



Standard Test Method for Determining Fatigue Failure of Compacted Asphalt Concrete Subjected to Repeated Flexural Bending¹

This standard is issued under the fixed designation D7460; 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 provides procedures for determining a unique failure point for estimating the fatigue life of 380 mm (14.96 in.) long by 50 mm (1.97 in.) thick by 63 mm (2.48 in.) wide asphalt concrete beam specimens sawed from laboratory or field compacted asphalt concrete, which are subjected to repeated flexural bending.

1.2 The between-laboratory reproducibility of this test method is being determined and will be available on or before June 2013. Therefore, this test method should not be used for acceptance or rejection of a material for purchasing purposes.

1.3 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.

1.4 *Units*—The values stated in SI units are to be regarded as standard. Other units of measurement included in this standard are for information only.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards*:²

- D75 Practice for Sampling Aggregates
- D140 Practice for Sampling Bituminous Materials
- D979 Practice for Sampling Bituminous Paving Mixtures
- D2041 Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

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.

- D3203 Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
- D3549 Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens
- D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
- D5361 Practice for Sampling Compacted Bituminous Mixtures for Laboratory Testing
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- 2.2 *AASHTO Standards*:³
- T 321 Standard Method of Test for Determining the Fatigue Life of Compacted Hot-Mix Asphalt (HMA) Subjected to Repeated Flexural Bending
- PP 3 Preparing Hot-Mix Asphalt (HMA) Specimens by Means of the Rolling Wheel Compactor
- R 30 Standard Practice for Mixture Conditioning of Hot-Mix Asphalt (HMA)

3. Terminology

3.1 *Definitions*:

3.1.1 *beam modulus*—Flexural Beam Stiffness, as determined in 10.1.3.

3.1.2 *failure point*—the number of cycles to failure, N_f , which corresponds to the maximum or peak Normalized Modulus \times Cycles (Fig. 13) when plotted versus Number of Cycles.

3.1.3 *initial beam modulus*—Flexural Beam Stiffness determined at approximately 50 load cycles.

3.1.4 *normalized modulus \times cycles*—see Rowe and Bouldin (1):⁴

$$\frac{(\text{Beam Stiffness} \times \text{Cycle Number})}{(\text{Initial Beam Modulus} \times \text{Cycle of Initial Beam Modulus})}$$

4. Summary of Test Method

4.1 The four-point flexural bending test method is conducted on compacted beam specimens to evaluate the fatigue

³ Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

⁴ The boldface numbers in parentheses refer to the list of references at the end of this standard.

properties of an asphalt concrete mixture. A cyclic haversine (displaced sine wave with full amplitude on tension side of zero) displacement is applied at the central H-frame third points of a beam specimen, while the outer third points are held in an articulating fixed position. The frequency rate ranges from 5 to 10 Hz. This produces a constant bending moment over the center third (L/3) span (118.5 to 119 mm (4.66 to 4.69 in.)) between the H-frame contact points on the beam specimen. The level of desired strain is pre-calculated and an input for the displacement control. The deflection at the mid-length position (L/2) of a beam specimen is regulated by the closed loop control system.

5. Significance and Use

5.1 The laboratory fatigue life determined by this standard for beam specimens have been used to estimate the fatigue life of asphalt concrete pavement layers under repeated traffic loading. Although the field performance of asphalt concrete is impacted by many factors (traffic variation, speed, and wander; climate variation; rest periods between loads; aging; etc.), it has been more accurately predicted when laboratory properties are known along with an estimate of the strain level induced at the layer depth by the traffic wheel load traveling over the pavement.

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 assure 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 *Test System*—The test system shall consist of a load frame, an environmental chamber (temperature control system) and a closed loop control and data acquisition system. The test system shall meet the minimum requirements specified in

TABLE 1 Test System Minimum Requirements

Load Measurement and Control	Range: 0 to 5 kN (0 to 1124 lbf) Resolution: 2.5 N (0.56 lbf) Accuracy: 5 N (1 lbf)
Displacement Measurement and Control	Range: 0 to 5 mm (0 to 0.2 in.) Resolution: 2.5 μm (9.8×10^5 in.) Accuracy: 5 μm (2.0×10^4 in.)
Frequency Measurement and Control	Range: 5 to 10 Hz Resolution: 0.005 Hz Accuracy: 0.01 Hz
Temperature Measurement and Control	Resolution: $\pm 0.25^\circ\text{C}$ ($\pm 0.45^\circ\text{F}$) Accuracy: $\pm 0.5^\circ\text{C}$ ($\pm 0.9^\circ\text{F}$)
Displacement Sensor	Linear Variable Differential Transducer (LVDT), Extensometer, or similar device

Table 1. This standard specifically describes the systems of two primary suppliers (Cox and Sons, Inc. [Cox] and Industrial Process Controls, Ltd. [IPC]); however, other similar equipment could also be used.

6.1.1 *Loading Device*—The test system shall include a closed-loop, computer controlled loading component which, during each load cycle in response to commands from the data processing and control component, adjusts and applies a load such that the specimen experiences a constant level of displacement (and resulting strain) during each load cycle. The loading device shall be capable of (1) providing cyclic haversine ($= \text{SIN}^2(\text{degrees}/2)$) loading at a frequency range of 5 to 10 Hz, (2) subjecting specimens to 4-point bending with free rotation and horizontal translation at all load and reaction points, and (3) forcing the specimen back to its original position (that is, zero deflection) at the end of each loading cycle. Fig. 1 illustrates the haversine waveform. Figs. 2 and 3 show the movements of the Cox and IPC loading devices, respectively; the Cox device loads in a downward direction and the IPC loads in an upward direction. The early version of the IPC device does not have free translation at the inner clamps; however, the newer model allows free rotation and translation at all four clamps.

6.1.2 *Environmental Chamber (Temperature Control System)*—The environmental chamber shall enclose the entire specimen and maintain the specimen at the desired test temperature. The temperature shall be within $\pm 0.5^\circ\text{C}$ ($\pm 0.9^\circ\text{F}$) throughout the conditioning and testing times. An environmental chamber is not required if the temperature of the surrounding environment can be maintained within the specified limits.

6.1.3 *Control and Data Acquisition System*—During each load cycle the control and data acquisition system shall be capable of measuring the displacement of the beam specimen, and adjusting the load applied by the loading device such that the specimen experiences a constant level of displacement on each load cycle. In addition, it shall be capable of recording load cycles, applied loads, beam displacements, and temperature while computing and recording the maximum tensile stress, maximum tensile strain, phase angle, and stiffness at load cycle intervals specified by the user.

6.2 *Miscellaneous Apparatus and Materials*—For the Cox device, an aluminum, wedge-shaped target for connecting the displacement sensor to the neutral axis of the specimen and cyanoacrylate (super glue) or equivalent is needed for attaching the target to the specimen. With both the Cox and the IPC equipment, an alignment fixture and a solid aluminum beam are needed for setting the proper clamp spacing and a saw suitable for cutting the beams with parallel faces to the proper tolerance.

7. Hazards

7.1 Observe standard laboratory safety precautions when preparing and testing asphalt concrete specimens.

8. Sampling and Test Specimen Preparation

8.1 *Laboratory-Mixed and Compacted Specimens*—Sample asphalt binder in accordance with Practice D140 and sample aggregate in accordance with Practice D75. If a complete

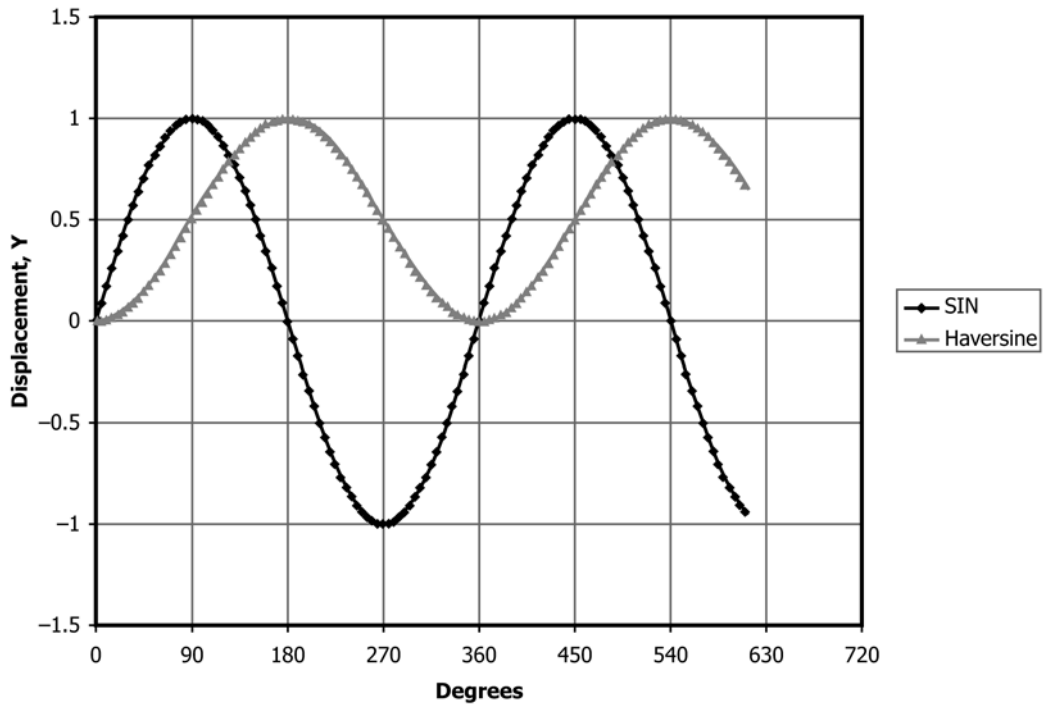


FIG. 1 Illustration of Haversine Wave Form Relative to Sine Wave

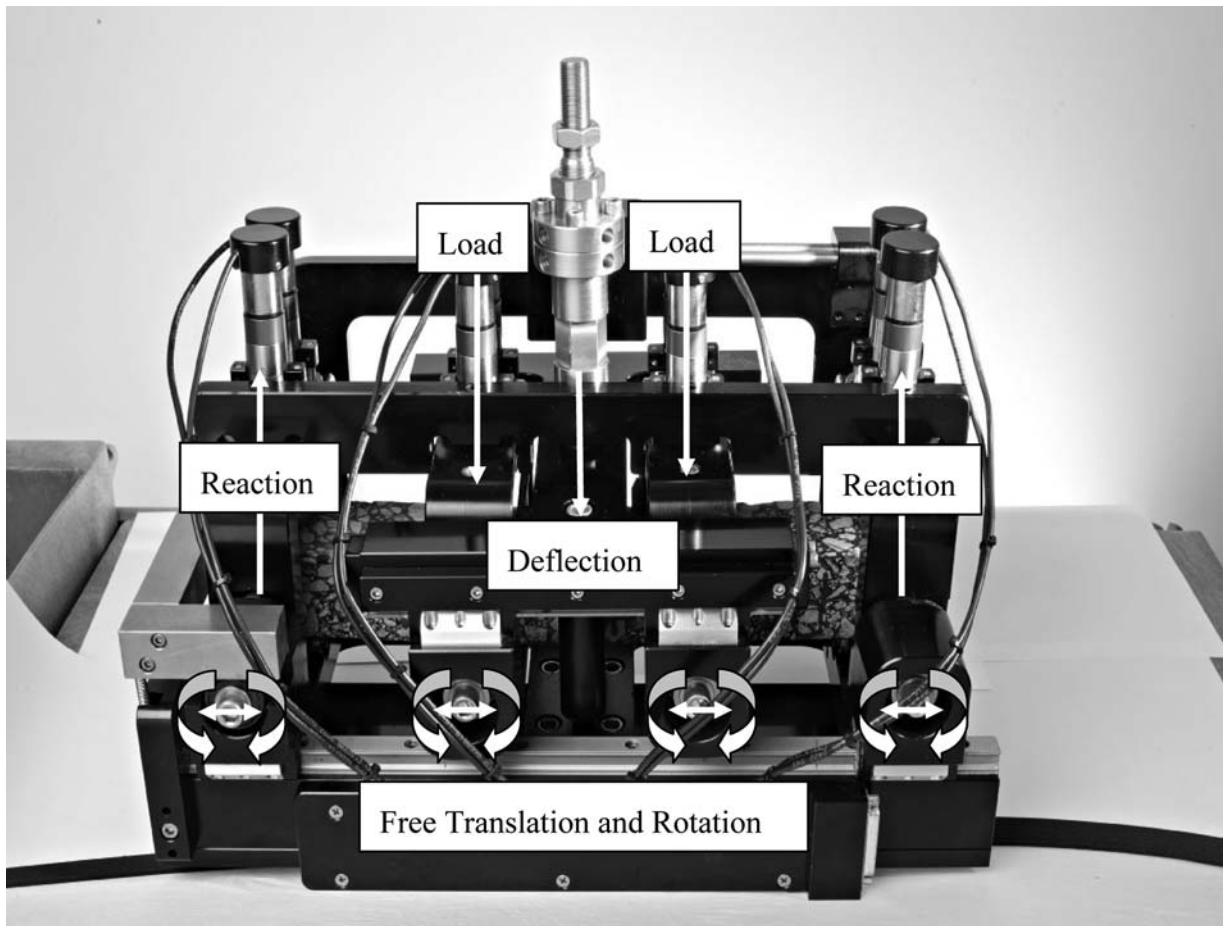


FIG. 2 Load and Freedom Characteristics of Fatigue Test Apparatus (Cox)