Designation: C1688/C1688M – 14a

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

This standard is issued under the fixed designation C1688/C1688M; 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 under standardized conditions and gives formulas for calculating the void content of pervious concrete. Test results are not intended to represent the in-place density and void content.

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]

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

C125 Terminology Relating to Concrete and Concrete Aggregates

C127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate

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

C150/C150M Specification for Portland Cement

C172/C172M Practice for Sampling Freshly Mixed Concrete

C188 Test Method for Density of Hydraulic Cement

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

C311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete

C595/C595M Specification for Blended Hydraulic Cements

C989/C989M Specification for Slag Cement for Use in Concrete and Mortars

C1157/C1157M Performance Specification for Hydraulic Cement

C1240 Specification for Silica Fume Used in Cementitious Mixtures

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3))

D6926 Practice for Preparation of Bituminous Specimens Using Marshall Apparatus

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this standard, refer to Terminology C125.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *concrete, pervious, n*—hydraulic cement concrete proportioned with sufficient, distributed, interconnected macroscopic voids that allow water to flow through the material under the action of gravity alone.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.49 on Pervious Concrete.

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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.

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

3.3 *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.

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 (Procedure A) or a standard Marshall hammer (Procedure B). 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 This method uses a standard consolidation procedure to measure fresh density and void content of a pervious concrete mixture as delivered. Test results are not intended to represent the density and void content of the in-place pervious concrete. This method shall not be used to determine the in-place void content or yield of the pervious concrete.

5.5 The fresh density and void content calculated from this test method may be different when comparing the results from Procedure A with Procedure B. Results are only comparable when obtained using the same procedure (Procedure A or B).

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 specimen for Procedure A that conforms to Test Method D698.

6.3 *Marshall Hammer*—A device used to compact a pervious concrete specimen for Procedure B that conforms to Practice D6926 manual compaction hammer.

6.4 *Measure*—A cylindrical container made of steel or other suitable metal 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 (See Note 2). The volume of the measure shall be determined as described in Test Method C29/C29M. 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. The measuring bowl of an air meter conforming to Test Method C231/C231M can meet the requirements for the measure.

NOTE 3—The top rim is satisfactorily plane if a 0.3 mm [0.01-in.] wire 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.

6.5 *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.].

6.6 *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 For field placements, obtain the sample of freshly-mixed pervious concrete in accordance with Practice C172/C172M.

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

7.2 For laboratory testing, obtain the sample of freshly-mixed pervious concrete in accordance with Practice C192/C192M.

7.2.1 Start the test for density within 5 min after obtaining the 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 thickness using the scoop described in 6.6. 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. For Procedure A, drop the hammer vertically 20 times per layer at the full 305 mm [12 in.] drop height. For Procedure B, drop the hammer vertically 10 times per layer at the full 457 mm [18 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 [⅛ in.] of excess pervious concrete protruding above the top of the measure. If after half the number of specified 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 half

the number of specified 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 *Theoretical Density*—Calculate the theoretical density from the following equation:

$$T = \frac{M_s}{V_s} \quad (2)$$

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 coarse aggregate in the saturated-surface-dry condition, the 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 C29/C29M). For the aggregate components, the relative density (specific gravity) shall be based on the saturated-surface-dry condition (as determined by Test Method C127 for coarse aggregate and Test Method C128 for fine aggregate). The relative density (specific gravity) for cements meeting Specifications C150/C150M, C595/C595M, and C1157/C1157M and for slag cement meeting Specification C989/C989M shall be determined by Test Method C188. It is permitted to use a value of 3.15 for portland cements manufactured to meet the requirements of Specification C150/C150M. The relative density (specific gravity) of fly ash shall be determined as directed in Test Method C311, and of silica fume as directed in Specification C1240

NOTE 4—The relative density (specific gravity) of portland cements, blended cements, and supplementary cementitious materials obtained by methods required in 9.2 are commonly available from the supplier. .

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

$$U = \frac{T - D}{T} \times 100 \quad (3)$$

10. Report

10.1 Report the following information:

10.1.1 Date, time, and name of individual molding specimens.

10.1.2 Mixture identification and location of concrete represented by the sample.

10.1.3 Volume of the density (unit weight) measure, to the nearest 0.01 L [0.001 ft^3].

10.1.4 Measured density (unit weight) of the concrete, to the nearest 1.0 kg/m^3 [0.1 lb/ft^3].

10.1.5 Theoretical density, to the nearest 1.0 kg/m^3 [0.1 lb/ft^3].

10.1.6 Void content, to the nearest 0.1 %.

10.1.7 Procedure followed (A or B).

11. Precision and Bias

11.1 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 5).

NOTE 5—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 C29/C29M
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 and Marshall Hammer produced a high degree of repeatability and employed a straightforward process.

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

11.1.2 The single-operator standard deviation of density of freshly mixed pervious concrete following Procedure B has been found to be 21 kg/m^3 [1.3 lb/ft^3].

11.1.3 The multi-operator standard deviation has not been developed. The reproducibility of this test method is being determined.

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

12. Keywords

12.1 density; fresh concrete; pervious concrete; Proctor hammer; Marshall hammer; void content

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this standard since the last issue (C1688/C1688M – 14) that may impact the use of this standard. (Approved October 1, 2014.)

(1) Revised 3.2.1.

(2) Revised 5.5.