Designation: C1800/C1800M – 16

Standard Test Method for Determining Density of Roller-Compacted Concrete Specimens Using the Gyratory Compactor[1]

This standard is issued under the fixed designation C1800/C1800M; 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 the compaction of cylindrical specimens of roller-compacted concrete (RCC) using the gyratory compactor to determine density.

1.2 *Units*—The values stated in 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]

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C125 Terminology Relating to Concrete and Concrete Aggregates

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

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

C188 Test Method for Density of Hydraulic Cement

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

C1077 Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation

C1170/C1170M Test Method for Determining Consistency and Density of Roller-Compacted Concrete Using a Vibrating Table

C1435/C1435M Practice for Molding Roller-Compacted Concrete in Cylinder Molds Using a Vibrating Hammer

D6925 Test Method for Preparation and Determination of the Relative Density of Asphalt Mix Specimens by Means of the Superpave Gyratory Compactor

3. Terminology

3.1 *Definitions*—For definitions of terms used in this Test Method, refer to Terminology C125.

4. Significance and Use

4.1 This Test Method is used to prepare specimens containing a nominal maximum aggregate size of up to 37.5 mm [1-½ in.] and a Vebe consistency time, in accordance with Test Method C1170/C1170M, of greater than 30 s for determining the density of compacted RCC mixtures. This method is not intended to specify a standard compactive effort in RCC mixture design, but rather to provide a standardized method for comparing various aggregate combinations.

4.2 This test method may be used for making specimens and determining densities of laboratory-produced RCC mixtures.

NOTE 1—The agency and personnel performing this test method should meet the criteria of Practice C1077 or equivalent.

NOTE 2—The use of gyratory-compacted RCC specimens for strength determinations is not recommended due to specimen geometry and low L/D ratios. Research has shown a lack of correlation between compressive strengths of gyratory-compacted RCC specimens and specimens prepared in accordance with Practice C1435/C1435M.

5. Apparatus

5.1 *Gyratory Compactor*—An electromechanical, electro-hydraulic, or electro-pneumatic compactor meeting the requirements of Test Method D6925.

5.2 *Specimen Molds*—Specimen molds having an inside diameter of approximately 150 mm [6 in.], meeting the requirements of Test Method D6925.

5.3 *Mold Plates and Ram Heads*—Mold plates and ram heads shall conform to Test Method D6925.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.45 on Roller-Compacted Concrete.

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[2] Section on Safety Precautions, Manual of Aggregate and Concrete Testing, Annual Book of ASTM Standards, Vol. 04.02. (see C09.95 Coordination Document)

[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.

5.4 *Balance*—The balance shall have a capacity of at least 20 kg [44 lb] and be capable of reading to the nearest 5 g [0.01 lb].

5.5 *Transfer Device*—A container such as a bowl or device suitable for transferring the loose mixture into the compaction mold in one lift.

5.6 *Miscellaneous Tools*—Miscellaneous equipment and small tools as described in Practice C192/C192M. Also required are 150 mm [6 in.] diameter paper disks, meeting the requirements of Test Method D6925.

6. Verification of Apparatus

6.1 The gyratory compactor and associated apparatus shall be verified and maintained in accordance with Test Method D6925.

7. Preparation and Compaction of Test Specimens

7.1 Confirm the settings of the compactor. Unless otherwise required by the specifier of tests, initialize the compactor to provide specimen compaction using the desired number of gyrations or target height, an internal angle of 1.16 degrees, and a pressure of 600 kPa [87 psi].

NOTE 3—Experience has shown that 50 to 60 gyrations may be appropriate for mixtures with Vebe times greater than 30 s.

7.2 Prepare and machine mix the materials in accordance with Practice C192/C192M. If compacting to a desired number of gyrations, adjust the specimen mass to result in a compacted specimen having a height of 115 ± 5 mm [4.53 ± 0.02 in.] at the desired number of gyrations. If compacting to a target height, adjust specimen mass to create a given density in a known volume.

NOTE 4—A volume of approximately 0.01 m^3 (10 L) [0.35 ft^3] of concrete is sufficient for preparing two gyratory-compacted specimens. Approximately 5 kg of concrete is required for a single specimen. It may be necessary to produce a trial specimen to achieve the height requirement or target density.

7.3 Inspect the interior of the mold and remove residual concrete or paste if present.

7.4 Determine and record the mass of two paper disks.

7.5 Place one paper disk inside the mold.

7.6 Place the mixture into the mold in one lift using the transfer device, taking care to minimize segregation of the mixture. Level the surface of the mixture and place the other paper disk on top of the mixture. If required by the manufacturer, place the top mold plate on top of the paper disk. Place the compaction mold into the gyratory compactor and initiate the compaction process within 15 minutes of completing the mixing process.

NOTE 5—In most gyratory compactors, the compaction process is automatic, and is initiated by pressing a key. The compactor will apply vertical pressure, induce the angle, and begin compaction. Compaction will proceed to the desired number of gyrations or specified height. At the completion of compaction, the machine will provide a measurement of specimen height to the nearest 0.1 mm.

7.7 Record the final specimen height measured by the compactor during the compaction process.

7.8 Extrude the compacted specimen from the mold. If the compacted specimen cannot be handled immediately, allow a resting period of 5 to 10 minutes before extruding the specimen. Specimens that have bulged or otherwise deformed shall not be used for any testing purposes.

7.9 Thoroughly clean the compactor and compaction mold assembly.

7.10 Within 15 minutes of the completion of compaction, determine the mass of the compacted specimen with paper disks and record to the nearest 5 g [0.01 lb].

7.11 Compute the net mass of the specimen by subtracting the mass of the paper disks from the mass determined in 7.10.

7.12 Calculate the volume of the specimen based on the inside diameter of the mold and the gyratory-derived height of the compacted specimen, according to Eq 1.

$$V = \frac{\pi d^2 h}{4 \times 10^9} \tag{1}$$

where:

V = specimen volume, m^3,
d = specimen diameter, mm, and
h = height of the compacted specimen at the final gyration, mm.

7.13 To express the volume in ft^3, multiply the value obtained in Eq 1 by 35.315.

8. Calculation of Density

8.1 Determine the density of the specimen as follows:

$$D = \frac{M_s}{V_s} \tag{2}$$

where:

D = density, kg/m^3 [lb/ft^3],
M_s = mass of specimen, kg [lb], and
V_s = volume of specimen, m^3 [ft^3], determined in 7.12 [7.13].

8.2 Determine the theoretical maximum density of the mixture by Eq 3 by considering the percentage by mass and the density of each material component (i.e., aggregates, water, additives and all cementitious materials). For the aggregate components, determine the relative density and mass based on the saturated, surface-dry condition in accordance with Test Method C127 for the coarse aggregate and Test Method C128 for the fine aggregate. Compute the density of each component by multiplying its relative density by the density of water, or 998 kg/m^3 [62.3 lb/ft^3], according to Eq 4.

8.3 For cementitious and supplementary cementitious materials, compute the density using the relative density determined by Test Method C188, or obtain from the manufacturer. Determine the density of the remainder of the materials according to applicable referenced standards, or obtain from the manufacturer.

$$TMD = \frac{100}{\frac{P_1}{D_1} + \frac{P_2}{D_2} + \ldots + \frac{P_n}{D_n}} \tag{3}$$

where:

TMD = theoretical maximum density, kg/m^3 [lb/ft^3],

P_n = percent by mass of the nth material in total mixture, %,
D_n = density of the nth material, kg/m^3 [lb/ft^3], and
1 through n = each individual component in the mixture.

$$D_n = RD_n \cdot w \quad (4)$$

where:

D_n = density of the nth material, kg/m^3 [lb/ft^3],
RD_n = relative density of the nth material, and
w = density of water, 998 kg/m^3 [62.3 lb/ft^3].

9. Report

9.1 Report the following information:

9.1.1 Project details, as directed by the purchaser of testing,

9.1.2 Date and time of specimen preparation,

9.1.3 Specimen identification,

9.1.4 Number of gyrations applied to the specimen,

9.1.5 Content, in kg/m^3 [lb/ft^3], and relative density of each material component of the mixture,

9.1.6 Mass of the specimen, to the nearest 5 g [0.01 lb],

9.1.7 Height of the specimen after the final gyration to the nearest 0.1 mm [0.004 in.],

9.1.8 Density of the compacted specimen to the nearest 10 kg/m^3 [0.5 pcf], and

9.1.9 Theoretical maximum density (TMD) to the nearest 10 kg/m^3 [0.5 pcf].

10. Precision and Bias

10.1 *Precision:*

10.1.1 *Single Operator Precision*—Based on testing by one operator in one laboratory using three replicate specimens from each of two concrete mixtures, the single-operator coefficient of variation of density for individual determinations was 1.1 %.

10.1.2 *Multilaboratory Precision*—An appropriate study for the purpose of determining multilaboratory precision has not been performed.

10.2 *Bias:*

10.2.1 *Bias Statement*—There is no accepted reference material suitable for determining the bias in this method, therefore, no statement on bias is made.

11. Keywords

11.1 density; gyratory compaction; roller-compacted concrete