WSDOT FOP for AASHTO T 304[1]

Uncompacted Void Content of Fine Aggregate

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).

Note: WSDOT Specifications require Method A.

1.2.2 See the Section 5 for guidance on the method to be used.

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

1.4 This standard does not purport to address all of the safety problems, 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. References Documents

2.1 AASHTO Standards

T 84 – Specific Gravity and Absorption of Fine Aggregate

2.1 WSDOT Standards

T 2 – FOP for AASHTO for the Sampling of Aggregates

T 248 – FOP for AASHTO for Reducing Field Samples of Aggregates to Testing Size

T 27/T 11 – FOP for WAQTC for the Sieve Analysis of Fine and Coarse Aggregates

[1]This FOP is based on AASHTO T 304-11 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.

2.1 ASTM Standards

B 88 – Specification for Seamless Copper Water Tube

B 88M – Specification for Seamless Copper Water Tube (Metric)

C 29/29M – Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C 117 – Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing

C 125 – Terminology Relating to Concrete and Concrete Aggregates

C 128 – Test Method for Specific Gravity and Absorption of Fine Aggregate

C 136 – Test Method for Sieve Analysis of Fine and Coarse Aggregates

C 702 – Practice for Reducing Samples of Aggregate to Testing Size

C 778 – Specification for Standard Sand

D 75 – Practice for Sampling Aggregates

2.2 ACI Document

ACI 116R – Cement and Concrete Terminology[1]

3. Terminology

3.1 Terms used in this standard are defined in ASTM C 125 or ACI 116R.

4. Summary of Test Method

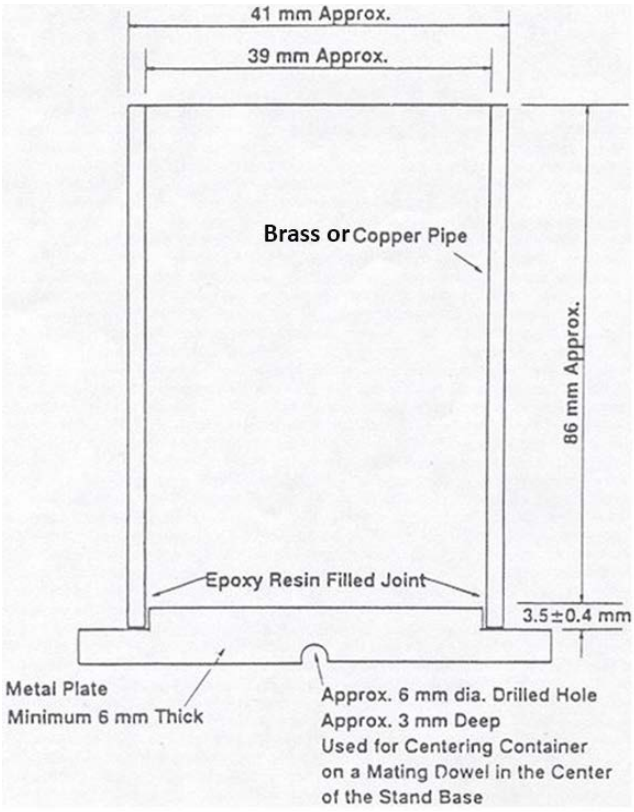
4.1 A nominal 100-mL calibrated cylindrical measure is filled with fine aggregate of prescribed grading by allowing the sample to flow through a funnel from a fixed height into the measure. The fine aggregate is struck off and its mass is determined by weighing. Uncompacted void content is calculated 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, the percent void content is determined directly and the average value from two runs is reported.

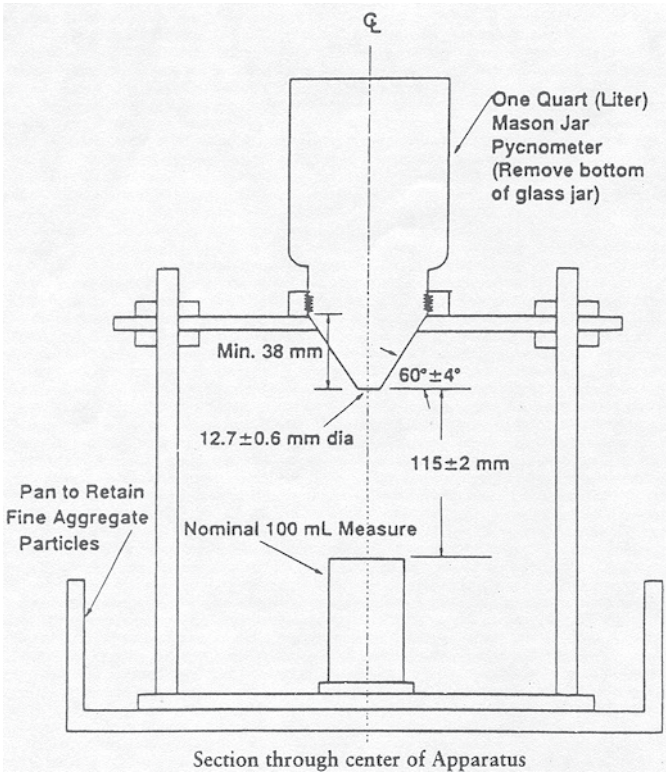
5. Significance and Use

5.1 Methods A provide percent void content determined under standardized conditions which 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 The standard graded sample (Method A) is most useful as a quick test which 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.



Nominal 100-ml Cylindrical Measure
Figure 1



Suitable Funnel Stand Apparatus With Cylindrical Measure in Place
Figure 2

5.3 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 minerals, or its porosity, in any of the size fractions varies markedly, it may be necessary to determine the specific gravity of the size fractions used in the test.

5.4 Void content information from Method A will be useful as an indicator of properties such as 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 brass or drawn copper water tube meeting ASTM Specification B 88 Type M, or B 88 M 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 ± 4º 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 21045, 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 suitable glass jar with the bottom removed (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 4º 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.

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 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 FOP for AASHTO T 2 and FOP for AASHTO T 248, or from sieve analysis samples used for FOP for WAQTC/AASHTO T 27/11, or from aggregate extracted from a bituminous concrete specimen. For Method A, the sample is washed over a 150-um (No. 100) or 75-um (No. 200) sieve in accordance with FOP for WAQTC/AASHTO T 27/11 and then dried and sieved into separate size fractions according to FOP for WAQTC/AASHTO T 27/11 procedures. Maintain the necessary size fractions obtained from one (or more) sieve analysis in a dry condition in separate containers for each size.

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 freshly boiled, deionized water at a temperature of 18 to 24ºC. 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 test.

8.2 Calculate the volume of the measure as follows:

$$V = 1000 \frac{M}{D}$$

Where:

V = volume of cylinder, mL,
M = net mass of water, g, and
D = density of water (see table in ASTM C 29/C 29M 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 FOP for AASHTO T 27/11.

Individual Size Fraction		
Passing	**Retained On**	**Mass, g**
No. 8 (2.36 mm)	No. 16 (1.18 mm)	44
No. 16 (1.18 mm)	No. 30 (600 um)	57
No. 30 (600 um)	No. 50 (300 um)	72
No. 50 (300 um)	No. 100 (150 um)	17
	Total	190

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

9.2 Method B – Individual Size Fractions – WSDOT has deleted this section. They use Method A.

9.3 Method C – As Received Grading – WSDOT has deleted this section. They use Method A.

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 No. 4 (4.75 mm) material according to AASHTO 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 um (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 single pass of the spatula with the width of the blade vertical using the straight part of its edge 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 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:

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

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.

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 1 percent.

12.1.2 The specific gravity value used in the calculations.

12.2 Report the results using one or more of the following:

- Materials Testing System (MATS)
- DOT Form 350-161
- Form approved in writing by the State Materials Engineer

13. Precision and Bias

See AASHTO T 304 for precision and bias.

Performance Exam Checklist

Uncompacted Void Content of Fine Aggregate
FOP AASHTO T 304

Participant Name _____ Exam Date _____

Procedure Element	**Yes**	**No**
1. The tester has a copy of the current procedure on hand?	☐	☐
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	☐	☐

Sample Preparation (Method A)

Note: If Bulk Dry Specific Gravity is unknown, determine it on the minus No. 4 (4.75 mm) material according to AASHTO T 84.

1	Field sample obtained per FOP for AASHTO T 2?	☐	☐
2.	Sample reduced to testing size per FOP for AASHTO T 248?	☐	☐
3.	Sample washed over No. 100 or No. 200 sieve in accordance with FOP for WAQTC/AASHTO T 27/11?	☐	☐
4.	Sample dried to constant weight?	☐	☐
5.	Standard Graded sample achieved per FOP for WAQTC/AASHTO T 27/11?	☐	☐
6.	Necessary size fractions obtained, maintained in a dry condition in separate containers for each size?	☐	☐
7.	Standard Graded sample-weighed out and combined per Section 9.1, FOP for AASHTO T 304?	☐	☐

Procedure Element **Procedure** (Method A) N***ote:*** If Bulk Dry Specific Gravity is unknown, determine it on the minus No. 4 (4.75 mm) material according to AASHTO T 84.	**Yes**	**No**
1. Test sample mixed until it appears to be homogeneous?	☐	☐
2. Jar and funnel section positioned in stand and cylindrical measure centered on stand?	☐	☐
3. Finger used to block the opening of the funnel?	☐	☐
4. Test sample poured into the funnel and leveled?	☐	☐
5. Finger removed and sample allowed to fall freely into cylindrical measure?	☐	☐
6. After funnel empties, is excess material struck off w/single pass of upright spatula?	☐	☐
7. Was care taken to avoid any vibration or disturbance that could cause compaction of material?	☐	☐
8. All adhering grains brushed off before weighing the cylindrical measure?	☐	☐
9. Mass of the cylindrical measure and contents weighed to nearest 0.1 gram?	☐	☐
10. All fine aggregate particles retained and re-homogenized for a second test run?	☐	☐
11. Percent (%) of Uncompacted Voids calculated for each run, as per FOP for AASHTO T 304, Method A?	☐	☐
12. Were the results for each run averaged for a final result?	☐	☐
13. Was the (%) percent of Uncompacted voids reported to the nearest one percent (1%)?	☐	☐
14. All calculations performed correctly?	☐	☐

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Signature of Examiner _____

Comments: