Designation: C 127 – 88 (Reapproved 2001)

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

This standard is issued under the fixed designation C 127; 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 specific gravity and absorption of coarse aggregate. The specific gravity may be expressed as bulk specific gravity, bulk specific gravity (SSD) (saturated-surface-dry), or apparent specific gravity. The bulk specific gravity (SSD) and absorption are based on aggregate after 24 h soaking in water. This test method is not intended to be used with lightweight aggregates.

1.2 The values stated in SI units are to be regarded as the standard.

1.3 *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. Referenced Documents

2.1 *ASTM Standards:*

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

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

C 128 Test Method for Specific Gravity and Absorption of Fine Aggregate[2]

C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates[2]

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 Field Samples of Aggregate to Testing Size[2]

D 75 Practice for Sampling Aggregates[3]

D 448 Classification for Sizes of Aggregate for Road and Bridge Construction[3]

E 11 Specification for Wire-Cloth and Sieves for Testing Purposes[4]

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

2.2 *AASHTO Standard:*

AASHTO No. T 85 Specific Gravity and Absorption of Coarse Aggregate[6]

## 3. Terminology

3.1 *Definitions:*

3.1.1 *absorption*—the increase in the weight of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry weight. The aggregate is considered "dry" when it has been maintained at a temperature of 110 ± 5°C for sufficient time to remove all uncombined water.

3.1.2 *specific gravity*—the ratio of the mass (or weight in air) of a unit volume of a material to the mass of the same volume of water at stated temperatures. Values are dimensionless.

3.1.2.1 *apparent specific gravity*—the ratio of the weight in air of a unit volume of the impermeable portion of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

3.1.2.2 *bulk specific gravity*—the ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

3.1.2.3 *bulk specific gravity (SSD)*—the ratio of the weight in air of a unit volume of aggregate, including the weight of water within the voids filled to the extent achieved by submerging in water for approximately 24 h (but not including the voids between particles) at a stated temperature, compared to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

NOTE 1—The terminology for specific gravity is based on terms in Terminology E 12, and that for absorption is based on that term in Terminology C 125.

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

Current edition approved Oct. 31, 1988. Published December 1988. Originally published as C 127 – 36 T. Last previous edition C 127 – 84.

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

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

[4] *Annual Book of ASTM Standards*, Vol 14.02.

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

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

## 4. Summary of Test Method

4.1 A sample of aggregate is immersed in water for approximately 24 h to essentially fill the pores. It is then removed from the water, the water dried from the surface of the particles, and weighed. Subsequently the sample is weighed while submerged in water. Finally the sample is oven-dried and weighed a third time. Using the weights thus obtained and formulas in this test method, it is possible to calculate three types of specific gravity and absorption.

## 5. Significance and Use

5.1 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. Bulk specific gravity (SSD) is used if the aggregate is wet, that is, if its absorption has been satisfied. Conversely, the bulk specific gravity (oven-dry) is used for computations when the aggregate is dry or assumed to be dry.

5.2 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 which is accessible to water.

5.3 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 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.

5.4 The general procedures described in this test method are suitable for determining the absorption of aggregates that have had conditioning other than the 24-h soak, such as boiling water or vacuum saturation. The values obtained for absorption by other test methods will be different than the values obtained by the prescribed 24-h soak, as will the bulk specific gravity (SSD).

5.5 The pores in lightweight aggregates may or may not become essentially filled with water after immersion for 24 h. In fact, many such aggregates can remain immersed in water for several days without satisfying most of the aggregates' absorption potential. Therefore, this test method is not intended for use with lightweight aggregate.

## 6. Apparatus

6.1 *Balance*—A weighing device that is sensitive, readable, and accurate to 0.05 % of the sample weight at any point within the range used for this test, or 0.5 g, whichever is greater. The balance shall be equipped with suitable apparatus for suspending the sample container in water from the center of the weighing platform or pan of the weighing device.

6.2 *Sample Container*—A wire basket of 3.35 mm (No. 6) or finer mesh, or a bucket of approximately equal breadth and height, with a capacity of 4 to 7 L for 37.5-mm (1½-in.) nominal maximum size aggregate or smaller, and a larger container as needed for testing larger maximum size aggregate. The container shall be constructed so as to prevent trapping air when the container is submerged.

6.3 *Water Tank*—A watertight tank into which the sample container may be placed while suspended below the balance.

6.4 *Sieves*—A 4.75-mm (No. 4) sieve or other sizes as needed (see 7.2-7.4), conforming to Specification E 11.

## 7. Sampling

7.1 Sample the aggregate in accordance with Practice D 75.

7.2 Thoroughly mix the sample of aggregate and reduce it to the approximate quantity needed using the applicable procedures in Methods C 702. Reject all material passing a 4.75-mm (No. 4) sieve by dry sieving and thoroughly washing to remove dust or other coatings from the surface. If the coarse aggregate contains a substantial quantity of material finer than the 4.75-mm sieve (such as for Size No. 8 and 9 aggregates in Classification D 448), use the 2.36-mm (No. 8) sieve in place of the 4.75-mm sieve. Alternatively, separate the material finer than the 4.75-mm sieve and test the finer material according to Test Method C 128.

7.3 The minimum weight of test sample to be used is given below. In many instances it may be desirable to test a coarse aggregate in several separate size fractions; and if the sample contains more than 15 % retained on the 37.5-mm (1½-in.) sieve, test the material larger than 37.5 mm in one or more size fractions separately from the smaller size fractions. When an aggregate is tested in separate size fractions, the minimum weight of test sample for each fraction shall be the difference between the weights prescribed for the maximum and minimum sizes of the fraction.

| Nominal Maximum Size, mm (in.) | Minimum Weight of Test Sample, kg (lb) |
|---|---|
| 12.5 (½) or less | 2 (4.4) |
| 19.0 (¾) | 3 (6.6) |
| 25.0 (1) | 4 (8.8) |
| 37.5 (1½) | 5 (11) |
| 50 (2) | 8 (18) |
| 63 (2½) | 12 (26) |
| 75 (3) | 18 (40) |
| 90 (3½) | 25 (55) |
| 100 (4) | 40 (88) |
| 112 (4½) | 50 (110) |
| 125 (5) | 75 (165) |
| 150 (6) | 125 (276) |

7.4 If the sample is tested in two or more size fractions, determine the grading of the sample in accordance with Test Method C 136, including the sieves used for separating the size fractions for the determinations in this method. In calculating the percentage of material in each size fraction, ignore the quantity of material finer than the 4.75-mm (No. 4) sieve (or 2.36-mm (No. 8) sieve when that sieve is used in accordance with 7.2).

## 8. Procedure

8.1 Dry the test sample to constant weight at a temperature of 110 ± 5°C (230 ± 9°F), cool in air at room temperature for 1 to 3 h for test samples of 37.5-mm (1½-in.) nominal maximum size, or longer for larger sizes until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50°C). Subsequently immerse the aggregate in water at room temperature for a period of 24 ± 4 h.

NOTE 2—When testing coarse aggregate of large nominal maximum size requiring large test samples, it may be more convenient to perform the test on two or more subsamples, and the values obtained combined for the computations described in Section 9.

8.2 Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement for initial drying to constant weight may be eliminated, and, if the surfaces of the particles in the sample have been kept continuously wet until test, the 24-h soaking may also be eliminated.

NOTE 3—Values for absorption and bulk specific gravity (SSD) may be significantly higher for aggregate not oven dried before soaking than for the same aggregate treated in accordance with 8.1. This is especially true of particles larger than 75 mm (3 in.) since the water may not be able to penetrate the pores to the center of the particle in the prescribed soaking period.

8.3 Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. A moving stream of air may be used to assist in the drying operation. Take care to avoid evaporation of water from aggregate pores during the surface-drying operation. Weigh the test sample in the saturated surface-dry condition. Record this and all subsequent weights to the nearest 0.5 g or 0.05 % of the sample weight, whichever is greater.

8.4 After weighing, immediately place the saturated-surface-dry test sample in the sample container and determine its weight in water at 23± 1.7°C (73.4 ± 3°F), having a density of 997 ± 2 kg/m $^3$. Take care to remove all entrapped air before weighing by shaking the container while immersed.

NOTE 4—The container should be immersed to a depth sufficient to cover it and the test sample during weighing. Wire suspending the container should be of the smallest practical size to minimize any possible effects of a variable immersed length.

8.5 Dry the test sample to constant weight at a temperature of 110 ± 5°C (230 ± 9°F), cool in air at room temperature 1 to 3 h, or until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50°C), and weigh.

## 9. Calculations

9.1 *Specific Gravity*:

9.1.1 *Bulk Specific Gravity*—Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), as follows:

$$\text{Bulk sp gr} = A/(B - C) \quad (1)$$

where:

$A$ = weight of oven-dry test sample in air, g,

$B$ = weight of saturated-surface-dry test sample in air, g, and

$C$ = weight of saturated test sample in water, g.

9.1.2 *Bulk Specific Gravity (Saturated-Surface-Dry)*—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:

$$\text{Bulk sp gr (saturated-surface-dry)} = B/(B - C) \quad (2)$$

9.1.3 *Apparent Specific Gravity*—Calculate the apparent specific gravity, 23/23°C (73.4/73.4°F), as follows:

$$\text{Apparent sp gr} = A/(A - C) \quad (3)$$

9.2 *Average Specific Gravity Values*— When the sample is tested in separate size fractions the average value for bulk specific gravity, bulk specific gravity (SSD), or apparent specific gravity can be computed as the weighted average of the values as computed in accordance with 9.1 using the following equation:

$$G = \frac{1}{\frac{P_1}{100\,G_1} + \frac{P_2}{100\,G_2} + \cdots \frac{P_n}{100\,G_n}} \text{ (see Appendix X1)} \quad (4)$$

where:

$G$ = average specific gravity. All forms of expression of specific gravity can be averaged in this manner.

$G_1, G_2 \ldots G_n$ = appropriate specific gravity values for each size fraction depending on the type of specific gravity being averaged.

$P_1, P_2, \ldots P_n$ = weight percentages of each size fraction present in the original sample.

NOTE 5—Some users of this test method may wish to express the results in terms of density. Density may be determined by multiplying the bulk specific gravity, bulk specific gravity (SSD), or apparent specific gravity by the weight of water (997.5 kg/m$^3$ or 0.9975 Mg/m$^3$ or 62.27 lb/ft $^3$ at 23°C). Some authorities recommend using the density of water at 4°C (1000 kg/m$^3$ or 1.000 Mg/m$^3$ or 62.43 lb/ft $^3$) as being sufficiently accurate. Results should be expressed to three significant figures. The density terminology corresponding to bulk specific gravity, bulk specific gravity (SSD), and apparent specific gravity has not been standardized.

9.3 *Absorption*—Calculate the percentage of absorption, as follows:

$$\text{Absorption, \%} = [(B - A)/A] \times 100 \quad (5)$$

9.4 *Average Absorption Value*—When the sample is tested in separate size fractions, the average absorption value is the average of the values as computed in 9.3, weighted in proportion to the weight percentages of the size fractions in the original sample as follows:

$$A = (P_1A_1/100) + (P_2A_2/100) + \ldots\ (P_nA_n/100) \quad (6)$$

where:

$A$ = average absorption, %,

$A_1, A_2 \ldots A_n$ = absorption percentages for each size fraction, and

$P_1, P_2, \ldots P_n$ = weight percentages of each size fraction present in the original sample.

## 10. Report

10.1 Report specific gravity results to the nearest 0.01, and indicate the type of specific gravity, whether bulk, bulk (saturated-surface-dry), or apparent.

10.2 Report the absorption result to the nearest 0.1 %.

10.3 If the specific gravity and absorption values were determined without first drying the aggregate, as permitted in 8.2, it shall be noted in the report.

## 11. Precision and Bias

11.1 The estimates of precision of this test method listed in Table 1 are based on results from the AASHTO Materials Reference Laboratory Reference Sample Program, with testing conducted by this test method and AASHTO Method T 85. The significant difference between the methods is that Test Method C 127 requires a saturation period of 24 ± 4 h, while Method T 85 requires a saturation period of 15 h minimum. 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.

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

**TABLE 1 Precision**

| | Standard Deviation (1S)[A] | Acceptable Range of Two Results (D2S)[A] |
|---|---|---|
| *Single-Operator Precision:* | | |
| Bulk specific gravity (dry) | 0.009 | 0.025 |
| Bulk specific gravity (SSD) | 0.007 | 0.020 |
| Apparent specific gravity | 0.007 | 0.020 |
| Absorption [B], % | 0.088 | 0.25 |
| *Multilaboratory Precision:* | | |
| Bulk specific gravity (dry) | 0.013 | 0.038 |
| Bulk specific gravity (SSD) | 0.011 | 0.032 |
| Apparent specific gravity | 0.011 | 0.032 |
| Absorption[B], % | 0.145 | 0.41 |

[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 reference sample data from laboratories using 15 h minimum saturation times and other laboratories using 24 ± 4 h saturation times. 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 2 %.

## 12. Keywords

12.1 absorption; aggregate; coarse aggregate; specific gravity

# APPENDIXES

**(Nonmandatory Information)**

## X1. DEVELOPMENT OF EQUATIONS

X1.1 The derivation of the equation is apparent from the following simplified cases using two solids. Solid 1 has a weight $W_1$ in grams and a volume $V_1$ in millilitres; its specific gravity ($G_1$) is therefore $W_1/V_1$. Solid 2 has a weight $W_2$ and volume $V_2$, and $G_2 = W_2/V_2$. If the two solids are considered together, the specific gravity of the combination is the total weight in grams divided by the total volume in millilitres:

$$G = (W_1 + W_2) / (V_1 + V_2) \quad \text{(X1.1)}$$

Manipulation of this equation yields the following:

$$G = \frac{1}{\frac{V_1 + V_2}{W_1 + W_2}} = \frac{1}{\frac{V_1}{V_1 + W_2} + \frac{V_2}{W_1}} \quad \text{(X1.2)}$$

$$G = \frac{1}{\frac{W_1}{W_1 + W_2}\left(\frac{V_1}{W_1}\right) + \frac{W_2}{W_1 + W_2}\left(\frac{V_2}{W_2}\right)} \quad \text{(X1.3)}$$

However, the weight fractions of the two solids are:

$$W_1/(W_1 + W_2) = P_1/100 \text{ and } W_2/(W_1 + W_2) = P_2/100 \quad \text{(X1.4)}$$

and,

$$1/G_1 = V_1/W_1 \text{ and } 1/G_2 = V_2/W_2 \quad \text{(X1.5)}$$

Therefore,

$$G = 1/[(P_1/100)(1/G_1) + (P_2/100)(1/G_2)] \quad \text{(X1.6)}$$

An example of the computation is given in Table X1.1.

**TABLE X1.1 Example of Calculation of Average Values of Specific Gravity and Absorption for a Coarse Aggregate Tested in Separate Sizes**

| Size Fraction, mm (in.) | % in Original Sample | Sample Weight Used in Test, g | Bulk Specific Gravity (SSD) | Absorption, % |
|---|---|---|---|---|
| 4.75 to 12.5 (No. 4 to ½) | 44 | 2213.0 | 2.72 | 0.4 |
| 12.5 to 37.5 (½ to 1½) | 35 | 5462.5 | 2.56 | 2.5 |
| 37.5 to 63 (1½ to 2½) | 21 | 12593.0 | 2.54 | 3.0 |

Average Specific Gravity (SSD)

$$G_{SSD} = \frac{1}{\frac{0.44}{2.72} + \frac{0.35}{2.56} + \frac{0.21}{2.54}} = 2.62$$

Average Absorption

$$A = (0.44)(0.4) + (0.35)(2.5) + (0.21)(3.0) = 1.7\ \%$$

## X2. INTERRELATIONSHIPS BETWEEN SPECIFIC GRAVITIES AND ABSORPTION AS DEFINED IN TEST METHODS C 127 AND C 128

X2.1 Let:

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

X2.2 Then,

$$S_s = (1 + A/100)S_d \quad \text{(X2.1)}$$

$$S_a = \frac{1}{\frac{1}{S_d} - \frac{A}{100}} = \frac{S_d}{1 - \frac{AS_d}{100}} \quad \text{(X2.2)}$$

$$S_a = \frac{1}{\frac{1 + A/100}{S_s} - \frac{A}{100}} = \frac{S_s}{1 - \left[\frac{A}{100}(S_s - 1)\right]} \quad \text{(X2.3)}$$

$$A = \left(\frac{S_s}{S_d} - 1\right) 100 \quad \text{(X2.4)}$$

$$A = \left(\frac{S_a - S_s}{S_a(S_s - 1)}\right) 100 \quad \text{(X2.5)}$$