Designation: C127 – 15

Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate[1]

This standard is issued under the fixed designation C127; 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 U.S. Department of Defense.

1. Scope

1.1 This test method covers the determination of relative density (specific gravity) and the absorption of coarse aggregates. The relative density (specific gravity), a dimensionless quantity, is expressed as oven-dry (OD), saturated-surface-dry (SSD), or as apparent relative density (apparent specific gravity). The OD relative density is determined after drying the aggregate. The SSD relative density and absorption are determined after soaking the aggregate in water for a prescribed duration.

1.2 This test method is not intended to be used with lightweight aggregates that comply with Specification C332 Group I aggregates.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 The text of this test method references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this test method.

1.5 *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:*[2]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C125 Terminology Relating to Concrete and Concrete Aggregates

C128 Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate

C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

C330 Specification for Lightweight Aggregates for Structural Concrete

C332 Specification for Lightweight Aggregates for Insulating Concrete

C566 Test Method for Total Evaporable Moisture Content of Aggregate by Drying

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C702 Practice for Reducing Samples of Aggregate to Testing Size

D75 Practice for Sampling Aggregates

D448 Classification for Sizes of Aggregate for Road and Bridge Construction

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *AASHTO Standard:*

AASHTO T 85 Specific Gravity and Absorption of Coarse Aggregate[3]

3. Terminology

3.1 For definition of terms used in this standard, refer to Terminology C125.

4. Summary of Test Method

4.1 A sample of aggregate is immersed in water for 24 ± 4 h to essentially fill the pores. It is then removed from the water, the water dried from the surface of the particles, and the mass determined. Subsequently, the volume of the sample is determined by the displacement of water method. Finally, the sample is oven-dried and the mass determined. Using the mass

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

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

values thus obtained and formulas in this test method, it is possible to calculate relative density (specific gravity) and absorption.

5. Significance and Use

5.1 Relative density (specific gravity) is the ratio of mass of an aggregate to the mass of a volume of water equal to the volume of the aggregate particles – also referred to as the absolute volume of the aggregate. It is also expressed as the ratio of the density of the aggregate particles to the density of water. Distinction is made between the density of aggregate particles and the bulk density of aggregates as determined by Test Method **C29/C29M**, which includes the volume of voids between the particles of aggregates.

5.2 Relative density is used to calculate the volume occupied by the aggregate in various mixtures containing aggregate, including hydraulic cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis. Relative density (specific gravity) is also used in the computation of voids in aggregate in Test Method **C29/C29M**. Relative density (specific gravity) (SSD) is used if the aggregate is in a saturated-surface-dry condition, that is, if its absorption has been satisfied. Alternatively, the relative density (specific gravity) (OD) is used for computations when the aggregate is dry or assumed to be dry.

5.3 Apparent relative density (specific gravity) pertain to the solid material making up the constituent particles not including the pore space within the particles that is accessible to water.

5.4 Absorption values are used to calculate the change in the mass 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 a prescribed period of time. Aggregates mined from below the water table commonly have a moisture content greater than the absorption determined by this test method, if used without opportunity to dry prior to use. Conversely, some aggregates that have not been continuously maintained in a moist condition until used are likely to 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 is determined by deducting the absorption from the total moisture content determined by Test Method C566.

5.5 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 soaking, as will the relative density (specific gravity) (SSD).

6. Apparatus

6.1 *Balance*—A device for determining mass that is sensitive, readable, and accurate to 0.05 % of the sample mass 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 platform or pan of the balance.

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 is 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 E11.

6.5 *Oven*—An oven of sufficient size, capable of maintaining a uniform temperature of 110 ± 5 °C (230 ± 9 °F).

7. Sampling

7.1 Sample the aggregate in accordance with Practice D75.

7.2 Thoroughly mix the sample of aggregate and reduce it to the approximate quantity needed using the applicable procedures in Practice C702. 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 D448), 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 C128.

NOTE 1—If aggregates smaller than 4.75 mm (No. 4) are used in the sample, check to ensure that the size of the openings in the sample container is smaller than the minimum size aggregate.

7.3 The minimum mass of test sample to be used is given as follows. Testing the coarse aggregate in several size fractions is permitted. 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 mass of test sample for each fraction shall be the difference between the masses prescribed for the maximum and minimum sizes of the fraction.

Nominal Maximum Size, mm (in.)	Minimum Mass 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)
125 (5)	75 (165)

7.4 If the sample is tested in two or more size fractions, determine the grading of the sample in accordance with Test Method C136, 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).

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. Procedure

8.1 Dry the test sample in the oven to constant mass at a temperature of 110 ± 5 °C, 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. When Specification C330 or Specification C332 Group II lightweight aggregates are used, immerse the aggregate in water at room temperature for a period of 72 ± 4 h, stirring for at least one minute every 24 h.

8.2 When the absorption and relative density (specific gravity) values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement in 8.1 for initial drying is optional, and, if the surfaces of the particles in the sample have been kept continuously wet until tested, the requirement in 8.1 for 24 ± 4 h or 72 ± 4 h soaking is also optional.

NOTE 3—Values for absorption and relative density (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 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 is permitted to assist in the drying operation. Take care to avoid evaporation of water from aggregate pores during the surface-drying operation. Determine the mass of the test sample in the saturated surface-dry condition. Record this and all subsequent masses to the nearest 0.5 g or 0.05 % of the sample mass, whichever is greater.

8.4 After determining the mass in air, immediately place the saturated-surface-dry test sample in the sample container and determine its apparent mass in water at 23 ± 2.0 °C. Take care to remove all entrapped air before determining its mass by shaking the container while immersed.

NOTE 4—The difference between the mass in air and the mass when the sample is submerged in water equals the mass of water displaced by the sample.

NOTE 5—The container should be immersed to a depth sufficient to cover it and the test sample while determining the apparent mass in water. 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 in the oven to constant mass at a temperature of 110 ± 5 °C, 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 determine the mass.

9. Calculations

9.1 *Relative Density (Specific Gravity):*

9.1.1 *Relative Density (Specific Gravity) (OD)*—Calculate the relative density (specific gravity) on the basis of oven-dry aggregate as follows:

$$\text{Relative density (specific gravity) (OD)} = A/(B - C) \tag{1}$$

where:

A = mass of oven-dry test sample in air, g,
B = mass of saturated-surface-dry test sample in air, g, and
C = apparent mass of saturated test sample in water, g.

9.1.2 *Relative Density (Specific Gravity) (SSD)*—Calculate the relative density (specific gravity) on the basis of saturated-surface-dry aggregate as follows:

$$\text{Relative density (specific gravity) (SSD)} = B/(B - C) \tag{2}$$

9.1.3 *Apparent Relative Density (Specific Gravity)*—Calculate the apparent relative density (specific gravity) as follows:

$$\text{Apparent relative density (specific gravity)} = A/(A - C) \tag{3}$$

9.2 *Average Relative Density (Specific Gravity) Values*—If the sample is tested in separate size fractions, compute the average values for relative density (specific gravity) of the size fraction computed in accordance with 9.1 using the following equation:

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

where:

G = average relative density (specific gravity). All forms of expression of relative density (specific gravity) can be averaged in this manner,
$G_1, G_2 ... G_n$ = appropriate average relative density (specific gravity) values for each size fraction depending on the type of relative density (specific gravity) being averaged, and
$P_1, P_2, ... P_n$ = mass percentages of each size fraction present in the original sample (not including finer material—see 7.4).

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

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

9.4 *Average Absorption Value*—If 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 mass percentages of each size fraction present in the original sample (not including finer material—see 7.4) as follows:

$$A = (P_1 A_1/100) + (P_2 A_2/100) + \dots (P_n A_n/100) \tag{6}$$

where:

A = average absorption, %,
$A_1, A_2 \ldots A_n$ = absorption percentages for each size fraction, and
$P_1, P_2, \ldots P_n$ = mass percentages of each size fraction present in the original sample.

10. Report

10.1 Report relative density (specific gravity) results to the nearest 0.01 and indicate the basis for relative density (specific gravity) as either (OD), (SSD), or apparent.

10.2 Report the absorption result to the nearest 0.1 %.

10.3 If the relative density (specific gravity) and absorption values were determined without first drying the aggregate, as permitted in 8.2, note that fact 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 Proficiency Sample Program, with testing conducted by this test method and AASHTO Method T 85. The significant difference between the methods is that Test Method C127 requires a saturation period of 24 ± 4 h, while AASHTO 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.

TABLE 1 Precision

	Standard Deviation	Acceptable Range of Two Results (d2s)[A]
Single-Operator Precision:		
Relative density (specific gravity) (OD)	0.009	0.025
Relative density (specific gravity) (SSD)	0.007	0.020
Apparent relative density (specific gravity)	0.007	0.020
Multilaboratory Precision:		
Relative density (specific gravity) (OD)	0.013	0.038
Relative density (specific gravity) (SSD)	0.011	0.032
Apparent relative density (specific gravity)	0.011	0.032

[A] These numbers represent the (d2s) limits as described in Practice C670. The precision estimates were obtained from the analysis of combined AASHTO Materials Reference Laboratory proficiency 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.

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.

12. Keywords

12.1 absorption; aggregate; apparent relative density; coarse aggregate; relative density; specific gravity

APPENDIXES

(Nonmandatory Information)

X1. DEVELOPMENT OF EQUATIONS

X1.1 The derivation of the equation is from the following simplified cases using two solids. Solid 1 has a mass M_1 in grams and a volume V_1 in millilitres; its relative density (specific gravity) (G_1) is therefore M_1/V_1. Solid 2 has a mass M_2 and volume V_2, and $G_2 = M_2/V_2$. If the two solids are considered together, the relative density (specific gravity) of the combination is the total mass in grams divided by the total volume in millilitres:

$$G = (M_1 + M_2)/(V_1 + V_2) \tag{X1.1}$$

Manipulation of this equation yields the following:

$$G = \frac{1}{\frac{V_1 + V_2}{M_1 + M_2}} = \frac{1}{\frac{V_1}{M_1 + M_2} + \frac{V_2}{M_1 + M_2}} \tag{X1.2}$$

$$G = \frac{1}{\frac{M_1}{M_1 + M_2}\left(\frac{V_1}{M_1}\right) + \frac{M_2}{M_1 + M_2}\left(\frac{V_2}{M_2}\right)} \tag{X1.3}$$

However, the mass fractions of the two solids are:

$$M_1/(M_1 + M_2) = P_1/100 \text{ and } M_2/(M_1 + M_2) = P_2/100 \tag{X1.4}$$

and,

$$1/G_1 = V_1/M_1 \text{ and } 1/G_2 = V_2/M_2 \tag{X1.5}$$

Therefore,

$$G = \frac{1}{\frac{P_1}{100}\frac{1}{G_1} + \frac{P_2}{100}\frac{1}{G_2}} \tag{X1.6}$$

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

TABLE X1.1 Example of Calculation of Weighted Values of Relative Density (Specific Gravity) and Absorption for a Coarse Aggregate Tested in Separate Sizes

Size Fraction, mm (in.)	% in Original Sample	Sample Mass Used in Test, g	Relative Density (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 Relative Density (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 RELATIVE DENSITIES (SPECIFIC GRAVITIES) AND ABSORPTION AS DEFINED IN TEST METHODS C127 AND C128

X2.1 Where:

S_d = relative density (specific gravity) (OD),
S_s = relative density (specific gravity) (SSD),
S_a = apparent relative density (apparent specific gravity), and
A = absorption in %.

X2.2 Calculate the values of each as follows:

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

$$S_a = \frac{1}{\frac{1}{S_d} - \frac{A}{100}} = \frac{S_d}{1 - \frac{AS_d}{100}} \tag{X2.2}$$

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

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

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