Standard Method of Test for

Determining the Resilient Modulus of Soils and Aggregate Materials

AASHTO Designation: T 307-99 (2021)[1]

Adopted: 1999 Reviewed but Not Updated: 2021 Editorially Revised: 2021

Technical Subcommittee: 1a, Soil and Unbound Recycled Materials

AASHTO

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1. SCOPE

1.1. This method covers procedures for preparing and testing untreated subgrade soils and untreated base/subbase materials for determination of resilient modulus (M_r) under conditions representing a simulation of the physical conditions and stress states of materials beneath flexible pavements subjected to moving wheel loads.

1.2. The methods described are applicable to undisturbed samples of natural and compacted subgrade soils, and to disturbed samples of subgrade soils and untreated base/subbase prepared for testing by compaction in the laboratory.

1.3. In this method, stress levels used for testing specimens for resilient modulus are based on the location of the specimen within the pavement structure. Samples located within the base and subbase are subjected to different stress levels as compared to those specimens that are from the subgrade. Generally, specimen size for testing depends on the type of material based on the gradation and the plastic limit of the material as described in a later section.

1.4. The value of resilient modulus determined from this procedure is a measure of the elastic modulus of untreated base and subbase materials and subgrade soils recognizing certain nonlinear characteristics.

1.5. Resilient modulus values can be used with structural response analysis models to calculate the pavement structural response to wheel loads, and with pavement design procedures to design pavement structures.

1.6. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

Note 1—Test specimens and equipment described in this method may be used to obtain other useful and related information such as the Poisson's ratio and rutting characteristics of subgrade soils and base/subbase materials. Procedures for obtaining these are not covered in this standard.

1.7. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- T 88, Particle Size Analysis of Soils
- T 89, Determining the Liquid Limit of Soils
- T 90, Determining the Plastic Limit and Plasticity Index of Soils
- T 99, Moisture–Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
- T 100, Specific Gravity of Soils
- T 180, Moisture–Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
- T 190, Resistance R-Value and Expansion Pressure of Compacted Soils
- T 191, Density of Soil In-Place by the Sand-Cone Method
- T 233, Density of Soil In-Place by Block, Chunk, or Core Sampling
- T 265, Laboratory Determination of Moisture Content of Soils
- T 296, Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression
- T 310, In-Place Density and Moisture Content of Soil and Soil–Aggregate by Nuclear Methods (Shallow Depth)

3. TERMINOLOGY

3.1. *untreated granular base and subbase materials*—these include soil-aggregate mixtures and naturally occurring materials. No binding or stabilizing agent is used to prepare untreated granular base or subbase layers. These materials may be classified as either Type 1 or Type 2 as subsequently defined in Sections 3.3 and 3.4.

3.2. *subgrade*—subgrade soils are prepared and compacted before the placement of subbase and/or base layers. These materials may be classified as either Type 1 or Type 2 as subsequently defined in Sections 3.3 and 3.4.

3.3. *Material Type 1*—for the purposes of resilient modulus testing, Material Type I includes all untreated granular base and subbase material and all untreated subgrade soils that meet the criteria of less than 70 percent passing the 2.00-mm (No. 10) sieve and less than 20 percent passing the 75-µm (No. 200) sieve, and that have a plasticity index of 10 or less. Soils classified as Type 1 will be molded in a 150-mm diameter mold.

3.4. *Material Type 2*—for the purpose of resilient modulus testing, Material Type 2 includes all untreated granular base/subbase and untreated subgrade soils not meeting the criteria for material Type 1 given in Section 3.3. Thin-walled tube samples of untreated subgrade soils fall into this Type 2 category.

3.5. *resilient modulus of untreated materials*—the modulus of an untreated material is determined by repeated load triaxial compression tests on test specimens of the untreated material samples. Resilient modulus (M_r) is the ratio of the amplitude of the repeated axial stress to the amplitude of the resultant recoverable axial strain.

3.6. *haversine-shaped load form*—the required load pulse form. The load pulse is in the form $(1 - \cos \theta)/2$ as shown in Figure 1.

3.7. *maximum applied axial load* (P_{max})—the total load applied to the sample, including the contact and cyclic (resilient) loads.

$$P_{max} = P_{contact} + P_{cyclic} \quad (1)$$

3.8. *contact load* ($P_{contact}$)—vertical load placed on the specimen to maintain a positive contact between the specimen cap and the specimen.

$$P_{contact} = 0.1P_{max} \quad (2)$$

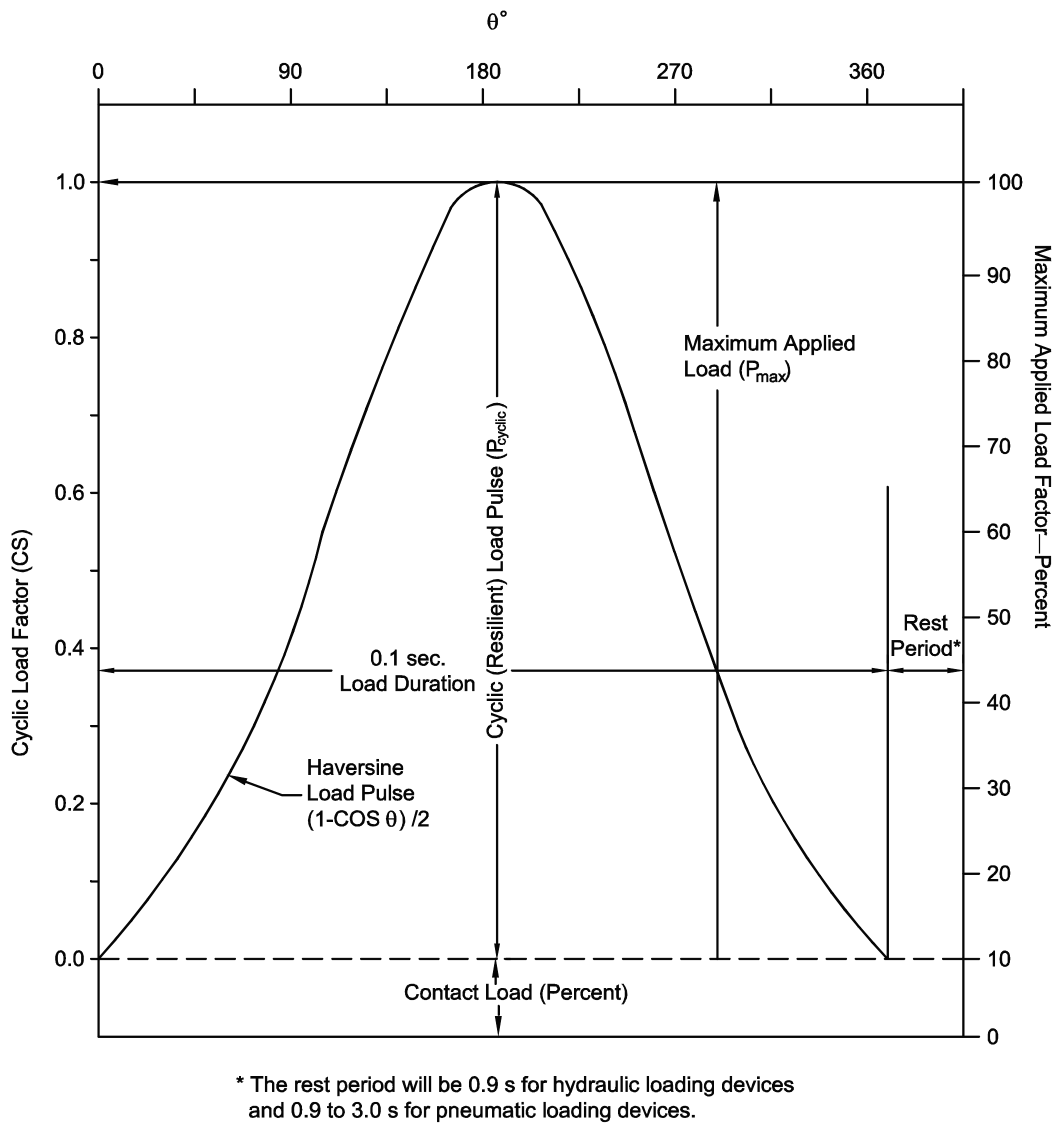

Figure 1—Definition of Resilient Modulus Terms Cyclic Axial Load (Resilient Vertical Load, P_{cyclic})—Repetitive Load Applied to a Test Specimen

$$P_{cyclic} = P_{max} - P_{contact} \quad (3)$$

3.9. *maximum applied axial stress* (S_{max})—the total stress applied to the sample including the contact stress and the cyclic (resilient) stress.

$$S_{max} = P_{max}/A \quad (4)$$

where:

A = initial cross-sectional area of the specimen.

3.10. *cyclic axial stress* (resilient stress, S_{cyclic})—Cyclic (resilient) applied axial stress.

$$S_{\text{cyclic}} = P_{\text{cyclic}} / A \quad (5)$$

3.11. *contact stress* (S_{contact})—axial stress applied to a test specimen to maintain a positive contact between the specimen cap and the specimen.

$$S_{\text{contact}} = P_{\text{contact}} / A \quad (6)$$

Also,

$$S_{\text{contact}} = 0.1 S_{\max} \quad (7)$$

3.12. S_3 is the total radial stress; that is, the applied confining pressure in the triaxial chamber (minor principal stress).

3.13. e_r is the resilient (recovered) axial deformation due to S_{cyclic}.

3.14. $\in_r$ is the resilient (recovered) axial strain due to S_{cyclic}.

$$\in_r = e_r / L \quad (8)$$

where:

L = original specimen length.

3.15. Resilient modulus (M_r) is defined as $S_{\text{cyclic}} / \in_r$.

3.16. Load duration is the time interval the specimen is subjected to a cyclic stress (usually 0.1 s).

3.17. Cycle duration is the time interval between the successive applications of a cyclic stress (usually 1.0 to 3.1 s, depending on type of loading device; see Section 6.2).

4. SUMMARY OF METHOD

4.1. A repeated axial cyclic stress of fixed magnitude, load duration (0.1 s), and cycle duration (1.0 to 3.1 s) is applied to a cylindrical test specimen. During testing, the specimen is subjected to a dynamic cyclic stress and a static-confining stress provided by means of a triaxial pressure chamber. The total resilient (recoverable) axial deformation response of the specimen is measured and used to calculate the resilient modulus.

5. SIGNIFICANCE AND USE

5.1. The resilient modulus test provides a basic relationship between stress and deformation of pavement materials for the structural analysis of layered pavement systems.

5.2. The resilient modulus test provides a means of characterizing pavement construction materials, including subgrade soils, under a variety of conditions (i.e., moisture, density) and stress states that simulate the conditions in a pavement subjected to moving wheel loads. Such material characterization may also be correlated with results from other tests such as T 88, T 89, T 90, T 100, and T 233.