| Statistics | MSE | 1871.79 | | |
| | $s_e$ | 43.264 | | |
| | $s_y$ | 75.312 | | |
| | $s_e/s_y$ | 0.5745 | | |
| | $R^2$ | -- | | |
| | No. of Points | 6329 | | |

Table 38. Results from the nonlinear optimization regression study for the LTPP base and subbase material code data set 302 – uncrushed gravel.

| Material | | LTPP Base and Subbase Material Code 302: Uncrushed Gravel | | |
|---|---|---|---|---|
| Model | | Coefficient | θ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | -1.8961 | 0.4960 | -0.5979 |
| | $P_{3/8"}$ | -- | -- | -- |
| | $P_{No. 4}$ | -- | -- | -- |
| | $P_{No. 40}$ | -- | -- | -- |
| | $P_{No. 200}$ | -- | -0.0074 | -- |
| | % Silt | -- | -- | -- |
| | % Clay | -- | -- | -- |
| | LL | -- | -- | -- |
| | PI | -- | -- | -- |
| | $w_{opt}$% | -- | -- | 0.0349 |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | 0.0004 |
| | $w_s$% | -- | -- | -- |
| | $\gamma_s$ (kg/m$^3$) | 0.0014 | -0.0007 | -- |
| | $\gamma_s/\gamma_{d,opt}$ | -- | 1.6972 | -- |
| | $w_s/w_{opt}$ | -0.1184 | 0.1199 | -0.5166 |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -- | -- | -- |
| Statistics | MSE | 475.85 | | |
| | $s_e$ | 21.814 | | |
| | $s_y$ | 63.045 | | |
| | $s_e/s_y$ | 0.346 | | |
| | $R^2$ | -- | | |
| | No. of Points | 461 | | |

Table 39. Results from the nonlinear optimization regression study for the LTPP base and subbase material code data set 303 – crushed stone.

| Material | | LTPP Base and Subbase Material Code 303: Crushed Stone | | |
|---|---|---|---|---|
| Model | | Coefficient | θ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | 0.7632 | 2.2159 | -1.1720 |
| | $P_{3/8"}$ | 0.0084 | -0.0016 | -- |
| | $P_{No. 4}$ | -- | -- | -- |
| | $P_{No. 40}$ | -- | -- | -- |
| | $P_{No. 200}$ | -- | -- | -- |
| | % Silt | -- | -- | -- |
| | % Clay | -- | -- | -- |
| | LL | 0.0088 | 0.0008 | -0.0082 |
| | PI | -- | -- | -- |
| | $w_{opt}$% | -0.0371 | -0.0380 | -0.0014 |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -0.0001 | -0.0006 | 0.0005 |
| | $w_s$% | -- | -- | -- |
| | $\gamma_s$ (kg/m$^3$) | -- | -- | -- |
| | $\gamma_s/\gamma_{d,opt}$ | -- | -- | -- |
| | $w_s/w_{opt}$ | -- | -- | -- |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -- | 2.4E-07 | -- |
| Statistics | MSE | 1699.64 | | |
| | $s_e$ | 41.227 | | |
| | $s_y$ | 87.416 | | |
| | $s_e/s_y$ | 0.4716 | | |
| | $R^2$ | -- | | |
| | No. of Points | 853 | | |

Table 40. Results from the nonlinear optimization regression study for the LTPP base and subbase material code data set 304 – crushed gravel.

| Material | | LTPP Base and Subbase Material Code 304: Crushed Gravel | | |
|---|---|---|---|---|
| Model | | Coefficient | $\theta$ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | -0.8292 | 4.9555 | -3.5141 |
| | $P_{3/8"}$ | -0.0065 | -- | -- |
| | $P_{No. 4}$ | -- | -- | -- |
| | $P_{No. 40}$ | -- | -- | -- |
| | $P_{No. 200}$ | -- | -- | -- |
| | % Silt | -- | -- | -- |
| | % Clay | -- | -- | -- |
| | LL | 0.0114 | -0.0057 | -- |
| | PI | 0.0004 | -0.0075 | -- |
| | $w_{opt}$% | -0.0187 | -- | -- |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | -- |
| | $w_s$% | 0.0036 | -0.0470 | -- |
| | $\gamma_s$ (kg/m$^3$) | 0.0013 | -0.0022 | 0.0016 |
| | $\gamma_s/\gamma_{d,opt}$ | -- | -- | -- |
| | $w_s/w_{opt}$ | -- | -- | -- |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -2.6E-06 | 2.8E-06 | -- |
| Statistics | MSE | 854.398 | | |
| | $s_e$ | 29.230 | | |
| | $s_y$ | 66.743 | | |
| | $s_e/s_y$ | 0.4380 | | |
| | $R^2$ | -- | | |
| | No. of Points | 404 | | |

Table 41. Results from the nonlinear optimization regression study for the LTPP base and subbase material code data set 306 – sand.

| Material | | LTPP Base and Subbase Material Code 306: Sand | | |
|---|---|---|---|---|
| Model | | Coefficient | θ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | -0.2786 | 1.1148 | -0.4508 |
| | $P_{3/8"}$ | 0.0097 | -0.0053 | 0.0029 |
| | $P_{No. 4}$ | -- | -- | -- |
| | $P_{No. 40}$ | -- | -- | -- |
| | $P_{No. 200}$ | -- | -- | -- |
| | % Silt | -- | -- | -- |
| | % Clay | -- | -- | -- |
| | LL | 0.0219 | -0.0095 | -0.0185 |
| | PI | -0.0737 | 0.0325 | 0.0798 |
| | $w_{opt}$% | -- | -- | -- |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | -- |
| | $w_s$% | -- | -- | -- |
| | $\gamma_s$ (kg/m$^3$) | -- | -- | -- |
| | $\gamma_s/\gamma_{d,opt}$ | -- | -- | -- |
| | $w_s/w_{opt}$ | -- | -- | -- |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | 1.8E-07 | 7.2E-07 | -- |
| Statistics | MSE | 512.674 | | |
| | $s_e$ | 22.642 | | |
| | $s_y$ | 51.605 | | |
| | $s_e/s_y$ | 0.4388 | | |
| | $R^2$ | -- | | |
| | No. of Points | 519 | | |

Table 42. Results from the nonlinear optimization regression study for the LTPP base and subbase material code data set 307 – fine-grained soil-aggregate mixture.

| Material | | LTPP Base and Subbase Material Code 307: Fine-Grained Soil-Aggregate Mix | | |
|---|---|---|---|---|
| | | Recalibrated Coefficient with $M_r$ Equation | | |
| Model | | Coefficient | θ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | -0.7668 | 0.4951 | 0.9303 |
| | $P_{3/8"}$ | -- | -- | 0.0293 |
| | $P_{No. 4}$ | 0.0051 | -0.0141 | -- |
| | $P_{No. 40}$ | -- | -- | -- |
| | $P_{No. 200}$ | 0.0128 | -0.0061 | -- |
| | % Silt | -- | -- | -- |
| | % Clay | -- | -- | -- |
| | LL | 0.0030 | -- | 0.0036 |
| | PI | -- | -- | -- |
| | $w_{opt}$% | -0.0510 | -- | -- |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | -- |
| | $w_s$% | -- | -- | -- |
| | $\gamma_s$ (kg/m$^3$) | -- | -- | -- |
| | $\gamma_s/\gamma_{d,opt}$ | 1.1729 | 1.3941 | -3.8903 |
| | $w_s/w_{opt}$ | -- | -- | -- |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -- | -- | -- |
| Statistics | MSE | 588.20 | | |
| | $s_e$ | 24.253 | | |
| | $s_y$ | 49.371 | | |
| | $s_e/s_y$ | 0.4912 | | |
| | $R^2$ | -- | | |
| | No. of Points | 390 | | |

Table 43. Results from the nonlinear optimization regression study for the LTPP base and subbase material code data set 308 – coarse-grained soil-aggregate mixture.

| Material | | Base and Subbase Material 308: Coarse-Grained Soil-Aggregate Mixture | | |
|---|---|---|---|---|
| Model | | Coefficient | $\theta$ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | -0.5856 | 0.7833 | -0.1906 |
| | $P_{3/8"}$ | 0.0130 | --- | -- |
| | $P_{No. 4}$ | -0.0174 | --- | -- |
| | $P_{No. 40}$ | --- | --- | -- |
| | $P_{No. 200}$ | 0.0027 | -0.0060 | -0.0026 |
| | % Silt | --- | --- | -- |
| | % Clay | --- | --- | -- |
| | LL | --- | --- | -- |
| | PI | 0.0149 | -0.0081 | -- |
| | $w_{opt}$% | --- | --- | -- |
| | $\gamma_{d, opt}$ (kg/m$^3$) | 1.6E-06 | 0.0001 | -- |
| | $w_s$% | -0.0426 | --- | -- |
| | $\gamma_s$ (kg/m$^3$) | --- | --- | -- |
| | $\gamma_s/\gamma_{d,opt}$ | 1.6456 | --- | -- |
| | $w_s/w_{opt}$ | 0.3932 | -0.1483 | -- |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -8.2E-07 | -2.7E-07 | 8.1E-07 |
| Statistics | MSE | 1883.89 | | |
| | $s_e$ | 43.404 | | |
| | $s_y$ | 80.186 | | |
| | $s_e/s_y$ | 0.5413 | | |
| | $R^2$ | -- | | |
| | No. of Points | 2323 | | |

Table 44. Results from the nonlinear optimization regression study for the LTPP base and subbase material code data set 309 – fine-grained soil.

| Material | | LTPP Base and Subbase Material Code 309: Fine-Grained Soil | | |
|---|---|---|---|---|
| Model | | Coefficient | θ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | 0.8409 | 0.6668 | -0.1667 |
| | $P_{3/8"}$ | -- | -- | -- |
| | $P_{No. 4}$ | -- | -- | -- |
| | $P_{No. 40}$ | 0.0004 | -0.0007 | -- |
| | $P_{No. 200}$ | -- | -- | -- |
| | % Silt | -- | -- | -- |
| | % Clay | -- | -- | -- |
| | LL | -- | -- | -- |
| | PI | 0.0161 | -0.0139 | -0.0207 |
| | $w_{opt}$% | -- | -- | -- |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | -- |
| | $w_s$% | -- | -- | -- |
| | $\gamma_s$ (kg/m$^3$) | -- | -- | -- |
| | $\gamma_s/\gamma_{d,opt}$ | -- | -- | -- |
| | $w_s/w_{opt}$ | -- | -- | -- |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -- | -- | -- |
| Statistics | MSE | 1167.03 | | |
| | $s_e$ | 34.162 | | |
| | $s_y$ | 62.8 | | |
| | $s_e/s_y$ | 0.5440 | | |
| | $R^2$ | -- | | |
| | No. of Points | 1079 | | |

Table 45. Results from the nonlinear optimization regression study for the combined subgrade soil data set.

| Material | | All Subgrade Soils Combined | | |
|---|---|---|---|---|
| Model | | Coefficient | $\theta$ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | 0.9848 | 0.4808 | 9.6691 |
| | $P_{3/8"}$ | -0.0050 | -0.0037 | -0.0302 |
| | $P_{No. 4}$ | -- | 0.0062 | 0.0065 |
| | $P_{No. 40}$ | 0.0011 | -0.0016 | 0.0192 |
| | $P_{No. 200}$ | -- | -0.0008 | -0.0115 |
| | % Silt | -- | -- | -- |
| | % Clay | 0.0085 | -0.0018 | 0.0040 |
| | LL | 0.0089 | -0.0078 | 0.0075 |
| | PI | -0.0094 | 0.0019 | 0.0401 |
| | $w_{opt}$% | -- | -- | 0.0020 |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | -0.0039 |
| | $w_s$% | -0.0235 | 0.0111 | -0.2750 |
| | $\gamma_s$ (kg/m$^3$) | -- | -- | -- |
| | $\gamma_s/\gamma_{d,opt}$ | -- | -0.1232 | -0.7177 |
| | $w_s/w_{opt}$ | 0.3290 | -0.0009 | 1.0262 |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -- | -- | 5.28E-06 |
| Statistics | MSE | 449.184 | | |
| | $s_e$ | 21.194 | | |
| | $s_y$ | 26.574 | | |
| | $s_e/s_y$ | 0.7975 | | |
| | $R^2$ | -- | | |
| | No. of Points | 6022 | | |

Table 46. Results from the nonlinear optimization regression study for the LTPP gravel subgrade soil data set.

| Material | | Gravel Subgrade Soils | | |
|---|---|---|---|---|
| Model | | Coefficient | $\theta$ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | 1.3429 | 0.3311 | 1.5167 |
| | $P_{3/8"}$ | -0.0051 | 0.0010 | -0.0302 |
| | $P_{No. 4}$ | -- | -- | -- |
| | $P_{No. 40}$ | -- | -- | -- |
| | $P_{No. 200}$ | -- | -- | -- |
| | % Silt | -- | -- | -- |
| | % Clay | 0.0124 | -0.0019 | 0.0435 |
| | LL | 0.0053 | -0.0050 | 0.0626 |
| | PI | -- | -0.0072 | 0.0377 |
| | $w_{opt}$% | -- | -- | -- |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | -- |
| | $w_s$% | -0.0231 | 0.0093 | -0.2353 |
| | $\gamma_s$ (kg/m$^3$) | -- | -- | -- |
| | $\gamma_s/\gamma_{d,opt}$ | -- | -- | -- |
| | $w_s/w_{opt}$ | -- | -- | -- |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -- | -- | -- |
| Statistics | MSE | 301.322 | | |
| | $s_e$ | 17.359 | | |
| | $s_y$ | 26.812 | | |
| | $s_e/s_y$ | 0.6474 | | |
| | $R^2$ | -- | | |
| | No. of Points | 957 | | |

Table 47. Results from the nonlinear optimization regression study for the LTPP sand subgrade soil data set.

| Material | | Sand Subgrade Soils | | |
|---|---|---|---|---|
| Model | | Coefficient | $\theta$ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | 3.2868 | 0.5670 | -3.5677 |
| | $P_{3/8"}$ | -0.0412 | 0.0045 | 0.1142 |
| | $P_{No. 4}$ | 0.0267 | -2.98E-05 | -0.0839 |
| | $P_{No. 40}$ | -- | -- | -- |
| | $P_{No. 200}$ | -- | -- | -0.1249 |
| | % Silt | -- | -0.0043 | 0.1030 |
| | % Clay | 0.0137 | -0.0102 | 0.1191 |
| | LL | 0.0083 | -0.0041 | -0.0069 |
| | PI | -- | -- | -- |
| | $w_{opt}$% | -0.0379 | 0.0014 | -0.0103 |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | -- |
| | $w_s$% | -- | -- | -- |
| | $\gamma_s$ (kg/m$^3$) | -0.0004 | -3.41E-05 | -0.0017 |
| | $\gamma_s/\gamma_{d,opt}$ | -- | -0.4582 | 4.3177 |
| | $w_s/w_{opt}$ | -- | 0.1779 | -1.1095 |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -- | -- | -- |
| Statistics | MSE | 357.7155648 | | |
| | $s_e$ | 18.91337 | | |
| | $s_y$ | 24.787 | | |
| | $s_e/s_y$ | 0.7630 | | |
| | $R^2$ | -- | | |
| | No. of Points | 3117 | | |

Table 48. Results from the nonlinear optimization regression study for the LTPP silt subgrade soil data set.

| Material | | Silt Subgrade Soils | | |
|---|---|---|---|---|
| Model | | Coefficient | θ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | 1.0480 | 0.5097 | -0.2218 |
| | $P_{3/8"}$ | -- | -- | -- |
| | $P_{No. 4}$ | -- | -- | -- |
| | $P_{No. 40}$ | -- | -- | -- |
| | $P_{No. 200}$ | -- | -- | -- |
| | % Silt | -- | -- | 0.0047 |
| | % Clay | 0.0177 | -- | -- |
| | LL | -- | -- | -- |
| | PI | 0.0279 | -0.0286 | 0.0849 |
| | $w_{opt}$% | -- | -- | -- |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | -- |
| | $w_s$% | -0.0370 | -- | -0.1399 |
| | $\gamma_s$ (kg/m$^3$) | -- | -- | -- |
| | $\gamma_s/\gamma_{d,opt}$ | -- | -- | -- |
| | $w_s/w_{opt}$ | -- | -- | -- |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -- | -- | -- |
| Statistics | MSE | 193.03 | | |
| | $s_e$ | 13.894 | | |
| | $s_y$ | 24.714 | | |
| | $s_e/s_y$ | 0.5622 | | |
| | $R^2$ | -- | | |
| | No. of Points | 464 | | |

Table 49. Results from the nonlinear optimization regression study for the LTPP clay subgrade soil data set.

| Material | | Clay Subgrade Soils | | |
|---|---|---|---|---|
| Model | | Coefficient | θ Exponent | $\tau_{oct}$ Exponent |
| Model Parameters | Intercept | 1.3577 | 0.5193 | 1.4258 |
| | $P_{3/8"}$ | -- | -- | -- |
| | $P_{No. 4}$ | -- | -0.0073 | -0.0288 |
| | $P_{No. 40}$ | -- | 0.0095 | 0.0303 |
| | $P_{No. 200}$ | -- | -0.0027 | -0.0521 |
| | % Silt | -- | -- | 0.0251 |
| | % Clay | 0.0106 | -- | -- |
| | LL | -- | -0.0030 | 0.0535 |
| | PI | -- | -- | -- |
| | $w_{opt}$% | -- | -0.0049 | -0.0672 |
| | $\gamma_{d, opt}$ (kg/m$^3$) | -- | -- | -0.0026 |
| | $w_s$% | -0.0437 | -- | -- |
| | $\gamma_s$ (kg/m$^3$) | -- | -- | 0.0025 |
| | $\gamma_s/\gamma_{d,opt}$ | -- | -- | -- |
| | $w_s/w_{opt}$ | -- | -- | -0.6055 |
| | $(\gamma_{d,opt})^2/P_{No. 40}$ | -- | -- | -- |
| Statistics | MSE | 557.918 | | |
| | $s_e$ | 23.620 | | |
| | $s_y$ | 29.224 | | |
| | $s_e/s_y$ | 0.8082 | | |
| | $R^2$ | -- | | |
| | No. of Points | 1484 | | |

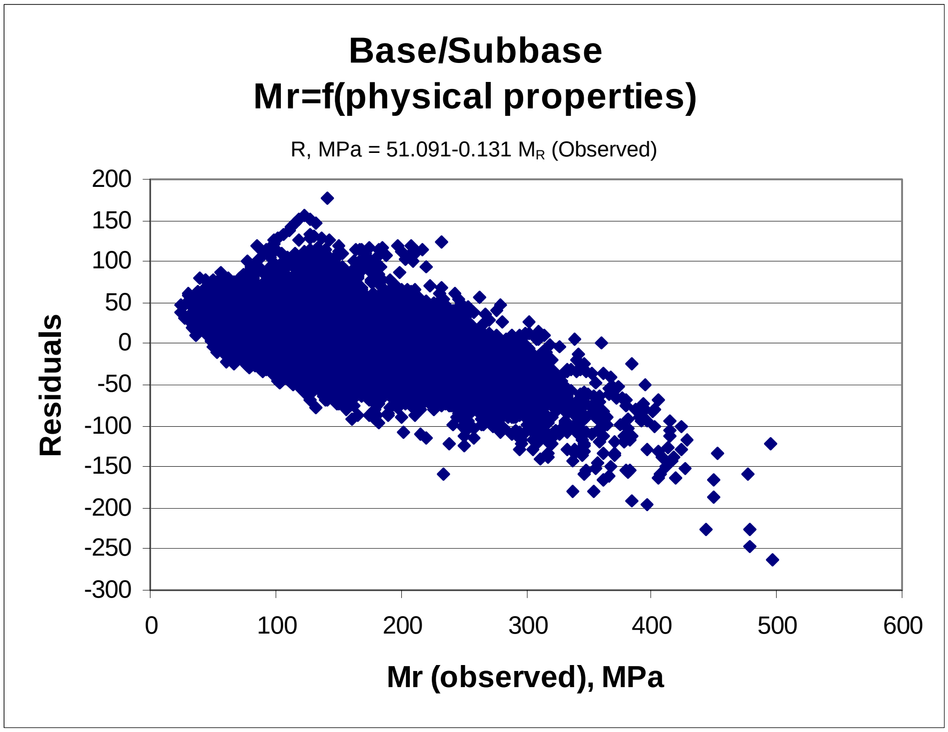



Figure 62. Residuals, *R*, for the combined resilient modulus prediction equation for all base and subbase materials.

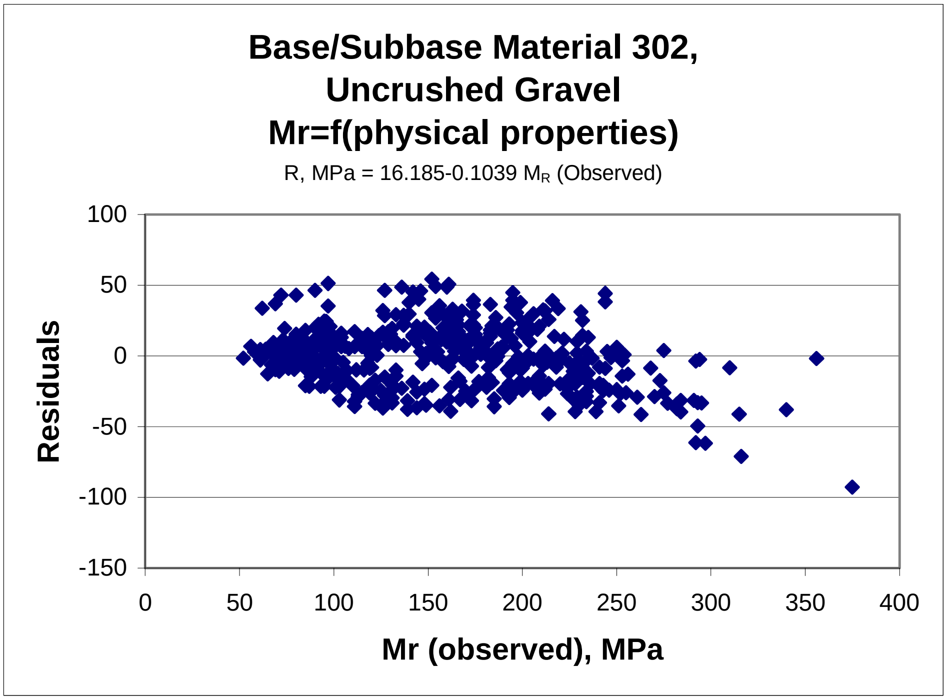



Figure 63. Residuals, *R*, for the uncrushed gravel (LTPP material code 302) resilient modulus prediction equation.

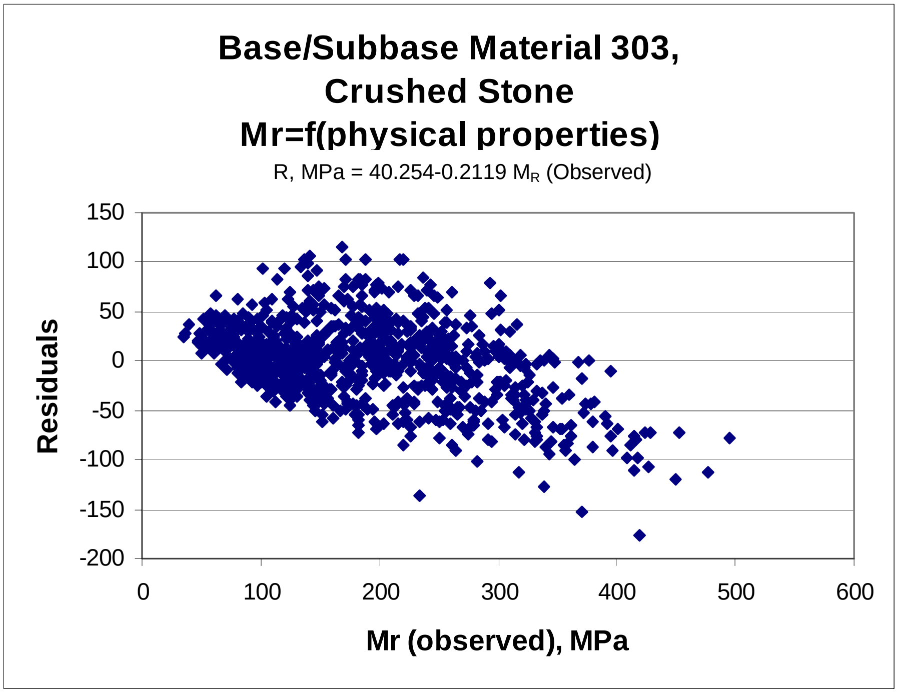



Figure 64. Residuals, *R*, for the crushed stone (LTPP material code 303) resilient modulus prediction equation.

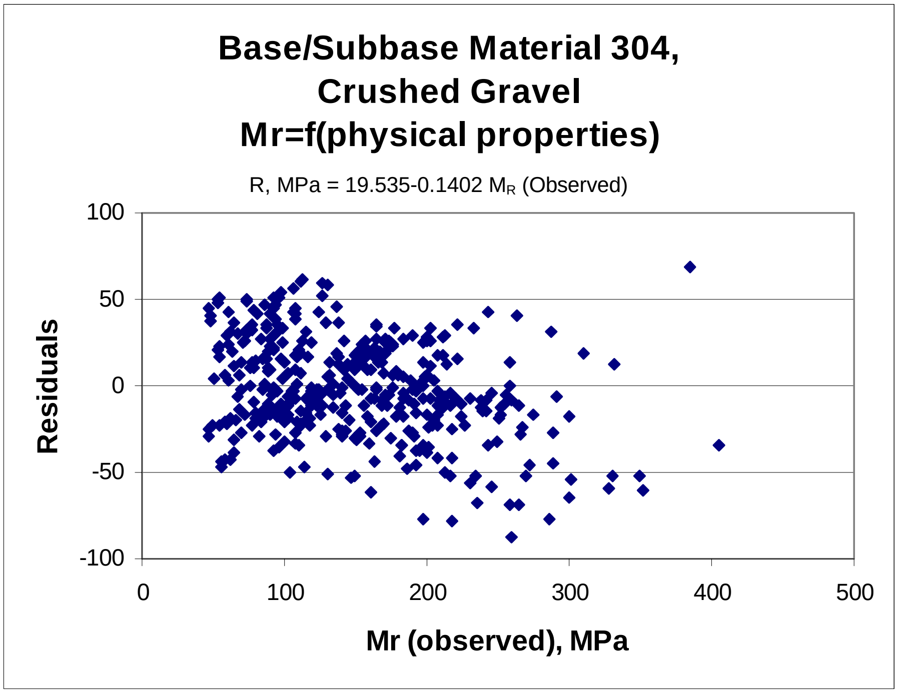



Figure 65. Residuals, *R*, for the crushed gravel (LTPP material code 304) resilient modulus prediction equation.

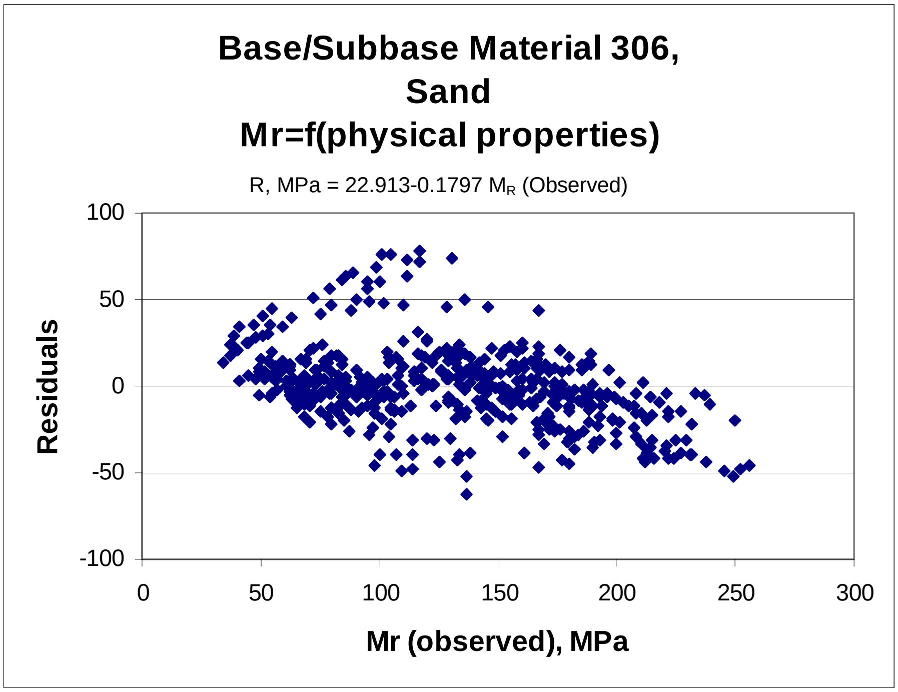



Figure 66. Residuals, *R*, for the sand (LTPP material code 306) resilient modulus prediction equation.

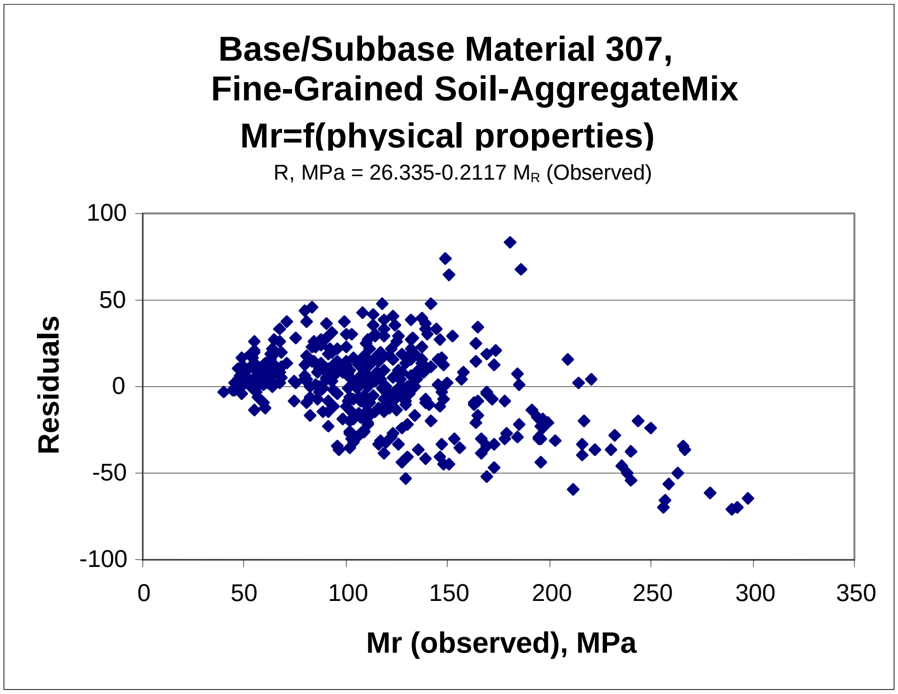



Figure 67. Residuals, *R*, for the fine-grained soil-aggregate mixture (LTPP material code 307) resilient modulus prediction equation.

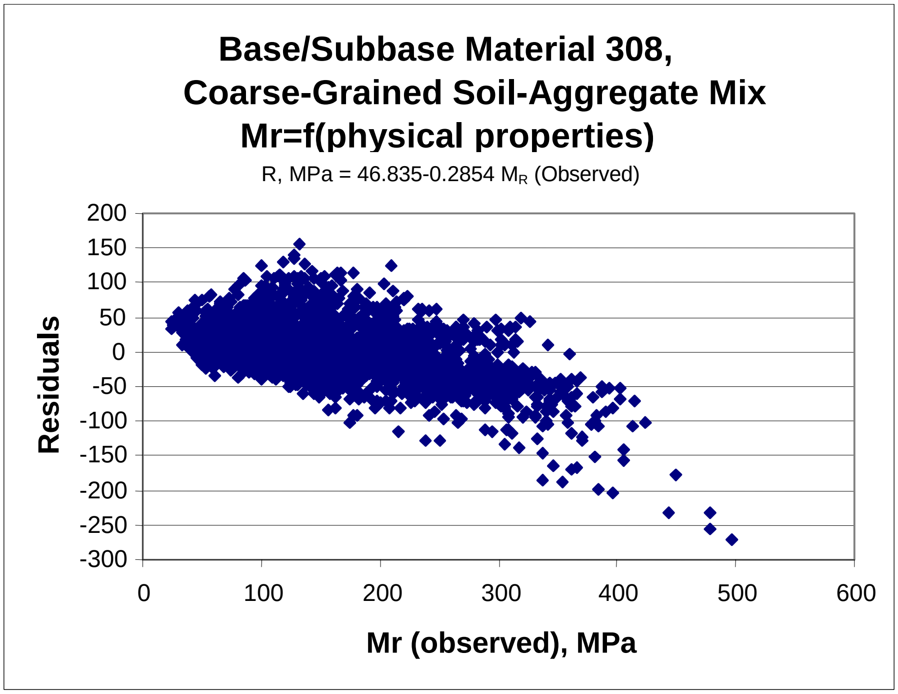



Figure 68. Residuals, *R*, for the coarse-grained soil-aggregate mixture (LTPP material, code 308) resilient modulus prediction equation.

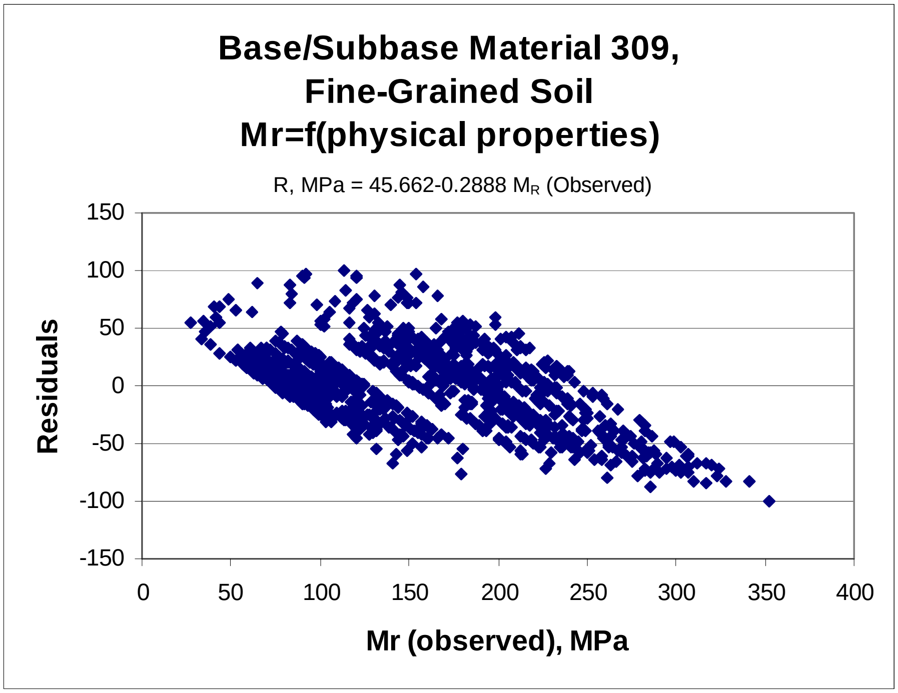



Figure 69. Residuals, *R*, for the fine-grained soil (LTPP material code 309) resilient modulus prediction equation.

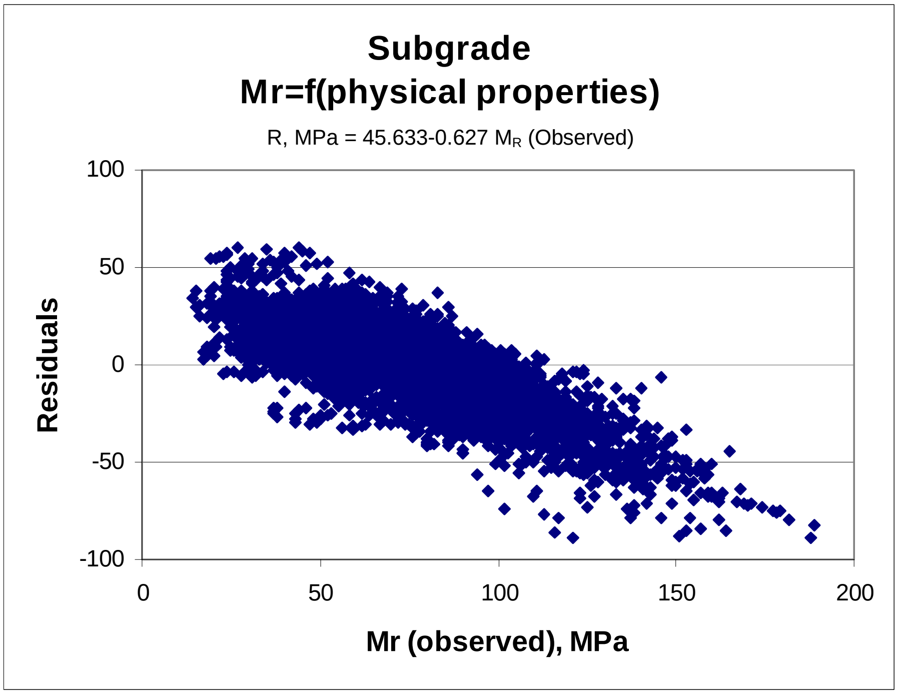



Figure 70. Residuals, *R*, for the resilient modulus prediction equation for all subgrade soils.

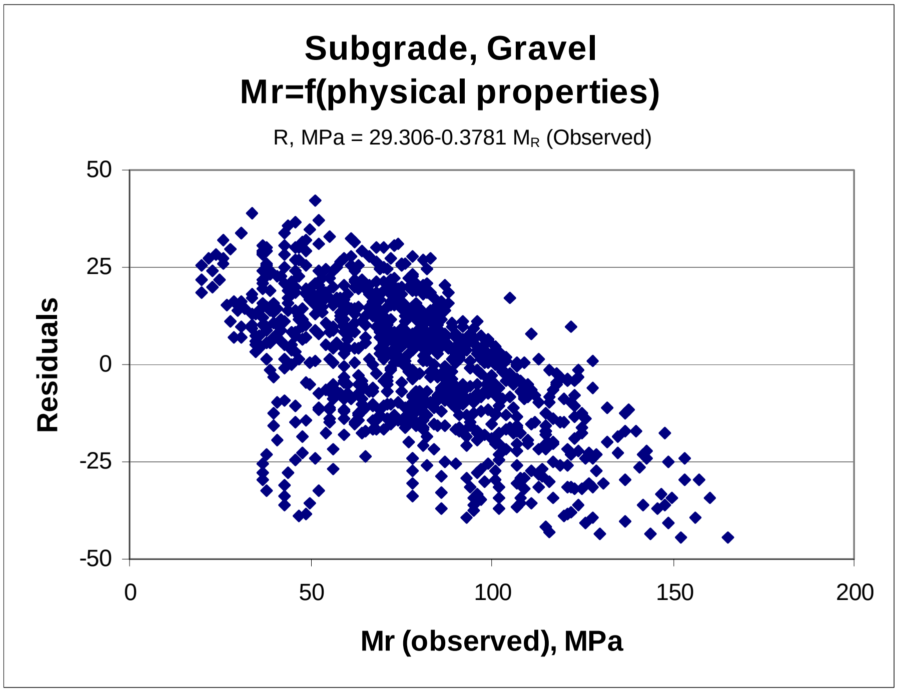



Figure 71. Residuals, *R*, for the gravel soils resilient modulus prediction equation.

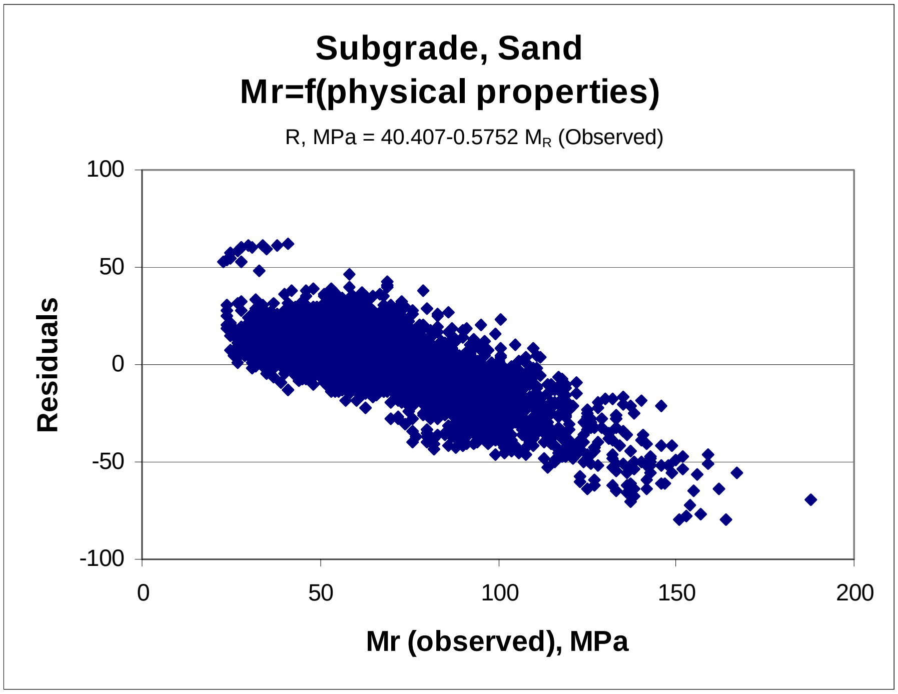



Figure 72. Residuals, *R*, for the sand soils resilient modulus prediction equation.

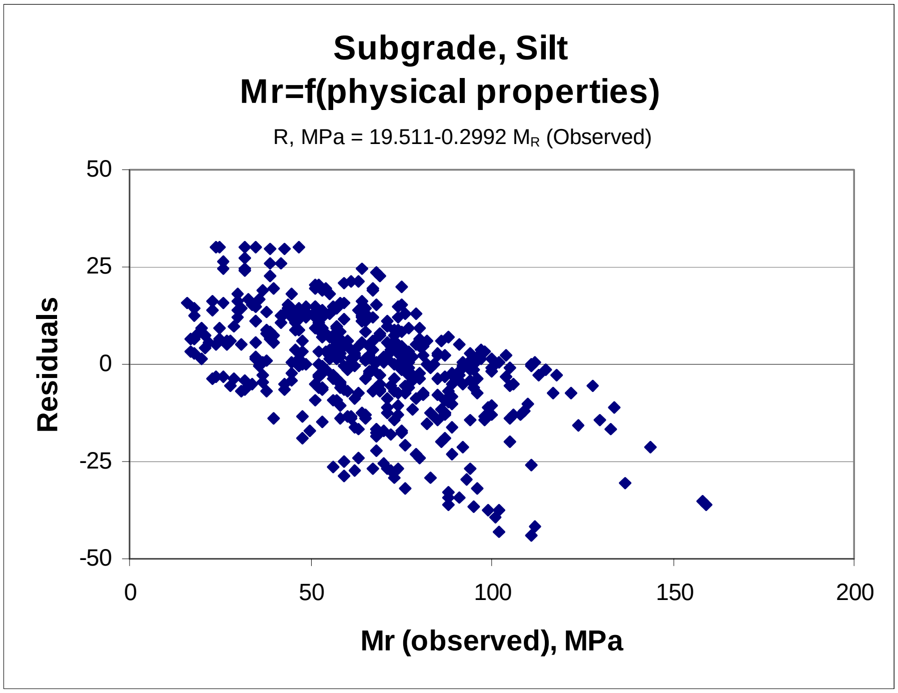



Figure 73. Residuals, *R*, for the silt soils resilient modulus prediction equation.

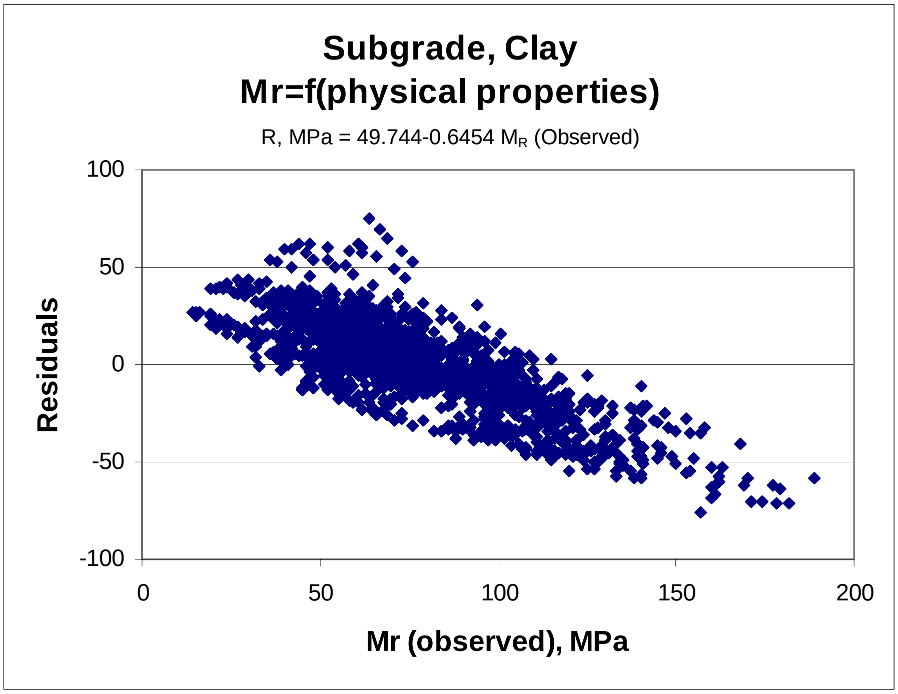



Figure 74. Residuals, *R*, for the clay soils resilient modulus prediction equation.

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