Designation: D7981 – 15

Standard Practice for Compaction of Prismatic Asphalt Specimens by Means of the Shear Box Compactor[1]

This standard is issued under the fixed designation D7981; 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 practice covers the fabrication of prismatic specimens of asphalt mixture using the Shear Box Compactor (SBC). Compacted specimens are suitable for volumetric and physical property testing. This standard practice should not be used for acceptance or rejection of a material or for purchasing purposes.

1.2 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard with exception of degrees (°) where angle is specified.

1.3 *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.*

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1188 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples

D2041 Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

D2726 Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures

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

D6752 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method

D6857 Test Method for Maximum Specific Gravity and Density of Bituminous Paving Mixtures Using Automatic Vacuum Sealing Method

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

E644 Test Methods for Testing Industrial Resistance Thermometers

2.2 *AASHTO Standards:*[3]

AASHTO TP79 Standard Method of Test for Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester

AASHTO T321 Standard Method of Test for Determining the Fatigue Life of Compacted Hot Mix Asphalt (HMA) Subjected to Repeated Flexural Bending

AASHTO T342 Standard Method of Test for Determining Dynamic Modulus of Hot Mix Asphalt Concrete Mixtures

3. Terminology

3.1 *Definitions:*

3.1.1 *load cycle*—the angular movement of the shearing platens in the compactor going from the vertical position to the position of maximum shear angle at one side, then going to the maximum shear angle at the other side and back to the vertical position (90 ± 0.25° with reference to the horizontal plane).

3.1.2 *shear angle*—the external angle measured between a vertical plane (angle of 90° with respect to a horizontal plane) and the plane formed by a shearing plate in the compactor when it has reached its maximum travel. Set at 4°.

4. Summary of Practice

4.1 A sample of loose asphalt mixture is compacted in a fully automatic apparatus by the combination of a static vertical force and a horizontal cyclic shear force applied to twin vertical parallel platens up to a fixed maximum shear angle, to produce a prismatic specimen of compacted asphalt to

[1] This practice is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.20 on Mechanical Tests of Asphalt Mixtures.

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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.

[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.

a target uncorrected density (that is, based on the geometric volume of the specimen).

5. Significance and Use

5.1 Asphalt prisms compacted with the Shear Box Compactor can be used to obtain specimens for further testing, including bulk specific gravity following Test Methods D6752 and D2726, Dynamic modulus following AASHTO T342, dynamic modulus, flow number, and flow time following AASHTO TP79, and fatigue performance characteristics following AASHTO T321.

5.2 Specimens to perform other standard tests could also be obtained, as long as their volume is contained within the volume of a prism having maximum width, length and height (W×L×H) of 150 mm, 450 mm, and 185 mm, respectively.

NOTE 1—The aggregate orientation in the samples produced by this method maybe different from samples produced by other laboratory compaction methods. This should be considered when comparing mechanical test results from different compaction methods.

NOTE 2—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 chr(59). 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 *Shear Box Compactor*—A compactor capable of fabricating asphalt prisms comprised of the following system components: *(1)* reaction frame, *(2)* fully integrated loading system, including loading rams, controller and data acquisition to record vertical force applied, height measurements and number of cycles, and *(3)* top and bottom compaction platens and wearing plates. The compactor must comply with the following specifications:

6.1.1 Vertical Stress adjustable by the user up to 1.0 MPa.

NOTE 3—The maximum vertical force required considering the specimen dimensions should be 67.5 kN (measured and controlled to an accuracy of ± 5% of applied load), The loading system used to achieve the required load can be electro-pneumatic, electro-mechanic, or hydraulic.

6.1.2 Shear Force of at least 50 kN, with the capability to perform horizontal cyclic loading at a rate of 3 to 4 cycles every minute.

6.1.3 Shear Angle fixed at 4° (± 0.25°).

6.1.4 The compactor must be capable of producing compacted prismatic specimens 450 mm (± 1.0 mm) long, 150 mm (± 1.0 mm) wide and with a height ranging from 120 mm to 185 mm (± 1.0 mm).

6.1.5 The controller must be capable to automatically terminate a compaction run after meeting one of two termination criteria: sample height or, number of loading cycles. The sample height and vertical load shall be recorded.

6.1.6 The reaction frame shall be rigid and capable of sustaining the maximum forces generated during the compaction process with system compliance of less than 0.1 mm per 1 kN. It shall also be able to sustain shear reaction forces being applied to the mold side plates and pivots.

6.1.7 The loading system (Fig. 1) shall consist of a con-

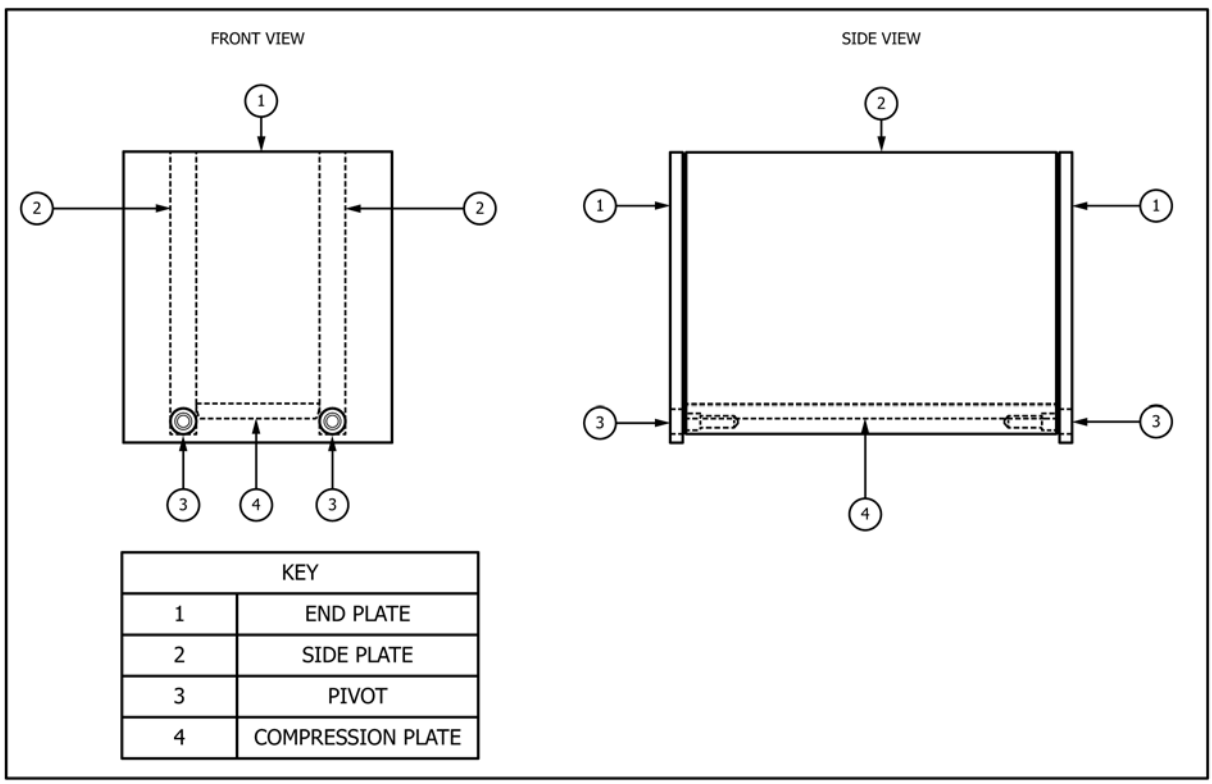

FIG. 1 Example Schematics of Shear Box Pivot Points

trolled dual axis loading system (vertical and horizontal). A constant vertical force shall be applied to achieve a vertical stress as per specified above . The horizontal force shall be perpendicular to the vertical load axis, and applied through a system that ensures the rotational parallel movement of the walls of the mold during the compaction process. The pivot points shall be concentrically located at both end of the mold walls such that ±2 mm of parallelism can be achieved see Fig. 1.

6.1.8 The horizontal loading system shall be capable of inducing a preset constant maximum degree of rotation (maximum shear angle) during a compaction of 4° (± 0.25°).

6.1.9 The vertical actuator or the reaction element shall slide freely and parallel to the horizontal loading axis Fig. 2. The vertical force applied shall be measured during the compaction process with suitable transducers.

6.1.10 The shear box compactor system shall also include a specimen extraction unit.

6.2 *Mold Plates, Wear Plates used on top and bottom of the specimen and Ram Heads*—All mold plates and ram heads shall be fabricated from steel with a minimum Rockwell hardness of C48. The mold plates and vertical ram heads shall be flat (< 0.1 mm over 500 mm).

6.3 *Loading Chute*—A purpose built heat resistant chute approximately 445 mm long, 140 mm wide and 295 mm high, with horizontal slots near the bottom of the chute approximately 75 mm apart and 75 mm tall, and with quick-release holding gates at the base to ensure the mix is transferred uniformly from the heating trays to the compaction mold assembled within the shear box compactor.

6.4 *Thermometers*—A platinum resistance thermometer (PRT), thermocouple, or dial-type thermometer with a range of at least 10 to 232°C. Calibrate the thermometer system (probe and readout) in accordance with Test Methods E644.

6.5 *Balance*—At least one balance with a minimum capacity of 30 000 g with a sensitivity of 0.1 g.

6.6 *Ovens*—At least one oven, capable of achieving up to 204°C, and thermostatically controlled to ±3°C must be available for heating aggregates, bitumen binders, and equipment. If short term oven aging is going to be conducted on the mixture, an additional forced draft oven capable of maintaining the requested temperature must be available.

6.7 *Tamping Rod or similar tool*—Diameter 10.0 mm, Length ~ 450 mm, Shape Round, Material Mild steel.

6.8 *Miscellaneous*—Miscellaneous equipment may include: flat bottom metal pans for heating aggregate and asphalt mixtures; scoops; containers for heating bituminous binders; mixing spoons; spatulas; protection gloves for handling hot equipment; portable aids to lift moderately heavy items in a laboratory setting; and mechanical mixers.

7. Hazards

7.1 This practice may involve hazardous materials, operations and equipment. It does not intend to cover all the safety concerns associated with its use. It is the responsibility of the user of this practice to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to its use. Observe standard laboratory safety precautions when preparing and testing asphalt specimens.

8. Preparation of Apparatus

8.1 Follow carefully the manufacturer's recommendations for turning on the shear box compactor.

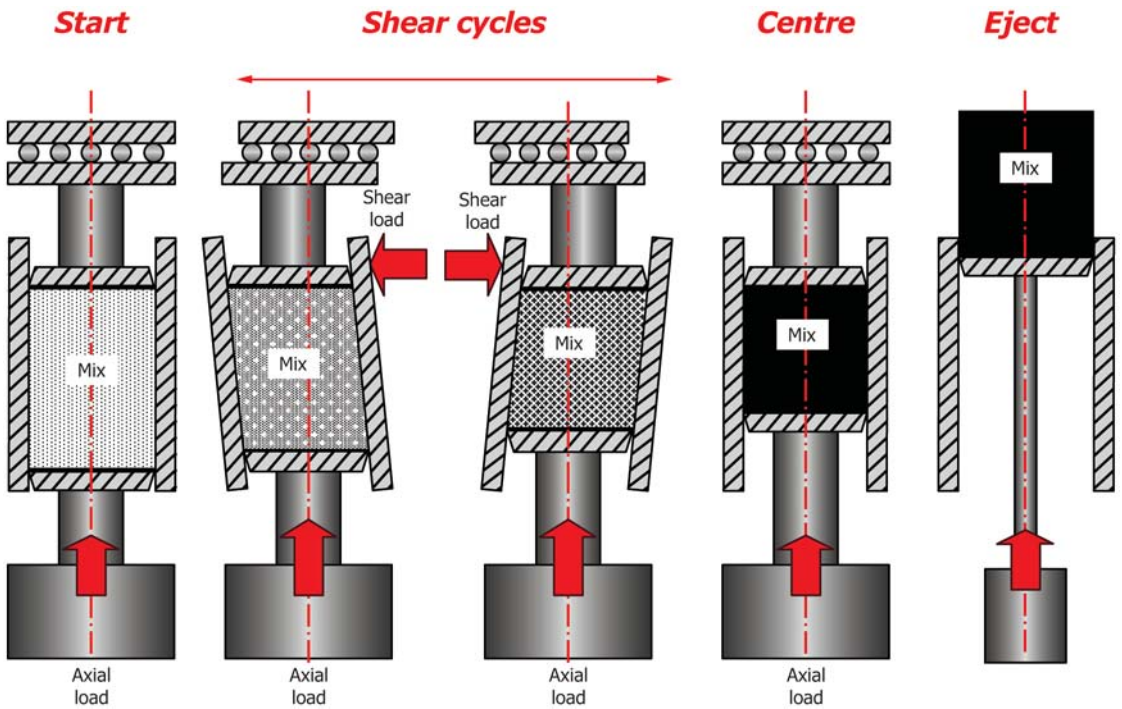

FIG. 2 Example Schematics of Shear Box Compactor Loading System

8.2 If the bottom platen and bottom wear plate are not installed, raise the ejector to near the top of the mold and install the bottom platen, with the wide side facing upwards, and then place a wear plate on top.

8.3 Lower the lower platen to position it at the bottom of the mold.

9. Preparation and Conditioning of the Loose Mixture

9.1 To prepare and condition the sample prior to compaction, follow local or national standards for preparation of samples, adjusting the quantities of materials such that the total mixture produced in the laboratory or obtained from a plant is sufficient to produce the required compacted specimen volume and a companion loose mix sample suitable to determine the Theoretical Maximum Specific Gravity of the mixture according to Test Method D2041 or D6857.

NOTE 4—For typical asphalt mixtures, the total weight required should be between 20 and 30 kg, depending on the density of the constituents and the target specimen height.

9.2 Place the mold plates and wearing plates in the oven at the selected compaction temperature at least 45 min prior to loading the mix in the compactor.

10. Procedure

10.1 *Loading a Specimen in the Shear Box Compactor:*

10.1.1 Considering the mass required to compact the prismatic specimens and to facilitate the transfer of the loose mixture to the compaction mold, distribute the total mass to be used during compaction in approximately equal amounts in separate pans, ensuring that the weight of each pan is easily manageable by the person performing the compaction.

NOTE 5—As a general recommendation, a total of 3 to 4 pans with net weights of asphalt between 6 and 8 kg have been found to be reasonably manageable during compaction. If splitting of the sample is not required due to lifting aids available in the premises, this process can be omitted.

NOTE 6—Consider pouring and compacting a hot sample into the mold to allow all machine components to heat up, prior to fabricating samples for actual testing.

NOTE 7—To avoid samples sticking to the side of the mold, consider using a release agent for rubber and polymer modified mixes.

10.1.2 Place the required mass (typically 25 to 30 kg) of heated mix into the preheated specimen trays.

10.1.3 Place the preheated loading chute on top of the compaction mold (ensuring that the bottom gates are secured in place).

10.1.4 Using the specimen trays, feed one half of the loose mixture carefully into the chute, alternating the side of the chute into which the mix is poured in.

10.1.5 Once the sample in the chute has been poured in, ensure that the mix is level and evenly spread along and across the chute.

NOTE 8—To avoid segregation of the mix; try to achieve a uniform surface in the chute with the least amount of intervention possible.

10.1.6 Release the discharge gates in the chute to allow the mix to flow into the compaction mold, and then slowly lift and remove the chute from the mold. Using a long tamping rod or similar tool, poke the mix five times near each of the four vertical corners of the mold, and ensure that the specimen surface is level.

10.1.7 Place the preheated loading chute back on top of the compaction mold, repeat 10.1.4 to 10.1.6 for the second half of the loose mixture.

10.1.8 Place the preheated wear plate and top platen with the wider side facing downward on top of the mix. Slide the mold into the frame and lock the mold to the frame following the instructions from the compactor manufacturer. The mold walls shall be perpendicular (90 ± 0.25° with reference to the horizontal plane) before the compaction begins.

10.2 *Compaction of a Specimen:*

10.2.1 Enter the vertical stress to be applied during compaction. This stress will be kept constant during the compaction process.

NOTE 9—A typical value of vertical stress suggested to be used during compaction is 600 kPa. Enter other specimen information as required in the shear box compactor software.

10.2.2 Set the desired compaction termination height and/or cycles criteria within the shear box compactor software.

10.2.3 Follow the manufacturer's instructions to begin the specimen preparation. When the required vertical stress is applied to the sample, the horizontal force system is switched on and compaction takes place until the first of the selected termination conditions is achieved.

10.2.4 When the termination criterion is met, the vertical stress is removed, and the height of the specimen when the compaction is finished is kept constant while the walls of the mold are brought back to the vertical position, if not already vertical. Follow manufacturer's instructions for removal of the specimen.

10.2.5 Compaction time will vary depending on mix type and termination criterion selected.

10.2.6 Allow the sample to cool prior to handling and removable from the machine.

11. Standardization

11.1 Items requiring periodic verification or calibration include the vertical force, angle of shear and specimen height measurement system. Verification of calibration, system standardization, and quality checks shall be performed by the manufacturer, other agencies providing standardization services, or in-house personnel.

11.2 It is required that the user verifies the calibration of the following items following the manufacturer's recommendations: vertical force, angle of shear and specimen height measurement system.

NOTE 10—If no manufacturer recommendations are available, the following schedule should be sufficient to assure the user that the Shearbox compactor is operating using the proper parameters: Vertical force annually, Height measurement annually, and Angle of shear annually.

NOTE 11—Calibration shall be performed if the Shearbox compactor is transported to a new location.

12. Report

12.1 Report the following information:

12.1.1 Mix and specimen identification details,

12.1.2 Date and time of specimen preparation,

12.1.3 Mass of the specimen, to the nearest 0.1 g,

12.1.4 Maximum theoretical specific gravity (G_{mm}) of the companion specimen by Test Method D2041 or D6857, to the nearest 0.001,

12.1.5 Vertical stress and angle used during compaction, and

12.1.6 Height of the compacted specimen after each load cycle (h_x), to the nearest 0.1 mm.

13. Keywords

13.1 air voids; asphalt; asphalt mixture performance tester; beam fatigue; beam samples; compaction; density; dynamic modulus; HMA; shear box compactor

REFERENCES

(1) Qiu, et al (2012). Evaluating Laboratory Compaction of Asphalt Mixtures Using the Shear Box Compactor. In *Journal of Testing and Evaluation (ASTM)*, Vol. 40, No. 5, pp 1-9.