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American Association State
Highway and Transportation Officials Standard
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Standard Test Method for Air Content of Hydraulic Cement Mortar[1]

This standard is issued under the fixed designation C 185; 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 Department of Defense.

1. Scope

1.1 This test method covers the determination of the air content of hydraulic cement mortar under the conditions hereinafter specified.

1.2 The values stated in SI units are to be regarded as the standard.

1.3 Values in SI shall be obtained by measurement in SI units or by appropriate conversion, using the Rules for Conversion and Rounding in IEEE/ASTM SI 10, of measurements made in other units.

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.*

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[1] This test method is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.21 on Air Entrainment.
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1.5 **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:*

C 91 Specification for Masonry Cement[3]

C 109/C 109M Test Method for Compressive Strength of Hydraulic-Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)[3]

C 150 Specification for Portland Cement[3]

C 183 Practice for Sampling and the Amount of Testing of Hydraulic Cement[3]

C 230/C 230M Specification for Flow Table for Use in Tests of Hydraulic Cement[3]

C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency[3]

C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes[3]

C 595 Specification for Blended Hydraulic Cements[3]

C 778 Specification for Standard Sand[3]

C 1005 Specification for Weights and Weighing Devices for Use in the Physical Testing of Hydraulic Cements[3]

C 1157 Performance Specification for Hydraulic Cement[3]

C 1328 Specification for Plastic Stucco Cement[3]

C 1328 Specification for Mortar Cement[3]

E 438 Specification for Glasses in Laboratory Apparatus[4]

E 694 Specification for Laboratory Glass Volumetric Apparatus[4]

IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System[4]

3. Summary of Test Method

3.1 Prepare a mortar with standard sand and the cement to be tested, using a water content sufficient to give a required flow. Compact the mortar into a measure of known volume and determine mass. Calculate the air content from the measured density of the mortar, the known densities of the constituents, and the mixture proportions.

4. Significance and Use

4.1 The purpose of this test method is to determine whether or not the hydraulic cement under test meets the air-entraining or non-air-entraining requirements of the applicable hydraulic cement specification for which the test is being made. The air content of concrete is influenced by many factors other than the potential of the cement for air entrainment.

5. Apparatus

5.1 *Flow Table, Flow Mold, and Caliper*, shall conform to Specification C 230/C 230M.

5.2 *Measure*—A cylindrical measure having an inside diameter of 76 ± 2 mm and a depth (approximately 88 mm) adjusted by standardization with water to contain 400 ± 1 mL at 23.0 ± 2.0°C (Note 1). For the purposes of this test, the capacity of the measure in millilitres is the mass of the water content of the measure, in grams, divided by 0.9976, no correction in mass being made for the buoyant effect of air. The measure shall have a uniform wall thickness. The thickness of the wall and bottom shall not be less than 2.9 mm. The total mass of the empty measure shall not be more than 900 g. The measure shall be made of a metal not attacked by the cement mortar.

NOTE 1—Calibrate the 400-mL measure by filling with distilled water at 23.0± 2.0°C to a point where the meniscus extends appreciably above the top of the measure, placing a clean piece of plate glass on the top of the measure, and allowing the excess water to be squeezed out. The absence of air bubbles as seen through the glass ensures that the measure is completely full. Care shall be taken that the excess water is wiped from the sides of the container before weighing.

5.3 *Mixer, Bowl, and Paddle*, shall conform to the apparatus section of Practice C 305.

5.4 *Straightedge*—A steel straightedge not less than 200 mm long and not less than 1.5 mm nor more than 3.5 mm in thickness.

5.5 *Weights and Weighing Devices*, shall conform to Specification C 1005. Evaluate the weighing device for precision and accuracy at a total load of 2 kg.

5.6 *Glass Graduates*—Glass graduates of 250-mL capacity, conforming to the requirements of Specifications E 438 and E 694.

5.7 *Tamper*, conforming to the requirements of Test Method C 109/C 109M. The tamping face of the tamper shall be flat and at right angles to the length of the tamper.

5.8 *Tapping Stick*, a piece of hard wood having a diameter of approximately 16 mm and a length of approximately 152 mm.

[2] Refer to the section on Safety Precautions, "Manual of Cement Testing," *Annual Book of ASTM Standards*, Vol 04.01.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

5.9 *Spoon*—A metal restaurant-type serving spoon not less than 230 mm in length and with a bowl approximately 100 mm in length.

6. Temperature and Humidity

6.1 Maintain the temperature of the room and dry materials at 23.0 ± 4.0 °C.

6.2 Condition the mixing water and the measure, if it is being calibrated at 23 ± 2°C.

6.3 Maintain the relative humidity of the laboratory at not less than 50 %.

7. Standard Sand

7.1 Use sand conforming to the requirements of Specification C 778 for 20–30 sand.

8. Sampling

8.1 Sample the cement in accordance with Practice C 183.

9. Procedure

9.1 *Batch*—Proportion the standard mortar using 350 g cement to 1400 g 20–30 standard sand and sufficient water to give a flow of 87½ ± 7½ % when determined in accordance with 9.3.

NOTE ~~2—Masonry~~ 2—Test Method C 185 refers to hydraulic cements that comply under Specification C 150, Specification C 595, and Performance Specification C 1157. Masonry cements (see Specification C 91), mortar cements (see Specification C 1329), and plastic cements (see Specification C 1328) require different sand, ~~sample~~ mass, and flow. Refer to ~~Specification C 91.~~ the applicable specification.

9.2 *Mixing of Mortar*—Mix the mortar in accordance with Practice C 305.

9.3 *Flow Determination*—Carefully wipe dry the flow-table top and place the flow mold at the center of it. Using the spoon, place a layer of mortar about 25 mm in thickness in the mold and tamp 20 times with the tamper. The tamping pressure shall be just sufficient to ensure uniform filling of the mold. Overfill the top of the mold approximately 20 mm with mortar and tamp as specified for the first layer. Then cut off the mortar to a plane surface, flush with the top of the mold, by drawing the straightedge with a sawing motion across the top of the mold. Wipe the flow table top clean and dry, being especially careful to remove any water from around the edge of the mold. Lift the mold away from the mortar 1 min after completing the mixing operation. Immediately drop the table 10 times in accordance with Specification C 230/C 230M. The flow is the resulting increase in average diameter of the mortar mass, as determined with the calipers, measured on at least four diameters at approximately equispaced intervals, expressed as a percentage of the original diameter. Make trial mortars with varying percentages of water until the specified flow is obtained. Make each trial with fresh mortar.

9.4 *Mass per 400 mL of Mortar*—When the quantity of mixing water has been found that produces a flow of 87½ ± 7½ %, immediately determine the mass per 400 mL of mortar, using the mortar remaining in the mixing bowl after the flow has been determined. In the determination of the mass per 400 mL, do not use the portion of the mortar used in the flow determination. Using the spoon, place the mortar gently into the 400–ml measure in three equal layers. Tamp each layer 20 times around the inner surface of the measure. For the final layer of mortar, overfill the 400–ml measure approximately 20 mm. The position of the tamper shall be that: the broad side of the tamper is parallel to the radius and is perpendicular to the inner surface of the measure. Each layer is tamped in one complete revolution (rotation) with only sufficient pressure to adequately fill the measure and eliminate voids within the mortar. After the measure has been filled and tamped in the above prescribed manner, tap the sides of the measure lightly with the side of the tapping stick, one each at five different points at approximately equal spacing around the outside of the measure, in order to preclude entrapment of extraneous air (Note 3). No obvious space shall be left between the mortar and the inner surface of the measure as a result of the tamping operation. Then cut the mortar off to a plane surface, flush with the top of the measure, by drawing the straightedge with a sawing motion across the top of the measure, making two passes over the entire surface, the second pass being made at right angles to the first. If, in the striking-off operation, loose sand grains cause the straightedge to ride above the top surface of the measure, these grains shall be removed, and the operation repeated. Complete the entire operation of filling and striking off the measure within 1½ min. Wipe off all mortar and water adhering to the outside of the measure. Determine the mass of the measure and its contents. Subtract the mass of the container, and record the mass of the mortar in grams.

NOTE 3—This operation may be facilitated by placing the measure on a steady flat-surfaced support of lesser diameter than the measure while filling and wiping.

10. Calculation

10.1 Calculate the air content of the mortar from the following formula which is based on the batch proportions given in 9.1, taking the specific gravity of portland cement as 3.15 and of 20–30 standard sand as 2.65. When the hydraulic cement is other than portland, the appropriate value for its specific gravity shall be substituted for the value of 3.15 and the formula rederived accordingly:

$$\text{Air content, volume \%} = 100 - W[(182.7 + P)/(2000 + 4P)] \quad (1)$$

where:
W = mass of 400 mL of mortar, g, and
P = percentage of mixing water, based on mass of cement used.

NOTE 4—This formula is derived as follows:

$$\text{Air content, volume \%} = 100[1 - (W_a / W_c)] \quad (2)$$

where:
W_a = actual mass per unit of volume as determined by this test method.
= W/400 g/mL, where W is the mass in grams of the specified 400 mL of mortar (9.4),
W_c = theoretical mass per unit of volume, calculated on an air-free basis as follows and using the values for quantities of materials and specific gravities as given in 9.1 and 10.1,

$$= \frac{350 + 1400 + 350 \times P \times 0.01}{\frac{350}{3.15} + \frac{1400}{2.65} + \frac{350 \times P \times 0.01}{1}}$$

$$= \frac{(5 + 0.01P)}{(1.827 + 0.01P)}, \text{ and}$$

P = percentage of mixing water, based on mass of cement.

Substituting for W_a and W_c we have:

$$\text{Air content, volume \%} = 100\left(1 - \frac{W}{400} \times \frac{1.827 + 0.01P}{5 + 0.01P}\right)$$

$$\text{Air content, volume \%} = 100 - \frac{W}{4} \times \frac{(1.827 + 0.01P)}{(5 + 0.01P)}$$

$$\text{Air content, volume \%} = 100 - 2.5W\frac{(182.7 + P)}{(5000 + 10P)}$$

$$\text{Air content, volume \%} = 100 - W\frac{(182.7 + P)}{(2000 + 4P)}$$

10.2 Make only one determination of air content on a batch.

NOTE 5—Difficulty has occasionally been experienced with this test method by some persons. These difficulties usually have taken the form of values for air content that are abnormally high and that may be greater than the specified maxima in specifications for hydraulic cement. The air-entraining potential of the sand may be reduced by washing in the laboratory with potable water by decantation until a clear, colorless supernatant liquid is obtained. In case of dispute, such freshly washed sand shall be used.

11. Report

11.1 When this test method is used for specific action in compliance testing, report the value for the air content to the nearest 1 %.

12. Precision and Bias

12.1 The single-operator, within-laboratory, standard deviation has been found to be 0.56 % air content throughout the range of 8 to 19 % air. Therefore, results of two properly conducted tests by the same operator on similar batches should not differ by more than 1.6 % air.

12.2 The multilaboratory standard deviation has been found to be 1.0 % air content throughout the range from 8 to 19 % air. Therefore, results of two different laboratories on similar batches should not differ from each other by more than 2.8 % air.

13. Keywords

13.1 air content; hydraulic cement mortar

For additional useful information on details of cement tests methods, references may be made to the "Manual of Cement Testing," which appears in the *Annual Book of ASTM Standards*, **Vol 04.01.**