



Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete¹

This standard is issued under the fixed designation C138/C138M; 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 determination of the density (see [Note 1](#)) of freshly mixed concrete and gives formulas for calculating the yield, cement content, and air content of the concrete. Yield is defined as the volume of concrete produced from a mixture of known quantities of the component materials.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

NOTE 1—Unit weight was the previous terminology used to describe the property determined by this test method, which is mass per unit volume.

1.3 The text of this test method refers to 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 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* (**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.²)

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recom-*

mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:³

- [C29/C29M](#) Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate
- [C31/C31M](#) Practice for Making and Curing Concrete Test Specimens in the Field
- [C125](#) Terminology Relating to Concrete and Concrete Aggregates
- [C143/C143M](#) Test Method for Slump of Hydraulic-Cement Concrete
- [C150/C150M](#) Specification for Portland Cement
- [C172/C172M](#) Practice for Sampling Freshly Mixed Concrete
- [C173/C173M](#) Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- [C188](#) Test Method for Density of Hydraulic Cement
- [C231/C231M](#) Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- [C1758/C1758M](#) Practice for Fabricating Test Specimens with Self-Consolidating Concrete

3. Terminology

3.1 *Definitions*—For definitions of terms used in this standard, refer to Terminology [C125](#).

3.2 Symbols:

- A = air content (percentage of voids) in the concrete
- C = actual cement content, kg/m^3 [lb/yd^3]
- C_b = mass of cement in the batch, kg [lb]
- D = density (unit weight) of concrete, kg/m^3 [lb/ft^3]
- M = total mass of all materials batched, kg [lb] (see [Note 3](#))
- M_c = mass of the measure filled with concrete, kg [lb] or

¹ This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.60 on Testing Fresh Concrete.

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² See section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol 04.02.

³ 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.

*A Summary of Changes section appears at the end of this standard



- M_m = mass of the measure, kg [lb]
 R_y = relative yield
 T = theoretical density of the concrete computed on an airfree basis, kg/m³ [lb/ft³] (see **Note 2**)
 Y = yield, volume of concrete produced per batch, m³ [yd³]
 Y_d = volume of concrete which the batch was designed to produce, m³ [yd³]
 Y_f = volume of concrete produced per batch, m³ [ft³]
 V = total absolute volume of the component ingredients in the batch, m³ [ft³]
 V_m = volume of the measure, m³ [ft³]

NOTE 2—The theoretical density is, customarily, a laboratory determination, the value for which is assumed to remain constant for all batches made using identical component ingredients and proportions.

NOTE 3—The total mass of all materials batched is the sum of the masses of the cement, the fine aggregate in the condition used, the coarse aggregate in the condition used, the mixing water added to the batch, and any other solid or liquid materials used.

4. Apparatus

4.1 Balance—A balance or scale accurate to 45 g [0.1 lb] or to within 0.3 % of the test load, whichever is greater, at any point within the range of use. The range of use shall be considered to extend from the mass of the measure empty to the mass of the measure plus its contents at 2600 kg/m³ [160 lb/ft³].

4.2 Tamping Rod—A round, smooth, straight steel rod, with a 16 mm [$\frac{5}{8}$ in.] $\pm$ 2 mm [$\frac{1}{16}$ in.] diameter. The length of the tamping rod shall be at least 100 mm [4 in.] greater than the depth of the measure in which rodding is being performed, but not greater than 600 mm [24 in.] in overall length (see **Note 4**). The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

NOTE 4—A rod length of 400 mm [16 in.] to 600 mm [24 in.] meets the requirements of the following: Practice **C31/C31M**, Test Method **C138/C138M**, Test Method **C143/C143M**, Test Method **C173/C173M** and Test Method **C231/C231M**.

4.3 Internal Vibrator—The vibrator frequency shall be at least 9000 vibrations per minute [150 Hz] while the vibrator is operating in the concrete. The outside diameter or the side dimension of the vibrating element shall be at least 19 mm [0.75 in.] and not greater than 38 mm [1.50 in.]. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 75 mm [3 in.]. The vibrator frequency shall be checked with a vibrating reed tachometer at an interval not to exceed two years. If the vibrator manufacturer recommends a shorter verification interval, a verification procedure, or other verification device, the manufacturer's recommendation shall be followed.

4.4 Measure—A cylindrical container made of steel or other suitable metal (see **Note 5**). The minimum capacity of the measure shall conform to the requirements of **Table 1** based on the nominal size of aggregate in the concrete to be tested. All measures, except for measuring bowls of air meters which are also used for Test Method **C138/C138M** tests, shall conform to the requirements of Test Method **C29/C29M**. When measuring bowls of air meters are used, they shall conform to the requirements of Test Method **C231/C231M**, and shall be calibrated for volume as described in Test Method **C29/C29M**.

TABLE 1 Capacity of Measures

Nominal Maximum Size of Coarse Aggregate		Capacity of Measure ^A	
mm	[in.]	L	[ft ³]
25.0	[1]	6	[0.2]
37.5	[1½]	11	[0.4]
50	[2]	14	[0.5]
75	[3]	28	[1.0]
112	[4½]	70	[2.5]
150	[6]	100	[3.5]

^A The indicated size of measure shall be used to test concrete containing aggregates of a nominal maximum size equal to or smaller than that listed. The actual volume of the measure shall be at least 95 % of the nominal volume listed.

The top rim of the air meter bowls shall be smooth and plane within 0.01 in. [0.3 mm] (see **Note 6**).

NOTE 5—The metal should not be readily subject to attack by cement paste. However, reactive materials such as aluminum alloys may be used in instances where as a consequence of an initial reaction, a surface film is rapidly formed which protects the metal against further corrosion.

NOTE 6—The top rim is satisfactorily plane if a 0.3-mm [0.01-in.] feeler gage cannot be inserted between the rim and a piece of 6-mm [$\frac{1}{4}$ -in.] or thicker plate glass laid over the top of the measure.

4.5 Strike-Off Plate—A flat rectangular metal plate at least 6 mm [$\frac{1}{4}$ in.] thick or a glass or acrylic plate at least 12 mm [$\frac{1}{2}$ in.] thick with a length and width at least 50 mm [2 in.] greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within a tolerance of 2 mm [$\frac{1}{16}$ in.].

4.6 Mallet—A mallet (with a rubber or rawhide head) having a mass of 600 $\pm$ 200 g [1.25 $\pm$ 0.50 lb] for use with measures of 14 L [0.5 ft³] or smaller, and a mallet having a mass of 1000 $\pm$ 200 g [2.25 $\pm$ 0.50 lb] for use with measures larger than 14 L [0.5 ft³].

4.7 Scoop—of a size large enough so each amount of concrete obtained from the sampling receptacle is representative and small enough so it is not spilled during placement in the measure.

5. Sample

5.1 Obtain the sample of freshly mixed concrete in accordance with Practice **C172/C172M**.

6. Procedure

6.1 Dampen the interior of the measure and remove any standing water from the bottom. Determine the mass of the empty measure to an accuracy consistent with the requirements of **4.1**. Place the measure on a flat, level, firm surface.

6.2 If self-consolidating concrete is being tested, follow the procedures in Practice **C1758/C1758M** for filling the measure. Upon completion of the filling process, proceed to Strike-Off (**6.8**).

NOTE 7—Practice **C1758/C1758M** covers the procedure for filling the specimen container in one layer and without using any additional consolidation method.

6.3 Base the selection of the method of consolidation on the slump, unless the method is stated in the specifications under