Standard Method of Test for

Specific Gravity and Absorption of Coarse Aggregate

AASHTO Designation: T 85-14

ASTM Designation: C127-12

AASHTO

1.	SCOPE

1.1.   This 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 (saturated surface-dry (SSD)), or apparent specific gravity. The bulk specific gravity (SSD) and absorption are based on aggregate after 15–19 h of soaking in water. This 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 may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2.	REFERENCED DOCUMENTS

2.1.   *AASHTO Standards*:
- M 43, Sizes of Aggregate for Road and Bridge Construction
- M 80, Coarse Aggregate for Hydraulic Cement Concrete
- M 92, Wire-Cloth Sieves for Testing Purposes
- M 231, Weighing Devices Used in the Testing of Materials
- T 2, Sampling of Aggregates
- 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
- T 255, Total Evaporable Moisture Content of Aggregate by Drying

2.2.   *ASTM Standard*:
- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

2.3.   *IEEE/ASTM Standard*:
- SI10, American National Standard for Metric Practice

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3. TERMINOLOGY

3.1.   *Definitions*:

3.1.1.   *absorption*—the increase in the mass 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 mass. The aggregate is considered "dry" when it has been maintained at a temperature of $110 \pm 5°C$ for sufficient time to remove all uncombined water by reaching a constant mass.

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 gas-free distilled 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 mass in air of a unit volume of aggregate, including the mass of water within the voids filled to the extent achieved by submerging in water for 15–19 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.

4. SUMMARY OF METHOD

4.1.   A sample of aggregate is immersed in water 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 mass and weight measurements thus obtained and formulas in the 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 T 19M/T 19. 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 that is accessible to water.

5.3.   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 soaking dry aggregate 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 required amount of time to achieve the 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 T 255.

5.4.   The general procedures described in this method are suitable for determining the absorption of aggregates that have had conditioning other than the required soak, such as boiling water or vacuum saturation. The values obtained for absorption by other methods will be different than the values obtained by the required 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 the required soaking period. In fact, many such aggregates can remain immersed in water for several days without satisfying most of the aggregates' absorption potential. Therefore, this method is not intended for use with lightweight aggregate.

6.   APPARATUS

6.1.   *Balance*—Conforming to the requirements of M 231, Class G 5. 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 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 ($1\frac{1}{2}$-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 and container are placed for complete immersion while suspended below the balance, equipped with an overflow outlet for maintaining a constant water level.

6.4.   *Suspended Apparatus*—Wire suspending the container shall be of the smallest practical size to minimize any possible effects of a variable immersed length.

6.5.   *Sieves*—A 4.75-mm (No. 4) sieve or other sizes as needed (Sections 7.2, 7.3, and 7.4), conforming to M 92.

7.   SAMPLING

7.1.   Sample the aggregate in accordance with T 2.

7.2.   Thoroughly mix the sample of aggregate and reduce it to the approximate quantity needed using the applicable procedures in T 248. 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 (No. 4) sieve (such as for Size No. 8 and 9 aggregates in M 43), use the 2.36-mm (No. 8) sieve in place of the 4.75-mm (No. 4) sieve. Alternatively, separate the material finer than the 4.75-mm (No. 4) sieve and test the finer material according to T 84.

7.3.	The minimum mass 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 percent retained on the 37.5-mm ($1^1/_2$-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 ($^1/_2$) or less	2 (4.4)
19.0 ($^3/_4$)	3 (6.6)
25.0 (1)	4 (8.8)
37.5 ($1^1/_2$)	5 (11)
50 (2)	8 (18)
63 ($2^1/_2$)	12 (26)
75 (3)	18 (40)
90 ($3^1/_2$)	25 (55)
100 (4)	40 (88)
112 ($4^1/_2$)	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 T 27, 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 Section 7.2.

## 8.	PROCEDURE

8.1.	Dry the test sample to constant mass at a temperature of $110 \pm 5°C$ ($230 \pm 9°F$), cool in air at room temperature for 1 to 3 h for test samples of 37.5-mm ($1^1/_2$-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 15 to 19 h.

Note 1—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 computation 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 mass may be eliminated, and, if the surfaces of the particles in the sample have been kept continuously wet until test, the required soaking may also be eliminated.

Note 2—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 Section 8.1. This is especially true of particles larger than 75 mm (3 in.) because the water may not be able to penetrate the pores to the center of the particle in the required 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 operation of surface-drying. If the test sample dries past the SSD condition, immerse in

water for 30 min, then resume the process of surface-drying. Determine the mass of the test sample in the saturated surface-dry condition. Record this and all subsequent masses to the nearest 1.0 g or 0.1 percent of the sample mass, whichever is greater.

8.4. After determining the mass, immediately place the saturated surface-dry test sample in the sample container and determine its mass in water at $23.0 \pm 1.7°C$ ($73.4 \pm 3°F$), having a density of 997 ± 2 kg/m³. Take care to remove all entrapped air before determining the mass by shaking the container while immersed. Maintain the water level in the bath at the overflow depth to obtain a constant water level throughout the test.

Note 3—The container should be immersed to a depth sufficient to cover it and the test sample during mass determination. 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 mass at a temperature of $110 \pm 5°C$ ($230 \pm 9°F$), 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 determine the mass. Use this weight for A in the calculations in Section 9.

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:

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

where:
A = mass of oven-dry test sample in air, g;
B = mass of saturated surface-dry test sample in air, g; and
C = mass 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 mass of saturated surface-dry aggregate as follows:

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

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

$$\text{apparent sp gr} = A / (A - C) \qquad (3)$$

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 Section 9.1 using the following equation:

$$G = \frac{1}{\dfrac{P_1}{100G_1} + \dfrac{P_2}{100G_2} + \cdots \dfrac{P_n}{100G_n}} \qquad (4)$$

where:
G = average specific gravity (All forms of expression of specific gravity can be averaged in this manner.);
$P_1, P_2 \dots P_n$ = mass percentages of each size fraction present in the original sample; and
$G_1, G_2 \dots G_n$ = appropriate specific gravity values for each size fraction depending on the type of specific gravity being averaged.

Note 4—Some users of this 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 density 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. 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:

$$\text{absorption, percent} = \left[(B - A) / A \right] \times 100 \qquad (5)$$

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 Section 9.3, weighted in proportion to the mass percentages of the size fractions in the original sample as follows:

$$A = \left(P_1 A_1 / 100 \right) + \left(P_2 A_2 / 100 \right) + \cdots \left(P_n A_n / 100 \right) \qquad (6)$$

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

10.   REPORT

10.1.   Report specific gravity results to the nearest 0.001 (Coarse Aggregate meeting M 80 requirements may be reported 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 percent.

10.3.   If the specific gravity and absorption values were determined without first drying the aggregate, as permitted in Section 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 ASTM C127. The significant difference between the methods is that ASTM C127 requires a saturation period of 24 ± 4 h, while T 85 requires a saturation period of 15-19 h. This difference has been found to have 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.

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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} percent	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} percent	0.145	0.41

^{a} These numbers represent, respectively, the (1s) and (d2s) limits as described in ASTM C670. 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 time. Testing was performed on aggregates of normal specific gravities and started with aggregates in the oven-dry condition.

^{b} Precision estimates are based on aggregates with absorptions of less than 2 percent.

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

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 mass W_1 in grams and a volume V_1 in milliliters; its specific gravity (G_1) is therefore W_1/V_1. Solid 2 has a mass 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 mass in grams divided by the total volume in milliliters:

$$G = (W_1 + W_2)/(V_1 + V_2) \qquad (X1.1)$$

Manipulation of this equation yields the following:

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

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

However, the mass fractions of the two solids are:

$$\frac{W_1}{(W_1 + W_2)} = \frac{P_1}{100} \qquad (X1.4)$$

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and:

$$\frac{W_2}{(W_1 + W_2)} = \frac{P_2}{100} \tag{X1.5}$$

and:

$$\frac{1}{G_1} = \frac{V_1}{W_1} \text{ and } \frac{1}{G_2} = \frac{V_2}{W_2} \tag{X1.6}$$

therefore:

$$G = \frac{1}{\left(\frac{P_1}{100}\right)\left(\frac{1}{G_1}\right) + \left(\frac{P_2}{100}\right)\left(\frac{1}{G_2}\right)} \tag{X1.7}$$

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

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

Size Fraction, mm (in.)	Percent in Original Sample	Bulk Specific Gravity (SSD)[a]	Sample Mass Used in Test, g	Absorption, %
4.75 to 12.5 (No. 4 to $^1/_2$)	44	2.72	2213.0	0.4
12.5 to 37.5 ($^1/_2$ to $1^1/_2$)	35	2.56	5462.5	2.5
37.5 to 63 ($1^1/_2$ to $2^1/_2$)	21	2.54	12593.0	3.0

[a] Average specific gravity (SSD)

$$G_{SSD} = \frac{1}{\frac{0.44}{2.72} + \frac{0.35}{2.56} + \frac{0.21}{2.54}} = 2.62 \tag{X1.8}$$

Average absorption:

$$A = (0.44)(0.4) + (0.35)(2.5) + (0.21)(3.0) = 1.7\% \tag{X1.9}$$

X2. INTERRELATIONSHIPS BETWEEN SPECIFIC GRAVITIES AND ABSORPTION AS DEFINED IN METHODS T 85 AND T 84

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 percent.

Then:

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

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

$$S_a = \frac{1}{\dfrac{1 + A/100}{S_s} - \dfrac{A}{100}} \tag{X2.3}$$

$$= \frac{S_s}{1 - \left(\dfrac{A}{100}\left(S_s - 1\right)\right)}$$

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

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