



Designation: C441/C441M – 11

Standard Test Method for Effectiveness of Pozzolans or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction¹

This standard is issued under the fixed designation C441/C441M; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This test method covers the determination of the effectiveness of pozzolans or slag in preventing the excessive expansion caused by reaction between aggregates and alkalis in portland cement mixtures. The evaluation is based on the expansion developed in mortar bars by a combination of portland cement and a pozzolan or slag, made with reactive aggregates (borosilicate glass), during storage under prescribed conditions of test.

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.

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.*

1.4 *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.*

¹ This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.50 on Aggregate Reactions in Concrete.

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2. Referenced Documents

2.1 ASTM Standards:²

C125 Terminology Relating to Concrete and Concrete Aggregates

C150 Specification for Portland Cement

C227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)

C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

C989 Specification for Slag Cement for Use in Concrete and Mortars

C1240 Specification for Silica Fume Used in Cementitious Mixtures

C1437 Test Method for Flow of Hydraulic Cement Mortar

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 may be used as a preliminary or screening test to evaluate the relative effectiveness of a number of different materials being considered for use to prevent excessive expansion due to alkali-silica reaction.

4.2 This test method may also be used to evaluate materials proposed for use on a particular job to prevent excessive expansion due to alkali-silica reaction, by testing in the quantity and in combination with the cement or cements to be used on the job.

² 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.

*A Summary of Changes section appears at the end of this standard

4.3 This test method does not assess the suitability of pozzolans or slag for use in concrete. These materials should comply with Specification **C618**, Specification **C989** or Specification **C1240**.

5. Apparatus

5.1 The apparatus shall be as described in Test Method **C227**.

6. Materials

6.1 *Borosilicate Glass*³—Borosilicate glass granules graded according to **Table 1** or crushed Pyrex Glass No. 7740 cullet or solid glass rod crushed and graded according to **Table 1**. After the glass cullet or rod has been crushed and separated into the various sieve sizes, wash with a water spray over the sieve to remove adhering dust and fine particles from the aggregate. Dry the portions retained on the various sieves and, unless used immediately, store each such portion individually in a clean container provided with a tight-fitting cover.

6.2 *High-Alkali Cement*—For the preparation of mortar bars for the preliminary or screening tests, use a blend of cement or cements that conform to Specification **C150** and contain between 0.95 and 1.05 % total alkalis as sodium oxide (Na₂O) calculated as % Na₂O + 0.658 × % potassium oxide (K₂O). If blending is needed, introduce the individual cements into the batch separately.

7. Proportioning and Consistency of Mortar

7.1 *Control Mixture*—The quantities of dry materials for the control mixture shall be 400 g of high-alkali cement and 900 g of glass aggregate made by recombining the portions retained on the various sieves in the prescribed grading (**Table 1**). Test specimens made from the control mixture shall have a 14-day increase in length of at least 0.250 %.

7.2 *Test Mixture Using Pozzolans*—The quantities of dry materials for the test mixture shall be 300 g of high-alkali cement, a mass of pozzolan having an absolute volume equal to the absolute volume of 100 g of portland cement (100 × density of pozzolan/3.15) and 900 g of glass aggregate made as described for the control mixture.

³ The sole source of supply of borosilicate glass granules in the specific sizes called for in this test method known to the committee at this time is VSI Products, LLC, Nampa, ID, 83651; phone: 208-468-9949; <http://www.vsiglass.com/borosilicate.php>. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

TABLE 1 Grading Requirements

Sieve Size		Mass, %
Passing	Retained on	
4.75-mm (No. 4)	2.36-mm (No. 8)	10
2.36-mm (No. 8)	1.18-mm (No. 16)	25
1.18-mm (No. 16)	600- μ m (No. 30)	25
600- μ m (No. 30)	300- μ m (No. 50)	25
300- μ m (No. 50)	150- μ m (No. 100)	15

7.3 *Test Mixture Using Slag*—The quantities of dry materials for this test mixture shall be 200 g of high-alkali cement, a mass of slag having an absolute volume of 200 g of portland cement (200 × density of slag/3.15) and 900 g of glass made in accordance with **7.1**.

7.4 A smaller quantity of the pozzolan or slag and a proportionately large quantity of cement may be used if there is evidence that it is unusually effective in reducing expansion due to the alkali-silica reaction and that the use of a smaller quantity is likely to produce a large reduction of expansion of the test mixture as compared to that of the control mixture.

7.5 *Job Mixture*—The quantities of dry materials used for the job mixture shall be in accordance with the requirements given above, except that the cement or cements to be used on the job shall be used instead of the high-alkali cement. Also, the quantity of pozzolan or slag, by mass, used with the portland cement shall be equivalent to that proposed for use on the job.

7.6 *Flow*—The amount of mixing water, measured in millilitres, shall be such as to produce a flow of between 100 and 115 as determined in accordance with Test Method **C1437**.

8. Temperature and Humidity

8.1 The temperature of the dry materials, water, molding room, and moist cabinet and the humidity of the laboratory and moist cabinet shall conform to the requirements of Test Method **C227**.

9. Test Specimen

9.1 *Preparation of Molds*—Prepare the molds as specified in Test Method **C227**.

9.2 *Mixing of Mortar*—Mix the mortar as specified in Test Method **C227**, except add the admixture or slag with the cement to the water.

9.3 *Molding Test Specimens*—Mold the specimens as specified in Test Method **C227**.

9.4 *Dimensions and Number of Test Specimens*—Make three [1 by 1 by 11¼-in.] or 25 by 25 by 285-mm test specimens having an effective gage length of [10 ± 0.1 in.] or 254 ± 2.5 mm from each batch of each mortar mixture. One set of three specimens shall represent each test mixture or each job mixture. On the same day that the test specimens are made, make one set of three specimens representing the control mixture and store in the same container with the corresponding test specimens. Make all specimens stored in a given container on the same day. If more specimens from test or job mixtures, or both, are made on a given day than can be stored in a single container with the specimens from the control mixture made on that day, make additional control mixture specimens for each additional storage container used.

10. Procedure

10.1 Store and measure the test specimens in accordance with the applicable requirements of Test Method **C227**.

11. Calculation

11.1 For tests of mixtures proportioned as prescribed, calculate the reduction of mortar expansion resulting from the use