Standard Practice for

Preparation of Cylindrical Performance Test Specimens Using the Superpave Gyratory Compactor (SGC)

AASHTO Designation: R 83-17[1]

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

Release: Group 3 (July)

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1. SCOPE

1.1. This practice covers the use of a Superpave gyratory compactor (SGC) to prepare 100-mm-diameter by 150-mm-tall cylindrical test specimens for use in a variety of axial compression and tension performance tests. This practice is intended for dense-, gap-, and open-graded asphalt mixtures with nominal maximum aggregate sizes up to 37.5 mm.

1.2. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns 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*:

- R 30, Mixture Conditioning of Hot Mix Asphalt (HMA)
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
- T 342, Determining Dynamic Modulus of Hot Mix Asphalt (HMA)
- T 378, Determining the Dynamic Modulus and Flow Number for Asphalt Mixtures Using the Asphalt Mixture Performance Tester (AMPT)

2.2. *ASTM Standard*:

- D3549/D3549M-11, Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens

3. TERMINOLOGY

3.1. *Definitions*:

3.1.1. *end perpendicularity*—the degree to which an end surface departs from being perpendicular to the axis of the cylindrical test specimen. This configuration is measured using a precision square with the beam touching the cylinder parallel to its axis and the blade touching the highest point on the end of the cylinder. The distance between the blade of the square and the lowest point on the end of the cylinder is checked with 1.0-mm-diameter wire or feeler gauges.

3.1.2. *end planeness*—maximum departure of the specimen end from a plane. This dimension is checked using a straightedge and 0.5-mm-diameter wire or feeler gauges.

3.1.3. *SGC specimen*—a 150-mm-diameter by 160-mm-tall (minimum) cylindrical specimen for compressive tests or a 150-mm-diameter by 180-mm-tall (minimum) cylindrical specimen for tensile or tension tests prepared in an SGC meeting the requirements of T 312. (See Notes 5 and 6.)

3.1.4. *test specimen*—a 100-mm-diameter by 150-mm-tall cylindrical specimen that is sawed and cored from the SGC specimen.

4. SUMMARY OF PRACTICE

4.1. This practice presents methods for preparing 100-mm-diameter by 150-mm-tall cylindrical test specimens for use in a variety of axial compression and tension performance tests.

5. SIGNIFICANCE AND USE

5.1. This practice should be used to prepare specimens for T 342 and T 378.

5.2. This practice may also be used to prepare specimens for other tests requiring 100-mm-diameter by 150-mm-tall cylindrical test specimens.

6. APPARATUS

6.1. *Superpave Gyratory Compactor*—Meeting the requirements of T 312 and capable of preparing 150-mm-diameter specimens that are a height of at least 160 mm.

6.2. *Mixture Preparation Equipment*—Balances, ovens, thermometers, mixer, pans, and other miscellaneous equipment needed to prepare SGC specimens in accordance with T 312, perform bulk specific gravity (G_{mb}) measurements in accordance with T 166, and perform maximum specific gravity (G_{mm}) measurements in accordance with T 209.

6.3. *Core Drill*—An air- or water-cooled, diamond-bit core drill capable of cutting cores to a nominal diameter of 100 mm and meeting the dimensional requirements of Section 9.6.3. The core drill shall be equipped with a fixture for holding 150-mm-diameter SGC specimens.

Note 1—Core drills with fixed and adjustable rotational speed have been used successfully to prepare specimens meeting the dimensional tolerances given in Section 9.6.3. Rotational speeds from 450 to 750 rpm have been used.

Note 2—Core drills with automatic and manual feed-rate control have been used successfully to prepare specimens meeting the dimensional tolerances given in Section 9.6.3.

6.4. *Masonry Saw*—An air- or water-cooled, diamond-bladed masonry saw capable of cutting specimens to a nominal length of 150 mm and meeting the tolerances for end perpendicularity and end flatness given in Section 9.6.3.

Note 3—Single- and double-bladed saws have been used successfully to prepare specimens meeting the dimensional tolerances given in Section 9.6.3. Both types of saws require a fixture to securely hold the specimen during sawing and to control the feed rate.

6.5. *Square*—Precision square with 8-in. beam and 12-in. blade. McMaster Carr Pro-Value Square, Catalog Number 2278A21 (http://www.mcmaster.com/#2278a21/=859bss) or equivalent.

6.6. *1.0-mm Diameter Carbon Steel Wire*—0.039-in. (1-mm) diameter carbon steel wire, McMaster Carr Catalog Number 8907K42 (http://www.mcmaster.com/#8907k42/=859ao7) or equivalent.

6.7. *0.5-mm Diameter Carbon Steel Wire*—0.020-in. (0.5-mm) diameter carbon steel wire, McMaster Carr Catalog Number 8907K21 (http://www.mcmaster.com/#8907k21/=859b98) or equivalent.

6.8. *Feeler Gauges*—Tapered-leaf feeler gauges in 0.05-mm increments.

6.9. *Metal Ruler*—Capable of measuring 150-mm-long (nominal) specimens to the nearest 1 mm.

6.10. *Calipers*—Capable of measuring 100-mm-diameter (nominal) specimens to the nearest 0.1 mm.

7. HAZARDS

7.1. This practice and associated standards involve handling of hot asphalt binder, aggregates, and asphalt mixtures, and the use of sawing and coring machinery. Use standard safety precautions, equipment, and clothing when handling hot materials and operating machinery.

8. STANDARDIZATION

8.1. Items associated with this practice that require calibration or verification are included in the AASHTO standards referenced in Section 2. Refer to the pertinent section of the referenced standards for information concerning calibration or verification.

9. PROCEDURE

9.1. *Select SGC Specimen Target Height*:

9.1.1. SGC specimens shall be prepared to a height of 160 mm (minimum) for compressive tests and to a height of 180 mm (minimum) for tensile or tension tests.

9.1.2. SGC specimen height shall be chosen based on the air void gradient produced by the specific SGC and effect of the sawing equipment.

Note 4—Test specimens with acceptable properties have been prepared from SGC specimens ranging in height from 160 mm to greater than 180 mm. Coarse-graded mixtures may require a taller height in order to ensure smooth, uniform ends with minimal or no surface irregularities after the sawing process. For tension performance testing, a taller height is required for all mixtures.

Note 5—Each laboratory should determine a target SGC specimen height based on the procedure for evaluating test specimen uniformity given in Appendix X2, and an evaluation of the ability of the sawing equipment to maintain the dimensional tolerances given in Table 1.

9.2. *Asphalt Mixture Preparation*:

9.2.1. Prepare asphalt mixture for each test specimen in accordance with T 312 and prepare a companion test specimen for maximum specific gravity (G_{mm}) in accordance with T 209.

9.2.2. The mass of asphalt mixture needed for each specimen will depend on the SGC specimen height, the G_{mm} of the aggregate, nominal maximum aggregate size, gradation (coarse or fine), and target air void content for the test specimens.

Note 6—Appendix X1 describes a trial-and-error procedure developed in NCHRP 9-19 for determining the mass of asphalt mixture required to reach a specified test specimen target air void content for SGC specimens prepared to a height of 170 mm.

9.2.3. Perform conditioning on the asphalt mixture for the test specimens and companion G_{mm} sample test in accordance with R 30.

9.3. *SGC Specimen Compaction*:

9.3.1. Compact the SGC specimens to the target specimen height determined in Section 9.1 in accordance with T 312.

9.4. *Long-Term Conditioning (Optional)*:

9.4.1. If it is desired to simulate long-term aging, condition the SGC specimen in accordance with R 30.

9.4.2. To obtain accurate volumetric measurements on the long-term-conditioned specimens, also condition a companion sample of short-term-conditioned loose asphalt mixture meeting the sample size requirements of T 209 in accordance with R 30.

9.5. *SGC Specimen Density and Air Voids (Optional)*:

9.5.1. Determine the G_{mm} of the asphalt mixture in accordance with T 209. If long-term conditioning has been used, determine the G_{mm} on the long-term-conditioned loose asphalt mixture. Record the G_{mm} of the mixture.

9.5.2. For dense- and gap-graded mixtures, determine the G_{mb} of the SGC specimen in accordance with T 166. Record the G_{mb} of the SGC specimen.

9.5.3. For open-graded mixtures, determine the G_{mb} of the SGC specimen in accordance with T 269. Record the G_{mb} of the SGC specimen.

9.5.4. Compute the air void content of the SGC specimen in accordance with T 269. Record the air void content of the SGC specimen.

Note 7—Section 9.5 is optional because acceptance of the test specimen for mechanical property testing is based on the air void content of the test specimen, not the SGC specimen. However, monitoring SGC specimen density can identify improperly prepared specimens early in the specimen fabrication process. Information on SGC specimen air voids and test specimen air voids will also assist the laboratory in establishing potentially more precise methods than Appendix X1 for preparing test specimens to a target air void content.

9.6. *Test Specimen Preparation*:

9.6.1. Drill a core of nominal diameter of 100 mm from the center of the SGC specimen. Both the SGC specimen and the drill shall be adequately supported to ensure that the resulting core is cylindrical with sides that are smooth, parallel, and meet the tolerances on specimen diameter given in Table 1.

9.6.2. Saw the ends of the core to obtain a test specimen of a nominal height of 150 mm. Both the core and the saw shall be adequately supported to ensure that the resulting test specimen meets the tolerances given in Table 1 for height, end flatness, and end perpendicularity.

Note 8—With most equipment, it is better to perform the coring before the sawing. However, these operations may be performed in either order as long as the dimensional tolerances in Table 1 are satisfied.

9.6.3. Test specimens shall meet the dimensional tolerances given in Table 1.

Table 1—Test Specimen Dimensional Tolerances

Item	Specification	Method Reference
Average diameter	98 to 104 mm	9.6.3.1
Standard deviation of diameter	≤0.5 mm	9.6.3.1
Height	147.5 to 152.5 mm	9.6.3.2
End flatness	≤0.5 mm	9.6.3.3
End perpendicularity	≤1.0 mm	9.6.3.4

9.6.3.1. Using calipers, measure the diameter at the center and third points of the test specimen along axes that are 90 degrees apart. Record each of the six measurements to the nearest 0.1 mm. Calculate the average and the standard deviation of the six measurements. Reject specimens not meeting the average and standard deviation requirements listed in Table 1. The average diameter, reported to the nearest 0.1 mm, shall be used in all material property calculations.

9.6.3.2. Measure the height of the test specimen in accordance with ASTM D3549/D3549M. Reject specimens with an average height outside the height tolerance listed in Table 1. Record the average height.

9.6.3.2.1. Using the blade of the precision square as a straightedge, check the flatness of each end at three locations approximately 120 degrees apart. At each location, place the blade of the precision square across the diameter of the specimen and check the maximum departure of the specimen from the blade using the 0.5-mm-diameter carbon steel wire or feeler gauge. Reject specimens if the 0.5-mm-diameter carbon steel wire fits between the blade and the specimen at any location.

9.6.3.3. Check the perpendicularity of each end of the specimen using the precision square and the 1.0-mm carbon steel wire at two locations approximately 90 degrees apart. Place the precision square on a table with the beam in contact with the table and the blade extending vertically. Place the long axis of the specimen on the beam such that the blade is in contact with the end of the specimen. Check the maximum departure of the specimen from the blade using the 1.0-mm-diameter carbon steel wire or feeler gauge. Reject specimens if the 1.0-mm-diameter carbon steel wire fits between the blade and the specimen at any location.

9.7. *Test Specimen Density and Air Voids*:

9.7.1. Determine the G_{mm} of the asphalt mixture in accordance with T 209. If long-term conditioning has been used, determine the G_{mm} on the long-term-conditioned loose asphalt mixture. Record the G_{mm} of the asphalt mixture.

9.7.2. For dense- and gap-graded mixtures, determine the G_{mb} of the test specimen in accordance with T 166. Record the G_{mb} of the test specimen.

Note 9—When wet-coring and sawing methods are used, measure the immersed mass, followed by the surface-dry mass followed by the dry mass, to minimize drying time and expedite the specimen fabrication process.

9.7.3. For open-graded mixtures, determine the G_{mb} of the test specimen in accordance with T 269. Record the G_{mb} of the test specimen.

9.7.4. Compute the air void content of the test specimen in accordance with T 269. Record the air void content of the test specimen. Reject test specimens exceeding the air void tolerances specified in the applicable test.

9.8. *Test Specimen Storage*:

9.8.1. Mark the test specimen with a unique identification number.

9.8.2. Store the test specimen, until tested, on its end on a flat shelf in a room with the temperature controlled between 15 and 27°C.

Note 10—Definitive research concerning the effects of test specimen aging on various mechanical property tests has not been completed. Some users enclose specimens in plastic wrap and minimize specimen storage time to two weeks.

10. REPORTING

10.1. *Report the following information*:

10.1.1. Unique test specimen identification number;

10.1.2. Mixture design data including design compaction level and air void content, asphalt binder type and grade, binder content, binder specific gravities, aggregate types and bulk specific gravities, aggregate consensus properties, and G_{mm};

10.1.3. Type of conditioning used;

10.1.4. G_{mm} for the conditioned specimens;

10.1.5. SGC specimen target height (optional);

10.1.6. SGC specimen G_{mb} (optional);

10.1.7. SGC specimen air void content (optional);

10.1.8. Test specimen average height;

10.1.9. Test specimen average diameter;

10.1.10. Test specimen G_{mb};

10.1.11. Test specimen air void content;

10.1.12. Test specimen end flatness for each end;

10.1.13. Test specimen end perpendicularity for each end; and

10.1.14. Remarks concerning deviations from this standard practice.

11. KEYWORDS

11.1. Gyratory compaction; performance test specimens.

APPENDIXES

(Nonmandatory Information)

X1. METHOD FOR ACHIEVING A TARGET AIR VOID CONTENT

X1.1. *Purpose*:

X1.1.1. This appendix presents a procedure for estimating the mass of asphalt mixture required to produce test specimens at a target air void content. It was developed to reduce the number of trial specimens needed to obtain a target air void content for a specific mixture.

X1.1.2. This procedure can be used with either plant-produced or laboratory-prepared asphalt mixtures.

X1.2. *Summary*:

X1.2.1. An estimate of the mass of mixture required is made knowing the maximum specific gravity, G_{mm}, of the mixture and the volume of the gyratory specimen.

X1.2.2. A trial gyratory specimen is compacted to the target height using this estimated mass and a test specimen is sawed and cored from the gyratory specimen.

X1.2.3. The air void content of the trial test specimen is measured and used to adjust the mass if necessary.

X1.2.4. Normally, only one trial specimen is needed when using this procedure

X1.3. *Procedure*:

X1.3.1. Measure the maximum specific gravity, G_{mm}, of the mixture in accordance with T 209.

X1.3.2. Calculate the mass of mixture required for a gyratory specimen of target height, H, using Equation X1.1:

$$\text{Mass} = \left[\frac{100-\left(Va_t + F\right)}{100}\right] \times G_{mm} \times 176.7147 \times H \qquad (X1.1)$$

where:

Mass = estimated mass of mixture to prepare a test specimen to the target air voids;

Va_t = target air void content for the test specimen, percent by volume;

G_{mm} = maximum specific gravity of the mixture;

H = height of the gyratory specimen, cm; and

F = air void adjustment factor: 1.0 for fine-graded; 1.5 for coarse-graded.

X1.3.3. Using the estimated mass from Equation X1.1, prepare the trial gyratory specimen and the trial test specimen in accordance with Section 9.

X1.3.4. Measure the bulk specific gravity of the trial test specimen and calculate the air void content of the trial test specimen in accordance with Section 9.7.

X1.3.5. If the air void content of the trial test specimen is not within the air void tolerance specified in the applicable test procedure, estimate an adjusted mass using Equation X1.2:

$$\mathrm{Mass}_{adj} = \left[\frac{(100 - Va_t)}{(100 - Va_m)}\right] \times \mathrm{Mass} \qquad (X1.2)$$

where:

Mass_{adj} = adjusted gyratory specimen mass, g;

Va_t = target air void content for the test specimen, percent by volume;

Va_m = measured trial test specimen air void content, percent by volume; and

Mass = mass used to prepare the gyratory specimen for the trial test specimen, g.

X1.3.6. Using the adjusted mass from Equation X1.2, prepare a second trial gyratory specimen and second trial test specimen in accordance with Section 9.

X1.3.7. Measure the bulk specific gravity, G_{mb}, of the second trial test specimen and calculate the air void content of the second trail test specimen in accordance with Section 9.7.

X1.3.8. If the air void content of the second trial test specimen is not within the air void tolerance specified in the applicable test procedure, estimate an adjusted mass using Equation X1.2 and prepare additional trial test specimens, making adjustments using Equation X1.2 until the air void tolerance is satisfied.

X1.3.9. Equation X1.2 can also be used during specimen fabrication to make small adjustments to the mass to maintain the air void content of the test specimens within the specified tolerance.

X1.3.10. Normally, only one trial specimen is needed when using this procedure.

X2. METHOD FOR ASSESSING TEST SPECIMEN UNIFORMITY

X2.1. *Purpose*:

X2.1.1. This appendix presents a procedure for assessing the uniformity of the air void content in test specimens produced using this standard practice.

X2.1.2. The approach tests the significance of the difference in mean G_{mb} between the top and bottom third of the specimen relative to the middle third.

X2.1.3. The procedure can be used to determine the height for preparing SGC specimens with a specific SGC to minimize within-sample variations in air voids.

X2.2. *Summary*:

X2.2.1. Three test specimens are prepared as described in this standard practice from SGC specimens produced with the same mass and compacted to the same height.

X2.2.2. The test specimens are cut into three slices of equal thickness and the G_{mb} of each slice is determined.

X2.2.3. A statistical hypothesis test is conducted to determine the significance of the difference in the mean G_{mb} of the top and bottom slices relative to the middle third.

X2.3. *Procedure*:

X2.3.1. Prepare three test specimens following this standard practice to a target air void content of 5.5 percent. All three specimens shall have air void contents between 5.0 and 6.0 percent.

X2.3.2. Label the top, middle, and bottom third of each specimen; then saw the specimens into three slices of equal thickness.

X2.3.3. Determine the G_{mb} of each of the nine test section slices in accordance with T 166 for dense- and gap-graded asphalt mixtures or T 269 for open-graded asphalt mixtures.

X2.3.4. Assemble a summary table of the G_{mb} data where each column contains data for a specific slice and each row contains the data from a specific core.

X2.3.5. For each column, compute the mean and variance of the G_{mb} measurements using Equations X2.1 and X2.2 as follows:

$$\overline{y} = \frac{\sum_{i=1}^{3} y_i}{3} \qquad (X2.1)$$

$$s^2 = \frac{\sum_{i=1}^{3} \left(y_i - \overline{y}\right)^2}{2} \qquad (X2.2)$$

where:

$\overline{y}$ = the mean of the G_{mb} of the three slices;

s^2 = the variance of the G_{mb} of the slices; and

y_i = the measured G_{mb} of each slice.

X2.3.6. *Statistical Comparison of Means*—Compare the mean G_{mb} of the top and bottom slices to the middle slice using the hypothesis tests described below. In the descriptions below, the subscripts *t*, *m*, and *b* refer to the top, middle, and bottom slices, respectively.

X2.3.6.1. Check the top slice relative to the middle slice.

Null Hypothesis:

The mean G_{mb} of the top slice equals the mean G_{mb} of the middle slice, $\mu_t^2 = \mu_m^2$.

Alternative Hypothesis:

The mean G_{mb} of the top slice is not equal to the mean G_{mb} of the middle slice, $\mu_t^2 \neq \mu_m^2$.

Test Statistic:

$$t = \frac{\left(\overline{y}_t - \overline{y}_m\right)}{0.8165(s)} \qquad (X2.3)$$

where:

$$s = \sqrt{\frac{s_t^{\ 2} + s_m^{\ 2}}{2}}$$

where:

$\overline{y}_t$ = the computed mean for the top slices;

$\overline{y}_m$ = the computed mean for the middle slices;

$s_t^{\ 2}$ = the computed variance for the top slices; and

$s_m^{\ 2}$ = the computed variance for the middle slices.

Region of Rejection:

For the sample sizes specified, the absolute value of the test statistic must be less than 2.78 to conclude that the G_{mb} of the top and middle slices are equal.

X2.3.6.2. Check the bottom slice relative to the middle slice.

Null Hypothesis:

The mean G_{mb} of the bottom slice equals the mean G_{mb} of the middle slice, $\mu_b^{\ 2} = \mu_m^{\ 2}$.

Alternative Hypothesis:

The mean G_{mb} of the bottom slice is not equal to the mean G_{mb} of the middle slice, $\mu_b^{\ 2} \neq \mu_m^{\ 2}$.

Test Statistic:

$$t = \frac{\left(\overline{y}_b - \overline{y}_m\right)}{0.8165\left(s\right)} \qquad (X2.4)$$

where:

$$s = \sqrt{\frac{s_b^{\ 2} + s_m^{\ 2}}{2}}$$

where:

$\overline{y}_b$ = the computed mean for the bottom slices;

$\overline{y}_m$ = the computed mean for the middle slices;

$s_b^{\ 2}$ = the computed variance for the bottom slices; and

$s_m^{\ 2}$ = the computed variance for the middle slices.

Region of Rejection:

For the sample sizes specified, the absolute value of the test statistic must be less than 2.78 to conclude that the G_{mb} of the bottom and middle third slices are equal.

X2.4. *Analysis*:

X2.4.1. Significant differences in the G_{mb} of the top and bottom slices relative to the middle third indicate a systematic variation in density within the specimen.

X2.4.2. Specimens with differences in the G_{mb} for the top or bottom slices relative to the middle slices on the order of 0.025 have performed satisfactorily in the dynamic modulus, flow number, flow time, and continuum damage fatigue tests.

X2.4.3. Changing the height of the SGC specimen can improve the uniformity of the density in the test specimen.