INTERNATIONAL

Designation: D7369 – 20

Standard Test Method for Determining the Resilient Modulus of Asphalt Mixtures by Indirect Tension Test[1]

This standard is issued under the fixed designation D7369; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers procedures for preparing and testing laboratory-fabricated or field-recovered cores of asphalt mixtures to determine resilient modulus values using a repeated-load indirect tension test.

1.2 The values stated in SI units are regarded as the standard. Values in parentheses are for informational use.

1.3 A precision and bias statement for this standard has not been developed at this time. Therefore, this standard should not be used for acceptance or rejection of a material for purchasing purposes.

1.4 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D8 Terminology Relating to Materials for Roads and Pavements

D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

D6925 Test Method for Preparation and Determination of the Relative Density of Asphalt Mix Specimens by Means of the Superpave Gyratory Compactor

D6926 Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus

D6931 Test Method for Indirect Tensile (IDT) Strength of Asphalt Mixtures

2.2 *Other Document:*

NCHRP Project 1-28A Research Results Digest Number 285—Laboratory Determination of Resilient Modulus for Flexible Pavement Design, January 2004

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology D8.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *contact load ($P_{contact}$), n*—the vertical load placed on the specimen to maintain a positive contact between the loading strip and the specimen. The suggested contact load is 8 % of the maximum load (0.08 P_{max}). The contact load should be not less than 22.2 N (5 lb) and no more than 89.0 N (20 lb).

3.2.2 *core, n*—an intact cylindrical specimen of pavement material, which is removed from the pavement by drilling and sampling at the designated location. A core may consist of or include one, two, or more than two different layers.

3.2.3 *cyclic load (resilient vertical load, P_{cyclic}), n*—load applied to a specimen, which is directly used to calculate resilient modulus.

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

3.2.4 *haversine-shaped load form, n*—the required load pulse for the resilient modulus test. The load pulse is in the form (1-cos θ)/2 with the cyclic load varying from the contact load ($P_{contact}$) to the maximum load (P_{max}).

3.2.5 *instantaneous resilient modulus, n*—determined from the deformation-time plots (both horizontal and vertical) as described in Section 10.

3.2.6 *lift, n*—that part of the pavement produced with similar material and placed with similar equipment and techniques. The lift thickness is the thickness of the compacted

[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.26 on Fundamental/Mechanistic Tests.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

asphalt mixture that is achieved with one pass of the laydown machine and the subsequent compaction process and can be equal to or less than the core thickness or length.

3.2.7 *maximum applied load (P_{max}), n*—the maximum total load applied to the sample, including the contact and cyclic (resilient) loads. A P_{max} load of 400 N (89.9 lb) is suggested for testing.

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

3.2.8 *test specimen, n*—that part of the layer which is used for, or in, the specified test. The thickness of the test specimen can be equal to or less than the layer thickness.

3.2.9 *total deformation, n*—determined from the deformation-time plots (both horizontal and vertical) as described in Section 10.

4. Summary of Test Method

4.1 The repeated-load indirect tension resilient modulus test of asphalt mixtures is conducted through repetitive applications of compressive loads in a haversine waveform. The compressive load is applied along a vertical diametral plane of a cylindrical specimen of asphalt concrete. The resulting horizontal and vertical deformations of the specimen are measured. Values of resilient Poisson's ratio are calculated using recoverable vertical and horizontal deformations. The resilient modulus values are subsequently calculated using the calculated Poisson's ratio. Two separate resilient modulus values are obtained. One, termed *instantaneous* resilient modulus, is calculated using the instantaneous recoverable deformation that occurs during the unloading portion of one load-unload cycle. The other, termed *total* resilient modulus, is calculated using total recoverable deformation which includes both the instantaneous recoverable and the time-dependent continuing recoverable deformation during the unload or rest-period portion of one cycle.

5. Significance and Use

5.1 Resilient modulus can be used in the evaluation of materials quality and as input for pavement design, evaluation, and analysis. With this method, the effects of temperature and load on resilient modulus can also be investigated. This modulus test can be run on pavement cores because of specimen orientation.

NOTE 1—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 Specification D3666 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Specification D3666 alone does not completely ensure reliable results. Reliable results depend on many factors; following the suggestions of Specification D3666 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.

6. Apparatus

6.1 *Testing Machine*—Testing machine shall be a closed-loop, servo-electric, electro-hydraulic, or pneumatic testing machine with a function generator capable of applying a haversine-shaped load pulse over a range of load durations, load levels, and rest periods.

6.2 *Loading Device*—Loading device should be capable of testing 101.6 or 152.4 mm (4 or 6 in.) diameter specimens of thicknesses up to 63.5 mm (2.5 in.). The device should be compact enough to be used within an environmental chamber. It should have a fixed bottom loading plate and a moving upper loading plate. The movement of the upper plate should be guided by two columns, one on each side of the specimen and equidistant from the loading axis and the loading strips, to ensure it has minimal translational or rotational motion during loading of the specimen. The guide columns shall have a near frictionless bearing surface. The surface of the guide columns shall be frequently inspected for any grooves caused due to friction. Alignment of the device within the loading system shall be achieved so that such friction is limited. The upper plate shall be rigid enough to prevent excessive or undue deflection during loading. The loading strips shall be perpendicular to the line connecting the two guide columns, Fig. 1.

6.3 *Temperature-Control System*—The temperature-control system should be capable of maintaining a temperature of 5 to 45 °C (41 to 113 °F) ±1.0 °C (±2 °F). The system shall include a temperature-controlled cabinet large enough to house the loading device and space adequate to precondition specimens at a time prior to testing, as described in 8.3.

6.4 *Measurement and Recording System*—The measurement and recording system shall include sensors for measuring and simultaneously recording horizontal and vertical deformations and loads. The system shall be capable of recording horizontal and vertical deformations in the range of 0.00038 mm (0.000015 in.) of deformation. Load cells shall be accurately calibrated with a resolution of 8.9 N (2 lb) or better.

6.4.1 *Data Acquisition*—The measuring or recording devices must provide real-time deformation and should be capable of monitoring readings on tests conducted to 1 Hz.

FIG. 1 Specimen with Loading Strip Parts

Computer monitoring systems are recommended. The data acquisition system shall be capable of collecting 200 scans per second (a scan includes all deformation and load values at a given point of time). The capability to have real-time plots (simultaneous to the data collection by the computer monitoring system) shall also be provided to check the progress of the test. If strip-chart recorders are used without computer monitoring systems, the plotting scale shall be adjusted such that there is a balance between the scale reduction required as a result of the pen reaction time and the scale amplification needed for purposes of accurate measurement of values from a plot. Actual load values, and not the intended load values, shall be used for calculation purposes and so the data acquisition system shall also be capable of monitoring the load values continuously during testing.

NOTE 2—Tests at multiple frequencies can be done. The frequencies of 0.33 and 0.5 Hz are suggested.

6.4.2 *Deformation Measurement*—Both horizontal and vertical deformation shall be measured on the surface of the specimen by mounting LVDTs between gauge points along the horizontal and vertical diameters. The gauge length can be of three sizes in relation to the diameter of the specimen: ¼ of the diameter or 25.4 mm for a 101.6 mm diameter of the specimen (1 in. for a 4 in.) or 38.1 mm for a 152.4 mm diameter of the specimen (1.5 in. for a 6 in.); ½ of the diameter or 50.8 mm for a 101.6 mm diameter of the specimen (2 in. for a 4 in.) or 76.2 mm for a 152.4 mm diameter of the specimen (3 in. for a 6 in.); and one diameter or 101.6 for a 101.6 mm diameter of the specimen (4 in. for a 4 in.) or 152.4 mm for a 152.4 mm diameter of the specimen (6 in. for a 6 in.). It is required to have the two LVDTs on each face of the specimen, one horizontal and one vertical, resulting in a total of four LVDTs for deformation measurement.

NOTE 3—The results obtained with gauge length of ¼ of the diameter of the specimen have the best precision.

6.4.3 *Load Measurement*—The repetitive loads shall be measured with an electronic load cell with a capacity adequate for the maximum required loading and a sensitivity of 0.5 % of the intended peak load. During period of resilient modulus testing, the load cell shall be monitored and checked once a month with a calibrated proving ring to ensure that the load cell is operating properly. Additionally, the load cell shall be checked at any time that the QC/QA testing with in-house synthetic specimen (see 9.1) indicates a change in the system response or when there is a suspicion of a load cell problem.

6.5 *Loading Strip*—Steel loading strips, with concave sample contact surfaces, machined to the radius of curvature of a 101.60 ± 0.10 mm diameter specimen (4.000 ± 0.004 in.) or 152.40 ± 0.15 mm diameter specimen (6.000 ± 0.006 in.), are required to apply load to the test specimens. The contact areas of the loading strips shall be 12.7 mm (½ in.) and 19 mm (¾ in.) wide, respectively, for the 4 in. specimen and 6 in. specimen. The outer edges of the curved surface shall be filed lightly to remove sharp edges that might cut the specimen during testing. Thin lines should be drawn along the length of the strip at its center to help alignment. Also, appropriate marking should be made so as to center the specimen within the length of the strips. This could be done either by matching the center of specimen with a mark at the center of the strip or by positioning the specimen between two marks at the ends of the specimen thickness, or both.

6.6 *Marking and Alignment Devices:*

6.6.1 The LVDT alignment device should align the horizontal and vertical LVDTs simultaneously on the top and bottom faces of the specimen for gluing. If such a device is not used, then a marking device shall be used to mark mutually perpendicular axes on the top and bottom faces of the specimen through the center. The axes shall be simultaneously marked on the top and bottom faces of the specimen to ensure that the axes on the front and the back lie in a single plane.

6.6.2 An alignment device shall be used to position and place horizontal and vertical supports for gages or LVDTs along the horizontal and vertical diameter of the specimen and hold them there until the glue that holds the supports cures. It shall be easily removable, without disturbing the LVDT (once the glue cures), and shall not be destructively mounted on the specimen. The device shall be capable of mounting the LVDT at a gauge length of one quarter and one half of the diameter of the specimen. The LVDT shall be as close as possible to (but not touching) the surface of the specimen so as to minimize the bulging effect. To ensure uniform test results, a spacing of 5.08 mm (0.2 in.) is recommended. The axis of the LVDT shall not be at a distance greater than 6.35 mm (0.25 in.) from the surface of the specimen. Fig. 2 shows an example of alignment device.

7. Specimens

7.1 *Specimen Size*—Resilient modulus testing shall be conducted on 101.6 ± 3.8 mm (4 in.) or 152.4 ± 9 mm (6 in.) diameter specimens that are 38.1 mm (1.5 in.) to 63.5 mm (2.5 in.) in thickness. The test specimen can be obtained from field coring or from a Marshall-compacted specimen (Practice D6926) or from a gyratory-compacted specimen (Test Method D6925). Depending on the height of the gyratory-compacted specimen and the thickness of the test specimen, two or three specimens can be sawed from a compacted specimen.

7.2 *Core Specimens:*

7.2.1 Cores for test specimen preparation, which may contain one or more testable layers, must have smooth and uniform surfaces and must meet specimen diametric and thickness requirements summarized in 7.1. Cores that are obviously deformed or have any visible cracks must be rejected. Irregular top and bottom surfaces shall be trimmed as necessary, and individual layer specimens shall be obtained by cutting with a diamond saw using water or air as coolant. Additional specimens for each layer must be collected in the field in order to perform the pretest tensile strength.

7.2.2 If a core specimen has more than one layer, the layers shall be separated at the layer interface. Layers containing more than one lift of the same material may be tested as a single specimen. If sample layers de-bond during testing, the results are invalid and shall not be used.

7.2.3 In order to limit non-parallelism of the two flat sides, it is recommended to place the specimen on a level surface and measure the departure from perpendicularity. The displacement