

WSDOT FOP for AASHTO T 312¹

Preparing Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyrotory Compactor

1. SCOPE

- 1.1. This standard covers the compaction of cylindrical specimens of hot-mix asphalt (HMA) using the Superpave gyrotory compactor.
- 1.2. This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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 AASHTO Standards:

- M 231, Weighing Devices Used in Testing of Materials
- TP 71, Evaluation of the Superpave Gyrotory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading
- R 30, Mixture Conditioning of Hot-Mix Asphalt (HMA)
- R 35, Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
- T 166, Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
- T 168, Sampling Bituminous Paving Mixtures
- T 209, Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
- T 275, Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
- T 316, Viscosity Determination of Asphalt Binder Using Rotational Viscometer

2.2 Other Standards:

- WSDOT SOP 731, Method for determining volumetric properties of asphalt concrete pavement class superpave
- WSDOT SOP 732, Superpave Volumetric Design for Hot-Mix Asphalt (HMA)

¹ This FOP is based on AASHTO T 312-08 and has been modified per WSDOT standards. To view the redline modifications, contact WSDOT Quality Systems Manager at (360) 709-5412.

3. SIGNIFICANCE AND USE

- 3.1. This standard is used to prepare specimens for determining the mechanical and volumetric properties of HMA. The specimens simulate the density, aggregate orientation, and structural characteristics obtained in the actual roadway when proper construction procedure is used in the placement of the paving mix.
- 3.2. This test method may be used to monitor the density of test specimens during their preparation. It may also be used for field control of an HMA production process.

4. APPARATUS

- 4.1. Superpave Gyrotory Compactor-An electrohydraulic or electromechanical compactor with a ram and ram heads as described in Section 4.3. The axis of the ram shall be perpendicular to the platen of the compactor. The ram shall apply and maintain a pressure of 600 ± 18 kPa perpendicular to the cylindrical axis of the specimen during compaction (Note 1). The compactor shall tilt the specimen molds at an average internal angle of $1.16 \pm 0.02^\circ$ (20.2 ± 0.35 mrad), determined in accordance with AASHTO TP 71. The compactor shall gyrate the specimen molds at a rate of 30.0 ± 0.5 gyrations per minute throughout compaction.

Note 1: This stress calculates to $10,600 \pm 310$ N total force for 6 inches (150 mm) specimens.

- 4.1.1 Specimen Height Measurement and Recording Device – When specimen density is to be monitored during compaction, a means shall be provided to continuously measure and record the height of the specimen to the nearest 0.1 mm during compaction once per gyration.
 - 4.1.2 The system may include a connected printer capable of printing test information, such as specimen height per gyration. In addition to a printer, the system may include a computer and suitable software for data acquisition and reporting.
- 4.2 Specimen Molds – Specimen molds shall have steel walls that are at least 0.3 inches (7.5 mm) thick and are hardened to at least a Rockwell hardness of C48. The initial inside finish of the molds shall have a root mean square (rms) of 1.60 μ m or smoother (Note 2). Molds shall have an inside diameter of 5.9 to 6.0 inches (149.90 to 150.00 mm) and be at least 9.8 inches (250 mm) high at room temperature.

Note 2: Smoothness measurement is in accordance with ANSI B 46.1. One source of supply for a surface comparator, which is used to verify the rms value of 1.60 μ m, is GAR Electroforming, Danbury, Connecticut.
- 4.3 Ram Heads and Mold Bottoms – Ram heads and mold bottoms shall be fabricated from steel with a minimum Rockwell hardness of C48. The ram heads shall stay perpendicular to its axis. The platen side of each mold bottom shall be flat and parallel to its face. All ram and base plate faces (the sides presented to the specimen) shall be flat to meet the smoothness requirement in Section 4.2 and shall have a diameter of 5.88 to 5.90 inches (149.50 to 149.75 mm).
- 4.4 Thermometric Device- used for determining the temperature of aggregates, binder, and HMA between 18 to 418°F (10 and 232°C).

- 4.5 Balance – A balance meeting the requirements of M 231, Class G5, for determining the mass of aggregates, binder, and HMA.
 - 4.6 Oven – An oven, thermostatically controlled to $\pm 5^{\circ}\text{F}$ ($\pm 3^{\circ}\text{C}$), for heating aggregates, binder, HMA, and equipment as required. The oven shall be capable of maintaining the temperature required for mixture conditioning in accordance with R 30.
 - 4.7 Miscellaneous – flat-bottom metal pans for heating aggregates, scoop for batching aggregates, containers (grill-type tins, beakers, containers for heating asphalt), large mixing spoon or small trowel, large spatula, gloves for handling hot equipment, paper disks, mechanical mixer (optional), lubricating materials recommended by the compactor manufacturer.
 - 4.8 Maintenance – In addition to routine maintenance recommended by the manufacturer, check the Superpave gyrotory compactor's mechanical components for wear, and perform repair, as recommended by the manufacturer.
5. HAZARDS
 - 5.1 Use standard safety precautions and protective clothing when handling hot materials and preparing test specimens.
6. STANDARDIZATION
 - 6.1 Items requiring periodic verification of calibration include the ram pressure, angle of gyration, gyration frequency, LVDT (or other means used to continuously record the specimen height), and oven temperature. Verification of the mold and platen dimensions and the inside finish of the mold are also required. When the computer and software options are used, periodically verify the data processing system output using a procedure designed for such purposes. Verification of calibration, system standardization, and quality checks may be performed by the manufacturer, other agencies providing such services, or in-house personnel. Frequency of verification shall follow the manufacturer's recommendations.
 - 6.2 The angle of gyration the internal angle (tilt of mold with respect to end plate surface within the gyrotory mold). The calibration of the internal angle of gyration should be verified in accordance with AASHTO TP 71.
7. PREPARATION OF APPARATUS
 - 7.1 Immediately prior to the time when the HMA is ready for placement in the mold, turn on the main power for the compactor for the manufacturer's required warm-up period.
 - 7.2 Verify the machine settings are correct for angle, pressure, and number of gyrations.
 - 7.3 Lubricate any bearing surfaces as needed per the manufacturer's instructions.
 - 7.4 When specimen height is to be monitored, the following additional item of preparation is required. Immediately prior to the time when the HMA is ready for placement in the mold, turn on the device for measuring and recording the height of the specimen, and verify the readout is in the proper units, mm, and the recording device is ready. Prepare the computer, if used, to record the height data, and enter the header information for the specimen.

8. HMA MIXTURE PREPARATION

- 8.1 Weigh the appropriate aggregate fractions into a separate pan, and combine them to the desired batch weight. The batch weight will vary based on the ultimate disposition of the test specimens. If a target air void level is desired, as would be the case for Superpave mix analysis and performance specimens, batch weights will be adjusted to create a given density in a known volume. If the specimens are to be used for the determination of volumetric properties, the batch weights will be adjusted to result in a compacted specimen having dimensions of 6 inches (150 mm) in diameter and 4.53 ± 0.12 inches (115 ± 5 mm) in height at the desired number of gyrations.

Note 3: It may be necessary to produce a trial specimen to achieve this height requirement. Generally, 4500 – 4700 g of aggregate are required to achieve this height for aggregates with combined bulk specific gravities of 2.55-2.70, respectively.

- 8.2 Place the aggregate and binder container in the oven, and heat them to the required mixing temperature.

8.2.1. The mixing temperature range is defined as the range of temperatures where the unaged binder has a kinematic viscosity of 170 ± 20 mm²/s (approximately 0.17 ± 0.02 Pa·s for a binder density of 1.00 g/cm³) measured in accordance with T 316.

Note 4: Modified asphalts may not adhere to the equi-viscosity requirements noted, and the manufacturer's recommendations should be used to determine mixing and compaction temperatures.

Note 5: The SI unit kinematic viscosity is m²/s; for practical use, the submultiple mm²/s is recommended. The more familiar centistokes is a cgs unit of kinematic viscosity; it is equal to 1 mm²/s. The kinematic viscosity is the ratio of the viscosity of the binder to its density. For a binder with a density equal to 1.000 g/cm³, a kinematic viscosity of 170 mm²/s is equivalent to a viscosity of 0.17 Pa·s measured in accordance with T 316.

- 8.3 Charge the mixing bowl with the heated aggregate from one pan, and dry-mix thoroughly. Form a crater in the dry blended aggregate, and weigh the required amount of binder into the mix. Immediately initiate mixing.
- 8.4 Mix the aggregate and binder as quickly and thoroughly as possible to yield HMA having a uniform distribution of binder. As an option, mechanical mixing may be used.
- 8.5 After completing the mixture preparation perform the required mixture conditioning in accordance with R 30.
- 8.6 Place a compaction mold and base plate in an oven above the required compaction temperature for a minimum of 60 minutes prior to the estimated beginning of compaction (during the time the mixture is being conditioned in accordance with R 30).

8.7 Following the mixture conditioning period specified in R 30, if the mixture is at the compaction temperature, proceed immediately with the compaction procedure as outlined in Section 9. If the compaction temperature is different from the mixture conditioning temperature used in accordance with R 30, place the mix in another oven at the compaction temperature for a brief time (maximum of 30 minutes) to achieve the required temperature.

8.7.1. The compaction temperature is the mid-point of the range of temperatures where the unaged binder has a kinematic viscosity of $280 \pm 30 \text{ mm}^2/\text{s}$ (approximately $0.28 \pm 0.03 \text{ Pa}\cdot\text{s}$) measured in accordance with T 316 (Note 4).

8.8 If loose HMA plant mix is used, the sample should be obtained in accordance with T 168. The mixture shall be brought to the compaction temperature range by careful, uniform heating in an oven immediately prior to molding.

9. COMPACTION PROCEDURE

9.1 When the temperature of the HMA is five degrees above the compaction temperature as shown on the "Mix Design Verification Report," remove the heated mold, base plate, and upper plate (if required) from the oven. Place the base plate and a paper disk in the bottom of the mold.

9.2 Remove the pan of HMA from the oven and in one motion invert the pan onto the construction paper, vinyl mat, etc. Quickly remove any material that remains in the pan and include it with the HMA sample to be compacted. Grasp opposing edges of the paper and roll them together to form the HMA into a cylindrical shape. Insert one end of the paper roll into the bottom of the compaction mold and remove the paper as the HMA slides into the mold. This process needs to be accomplished in approximately 60 seconds. Place the mixture into the mold in one lift. Care should be taken to avoid segregation in the mold. After all the mix is in the mold, level the mix, and place another paper disk and upper plate (if required) on top of the leveled materials.

9.3 Load the charged mold into the compactor, and center the loading ram.

9.4 Apply a pressure of $600 \pm 18 \text{ kPa}$ on the specimen.

9.5 Apply a $1.16 \pm 0.02^\circ$ ($20.2 \pm 0.35 \text{ mrad}$) average internal angle, as appropriate, to the mold assembly, and begin.

9.6 Allow the compaction to proceed until the desired number of gyrations specified in R 35 is reached and the gyratory mechanism shuts off.

9.7 Remove the angle from the mold assembly; retract the loading ram; remove the mold from the compactor (if required); and extrude the specimen from the mold.

Note 6: The specimens can be extruded from the mold immediately after compaction for most HMA. However, a cooling period of 5 to 10 minutes in front of a fan may be necessary before extruding some specimens to insure the specimens are not damaged.

9.8 Remove the paper disks from the top and bottom of the specimens.

Note 7: Before reusing the mold, place it in an oven for at least 5 minutes. The use of multiple molds will speed up the compaction process.

10. DENSITY PROCEDURE

10.3 When the specimen height is to be monitored, record the specimen height to the nearest 0.1 mm after each revolution.

11. DENSITY CALCULATIONS

WSDOT has removed this section refer to WSDOT SOP 731.

12. REPORT

WSDOT has removed this section refer to WSDOT SOP 731.

12.2 Report results on WSDOT form 350-162 or other report approved by the State Materials Engineer.

13. PRECISION AND BIAS

See AASHTO T 312 for Precision and Bias

Performance Exam Checklist

Determining Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyrotory Compactor FOP For AASHTO T 312

Participant Name _____ Exam Date _____

Procedure Element	Yes	No
1. The tester has a copy of the current procedure on hand?	<input type="checkbox"/>	<input type="checkbox"/>
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	<input type="checkbox"/>	<input type="checkbox"/>
3. Main power for compactor turned on for manufacturer's required warm-up period if applicable?	<input type="checkbox"/>	<input type="checkbox"/>
4. Angle, pressure and number of gyrations set?	<input type="checkbox"/>	<input type="checkbox"/>
5. Bearing surfaces, rotating base surface and rollers lubricated?	<input type="checkbox"/>	<input type="checkbox"/>

Preparation of Mixtures

1. Is mixture at compaction temperature? If not, was mixture placed in an oven and brought up to compaction temperature?	<input type="checkbox"/>	<input type="checkbox"/>
2. Mold and base plate heated for a minimum of 60 minutes in an oven at a temperature not to exceed the compaction temperature by 25 F?	<input type="checkbox"/>	<input type="checkbox"/>

Plant mix – Loose mix brought to compaction temperature by uniform heating immediately prior to molding.

1. Mold, base plate and upper plate (if required) removed from oven and paper disk placed on bottom of mold?	<input type="checkbox"/>	<input type="checkbox"/>
2. Mixture placed into mold in one lift, mix leveled, and paper disk and upper plate (if required) placed on top of material?	<input type="checkbox"/>	<input type="checkbox"/>
3. Mold loaded into compactor and a pressure of 600 ± 18 kPa applied?	<input type="checkbox"/>	<input type="checkbox"/>
4. Angle of $1.16 \pm 0.02^\circ$ (20.2 ± 0.35 mrad) applied to the mold assembly and gyrotory compaction started?	<input type="checkbox"/>	<input type="checkbox"/>
5. Compactor shuts off when appropriate gyration level is reached?	<input type="checkbox"/>	<input type="checkbox"/>
6. Mold removed and specimen extruded?	<input type="checkbox"/>	<input type="checkbox"/>
7. Paper disks removed?	<input type="checkbox"/>	<input type="checkbox"/>
8. If specimens are used for determination of volumetric properties, are the heights of the specimens 115 ± 5 mm?	<input type="checkbox"/>	<input type="checkbox"/>
9. All calculations performed correctly?	<input type="checkbox"/>	<input type="checkbox"/>

First attempt: Pass Fail

Second attempt: Pass Fail

Signature of Examiner _____

Comments: