Designation: C 128 – 97

Standard Test Method for Specific Gravity and Absorption of Fine Aggregate[1]

This standard is issued under the fixed designation C 128; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of bulk and apparent specific gravity, 23/23°C (73.4/73.4°F), and absorption of fine aggregate.

1.2 This test method determines (after 24 h in water) the bulk specific gravity and the apparent specific gravity as defined in Terminology E 12, the bulk specific gravity on the basis of weight of saturated surface-dry aggregate, and the absorption as defined in Definitions C 125.

NOTE 1—The subcommittee is considering revising Test Methods C 127 and C 128 to use the term "density" instead of "specific gravity" for coarse and fine aggregate, respectively.

1.3 The values stated in SI units are to 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 *ASTM Standards:*

C 29/C 29M Test Method for Unit Weight and Voids in Aggregate[2]

C 70 Test Method for Surface Moisture in Fine Aggregate[2]

C 125 Terminology Relating to Concrete and Concrete Aggregates[2]

C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate[2]

C 188 Test Method for Density of Hydraulic Cement[3]

C 566 Test Method for Total Moisture Content of Aggregate by Drying[2]

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[2]

C 702 Practice for Reducing Samples of Aggregate to Testing Size[2]

D 75 Practice for Sampling Aggregates[4]

E 12 Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases[5]

E 380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)[6]

2.2 *AASHTO Standard:*

AASHTO No. T 84 Specific Gravity and Absorption of Fine Aggregates[7]

3. Significance and Use

3.1 Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate including portland cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis. Bulk specific gravity is also used in the computation of voids in aggregate in Test Method C 29 and the determination of moisture in aggregate by displacement in water in Test Method C 70. Bulk specific gravity determined on the saturated surface-dry basis is used if the aggregate is wet, that is, if its absorption has been satisfied. Conversely, the bulk specific gravity determined on the oven-dry basis is used for computations when the aggregate is dry or assumed to be dry.

3.2 Apparent specific gravity pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles that is accessible to water. This value is not widely used in construction aggregate technology.

3.3 Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential. The laboratory standard for absorption is that obtained after submerging dry aggregate for approximately 24 h in water. Aggregates mined from below the water table may have a higher absorption when used, if not allowed to dry. Conversely, some aggregates when used may contain an amount of absorbed moisture less than the 24 h-soaked

[1] This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.20 on Normal Weight Aggregates.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] *Annual Book of ASTM Standards*, Vol 04.03.

[5] *Annual Book of ASTM Standards*, Vol 15.05.

[6] *Annual Book of ASTM Standards*, Vol 14.02. Excerpts in all volumes.

[7] Available from American Association of State Highway and Transportation Officials, 444 North Capitol St. N.W., Suite 225, Washington, DC 20001.

condition. For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture can be determined by deducting the absorption from the total moisture content determined by Test Method C 566 by drying.

4. Apparatus

4.1 *Balance*—A balance or scale having a capacity of 1 kg or more, sensitive to 0.1 g or less, and accurate within 0.1 % of the test load at any point within the range of use for this test. Within any 100-g range of test load, a difference between readings shall be accurate within 0.1 g.

4.2 *Pycnometer*—A flask or other suitable container into which the fine aggregate test sample can be readily introduced and in which the volume content can be reproduced within ±0.1 cm^3. The volume of the container filled to mark shall be at least 50 % greater than the space required to accommodate the test sample. A volumetric flask of 500 cm^3 capacity or a fruit jar fitted with a pycnometer top is satisfactory for a 500-g test sample of most fine aggregates. A Le Chatelier flask as described in Test Method C 188 is satisfactory for an approximately 55-g test sample.

4.3 *Mold*—A metal mold in the form of a frustum of a cone with dimensions as follows: 40 ± 3 mm inside diameter at the top, 90 ± 3 mm inside diameter at the bottom, and 75 ± 3 mm in height, with the metal having a minimum thickness of 0.8 mm.

4.4 *Tamper*—A metal tamper weighing 340± 15 g and having a flat circular tamping face 25 ± 3 mm in diameter.

5. Sampling

5.1 Sampling shall be accomplished in general accordance with Practice D 75.

6. Preparation of Test Specimen

6.1 Obtain approximately 1 kg of the fine aggregate from the sample using the applicable procedures described in Practice C 702.

6.1.1 Dry the test specimen in a suitable pan or vessel to constant weight at a temperature of 110 ± 5°C (230 ± 9°F). Allow it to cool to comfortable handling temperature, cover with water, either by immersion or by the addition of at least 6 % moisture to the fine aggregate, and permit to stand for 24 ± 4 h.

6.1.2 As an alternative to 6.1.1, where the absorption and specific gravity values are to be used in proportioning concrete mixtures with aggregates used in their naturally moist condition, the requirement for initial drying to constant weight may be eliminated and, if the surfaces of the particles have been kept wet, the 24-h soaking may also be eliminated.

NOTE 2—Values for absorption and for specific gravity in the saturated surface-dry condition may be significantly higher for aggregate not oven dried before soaking than for the same aggregate treated in accordance with 6.1.1.

6.2 Decant excess water with care to avoid loss of fines, spread the sample on a flat nonabsorbent surface exposed to a gently moving current of warm air, and stir frequently to secure homogeneous drying. If desired, mechanical aids such as tumbling or stirring may be employed to assist in achieving the saturated surface-dry condition. Continue this operation until the test specimen approaches a free-flowing condition. Follow the procedure in 6.2.1 to determine whether or not surface moisture is present on the constituent fine aggregate particles. It is intended that the first trial of the cone test will be made with some surface water in the specimen. Continue drying with constant stirring and test at frequent intervals until the test indicates that the specimen has reached a surface-dry condition. If the first trial of the surface moisture test indicates that moisture is not present on the surface, it has been dried past the saturated surface-dry condition. In this case thoroughly mix a few millilitres of water with the fine aggregate and permit the specimen to stand in a covered container for 30 min. Then resume the process of drying and testing at frequent intervals for the onset of the surface-dry condition.

6.2.1 *Cone Test for Surface Moisture*—Hold the mold firmly on a smooth nonabsorbent surface with the large diameter down. Place a portion of the partially dried fine aggregate loosely in the mold by filling it to overflowing and heaping additional material above the top of the mold by holding it with the cupped fingers of the hand holding the mold. Lightly tamp the fine aggregate into the mold with 25 light drops of the tamper. Each drop should start about 5 mm (0.2 in.) above the top surface of the fine aggregate. Permit the tamper to fall freely under gravitational attraction on each drop. Adjust the starting height to the new surface elevation after each drop and distribute the drops over the surface. Remove loose sand from the base and lift the mold vertically. If surface moisture is still present, the fine aggregate will retain the molded shape. When the fine aggregate slumps slightly it indicates that it has reached a surface-dry condition. Some angular fine aggregate or material with a high proportion of fines may not slump in the cone test upon reaching a surface-dry condition. This may be the case if fines become airborne upon dropping a handful of the sand from the cone test 100 to 150 mm onto a surface. For these materials the saturated surface-dry condition should be considered as the point that one side of the fine aggregate slumps slightly upon removing the mold.

NOTE 3—The following criteria have also been used on materials that do not readily slump:

(1) *Provisional Cone Test*—Fill the cone mold as described in 6.2.1 except only use 10 drops of the tamper. Add more fine aggregate and use 10 drops of the tamper again. Then add material two more times using 3 and 2 drops of the tamper, respectively. Level off the material even with the top of the mold, remove loose material from the base; and lift the mold vertically.

(2) *Provisional Surface Test*—If airborne fines are noted when the fine aggregate is such that it will not slump when it is at a moisture condition, add more moisture to the sand, and at the onset of the surface-dry condition, with the hand lightly pat approximately 100 g of the material on a flat, dry, clean, dark or dull nonabsorbent surface such as a sheet of rubber, a worn oxidized, galvanized, or steel surface, or a black-painted metal surface. After 1 to 3 s remove the fine aggregate. If noticeable moisture shows on the test surface for more than 1 to 2 s then surface moisture is considered to be present on the fine aggregate.

(3) Colorimetric procedures described by Kandhal and Lee, Highway Research Record No. 307, p. 44.

(4) For reaching the saturated surface-dry condition on a single size material that slumps when wet, hard-finish paper towels can be used to surface dry the material until the point is just reached where the paper

towel does not appear to be picking up moisture from the surfaces of the fine aggregate particles.

7. Procedure

7.1 Make and record all weight determinations to 0.1 g.

7.2 Partially fill the pycnometer with water. Immediately introduce into the pycnometer 500 ± 10 g of saturated surface-dry fine aggregate prepared as described in Section 6, and fill with additional water to approximately 90 % of capacity. Manually roll, invert, and agitate the pycnometer, or mechanically agitate the pycnometer, to eliminate all air bubbles (see Note 4). Accomplish mechanical agitation by external vibration of the pycnometer in a manner that will not degrade the sample. A level of agitation adjusted to just set individual particles in motion is sufficient to promote de-airing without degradation. A mechanical agitator shall be considered acceptable for use if comparison tests for each six month period of use show variations less than the acceptable range of two results (d2s) indicated in Table 1 from results of manual agitation on the same material. Adjust the temperature of the pycnometer and its contents to 23 ± 1.7°C (73.4 ± 3°F), if necessary, by immersion in circulating water, and bring the water level in the pycnometer to its calibrated capacity. Determine the total weight of the pycnometer, specimen, and water.

NOTE 4—About 15 to 20 minutes are normally required to eliminate air bubbles by manual methods. Dipping the tip of a paper towel into the pycnometer has been found to be useful in dispersing the foam that sometimes builds up when eliminating the air bubbles. Optionally, a small amount of isopropyl alcohol may be used to disperse the foam. Do *not* use either of these procedures when using the alternate method described in 7.2.1.

7.2.1 *Alternative to Weighing in 7.2*—The quantity of added water necessary to fill the pycnometer at the required temperature may be determined volumetrically using a buret accurate to 0.15 mL. Compute the total weight of the pycnometer, specimen, and water as follows:

$$C = 0.9975\ V_a + S + W \quad (1)$$

TABLE 1 Precision

	Standard Deviation (1S)[A]	Acceptable Range of Two Results (D2S)[A]
Single-Operator Precision:		
Bulk specific gravity (dry)	0.011	0.032
Bulk specific gravity (SSD)	0.0095	0.027
Apparent specific gravity	0.0095	0.027
Absorption[B], %	0.11	0.31
Multilaboratory Precision:		
Bulk specific gravity (dry)	0.023	0.066
Bulk specific gravity (SSD)	0.020	0.056
Apparent specific gravity	0.020	0.056
Absorption[B], %	0.23	0.66

[A] These numbers represent, respectively, the (1S) and (D2S) limits as described in Practice C 670. The precision estimates were obtained from the analysis of combined AASHTO Materials Reference Laboratory proficiency sample data from laboratories using 15 to 19 h saturation times and other laboratories using 24 ± 4 h saturation time. Testing was performed on normal weight aggregates, and started with aggregates in the oven-dry condition.

[B] Precision estimates are based on aggregates with absorptions of less than 1 % and may differ for manufactured fine aggregates and fine aggregates having absorption values greater than 1 %.

where:

C = weight of pycnometer with specimen and water to calibration mark, g,
V_a = volume of water added to pycnometer, mL,
S = weight of the saturated surface-dry specimen, and
W = weight of the empty pycnometer, g.

7.2.2 *Alternative to the Procedure in 7.2*—Use a Le Chatelier flask initially filled with water to a point on the stem between the 0 and the 1-mL mark. Record this initial reading with the flask and contents within the temperature range of 23 ± 1.7°C (73.4 ± 3°F). Add 55 ± 5 g of fine aggregate in the saturated surface-dry condition (or other weight as necessary to result in raising the water level to some point on the upper series of gradation). After all fine aggregate has been introduced, place the stopper in the flask and roll the flask in an inclined position, or gently whirl it in a horizontal circle so as to dislodge all entrapped air, continuing until no further bubbles rise to the surface (Note 5). Take a final reading with the flask and contents within 1°C (1.8°F) of the original temperature.

NOTE 5—When using the Le Chatelier flask method, the operator may use a small measured amount (not to exceed 1 mL) of isopropyl alcohol to eliminate foam appearing on the water surface. The volume of alcohol used must be subtracted from the final reading (R_2).

7.3 Remove the fine aggregate from the pycnometer, dry to constant weight at a temperature of 110 ± 5°C (230 ± 9°F), cool in air at room temperature for 1 ± ½ h, and weigh.

7.3.1 If the Le Chatelier flask method is used, a separate sample portion is needed for the determination of absorption. Weigh a separate 500 ± 10-g portion of the saturated surface-dry fine aggregate, dry to constant weight, and reweigh.

7.4 Determine the weight of the pycnometer filled to its calibration capacity with water at 23 ± 1.7°C (73.4 ± 3°F).

7.4.1 *Alternative to Weighing in 7.4*—The quantity of water necessary to fill the empty pycnometer at the required temperature may be determined volumetrically using a buret accurate to 0.15 mL. Calculate the weight of the pycnometer filled with water as follows:

$$B = 0.9975\ V + W \quad (2)$$

where:

B = weight of flask filled with water, g,
V = volume of flask, mL, and
W = weight of the flask empty, g.

8. Bulk Specific Gravity

8.1 Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), as defined in Terminology E 12, as follows:

$$\text{Bulk sp gr} = A/(B + S - C) \quad (3)$$

where:

A = weight of oven-dry specimen in air, g,
B = weight of pycnometer filled with water, g,
S = weight of the saturated surface-dry specimen, and
C = weight of pycnometer with specimen and water to calibration mark, g.

8.1.1 If the Le Chatelier flask method was used, calculate the bulk specific gravity, 23/23°C, as follows:

$$B\text{ulk sp gr} = \frac{S_1(A/S)}{0.9975\,(R_2 - R_1)} \quad (4)$$

where:

S_1 = weight of saturated surface-dry specimen used in Le Chatelier flask, g,
R_1 = initial reading of water level in Le Chatelier flask, and
R_2 = final reading of water level in Le Chatelier flask.

9. Bulk Specific Gravity (Saturated Surface-Dry Basis)

9.1 Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), on the basis of weight of saturated surface-dry aggregate as follows:

$$B\text{ulk sp gr (saturated surface}-\text{dry basis)} = S/(B + S - C) \quad (5)$$

9.1.1 If the Le Chatelier flask method was used, calculate the bulk specific gravity, 23/23°C, on the basis of saturated surface-dry aggregate as follows:

$$B\text{ulk sp gr (saturated surface}-\text{dry basis)} = \frac{S_1}{0.9975\,(R_2 - R_1)} \quad (6)$$

10. Apparent Specific Gravity

10.1 Calculate the apparent specific gravity, 23/23°C (73.4/73.4°F), as defined in Terminology E 12, as follows:

$$A\text{pparent sp gr} = A/(B + A - C) \quad (7)$$

11. Absorption

11.1 Calculate the percentage of absorption, as defined in Terminology C 125, as follows:

$$A\text{bsorption, \%} = [(S - A)/A] \times 100 \quad (8)$$

12. Report

12.1 Report specific gravity results to the nearest 0.01 and absorption to the nearest 0.1 %. The Appendix gives mathematical interrelationships among the three types of specific gravities and absorption. These may be useful in checking the consistency of reported data or calculating a value that was not reported by using other reported data.

12.2 If the fine aggregate was tested in a naturally moist condition other than the oven dried and 24 h-soaked condition, report the source of the sample and the procedures used to prevent drying prior to testing.

13. Precision and Bias

13.1 *Precision*—The estimates of precision of this test method (listed in Table 1) are based on results from the AASHTO Materials Reference Laboratory Proficiency Sample Program, with testing conducted by this test method and AASHTO Method T 84. The significant difference between the methods is that Test Method C 128 requires a saturation period of 24 ± 4 h, and Method T 84 requires a saturation period of 15 to 19 h. This difference has been found to have an insignificant effect on the precision indices. The data are based on the analyses of more than 100 paired test results from 40 to 100 laboratories.

13.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for this test method, no statement on bias is being made.

14. Keywords

14.1 absorption; aggregate; fine aggregate; specific gravity

APPENDIX

(Nonmandatory Information)

X1. INTERRELATIONSHIPS BETWEEN SPECIFIC GRAVITIES AND ABSORPTION AS DEFINED IN TEST METHODS C 127 AND C 128

X1.1 Let:

S_d = bulk specific gravity (dry-basis),
S_s = bulk specific gravity (SSD-basis),
S_a = apparent specific gravity, and
A = absorption in %.

Then:

$$S_s = (1 + A/100)S_d \quad (X1.1)$$

$$S_a = \frac{1}{\frac{1}{S_d} - \frac{A}{100}} = \frac{S_d}{1 - \frac{AS_d}{100}} \quad (X1.2)$$

$$\text{or } S_a = \frac{1}{\frac{1 + A/100}{S_s} - \frac{A}{100}} = \frac{S_s}{1 - \frac{A}{100}(S_s - 1)} \quad (X1.3)$$

$$A = \left(\frac{S_s}{S_d} - 1\right) 100 \quad (X1.4)$$

$$A = \left(\frac{S_a - S_s}{S_a(S_s - 1}\right) 100 \quad (X1.5)$$