Designation: C 452 – 95

Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate[1]

This standard is issued under the fixed designation C 452; 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, which is applicable only to portland cements, covers the determination of the expansion of mortar bars made from a mixture of portland cement and gypsum in such proportions that the mixture has a sulfur trioxide (SO_3) content of 7.0 mass %.

1.2 The values stated in SI (Practice E 380) units are to be regarded as 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

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

C 150 Specification for Portland Cement[2]

C 230 Specification for Flow Table for Use in Tests of Hydraulic Cement[2]

C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency[2]

C 471 Test Methods for Chemical Analysis of Gypsum and Gypsum Products[2]

C 490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete[2]

C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes[2]

C 778 Specification for Standard Sand[2]

C 1005 Specification for Weights and Weighing Devices for Use in the Physical Testing of Hydraulic Cements[2]

D 1193 Specification for Reagent Water[3]

E 380 Practice for Use of the International System of Units (SI) (The Modernized Metric System)[4]

3. Significance and Use

3.1 This test method is used primarily by those interested in research on methods for determining the potential sulfate resistance of portland cement. This test method is also used to establish that a sulfate-resisting portland cement meets the performance requirements of Specification C 150.

4. Apparatus

4.1 *Weights and Weighing Devices*, conforming to the requirements of Specification C 1005.

4.2 *Flow Table*, conforming to the requirements of Specification C 230.

4.3 *Mixer, Bowl, and Paddle*, conforming to the requirements of Practice C 305.

4.4 *Trowel and Tamper*, conforming to the requirements of Test Method C 109.

4.5 *Glass Graduates, Molds, and Length Comparator*, conforming to the requirements of Practice C 490.

5. Temperature and Humidity

5.1 *Molding Room, Dry Materials, and Mixing Water*—The temperature of the molding room, dry materials, and mixing water shall be maintained between 20 and 27.5°C (68 and 81.5°F) and the relative humidity of the molding room shall not be less than 50 %.

5.2 *Moist Cabinet or Room*, conforming to the requirements of Specification C 511.

6. Materials

6.1 The sand used for making the test mortar shall conform to Specification C 778.

6.2 The gypsum[5] used for addition to the portland cement shall be high grade natural gypsum with 100 % passing the 150-µm (No. 100) sieve, at least 94 % passing the 75-µm (No. 200) sieve, and at least 90 % passing the 45-µm (No. 325) sieve. Calculate the percentage of cement and gypsum required to provide a mixture containing 7.0 mass % SO_3 as follows:

$$\text{Cement, \%} = [(g - 7.0)/(g - c)] \times 100 \quad (1)$$

[1] This test method is under the jurisdiction of ASTM Committee C-1 on Cement and is the direct responsibility of Subcommittee C01.29 on Sulfate Resistance.

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

[3] *Annual Book of ASTM Standards*, Vol 11.01.

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

[5] Terra Alba No. 1, available from the U.S. Gypsum Co., Southard, OK plant, meets these requirements.

$$\text{Gypsum, \%} = [(7.0 - c)/(g - c)] \times 100 \quad (2)$$

where:

c = SO_3 content of the portland cement, %,
g = SO_3 content of the gypsum, %, and
7.0 = SO_3 content of the cement-gypsum mixture, %.

6.3 If the SO_3 content of the gypsum is unknown, the gypsum shall be analyzed for SO_3 content using Test Methods C 471. The SO_3 content shall be determined to the nearest 0.1 %.

6.4 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Type IV of Specification D 1193.

7. Number and Dimensions of Test Specimens

7.1 Six 25 by 25 by 285-mm (or 1 by 1 by 11¼-in.) test specimens, three from each of two batches, shall be made for each cement.

7.2 In routine tests, 25 by 25 by 160-mm (or 1 by 1 by 6¼-in.) specimens may be used, but in case of dispute, results obtained with 25 by 25 by 285-mm (or 1 by 1 by 11¼-in.) specimens shall govern.

8. Preparing Specimen Molds

8.1 The molds shall be prepared in accordance with Specification C 490.

9. Proportioning, Consistency, and Mixing of Mortar

9.1 The quantities of dry materials required for each batch shall be 400 g (cement plus gypsum) and 1100 g of sand. The amount of mixing water shall be 194 mL for all non-air-entraining portland cements and 184 mL for all air-entraining portland cements.

9.2 Mix the mortar according to the procedure for mixing mortars of Practice C 305, except after placing the mixing water in the bowl, add the gypsum and mix at the slow speed for 15 s, then stop the mixer, add the cement, and continue as prescribed in Practice C 305.

10. Procedure

10.1 *Molding Test Specimens:*

10.1.1 Immediately upon completion of the flow test, return the mortar to the bowl, scrape down into the batch any mortar on the side of the bowl, and remix at the medium speed (285 ± 10 r/min) for 15 s. Remove the paddle and the bowl from the mixer and shake the excess mortar from the paddle into the bowl. Fill the mold in two layers, each layer being compacted with the tamper. Work the mortar into the corners, around the gage studs, and along the surfaces of the mold with the tamper until a homogeneous specimen is obtained. After the top layer has been compacted, cut the mortar off flush with the top of the mold and smooth the surface with a few strokes of the trowel.

10.2 *Storage of Test Specimens:*

10.2.1 *Initial Storage*—Cure the specimens in the molds in the moist closet at 23 ± 1.7°C (73.4 ± 3°F) for 22 to 23 h. Then remove them from the molds, properly identify, and place in water at 23 ± 1.7°C (73.4 ± 3°F) for at least 30 min prior to making the initial length measurement.

10.2.2 *Subsequent Storage*—After the bars have been removed from the molds and measured, store them horizontally in water at 23 ± 1.7°C (73.4 ± 3°F). Store the specimens with at least 6-mm (¼-in.) clearance on all sides except for the necessary supports. Cover the specimens with at least 13 mm (½ in.) of water. The ratio of the volume of water to a volume of the bars shall not exceed 5 to 1 to prevent excessive leaching. Replenish the water with fresh water every 7 days for the first 28 days and every 28 days thereafter.

11. Length Measurement

11.1 Measure the specimens for length by means of the length comparator. Remove them from the water storage, one at a time, and wipe with a damp cloth before measuring.

11.2 Make the first reading at the age of 24 h ± 15 min from the time the cement and water are mixed together. Measure the specimen again at the age of 14 days.

NOTE 1—Additional information of value may be obtained by returning the specimen to water storage after the 14-day test and making additional measurements at later ages.

12. Calculation

12.1 Calculate the difference in length of the specimen at 24 h and at 14 days to the nearest 0.001 % of the effective gage length and report as the expansion of the specimen at that period. All specimens remaining after 14 days must comprise a set having at least three specimens with a permissible range depending on the number of the remaining specimens, as follows:

No. of Specimens	Maximum Permissible Range, %
3	0.010
4	0.011
5	0.012
6	0.012

13. Report

13.1 Report the average of the specimens comprising the set to the nearest 0.001 %.

14. Precision and Bias

14.1 *Precision*:

14.1.1 The single-operator standard deviation has been found to be: 0.003 % for expansions between 0.01 and 0.04 %. Therefore, results of two properly conducted tests by the same operator on the same material should not differ from each other by more than 0.009 %.

14.1.2 The multilaboratory standard deviation has been found to be 0.005 % for expansions between 0.01 and 0.04 %. Therefore, results of two properly conducted tests on the same material in two different laboratories should not differ from each other by more than 0.014 %.

14.1.3 The precision of this test method has been evaluated by cooperative testing.[6]

14.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for this test method, no statement on bias is being made.

[6] A research report is available from ASTM Headquarters. Request RR: 001–1004.

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