



## Standard Test Method for Restrained Expansion of Expansive Cement Mortar<sup>1</sup>

This standard is issued under the fixed designation C 806; 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 length changes of expansive cement mortar, while under restraint, due to the development of internal forces resulting from hydration of the cement.

1.2 The values stated in non-SI 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:

- A 307 Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength<sup>2</sup>
- C 157 Test Method for Length Change of Hardened-Hydraulic-Cement Mortar and Concrete<sup>3</sup>
- C 219 Terminology Relating to Hydraulic Cement<sup>4</sup>
- C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency<sup>4</sup>
- C 490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete<sup>4</sup>
- C 778 Specification for Standard Sand<sup>4</sup>
- C 1005 Specification for Weights and Weighing Devices for Use in the Physical Testing of Hydraulic Cements<sup>4</sup>
- E 11 Specification for Wire-Cloth Sieves for Testing Purposes<sup>5</sup>
- F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets<sup>2</sup>

### 3. Terminology

3.1 Definitions of terms used in this test method are given in Terminology C 219.

### 4. Apparatus

4.1 *Molds*—The molds for casting test specimens, when used in conjunction with the restraining cage described in 4.2, shall provide for forming either 2 by 2 by 10-in. prisms having a 10-in. gage length, or 50 by 50 by 250-mm prisms having a 250-mm gage length. The molds shall otherwise conform to the requirements of Practice C 490, except that the gage stud holder, gage studs, and spacer screws described in that specification will not be used.

4.2 *Restraining Cage*, consisting of a threaded steel rod with steel end plates held in place by nuts as shown in Fig. 1. The rod shall be provided with cap nuts for prevention of corrosion. The rod shall conform to Specification A 307 Grade A except, it shall support 1180-lbf (5249 N) proof load when tested in accordance with Method 1 of Test Methods F 606.

4.3 *Length Comparator*—The length comparator for measuring length shall conform to and be used in accordance with the requirements of Practice C 490. If the terminals of the comparator are fitted with collars, they shall be such that the cap nuts on the ends of the threaded rod of the specimen do not rest on the collar during measuring.

4.4 *Tamper*—The tamper shall be made of nonabsorptive, nonabrasive material such as medium-hard rubber or seasoned oak wood, rendered nonabsorptive by immersion for 15 min in paraffin at approximately 392°F (200°C), and shall have a cross section of ½ by 1 in. (13 by 25 mm) and convenient length of about 6 in. (150 mm). The tamping face of the tamper shall be flat and at right angles to the length of the tamper.

4.5 *Apparatus for Demolding Specimens*—Apparatus similar to that described in the Apparatus section of Test Method C 157, may be found useful for demolding specimens.

4.6 *Weights and Weighing Devices*—Scales used shall comply with Specification C 1005.

NOTE 1—Generally defined, the sensibility reciprocal is the change in load required to change the position of rest of the indicating element or elements of a nonautomatic-indicating scale a definite amount at any load.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee C-1 on Cement and is the direct responsibility of Subcommittee C01.13 on Special Cements.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 15.08.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 04.02.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 04.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 14.02.

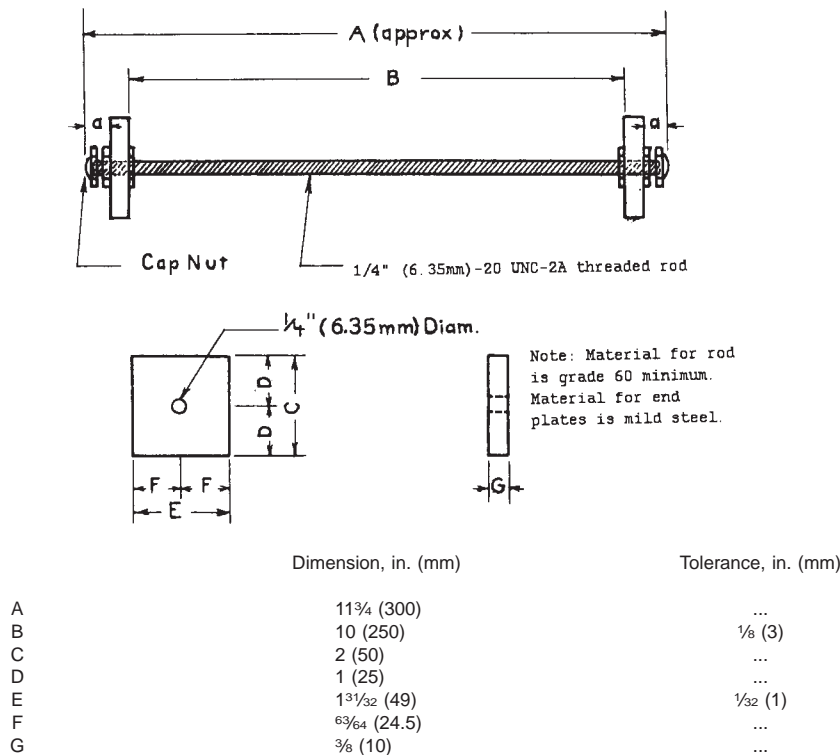


FIG. 1 Restraining Cage

4.7 *Glass Graduates*, of suitable capacities (preferably large enough to measure the mixing water in a single operation) shall be made to deliver the indicated volume at 68°F (20°C). The permissible variation shall be  $\pm 2$  mL. These graduates shall be subdivided to at least 5 mL, except that the graduation lines may be omitted for the lowest 10 mL for a 250-mL graduate and the lowest 25 mL for a 500-mL graduate. The main graduation lines shall be circles and shall be numbered. The least graduations shall extend at least one seventh of the way around, and intermediate graduations shall extend at least one fifth of the way around.

4.8 *Mixer, Bowl, and Paddle*—The mixer shall be an electrically driven mechanical mixer of the type equipped with paddle and mixing bowl, as specified in the Apparatus section of Practice C 305.

4.9 *Trowel*—The trowel shall have a steel blade 4 to 6 in. (102 to 152 mm) in length, with straight edges.

## 5. Temperature and Humidity

5.1 The temperature of the air in the vicinity of the mixing operation, the dry materials, mixing water, molds, base plates, mixing bowl, moist closet or moist room, and storage water shall not vary from 73.4°F (23°C) by more than  $\pm 3^\circ\text{F}$  ( $\pm 1.7^\circ\text{C}$ ).

5.2 The relative humidity of the laboratory shall be not less than 50 %. The moist closet or moist room shall provide a relative humidity of not less than 95 %.

## 6. Graded Standard Sand

6.1 Sand used shall comply with the graded sand requirement of Specification C 778.

Passing Sieve	Percentage Retained
No. 100 (150- $\mu\text{m}$ )	98 $\pm$ 2
No. 50 (300- $\mu\text{m}$ )	72 $\pm$ 5
No. 30 (600- $\mu\text{m}$ )	2 $\pm$ 2
No. 16 (1.18-mm)	none

NOTE 2—*Segregation of Graded Sand*—The graded standard sand should be handled in such a manner as to prevent segregation, since variations in the grading of the sand cause variations in the consistency of the mortar. In emptying sacks of sand into bins or in scooping sand out of bins or sacks, care should be exercised to prevent the formation of mounds of sand or craters in the sand, down the slopes of which the coarser particles will roll. Bins should be of sufficient size to permit these precautions. Devices for drawing the sand from bins by gravity should not be used.

## 7. Test Specimen

7.1 The test specimen shall be a 2 by 2 by 10-in. prism having a 10-in. gage length, or a 50 by 50 by 250-mm prism having a 250-mm gage length. At least two specimens shall be prepared for each test.

## 8. Preparation and Assembly of Specimen Molds and Restraining Cage

8.1 Install the cap nuts firmly in place on the ends of the restraining rods and measure the restraining rods for length while they are at a temperature of  $73.4 \pm 1^\circ\text{F}$  ( $23.0 \pm 0.5^\circ\text{C}$ ).

8.2 The edges of the end plates of the restraining cage that contact the sides and bottom of the mold shall be thinly covered with a heavy mineral oil or light cup grease such as petrolatum. After assembly of the molds, place a restraining cage in each compartment. Seal the contact lines between the outer sides and base plate of the molds with paraffin or micro-crystalline wax. Thinly cover the interior faces of the molds with mineral oil and remove any oil or grease from the restraining cage rod and end plates.

## 9. Proportioning and Mixing of Mortars

9.1 Proportion the standard mortar by using one part of cement to 2.75 parts of graded standard sand by mass. Mix 800 g of cement, 2200 g of graded standard sand, and 400 mL of water to produce a batch sufficient for two test specimens.

9.2 Mix in accordance with the procedure for mixing mortars given in Practice C 305. Upon completion of mixing, shake the mixing paddle into the mixing bowl to remove excess mortar.

## 10. Molding Specimens

10.1 Start molding specimens immediately after completion of mixing. Place the mortar in the mold in two layers with the first layer just covering the restraining rod and the second layer slightly overfilling the mold. Compact each layer by tamping. Work the mortar into the corners, around the restraining rod, without striking the rod, and along the surfaces of the mold with the tamper until a homogeneous specimen is obtained. After the top layer has been compacted, strike-off the mortar flush with the top of the mold, and smooth the surface with a few strokes of the trowel.

## 11. Curing of Specimens

11.1 Immediately after completion of molding, cover the specimens with a polyethylene sheet, or other suitable material for preventing loss or gain of moisture, at the surface of the specimens. The cover should make contact with the surface of the mortar. Place the specimens in the moist room or moist cabinet.

11.2 Remove the specimens from the molds at an age of  $6 \pm \frac{1}{4}$  h after the addition of water to the cement during the mixing operation (Note 3). Particular care must be exercised in this operation in order not to damage the specimens because of their low strength at this age. It is preferable to use the demolding devices referred to in 4.5 for freeing specimens from the base and side plates.

NOTE 3—At this time comparator readings may be made. Although these readings may differ slightly from the initial reading made on the restraining rod prior to molding the specimen, it can serve as a check on the initial reading which should be used as the basis for calculating the length change.

11.3 Cure the specimens in lime-saturated water at  $73.4 \pm 3.0^\circ\text{F}$  ( $23.0 \pm 1.7^\circ\text{C}$ ) until they have reached an age of 7 days

$\pm 1$  h, including the period in the molds, except that the temperature of the curing water shall be  $73.4 \pm 1^\circ\text{F}$  ( $23.0 \pm 0.5^\circ\text{C}$ ) for at least the last 15 min. At the end of this period, remove the specimens from the water one at a time, wipe with a damp cloth, and immediately make comparator readings with the cap nuts in place.

11.4 Return the specimens to curing in lime-saturated water at  $73.4 \pm 3.0^\circ\text{F}$  ( $23.0 \pm 1.7^\circ\text{C}$ ) until they have reached an age of 28 days including the period in the molds. At the end of the curing period, make comparator readings immediately after the specimens have been subjected to about 15 min of storage in water at  $73.4 \pm 1.0^\circ\text{F}$  ( $23.0 \pm 0.5^\circ\text{C}$ ) and in the same manner as described in 11.3.

## 12. Calculation

12.1 Calculate the expansion or shrinkage at any age as follows:

$$E_x = \frac{L_x - L_i}{10(250)} \times 100 \quad (1)$$

where:

$E_x$  = expansion at  $x$  age, %,

$L_x$  = comparator reading of specimen at  $x$  age – reference bar comparator reading, in. (mm), and

$L_i$  = initial comparator reading of restraining rod – reference bar comparator reading, in. (mm).

## 13. Report

13.1 Report the following information:

13.1.1 Number of specimens for each condition and date molded,

13.1.2 Source and identification of cement.

13.1.3 Age of specimen for each observation for length change,

13.1.4 Length-change data, expressed as linear expansion or contraction based on the length of the specimen at time of molding shall be reported as percent change dimension to the nearest 0.001 %, and

13.1.5 Any other pertinent information.

## 14. Precision and Bias <sup>6</sup>

14.1 *Precision*:

14.1.1 *Within Batch Precision*—The standard deviation of two bars made from the same batch and tested together was found to be 0.00276 %. Therefore two bars made from the same batch should not differ from each other by more than 0.008 % length change.<sup>7</sup>

14.1.2 *Single Operator Precision*—The single operator standard deviation has been found to be 0.0038 at seven and twenty eight days age, based on the average of two bars. Therefore the results of two properly conducted tests by the same operator on the same material should not differ by more than 0.011 % length change.<sup>7</sup>

<sup>6</sup> Supporting data are available from ASTM Headquarters. Request RR: C01-1001.

<sup>7</sup> These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C 670.

14.1.3 *Multilaboratory Precision*—The multilaboratory standard deviation has been found to be 0.0093 at seven and twenty eight days age, based on the average of two bars. Therefore the results of two properly conducted tests on the same material in two different laboratories should not differ by more than 0.026 % length change.<sup>7</sup>

14.2 *Bias*—A bias statement cannot be prepared due to the fact that absolute standards are not available.

## **15. Keywords**

15.1 cement mortar; expansive cement; restrained expansion

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