Designation: C 1688/C 1688M – 08

Standard Test Method for Density and Void Content of Freshly Mixed Pervious Concrete[1]

This standard is issued under the fixed designation C 1688/C 1688M; 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.

1. Scope

1.1 This test method covers determining the density of freshly mixed pervious concrete and gives formulas for calculating the void content of pervious concrete.

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.

1.3 *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.* (**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C 29/C 29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C 125 Terminology Relating to Concrete and Concrete Aggregates

C 127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate

C 128 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate

C 150 Specification for Portland Cement

C 172 Practice for Sampling Freshly Mixed Concrete

C 188 Test Method for Density of Hydraulic Cement

C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

C 311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete

C 595 Specification for Blended Hydraulic Cements

C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

C 1157 Performance Specification for Hydraulic Cement

C 1240 Specification for Silica Fume Used in Cementitious Mixtures

D 698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3(600 kN-m/m^3))

3. Terminology

3.1 *Definitions*:

3.1.1 For definitions of terms used in this test method, refer to Terminology C 125.

3.2 *Symbols*:

D	=	density (unit weight) of concrete kg/m^3 [lb/ft^3]
M_s	=	total mass of all materials batched, kg [lb] (see Note 1)
M_c	=	mass of the measure filled with concrete, kg [lb]
M_m	=	mass of the measure, kg [lb]
T	=	theoretical density of the concrete computed on an airfree basis, kg/m^3 [lb/ft^3] (see Note 1)
U	=	percentage of voids in the fresh pervious concrete, including entrained and entrapped air voids in the cement paste.
V_s	=	sum of the absolute volumes of the component ingredients in the batch, m^3 [ft^3]
V_m	=	volume of the measure, m^3 [ft^3]

NOTE 1—The theoretical density is a laboratory determination, and is assumed to remain constant for all batches made using identical component ingredients and proportions. It is calculated from the following equation:

$$T = \frac{M_s}{V_s}$$

The total mass of all materials batched is the sum of the masses of the cement, the fine aggregate in the saturated-surface-dry condition, the

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[2] 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.

coarse aggregate in the saturated-surface-dry condition, the mixing water in the batch (includes free water from the aggregate), and any other solid or liquid materials used.

The absolute volume of each ingredient is equal to the quotient of the mass of that ingredient divided by the product of its relative density (specific gravity) times the density of water (See Test Method C 29/C 29M). For the aggregate components, the relative density (specific gravity) should be based on the saturated-surface-dry condition (as determined by Test Method C 127 for coarse aggregate and Test Method C 128 for fine aggregate). For cements meeting Specification C 150, Specification C 595, and Specification C 1157, the relative density should be determined by Test Method C 188, and is typically available from the cement manufacturer. A value of 3.15 may be used for Portland cements manufactured to meet the requirements of Specification C 150. The relative density of supplementary cementitious materials should be determined as follows: for fly ash, use Test Methods C 311; for silica fume, use Specification C 1240; and for slag cement, use Specification C 989.

4. Summary of Test Method

4.1 A sample of fresh pervious concrete is placed and consolidated in a standard measure. The concrete is consolidated using a standard Proctor hammer. The density and void content of the pervious concrete are calculated based on the measured mass of the consolidated concrete specimen, the volume of the measure, and the total mass of materials batched.

5. Significance and Use

5.1 This test method provides a procedure for determining the density and void content of freshly mixed pervious concrete.

5.2 This test method is applicable to pervious concrete mixtures containing coarse aggregate with a nominal maximum size of 25 mm [1 in.] or smaller.

5.3 The measured fresh density may be used as verification of mixture proportions.

5.4 The fresh density and void content calculated from this test may differ from the in-place density and void content, and this test shall not be used to determine in-place yield.

6. Apparatus

6.1 *Balance*—A balance or scale accurate to 50 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 empty measure to the mass of the measure filled with concrete having an assumed density of 2600 kg/m^3 [160 lb/ft^3].

6.2 *Standard Proctor Hammer*—A device used to compact a pervious concrete sample that conforms to Test Method D 698.

6.3 *Measure*—A cylindrical container made of steel or other suitable metal (See Note 2) with a capacity of 7.0 ± 0.6 L [0.25 ± 0.02 ft^3] and a diameter equal to 0.75 to 1.25 times the height. The measuring bowl of a Type B air meter conforming to Test Method C 231 meets the requirements for the measure. The volume of the measure shall be determined as described in Test Method C 29/C 29M. The top rim of the container shall be plane within 0.3 mm [0.01 in.] (See Note 3).

NOTE 2—The metal should not be attacked readily by cement paste. However, a reactive material such as aluminum alloy may be used if, as a result of an initial reaction, a surface film is formed that protects the metal against further corrosion.

NOTE 3—The top rim is satisfactorily plane if a 0.3 mm [0.01-in.] feeler gauge cannot be inserted between the rim and a piece of 6 mm [¼-in.] or thicker plate glass laid over the top of the measure.

6.4 *Strike-Off Plate*—A flat rectangular metal plate at least 6 mm [¼ in.] thick or a glass or acrylic plate at least 12 mm [½ in.] thick with length and width that are 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 within a tolerance of 2 mm [1⁄16 in.].

6.5 *Scoop*—Of a size large enough so each amount of pervious concrete obtained from the sampling receptacle is representative and small enough so that the concrete is not spilled during placement in the measure.

7. Sampling

7.1 Obtain the sample of freshly mixed pervious concrete on field placements in accordance with Practice C 172.

7.2 Obtain the sample of freshly mixed pervious concrete in laboratory testing in accordance with Practice C 192/C 192M.

7.3 The elapsed time between obtaining the first and final portions of the composite sample shall not exceed 15 min.

7.3.1 Transport the individual samples to the place where fresh concrete tests are to be performed. Combine and remix the samples with a shovel the minimum amount necessary to ensure uniformity and compliance with the maximum time limits specified in 7.3.2. Protect the composite sample from the sun, wind, and other sources of rapid evaporation.

7.3.2 Start the test for density within 5 min after obtaining the final portion of the composite sample.

8. Procedure

8.1 Place the measure on a flat, level surface free from vibration. Moisten the inside of the measure before placing pervious concrete. Remove any standing water from the bottom of the container using a moistened sponge. Place the pervious concrete in the measure in two layers of approximately equal depth using the scoop described in 6.5. During filling of the measure, move the scoop around the perimeter of the opening to ensure an even distribution of the concrete with minimal segregation. Drop the hammer 20 times per layer at the full 305 mm [12 in.] drop height. For each layer, distribute the position of the tamper so that the entire surface area of the pervious concrete in the measure is consolidated equally. Before consolidating the final layer, fill the measure to overflowing. After completion of consolidation, the measure must contain about 3 mm [¼ in.] of excess pervious concrete protruding above the top of the measure. If after 10 hammer drops to the final layer it appears that there will be insufficient concrete, add a small quantity of concrete to correct the deficiency. If after 10 hammer drops to the final layer it appears that there will be too much concrete in the measure, remove a representative portion of excess concrete with a trowel or scoop. Complete the consolidation of the final layer.

8.2 *Strike Off*—After consolidation, strike off the top surface of the concrete and finish it flat with the strike-off plate so that the concrete surface is level with the top of the measure. Accomplish the strike-off by pressing the strike-off plate on the top surface of the measure to cover about two thirds of the surface and withdrawing the plate with a sawing motion to

strike off the area originally covered. Then place the plate on the top of the measure to cover the same two thirds of the surface and advance it with a vertical pressure and a sawing motion to cover the whole surface of the measure; continue to advance plate until it slides completely off the measure. Several final sawing-motion strokes with the edge of the plate, which has been inclined to the top of the measure, will produce a flat finished surface.

8.3 *Cleaning and Weighing*—After strike-off, clean excess concrete from the exterior of the measure and determine the mass of the concrete and measure to an accuracy consistent with the requirements of 6.1.

9. Calculation

9.1 *Density (Unit Weight)*—Calculate the net mass of the concrete by subtracting the mass of the measure, M_m, from the mass of the measure filled with concrete, M_c. Calculate the density (unit weight), D, by dividing the net mass of concrete by the volume of the measure, V_m, as follows:

$$D = \frac{M_c - M_m}{V_m} \quad (1)$$

9.2 *Void Content*—Calculate the percentage of voids as follows:

$$U = \frac{T - D}{T} \times 100\ \% \quad (2)$$

10. Precision and Bias

10.1 Repeatability testing was performed by six laboratories using pervious concrete mixtures proportioned using local materials. Each laboratory prepared three batches and performed two replicate tests per batch. The range of density of fresh pervious concrete was from 1750 to 2000 kg/m^3[109 to 125 lb/ft^3] (See Note 4).

NOTE 4—Round robin testing was performed using the following six consolidation methods:

Proctor Hammer-2 equal layers, 20 times per layer
Marshall Hammer-2 equal layers, 5 times per layer
Marshall Hammer-2 equal layers, 10 times per layer
ASTM C29 Jigging-2 equal layers, 50 drops per layer as per Test Method C 29/C 29M
ASTM C138 Rodding Method-2 equal layers, 25 times per layer
No Consolidation-Fill the empty unit weight bucket.

Of the six consolidation methods evaluated, the method using the Proctor Hammer produced a high degree of repeatability, employed a straightforward process, and was not physically demanding due to the lower weights as compared to the Marshall Hammer.

10.1.1 The single-operator standard deviation of density of freshly mixed pervious concrete has been found to be 22 kg/m^3 [1.4 lb/ft^3].

10.1.2 The multi-operator standard deviation has not been developed.

10.2 This test method has no bias because the density of pervious concrete is defined only in terms of this test method.

11. Keywords

11.1 density; fresh concrete; pervious concrete; Proctor hammer; void content