Standard Method of Test for

Uncompacted Void Content of Fine Aggregate

AASHTO Designation: T 304-11 (2015)

AASHTO

1. SCOPE

1.1. This method describes the determination of the loose uncompacted void content of a sample of fine aggregate. When measured on any aggregate of a known grading, void content provides an indication of that aggregate's angularity, sphericity, and surface texture compared with other fine aggregates tested in the same grading. When void content is measured on an as-received fine aggregate grading, it can be an indicator of the effect of the fine aggregate on the workability of a mixture in which it may be used.

1.2. Three procedures are included for the measurement of void content. Two use graded fine aggregate (standard grading or as-received grading), and the other uses several individual size fractions for void content determinations:

1.2.1. *Standard Graded Sample (Method A)*—This method uses a standard fine aggregate grading that is obtained by combining individual sieve fractions from a typical fine aggregate sieve analysis. See Section 9, Preparation of Test Samples, for the grading.

1.2.2. *Individual Size Fractions (Method B)*—This method uses each of three fine aggregate size fractions: (a) 2.36 mm (No. 8) to 1.18 mm (No. 16); (b) 1.18 mm (No. 16) to 600 μm (No. 30); and (c) 600 μm (No. 30) to 300 μm (No. 50). For this method, each size is tested separately.

1.2.3. *As-Received Grading (Method C)*—This method uses that portion of the fine aggregate finer than a 4.75-mm (No. 4) sieve.

1.2.4. See Section 5, Significance and Use, for guidance on the method to be used.

1.3. The values stated in SI units shall be regarded as the standard.

1.4. *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. *AASHTO Standards*:

- T 2, Sampling of Aggregates
- T 11, Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
- T 19M/T 19, Bulk Density ("Unit Weight") and Voids in Aggregate
- T 27, Sieve Analysis of Fine and Coarse Aggregates

- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 248, Reducing Samples of Aggregate to Testing Size

2.2. *ASTM Standards*:

- B88, Standard Specification for Seamless Copper Water Tube
- B88M, Standard Specification for Seamless Copper Water Tube [Metric]
- C125, Standard Terminology Relating to Concrete and Concrete Aggregates
- C778, Standard Specification for Standard Sand

2.3. *ACI Document*:

- ACI 116R, Cement and Concrete Terminology[1]

3. TERMINOLOGY

3.1. Terms used in this standard are defined in ASTM C125 or ACI 116R.

4. SUMMARY OF TEST METHOD

4.1. A nominal 100-mL calibrated cylindrical measure is filled with fine aggregate of prescribed grading by allowing the sample to flow through a funnel from a fixed height into the measure. The fine aggregate is struck off, and its mass is determined by weighing. Uncompacted void content is calculated as the difference between the volume of the cylindrical measure and the absolute volume of the fine aggregate collected in the measure. Uncompacted void content is calculated using the bulk dry specific gravity of the fine aggregate. Two runs are made on each sample and the results are averaged.

4.1.1. For a graded sample (Method A or Method C), the percent void content is determined directly, and the average value from two runs is reported.

4.1.2. For the individual size fractions (Method B), the mean percent void content is calculated using the results from tests of each of the three individual size fractions.

5. SIGNIFICANCE AND USE

5.1. Methods A and B provide percent void content determined under standardized conditions that depend on the particle shape and texture of a fine aggregate. An increase in void content by these procedures indicates greater angularity, less sphericity, or rougher surface texture, or some combination of the three factors. A decrease in void content results is associated with more rounded, spherical, smooth-surfaced fine aggregate, or a combination of these factors.

5.2. Method C measures the uncompacted void content of the minus 4.75-mm (No. 4) portion of the as-received material. This void content depends on grading as well as particle shape and texture.

5.3. The void content determined on the standard graded sample (Method A) is not directly comparable with the average void content of the three individual size fractions from the same sample tested separately (Method B). A sample consisting of single-size particles will have a higher void content than a graded sample. Therefore, use either one method or the other as a comparative measure of shape and texture, and identify which method has been used to obtain the reported data. Method C does not provide an indication of shape and texture directly if the grading from sample to sample changes.

5.3.1. The standard graded sample (Method A) is most useful as a quick test that indicates the particle shape properties of a graded fine aggregate. Typically, the material used to make up the standard graded sample can be obtained from the remaining size fractions after performing a single sieve analysis of the fine aggregate.

5.3.2. Obtaining and testing individual size fractions (Method B) is more time consuming and requires a larger initial sample than using the graded sample. However, Method B provides additional information concerning the shape and texture characteristics of individual sizes.

5.3.3. Testing samples in the as-received grading (Method C) may be useful in selecting proportions of components used in a variety of mixtures. In general, high void content suggests that the material could be improved by providing additional fines in the fine aggregate or more cementitious material may be needed to fill voids between particles.

5.3.4. The bulk dry specific gravity of the fine aggregate is used in calculating the void content. The effectiveness of these methods of determining void content and its relationship to particle shape and texture depends on the bulk specific gravity of the various size fractions being equal, or nearly so. The void content is actually a function of the volume of each size fraction. If the type of rock or mineral or its porosity varies markedly in any of the size fractions, it may be necessary to determine the specific gravity of the size fractions used in the test.

5.4. Void content information from Methods A, B, or C will be useful as an indicator of properties such as: the mixing water demand of hydraulic cement concrete; flowability, pumpability, or workability factors when formulating grouts or mortars; or, in bituminous concrete, the effect of the fine aggregate on stability and voids in the mineral aggregate; or the stability of the fine aggregate portion of a base course aggregate.

6. APPARATUS

6.1. *Cylindrical Measure*—A right cylinder of approximately 100 mL capacity having an inside diameter of approximately 39 mm and an inside height of approximately 86 mm made of drawn copper water tube meeting ASTM B88 Type M or B88M Type C. The bottom of the measure shall be metal at least 6 mm thick, shall be firmly sealed to the tubing, and shall be provided with means for aligning the axis of the cylinder with that of the funnel. (See Figure 1.)

6.2. *Funnel*—The lateral surface of the right frustum of a cone sloped 60° ± 4° from the horizontal with an opening of 12.7 ± 0.6 mm diameter. The funnel section shall be a piece of metal, smooth on the inside and at least 38 mm high. It shall have a volume of at least 200 mL or shall be provided with a supplemental glass or metal container to provide the required volume. (See Figure 2.)

Note 1—Pycnometer top C9455 sold by Hogentogler and Co., Inc., 9515 Gerwig, Columbia, MD 21046, 410-381-2390 is satisfactory for the funnel section, except that the size of the opening has to be enlarged and any burrs or lips that are apparent should be removed by light filing or sanding before use. This pycnometer top must be used with a suitable glass jar with the bottom removed (see Figure 2).

6.3. *Funnel Stand*—A three- or four-legged support capable of holding the funnel firmly in position with the axis of the funnel colinear (within a 4-degree angle and a displacement of 2 mm) with the axis of the cylindrical measure. The funnel opening shall be 115 ± 2 mm above the top of the cylinder. A suitable arrangement is shown in Figure 2.

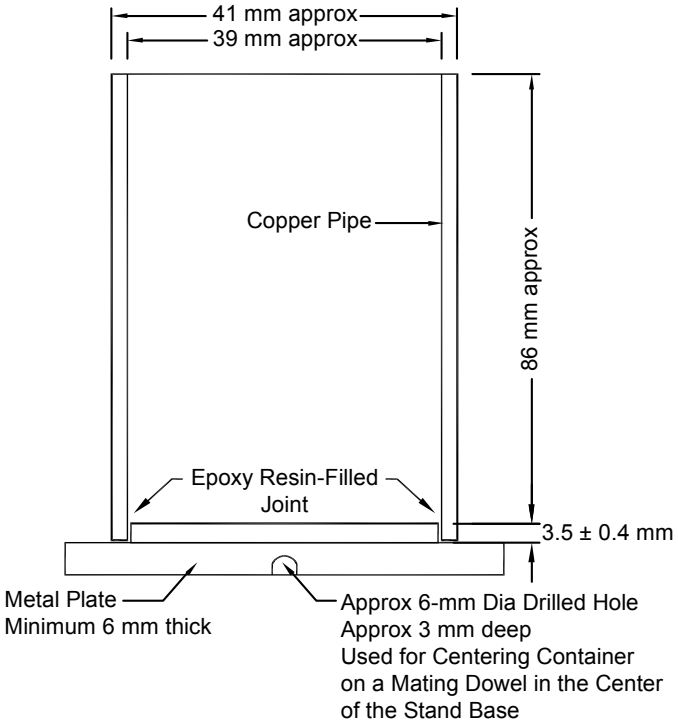

Figure 1—Nominal 100-mL Cylindrical Measure

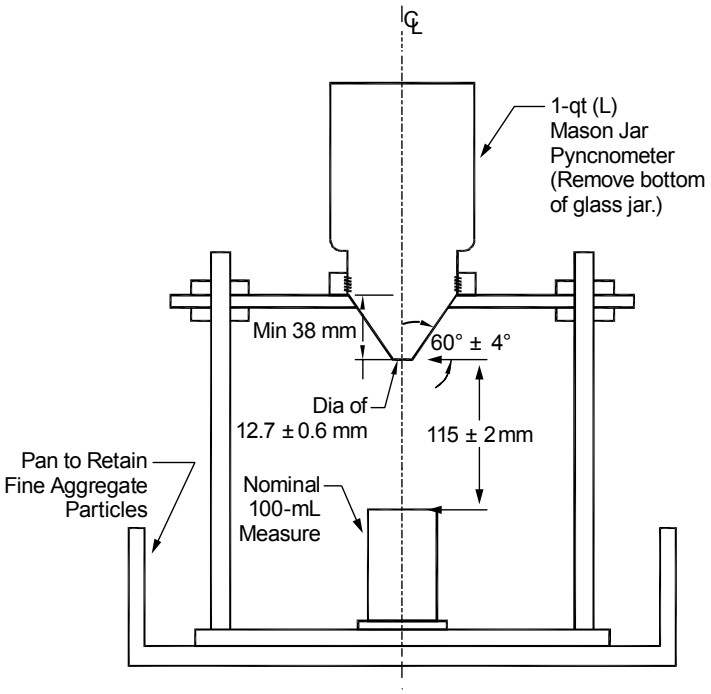

Figure 2—Suitable Funnel Stand Apparatus with Cylindrical Measure in Place

6.4. *Glass Plate*—A square glass plate approximately 60 mm by 60 mm with a minimum 4-mm thickness used to calibrate the cylindrical measure.

6.5. *Pan*—A flat metal or plastic pan of sufficient size to contain the funnel stand and to prevent loss of material. The purpose of the pan is to catch and retain fine aggregate particles that overflow the measure during filling and strike off. The pan shall not be warped so as to prevent rocking of the apparatus during testing.

6.6. Metal spatula with a blade approximately 100 mm long, and at least 20 mm wide, with straight edges. The end shall be cut at a right angle to the edges. The straight edge of the spatula blade is used to strike off the fine aggregate.

6.7. Scale or balance accurate and readable to ±0.1 g within the range of use, capable of weighing the cylindrical measure and its contents.

7. SAMPLING

7.1. The sample(s) used for this test shall be obtained using T 2 and T 248, or from sieve analysis samples used for T 27, or from aggregate extracted from a bituminous concrete specimen. For Methods A and B, the sample is washed over a 150-µm (No. 100) or 75-µm (No. 200) sieve in accordance with T 11 and then dried and sieved into separate size fractions according to T 27 procedures. Maintain the necessary size fractions obtained from one (or more) sieve analysis in a dry condition in separate containers for each size. For Method C, dry a split of the as-received sample in accordance with the drying procedure in T 27.

8. CALIBRATION OF CYLINDRICAL MEASURE

8.1. Apply a light coat of grease to the top edge of the dry, empty cylindrical measure. Weigh the measure, grease, and glass plate. Fill the measure with freshly boiled, deionized water at a temperature of 18 to 24°C. Record the temperature of the water. Place the glass plate on the measure, being sure that no air bubbles remain. Dry the outer surfaces of the measure and determine the combined mass of measure, glass plate, grease, and water by weighing. Following the final weighing, remove the grease, and determine the mass of the clean, dry, empty measure for subsequent tests.

8.2. Calculate the volume of the measure as follows:

$$V = 1000\frac{M}{D} \qquad (1)$$

where:

V = volume of cylinder, mL;

M = net mass of water, g; and

D = density of water (see table in T 19M/T 19 for density at the temperature used), kg/m^3.

Determine the volume to the nearest 0.1 mL.

Note 2—If the volume of the measure is greater than 100.0 mL, it may be desirable to grind the upper edge of the cylinder until the volume is exactly 100.0 mL, to simplify subsequent calculations.

9. PREPARATION OF TEST SAMPLES

9.1. *Method A—Standard Graded Sample*—Weigh out and combine the following quantities of fine aggregate, which has been dried and sieved in accordance with T 27.

Individual Size Fraction	Mass, g
2.36 mm (No. 8) to 1.18 mm (No. 16)	44
1.18 mm (No. 16) to 600 μm (No. 30)	57
600 μm (No. 30) to 300 μm (No. 50)	72
300 μm (No. 50) to 150 μm (No. 100)	17
	190

The tolerance on each of these amounts is ±0.2 g.

9.2. *Method B—Individual Size Fractions*—Prepare a separate 190-g sample of fine aggregate, dried and sieved in accordance with T 27, for each of the following size fractions:

Individual Size Fraction	Mass, g
2.36 mm (No. 8) to 1.18 mm (No. 16)	190
1.18 mm (No. 16) to 600 μm (No. 30)	190
600 μm (No. 30) to 300 μm (No. 50)	190

The tolerance on each of these amounts is ±1 g. Do not mix these samples together. Each size is tested separately.

9.3. *Method C—As-Received Grading*—Pass the sample (dried in accordance with T 27) through a 4.75-mm (No. 4) sieve. Obtain a 190 ± 1-g sample of the material passing the 4.75-mm (No. 4) sieve for test.

9.4. *Specific Gravity of Fine Aggregate*—If the bulk dry specific gravity of fine aggregate from the source is unknown, determine it on the minus 4.75-mm (No. 4) material according to T 84. Use this value in subsequent calculations unless some size fractions differ by more than 0.05 from the specific gravity typical of the complete sample, in which case the specific gravity of the fraction (or fractions) being tested must be determined. An indicator of differences in specific gravity of various particle sizes is a comparison of specific gravities run on the fine aggregate in different gradings. Specific gravity can be run on gradings with and without specific size fractions of interest. If specific gravity differences exceed 0.05, determine the specific gravity of the individual 2.36-mm (No. 8) to 150-μm (No. 100) sizes for use with Method A or the individual size fractions for use with Method B either by direct measurement or by calculation using the specific gravity data on gradings with and without the size fraction of interest. A difference in specific gravity of 0.05 will change the calculated void content about 1 percent.

10. PROCEDURE

10.1. Mix each test sample with the spatula until it appears to be homogeneous. Position the jar and funnel section in the stand and center the cylindrical measure as shown in Figure 2. Use a finger to block the opening of the funnel. Pour the test sample into the funnel. Level the material in the funnel with the spatula. Remove the finger and allow the sample to fall freely into the cylindrical measure.

10.2. After the funnel empties, strike off excess heaped fine aggregate from the cylindrical measure by a rapid single pass of the spatula with the width of the blade vertical, keeping the straight part of its

edge horizontal and in light contact with the top of the measure. Until this operation is complete, exercise care to avoid vibration or any disturbance that could cause compaction of the fine aggregate in the cylindrical measure (Note 3). Brush adhering grains from the outside of the container and determine the mass of the cylindrical measure and contents to the nearest 0.1 g. Retain all fine aggregate particles for a second test run.

Note 3—After strike off, the cylindrical measure may be tapped lightly to compact the sample to make it easier to transfer the container to the scale or balance without spilling any of the sample.

10.3. Recombine the sample from the retaining pan and cylindrical measure and repeat the procedure. The results of two runs are averaged. See Section 11.

10.4. Record the mass of the empty measure. Also, for each run, record the mass of the measure and fine aggregate.

11. CALCULATION

11.1. Calculate the uncompacted voids for each determination as follows:

$$U = \frac{V - (F / G)}{V} \times 100 \qquad (2)$$

where:

V = volume of cylindrical measure, mL;

F = net mass, g, of fine aggregate in measure (gross mass minus the mass of the empty measure);

G = bulk dry specific gravity of fine aggregate; and

U = uncompacted voids, percent, in the material.

11.2. *For the Standard Graded Sample* (Method A), calculate the average uncompacted voids for the two determinations and report the result as U_s.

11.3. *For the Individual Size Fractions* (Method B), calculate:

11.3.1. First, the average uncompacted voids for the determination made on each of the three size-fraction samples:

U_1 = uncompacted voids, 2.36 mm (No. 8) to 1.18 mm (No. 16), percent;

U_2 = uncompacted voids, 1.18 mm (No. 16) to 600 μm (No. 30), percent; and

U_3 = uncompacted voids, 600 μm (No. 30) to 300 μm (No. 50), percent.

11.3.2. Second, the mean uncompacted voids (U_m) including the results for all three sizes:

$$U_m = (U_1 + U_2 + U_3) / 3 \qquad (3)$$

11.4. *For the As-Received Grading* (Method C), calculate the average uncompacted voids for the two determinations and report the result as U_R.

12. REPORT

12.1. *For the Standard-Graded Sample* (Method A), report:

12.1.1. The uncompacted voids (U_s) in percent to the nearest 0.1 percent.

12.1.2. The specific gravity value used in the calculations.

12.2. *For the Individual-Size Fractions* (Method B), report the following percent voids to the nearest 0.1 percent:

12.2.1. Uncompacted voids for size fractions: (a) 2.36 mm (No. 8) to 1.18 mm (No. 16) (U_1); (b) 1.18 mm (No. 16) to 600 μm (No. 30) (U_2); and (c) 600 μm (No. 30) to 300 μm (No. 50) (U_3).

12.2.2. Mean uncompacted voids (U_m).

12.2.3. Specific gravity value(s) used in the calculations, and whether the specific gravity value(s) were determined on a graded sample or the individual size fractions used in the test.

12.3. *For the As-Received Sample* (Method C), report:

12.3.1. The uncompacted voids (U_R) in percent to the nearest 0.1 percent.

12.3.2. The specific gravity value used in the calculation.

13. PRECISION AND BIAS

13.1. *Precision*:

13.1.1. The single-operator standard deviation has been found to be 0.13 percent voids (1s), using the graded standard silica sand as described in ASTM C778. Therefore, results of two properly conducted tests by the same operator on similar samples should not differ by more than 0.37 percent (d2s).

13.1.2. The multilaboratory standard deviation has been found to be 0.33 percent (1s) using the standard fine aggregate as described in ASTM C778. Therefore, results of two properly conducted tests by different laboratories on similar samples should not differ by more than 0.93 percent (d2s).

13.1.3. The above statements pertain to void contents determined on "graded standard sand" as described in ASTM C778, which is considered rounded, and is graded from 600 μm (No. 30) to 150 μm (No. 100), and may not be typical of other fine aggregates. Additional precision data are needed for tests of fine aggregates having different levels of angularity and texture tested in accordance with this test method.

13.2. *Bias*—Because there is no accepted reference material suitable for determining the bias for the procedures in this test method, bias has not been determined.

14. KEYWORDS

14.1. Angularity; fine aggregate; particle shape; sand; surface texture; void content.

[1] Copies may be obtained from the American Concrete Institute, Box 19150, Detroit, MI 48219.