

Standard Test Method for Determining the Permanent Shear Strain and Stiffness of Asphalt Mixtures Using the Superpave Shear Tester (SST)

AASHTO Designation: TP7-01^{1,2}

1. Scope

1.1 This standard provides performance-related test procedures for the determination of stiffness and permanent shear strain of asphalt mixtures using the SST. Modified and unmodified asphalt mixtures can be tested and analyzed using this standard.

1.2 This standard is applicable to specimens prepared in a laboratory or cored from a pavement for post-construction analysis. It is intended for use with specimens having the following minimum dimensions:

Nominal Maximum Aggregate Size in Asphalt Mixture (mm)	Specimen Diameter (mm)	Specimen Height (mm)
19	150	50
12.5, 9.5, 4.75	150	38

Note 1 - Nominal maximum aggregate size is defined in AASHTO PP28 as the sieve greater than the first sieve to retain more than 10 percent of the total aggregate. Asphalt mixtures with a nominal maximum aggregate size greater than 19 mm can be tested using this procedure, but it is not recommended. The larger aggregate sizes may significantly interfere with the material response, thereby affecting the repeatability of the test.

Note 2 - The SST is only capable of testing specimens with a maximum diameter of 150 mm. The specimen height of 50 mm is preferred, but may not be available in roadway cores where layer thickness may only be 38 millimeters. Specimen heights less than 38 mm cannot be tested because of equipment constraints.

Note 3 - The diameter-to-height ratio for shear test specimens should be 3:1 or greater. This effectively eliminates

the use of 100-mm diameter specimens (because of minimum height requirement for testing discussed in Note 2).

1.3 *This practice may involve hazardous materials, operations, and equipment. It does not purport to address 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.*

2. Referenced Documents

2.1 AASHTO Standards:

- T2 Sampling Aggregates
- T40 Sampling Bituminous Materials
- T166 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
- T209 Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
- T269 Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
- T168 Sampling Bituminous Paving Mixtures
- TP4 Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
- PP2 Mixture Conditioning of Hot Mix Asphalt (HMA)
- PP28 Superpave Volumetric Design for Hot Mix Asphalt (HMA)

2.2 ASTM Standards:

- D3519 Thickness or Height of Compacted Bituminous Paving Mixture Specimens
- D5361 Sampling Compacted Bituminous Mixtures for Laboratory Testing

¹ This Standard is based on SHRP product 1017.

² Originally approved in October 1994, it received a major rewrite for the 2001 ballot.

3. **Significance and Use** – The test procedures and associated analysis techniques described in this method can be used to determine shear stiffness and permanent shear strain of asphalt mixtures. The shear frequency sweep test at constant height can be used to determine mixture stiffness. The simple shear test at constant height can be used to determine shear deformation from the application of a static shear load. The repeated shear test at constant height can be used with corresponding analysis procedures to estimate the rutting susceptibility of an asphalt mixture.

4. **Equipment and Materials**

4.1 **Shear Test System** – The shear test system shall consist of a loading device, specimen deformation measurement equipment, an environmental chamber, and a control and data acquisition system. It shall accommodate test specimens 150 mm in diameter and 50 mm in height.

4.1.1 **Loading Device** – The loading device shall be capable of simultaneously applying both vertical and horizontal loads to a specimen. It shall also be capable of applying static, ramped (increasing or decreasing), and repetitive loads of various waveforms. As a minimum, the loading device shall be capable of applying horizontal shear load pulses in a haversine wave form with a load duration of 0.1-seconds and 0.6-seconds between load pulses. Loading shall be provided by two hydraulic actuators (one each horizontal and vertical) and shall be controlled by closed-loop feedback using either stress or strain control throughout the entire range of frequencies and temperatures. The loading device shall be capable of meeting the minimum requirements specified in Table 1.

4.1.2 **Environmental Chamber** – The environmental chamber shall be capable of maintaining the temperature of the test specimen as specified in Table 1 during the testing sequence.

4.1.3 **Data Acquisition and Control System** – The data acquisition and control system shall automatically control user-selected measurement parameters, within the accuracy specified in Table 1, during the testing sequence, and shall record load cycles, applied horizontal and vertical loads, specimen deformation in two directions (vertical and

horizontal), environmental conditions, and the required frequency of data sampling. At the conclusion of the test, the data acquisition and control system shall provide all applicable test data.

4.2 **Conditioning Chamber** – The conditioning chamber shall be capable of maintaining the specimen conditioning temperatures as specified in Table 1.

4.3 **Platen-Specimen Assembly Device (optional)** – The platen-specimen assembly device is used to facilitate bonding the specimen to the loading platens with adhesive. The device shall maintain the platens in a parallel position (relative to each other) during the gluing operation. The platens must remain parallel so that stresses do not develop in the specimen when the specimen-platen assembly is clamped in the test system. The device shall accommodate test specimens 150 mm in diameter with a height of 50 mm.

4.4 **Aluminum Loading Platens** – Top and bottom aluminum loading platens at least 6.35 millimeters greater in diameter than the diameter of the specimen to be tested and at least 20 mm thick. The bearing face of each platen shall be plane to 0.025 mm.

4.5 **Adhesive** – Quick-set adhesive with a minimum hardened stiffness modulus of 2000 MPa for bonding the platens to the specimen ends.

Note 4 - Devcon™ 5-Minute Plastic Steel Epoxy Cement is satisfactory for tests conducted at 20°C or higher.

4.6 **Acetone, Kerosene, or Other Solvent** – Acetone, kerosene, or other equivalent solvent for cleaning the platens after testing.

Note 5 – Most of the epoxy and samples can be removed by heating and scraping the platens. The solvent is used only for a final cleaning.

5. **Standardization**

5.1 The testing system shall be standardized prior to initial use and at least once every 12 months thereafter.

5.1.1 Verify the capability of the environmental control chamber to maintain the required temperature within the accuracy specified in Table 1.

5.1.2 Verify the calibration of all measurement components (such as load cells and LVDTs) of the testing system.

5.1.3 If any of the verifications yield data that do not comply with the accuracy requirements specified in Table 1, correct the problem prior to proceeding with testing. Appropriate action may involve correction of menu entries, maintenance on system components, calibration of system components (using an independent calibration service, manufacturer service, or in-house resources), or replacement of system components.

6. Sampling and Specimen Preparation

6.1 Five test specimens are preferred, and a minimum of three specimens are required, for performing the repeated shear test at constant height to determine the rutting susceptibility of an asphalt mixture. Three test specimens are preferred for performing the shear frequency sweep test at constant height and the simple shear test at constant height.

6.2 Laboratory-Mixed, Laboratory-Compacted (LMLC) Specimens – Sample asphalt binder and aggregates in accordance with AASHTO T40 and T2, respectively. Use the appropriate proportions of asphalt binder and aggregates to match the final asphalt mix design.

6.2.1 Prepare aggregate batches of the appropriate size to produce a compacted specimen that will be 150-mm diameter and 75-mm height. Heat the aggregate batches to the appropriate mixing temperature.

Note 6 – The Appendix contains information on the calculation of the appropriate aggregate batch weight to achieve the correct specimen dimension at the proper percentage of air voids.

6.2.2 Heat the asphalt binder to the appropriate mixing temperature. Mix the correct proportions of

asphalt binder and combined aggregates to match the asphalt mix design.

6.2.3 After mixing, the asphalt mixture is required a short term conditioning for four hours at 135°C in accordance with AASHTO PP2.

6.2.4 After the short-term conditioning is complete, the asphalt mixture specimen should be compacted to the appropriate percentage of air voids according to TP4. For the repeated shear test and associated analysis, the percentage of air voids in the test specimen (which may be cut to the appropriate dimensions of 150-mm diameter and 50-mm height) is usually 4.0 ± 0.5 percent. For the simple shear and shear frequency sweep tests, the percentage of air voids in the test specimen (which may be cut to the appropriate dimensions of 150-mm diameter and 50-mm height) is usually 7.0 ± 0.5 percent. To achieve these target percentages of air voids, it may be necessary to compact the specimen (before cutting) to a slightly higher target percentage of air voids.

Note 7 – Other compaction procedures than the Superpave gyratory compactor (TP4) and other target air void percentages may be used. However, caution is needed to prevent comparisons between asphalt mixtures with different target air voids or compaction. The test procedures and analyses are sensitive to both the percentage of air voids and the compaction procedure.

Note 8 – Specimens are often compacted to a target air void percentage that is higher than the anticipated percentage of air voids in the cut test specimen. This is done because cutting the top and bottom of a compacted specimen removes lower density material, thereby raising the density (lowering the air voids) of the test specimen. The magnitude of the difference between the target percentage of air voids for the compacted specimen and the target percentage of air voids for the test specimen is dependent upon the nominal maximum aggregate size of the mixture and the mixture gradation.

Coarse mixes, and/or mixes with a larger nominal maximum aggregate size, tend to have greater differences between the compacted specimen air voids and the test specimen air voids. In general, a 1.0 percent offset (compact to a target of 5.0 percent air voids or 8.0 percent air voids) should be sufficient to achieve the appropriate percentage of air voids in the test specimen.

6.2.5 Allow the compacted mixture specimens to cool completely to room temperature. Cut the specimens to the proper test dimensions. Cut faces should be parallel to within 2 mm of each other.

6.2.6 Determine the percentage of air voids in the test specimens in accordance with AASHTO T166, T209, and T269. Determine the height of the test specimens in accordance with ASTM D3549.

6.3 Field-Mixed, Laboratory-Compacted (FMLC) Specimens - Obtain HMA samples in accordance with AASHTO T168. Compact specimens using AASHTO TP4 to the appropriate percentage of air voids (see Section 6.2.4 and Notes 7 and 8).

Note 9 - The Appendix contains information on the calculation of the appropriate mixture sample weight to achieve the correct specimen dimension at the proper percentage of air voids.

6.3.1 Allow the compacted mixture specimens to cool completely to room temperature. Cut the specimens to the proper test dimensions. Cut faces should be parallel to within 2 mm of each other.

6.3.2 Determine the percentage of air voids in the test specimens in accordance with AASHTO T166, T209, and T269. Determine the height of the test specimens in accordance with ASTM D3549.

6.4 Field-Mixed, Field-Compacted (FMFC or Pavement Core) Specimens - Obtain asphalt pavement specimens having a diameter of 150 mm and a minimum thickness of 38 mm in accordance with ASTM D5361.

6.4.1 Cut the specimens to the proper test dimensions. Cut faces should be parallel to within 2 mm of each other.

6.4.2 Determine the percentage of air voids in the test specimens in accordance with AASHTO T166, T209, and T269. Determine the height and diameter of the test specimens in accordance with ASTM D3549.

6.5 Preparing the Specimens for Testing - The following steps discuss the bonding of the test specimen to the platens for testing in the shear tester.

6.5.1 Ensure that the platens are clean, aligned, and clamped in place in the platen-specimen assembly device (optional) or shear test device.

6.5.2 Proportion and mix the epoxy resin and hardener together in accordance with the manufacturer's instructions (Note 4).

6.5.3 Apply a thin coating of the epoxy cement to the top of the test specimen and to the bottom platen. Center the test specimen on the bottom platen and lower the top platen onto the specimen. Rotate the specimen slightly to ensure good bonding.

Note 10 - Approximately 135 g of epoxy cement has been found suitable to provide bonding without excess waste. Half of the epoxy cement should be used on the bottom platen and the other half on the top of the specimen.

6.5.4 Bond the specimen to the platens using a light pressure (approximately 35 kPa) for five minutes. Begin removing excess epoxy cement from the sides of the test specimen by trimming as soon as the light pressure is applied.

6.5.5 After 20 minutes, remove the test assembly (specimen with attached platens) from the platen-specimen assembly device (optional) or shear test device and allow the epoxy to cure for the minimum time recommended by the manufacturer.

Note 11 - For Devcon™ 5-Minute Plastic Steel Epoxy Cement, a