Designation: C1849/C1849M – 17

Standard Test Method for Density and Air Content (Pressure Method) of Freshly Mixed Roller-Compacted Concrete[1]

This standard is issued under the fixed designation C1849/C1849M; 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 determination of density and air content of freshly mixed roller-compacted concrete (RCC) using the apparatus described in Test Method C231/C231M and the vibrating hammer described in Test Method C1435/C1435M.

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—Sieve size is identified by its standard designation in Specification E11. The alternative designation given in parentheses is for information only and does not represent a different standard sieve size.

1.3 The text of this test method references notes and footnotes that provide explanatory information. 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 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]

1.5 *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 Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C125 Terminology Relating to Concrete and Concrete Aggregates

C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

C172/C172M Practice for Sampling Freshly Mixed Concrete

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

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C1067 Practice for Conducting a Ruggedness Evaluation or Screening Program for Test Methods for Construction Materials

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

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Terminology

3.1 *Definitions:*

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

4. Significance and Use

4.1 The test determines the air content of freshly mixed RCC exclusive of any air that may exist inside voids within aggregate particles. For this reason, it is applicable to concrete made with normal-density or high-density aggregate particles

[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.

[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.

and requires determination of the aggregate correction factor described in Test Method C231/C231M.

4.2 If the concrete being tested contains aggregate that would be retained on a 50-mm (2-in.) sieve, the air content of the total mixture is only approximated by the test.

4.3 The test determines the density of freshly mixed RCC containing aggregate with a maximum size not greater than 50-mm (2-in.).

4.4 The air content of hardened RCC may be either higher or lower than that determined by this test method. This depends upon the methods and amount of consolidation effort applied to the RCC from which the hardened concrete specimen is taken; uniformity and stability of the air bubbles in the fresh RCC; accuracy of the microscopic examination, if used; stage in the delivery at which the air content of the unhardened RCC is determined; and other factors.

5. Apparatus

5.1 *Air Meter*—Type B air meter and auxiliary equipment conforming to Test Method C231/C231M.

5.2 *Vibrating Hammer*—A vibrating compaction hammer conforming to Practice C1435/C1435M.

5.3 *Tamping Plate*—A circular steel plate attached to a steel shaft, which is inserted into the vibrating hammer chuck. The plate diameter shall be 6 to 13 mm [¼ to ½ in.] less than the inside diameter of the measuring bowl. The mass of the plate and shaft assembly shall be 8 to 12 kg [18 to 26 lb] (see Fig. 1).

5.4 *Mallet*—A mallet conforming to Test Method C231/C231M.

5.5 *Strike-Off Plate*—A strike-off plate conforming to Test Method C231/C231M.

5.6 *Sieve*—37.5-mm (1½-in.) with at least 0.2 m^2 [2 ft^2] of sieving area.

5.7 *Scoop*—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 measuring bowl.

5.8 *Stopwatch*—A stopwatch capable of measuring elapsed time to the nearest second.

5.9 *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 measure empty to the mass of the measure plus its contents at 2600 kg/m^3 [160 lb/ft^3].

5.10 *Syringe*—A syringe capable of injecting water into one petcock on the cover assembly.

6. Standardization of Apparatus

6.1 Standardize the apparatus and maintain standardization records in accordance with the procedure prescribed in Annex A1 of Test Method C231/C231M for a Type B meter.

7. Determination of Aggregate Correction Factor

7.1 Determine the aggregate correction factor on a combined sample of fine and coarse aggregate as directed in Test Method C231/C231M.

NOTE 2—The aggregate correction factor will vary with different aggregates. It can be determined only by test. The test can be made easily. Ordinarily the factor will remain reasonably constant for given aggregates, but an occasional check test is recommended.

8. Preparation of Concrete Test Sample

8.1 Obtain the sample of freshly mixed concrete in accordance with applicable procedures of Practice C172/C172M.

8.2 Use concrete that does not appear to have undergone segregation.

NOTE 3—Concrete with stiff to very dry consistency is highly susceptible to segregation during handling, transporting, and preparing samples for testing.

8.3 If the concrete contains coarse aggregate particles that would be retained on a 50-mm (2-in.) sieve, wet-sieve a sufficient amount of the representative sample over a 37.5-mm (1½-in.) sieve, as described in Practice C172/C172M, to yield sufficient material to completely fill the measuring bowl. Weigh and record the mass of the sample before and after wet-sieving. Make no attempt to wipe adhering mortar from coarse aggregate particles retained on the sieve.

8.4 Remix the concrete passing through the sieve with a shovel until it appears uniform and proceed with testing.

9. Procedure

9.1 *Placement*—Dampen the interior of the measuring bowl. Weigh the dampened bowl. Record the mass of the bowl and place it on a supporting surface that will not deform during the test procedure. The entire surface of the bottom of the bowl shall remain in contact with the supporting surface during the test procedure with the sides of the bowl plumb to within 5 degrees of vertical. Using the scoop described in 5.7, place the concrete in the measuring bowl in two layers of approximately equal volume. While placing the concrete in the bowl, move the scoop around the perimeter of the bowl opening to ensure an even distribution of the concrete with minimal segregation.

9.2 *Consolidation*—Place the vibrating hammer with tamping plate onto the first layer of concrete. Start the vibrating hammer and allow the concrete to consolidate under the tamping plate. Observe the concrete in the annular space between the outer edge of the tamping plate and the inside wall of the measuring bowl. As the concrete consolidates, mortar should move into the annular space between the outer edge of the tamping plate and the inside wall of the measuring bowl. Observe the mortar until it forms a ring around the total perimeter of the tamping plate. Stop the vibrating hammer when the mortar ring forms completely around the tamping plate. Return mortar that remains on the tamping plate to the measuring bowl before placing the second layer. Place the second layer and repeat the process to consolidate the second layer. Return mortar that remains on the tamping plate to the measuring bowl. If the top of the concrete is below the top of the measuring bowl after returning the mortar that remains on the tamping plate, add concrete and repeat the process to

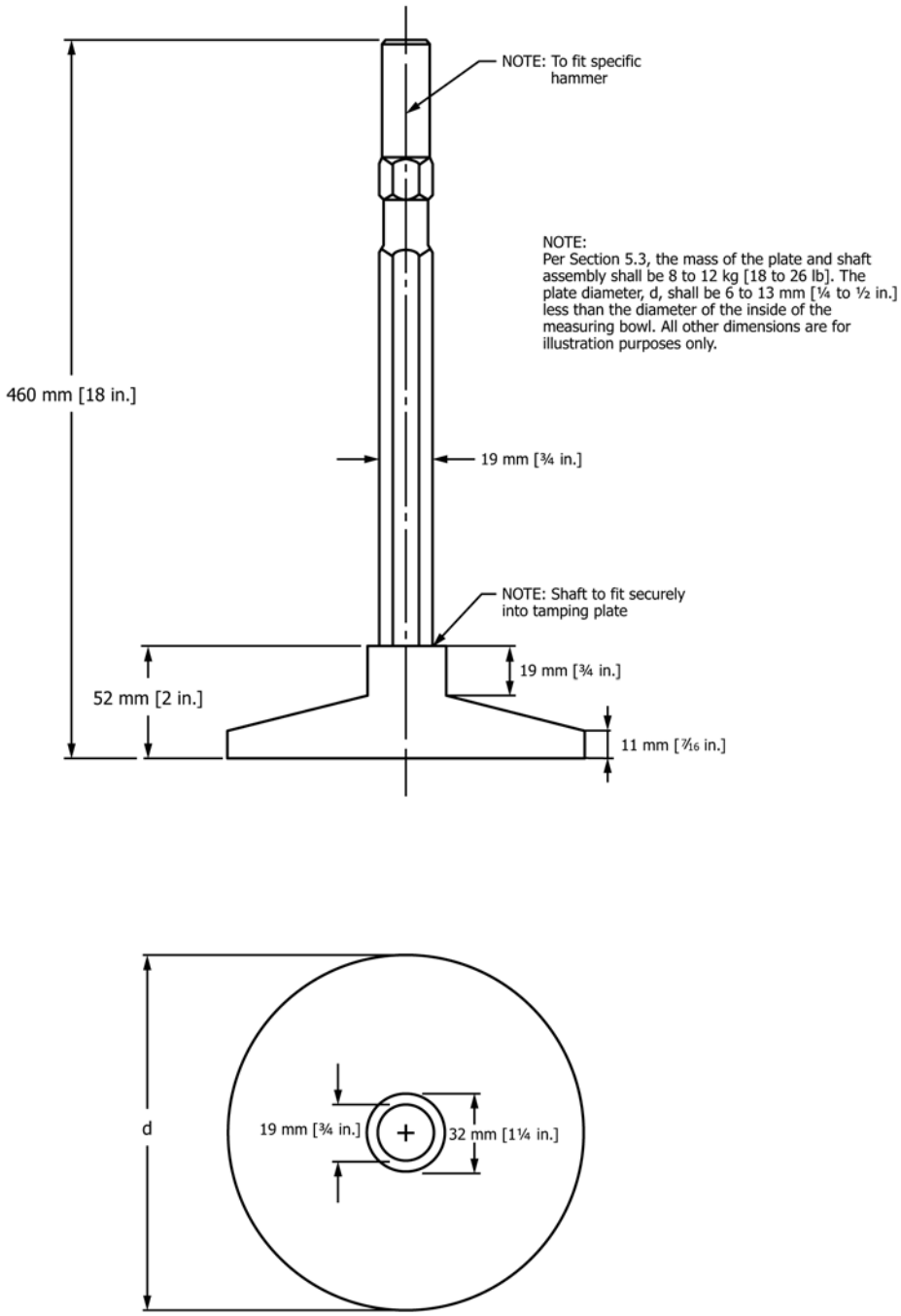

FIG. 1 Example of Tamping Plate and Shaft Assembly

consolidate the added concrete. Before strike off, return mortar that remains on the tamping plate to the measuring bowl. If a rock or rock pocket prevents the mortar ring from forming at one location, even though it has formed in all other locations, stop the vibrating hammer and add the next layer of concrete or finish the top surface as described in 9.3. If a significant portion of the mortar ring does not form after 20 s, stop the vibrating hammer and add the next layer of concrete or finish the top surface as described in 9.3.

9.3 *Strike-Off*—After consolidation, strike-off the top surface of the concrete and finish it using the strike-off plate so that the measure is level full. A small quantity of concrete may be added or removed to correct a deficiency. Strike off the measure by pressing the strike-off plate on the top surface of the measure to cover about two thirds of the surface and withdraw the plate with a sawing motion to finish only the area originally covered. Then return the plate to the top of the measure to cover the same two thirds of the surface and strike off the other one third of the surface by advancing it with a vertical pressure and a sawing motion until it slides completely off the measure. Repeat as necessary to produce a surface that is even with the rim of the bowl. Removal of 3 mm [⅛ in.]

during strike off is optimal. If the consistency of the concrete is such that a smooth surface cannot be attained with the strike-off plate, use the vibrating hammer and tamping plate to strike-off and finish the top surface of the concrete. With the hammer in operation and the tamping plate in contact with the rim of the measuring bowl, move the tamping plate back and forth across the top of the measuring bowl to force excess material beyond the rim. Continue working the surface until it is smooth and level with the top of the measuring bowl. (See Note 4.) Avoid tearing the surface of the concrete. If necessary, complete strike-off with the strike-off plate as detailed above to produce a flat finish.

NOTE 4—The use of the tamping or strike-off plate on cast aluminum or other relatively soft metal measuring bowl rims may cause rapid wear of the rim and require frequent maintenance, standardization, and ultimately, replacement.

9.4 *Preparation for Test*—Thoroughly clean the flange or rim of the measuring bowl and the cover assembly so that when the cover is clamped in place a pressure-tight seal will be obtained. Remove any concrete remaining on the outside of the measuring bowl and determine and record the mass of the measuring bowl full of compacted concrete to the nearest 0.05 kg [0.1 lb]. Assemble the apparatus. Close the main air valve between the air chamber and the measuring bowl and open both petcocks on the cover. Using the syringe, inject water through one petcock until water emerges from the opposite petcock. Jar the meter gently until air is no longer expelled from the petcocks.

9.5 *Test*—Close the air bleeder valve on the air chamber and pump air into the air chamber until the gauge hand is on the initial pressure line. Allow a few seconds for the compressed air to cool. Stabilize the gauge hand at the initial pressure line by pumping or bleeding-off air as necessary, tapping the gauge lightly by hand. Close both petcocks. Open the main air valve between the air chamber and the measuring bowl. While maintaining the main air valve in an open position, tap the sides of the measuring bowl smartly with the mallet. (See Note 5.) Observe the apparent air content on the dial of the pressure gauge for 2 minutes or longer until the reading stops changing. (See Note 6.) Tap the sides of the measuring bowl and observe the pressure gauge until the reading stops changing. Lightly tap the pressure gauge by hand to stabilize the gauge hand and record the reading. Close the main air valve. Failure to close the main air valve before releasing the pressure from either the container or the air chamber will result in water being drawn into the air chamber, thus introducing error into subsequent measurements. In the event water enters the air chamber, it must be bled from the air chamber through the air bleeder valve followed by several strokes of the pump to blow out the last traces of water. Release the pressure from the measuring bowl by opening both petcocks before removing the cover.

NOTE 5—The main air valve on most Type B meters is a spring loaded valve that is designed to close automatically when the lever is not depressed. In order to keep the main air valve open on this type of air meter, the operator must keep the lever depressed with one hand while tapping the sides of the bowl and gauge with the other hand.

NOTE 6—The apparent air content reading may continue to rise until the no-slump mixture fully reacts to the pressure. The reading may continue to rise for two minutes or longer after opening the main air valve between the air chamber and the measuring bowl.

10. Calculation

10.1 *Air Content:*

10.1.1 *Air Content of Sample Tested*—Calculate the air content of the concrete compacted in the measuring bowl as follows:

$$A_s = A_1 - G \tag{1}$$

where:

A_s = air content of the sample tested, %,
A_1 = apparent air content from gauge reading, %, and
G = aggregate correction factor, %.

10.1.2 *Approximate Air Content of Full Mixture*—If the sample tested represents that portion of the mixture that is obtained by wet sieving on the 37.5-mm (1½-in.) sieve, the absolute volume of all ingredients in the mixture, air-free, and the approximate absolute volume of the aggregate particles retained on the 37.5-mm (1½-in.) sieve must first be determined using Eq 2 and Eq 3. (See Note 7.)

$$V_t = \Sigma \frac{m_i}{r_i d} \tag{2}$$

where:

V_t = absolute volume of all ingredients in the mixture, air-free, m^3 [ft^3],
i = individual ingredients,
m_i = mass (saturated-surface-dry as applicable) of ingredient i in the total batch or mortar fraction as applicable, kg [lb],
r_i = relative density (saturated-surface-dry as applicable) of ingredient, and
d = density of water, 1000 kg/m^3 [62.4 lb/ft^3].

NOTE 7—The volume of the aggregate particles retained on the 37.5-mm (1½-in.) sieve can only be approximated because a correction for the volume of the small amount of mortar that is retained on the sieve is not being made. Thus, the air content of the full mixture can only be approximated.

$$V_a = \frac{(m_b - m_a)}{r_a d} \tag{3}$$

where:

V_a = approximate volume of aggregate particles retained on the 37.5-mm (1½-in.) sieve, m^3 [ft^3],
m_a = mass of sample after wet-sieving, kg [lb],
m_b = mass of sample before wet-sieving, kg [lb], and
r_a = relative density (saturated-surface-dry) of aggregate particles retained on the 37.5-mm (1½-in.) sieve.

The approximate air content of the full mixture is calculated as follows:

$$A_t = 100A_s(V_t - V_a) / (100\ V_t - A_s\ V_a) \tag{4}$$

where:

A_t = approximate air content of the full mixture, %.

10.1.3 *Approximate Air Content of the Mortar Fraction*—If it is desired to know the air content of the mortar fraction of the mixture, first determine the absolute volume of the ingredients in the mortar fraction of the mixture, air-free, as follows:

$$V_m = \Sigma \frac{m_i}{r_i d} \tag{5}$$

where:

V_m = absolute volume of the ingredients in the mortar fraction of the mixture, air-free, m^3 [ft^3].

Calculate the air content of the mortar fraction as follows:

$$A_m = 100A_s(V_t - V_a) / [100\ V_m + A_s\ (V_t - V_a - V_m)] \quad (6)$$

where:

A_m = approximate air content of the mortar fraction, %.

NOTE 8—If the sample is wet-sieved prior to testing, the air content of the mortar fraction can only be approximated (see Note 7).

NOTE 9—The absolute volume of the mortar fraction can be obtained from data on the concrete mixture tabulated as follows for a batch of any size:

	Absolute Volume, m^3 [ft^3]	
Cement	_____	V_m
Water	_____	
Fine Aggregate	_____	
Coarse Aggregate	_____	V_a
Total	_____	V_t

10.2 *Density of Sample Tested*—Calculate the density of the concrete compacted in the measuring bowl as follows:

$$D_s = (M_s - M)/V \quad (7)$$

where:

D_s = density of the sample tested, kg/m^3 [lb/ft^3],
M_s = mass of measuring bowl full of compacted concrete, kg [lb],
M = mass of measuring bowl, kg [lb], and
V = volume of measuring bowl, m^3 [ft^3].

NOTE 10—If the sample tested represents that portion of the mixture that is obtained by wet sieving to remove aggregate particles retained on the 37.5-mm (1½-in.) sieve, the density of concrete compacted in the measuring bowl will not represent the density of the full mixture.

11. Report

11.1 Report the following information:

11.1.1 The aggregate correction factor.

11.1.2 The air content of the sample tested to the nearest 0.1 % after subtracting the aggregate correction factor, unless the gauge reading of the meter exceeds 8 %, in which case the corrected reading shall be reported to the nearest ½ scale division on the dial.

11.1.3 The approximate air content of the full mixture to the nearest 0.1 % if wet sieving was required.

11.1.4 The density of the sample tested to the nearest 1 kg/m^3 [0.1 lb/ft^3].

11.1.5 If requested, and if the absolute volume of the ingredients in the mortar fraction of the mixture can be determined, the approximate air content of the mortar fraction of the mixture to the nearest ¼ %.

11.1.6 The date and time of the test.

12. Precision and Bias

12.1 *Precision*—A ruggedness evaluation was executed in accordance with Practice C1067-12 to determine the sensitivity of the test method to changes in levels of pertinent operating factors.[4] A report of results and calculations has been forwarded to the Interlaboratory Study Program at ASTM Headquarters.

12.1.1 *Single-Operator Precision:*

12.1.1.1 *Air Content*—The single-operator standard deviation has been found to be 0.2 % air by volume of concrete for mixtures with Vebe consistencies, determined in accordance with Test Method C1170/C1170M, below 20 s, 0.4 % air by volume of concrete for mixtures with Vebe consistencies over the range from 20 s to 30 s, and 1.1 % air by volume of concrete for mixtures with Vebe consistencies above 30 s.

12.1.1.2 *Density*—The single-operator standard deviation has been found to be 9.6 kg/m^3 [0.6 lb/ft^3] for mixtures with Vebe consistencies below 20 s, 8.0 kg/m^3 [0.5 lb/ft^3] for mixtures with Vebe consistencies over the range from 20 s to 30 s, and 14.4 kg/m^3 [0.9 lb/ft^3] for mixtures with Vebe consistencies above 30 s.

12.2 *Bias*—The test method has no bias because the values determined can be defined only in terms of the test method.

13. Keywords

13.1 air content; calibration; correction factor; density; measuring bowl; meter; pressure; RCC; roller-compacted concrete; unit weight

[4] The data used to develop the temporary precision statement were obtained using the inch-pound version of this test method. The precision indices shown in SI units are exact conversions of the values in brackets.