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# Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)<sup>1</sup>

This standard is issued under the fixed designation C1567; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This test method permits detection within 16 days of the potential for deleterious alkali-silica reaction of combinations of cementitious materials and aggregate in mortar bars. The cementitious materials are composed of various proportions of hydraulic cement, pozzolans and ground granulated blast-furnace slag.

1.2 The test results are only valid for the specific combinations of pozzolan, slag, and reactive aggregates tested.

1.3 This test is not suitable for evaluating the potential for deleterious reaction of combinations of hydraulic cement and aggregate (that is, in the absence of pozzolans or ground granulated blast-furnace slag).

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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. A specific precautionary statement is given in the section on Reagents.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
- C125 Terminology Relating to Concrete and Concrete Aggregates

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.26 on Chemical Reactions.

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<sup>2</sup> 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.

- C127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
- C128 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
- C150 Specification for Portland Cement
- C151 Test Method for Autoclave Expansion of Hydraulic Cement
- C305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
- C490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
- C494/C494M Specification for Chemical Admixtures for Concrete
- C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
- C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- C989 Specification for Slag Cement for Use in Concrete and Mortars
- C1240 Specification for Silica Fume Used in Cementitious Mixtures
- C1260 Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
- C1293 Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
- C1437 Test Method for Flow of Hydraulic Cement Mortar
- D1193 Specification for Reagent Water
- E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

## 3. Terminology

### 3.1 Definitions:

3.1.1 For definitions of terms relating to concrete or aggregates, see Terminology C125.

3.2 *relative density (OD), n*—as defined in Test Methods C127 or C128, for coarse and fine aggregates, respectively.

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

## 4. Significance and Use

4.1 This test method provides a means for evaluating the ability of pozzolans and ground granulated blast-furnace slag to control deleterious internal expansion due to alkali-silica reaction when used with an aggregate intended for use in concrete. It is based on the Accelerated Test Method developed at the National Building Research Institute (NBRI) in the Republic of South Africa (1-4).<sup>3</sup>

4.2 This test method has been developed for evaluating combinations of certain cementitious materials with a single aggregate source in a mortar of standard proportions. It yields an empirical result, which is utilized to compare to criteria within some specifications to accept or reject the combination of materials being evaluated for a particular application. Currently this method has no standard procedure for testing fine and coarse aggregates proposed for use in concrete together in a single batch of mortar, nor for varying the proportions of the constituent materials of the mortar beyond the relative proportions of the individual cementitious material constituents to each other, as the significance of these practices have not been determined nor have appropriate limits been established for evaluating the results of tests conducted using these modifications.

4.3 Results obtained using this test method may overestimate the reactivity of some types of aggregates if used in service with the same pozzolans or slag and hydraulic cement of low alkali content.

4.4 Different levels of pozzolan and ground granulated blast-furnace slag may require testing to determine the amount required to reduce expansion to an acceptable level. Pozzolans and ground granulated blast-furnace slag may be tested separately or in combination.

4.5 It is recommended to test the same aggregate and hydraulic cement (without pozzolans and slag) using Test Method C1260.

4.6 This test method may underestimate the expansion of cementitious systems containing pozzolans with an alkali content > 4.0 % sodium oxide equivalent (7-9). It is recommended that such materials be tested using Test Method C1293.

## 5. Apparatus

5.1 The apparatus shall conform to Practice C490, except as follows:

5.2 *Sieves*—Square hole, woven-wire cloth sieves, shall conform to Specification E11.

5.3 *Mixer, Paddle, and Mixing Bowl*—Mixer, paddle, and mixing bowl shall conform to the requirements of Practice C305, except that the clearance between the lower end of the paddle and the bottom of the bowl shall be  $5.1 \pm 0.3$  mm.

5.4 *Tamper and Trowel*—The tamper and trowel shall conform to Test Method C109/C109M.

5.5 *Containers*—The containers shall be of such a nature that the bars can be totally immersed in either the water or 1N sodium hydroxide (NaOH) solution. The containers shall be made of material that can withstand prolonged exposure to 80 °C and must be resistant to a 1N NaOH solution (see Note 1). The containers must be so constructed that when used for storing specimens, the loss or gain of moisture is prevented by tight-fitting covers, by sealing, or both (see Note 2). The bars in the solution must be placed and supported so that the solution has access to the entire surface of each bar; therefore, ensure that the specimens do not touch the sides of the container or each other. The specimens, if stood upright in the solution, shall not be supported by the metal gage stud.

NOTE 1—The NaOH solution corrodes glass or metal containers.

NOTE 2—Some microwave-proof food storage containers made of polypropylene or high-density polyethylene have been found to be acceptable.

5.6 *Oven, or Water Bath*—A convection oven or water bath with temperature control maintaining  $80.0 \pm 2.0$  °C.

## 6. Reagents

6.1 *Sodium Hydroxide (NaOH)*—USP or technical grade may be used, provided the Na<sup>+</sup> and OH<sup>-</sup> concentrations are shown by chemical analysis to lie between 0.99N and 1.01N.

6.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Type IV of Specification D1193.

6.3 *Sodium Hydroxide Solution*—Each litre of solution shall contain 40.0 g of NaOH dissolved in 900 mL of water, and shall be diluted with additional distilled or deionized water to obtain 1.0 L of solution. The volume proportion of sodium hydroxide solution to mortar bars in a storage container shall be  $4 \pm 0.5$  volumes of solution to 1 volume of mortar bars. The volume of a mortar bar may be taken as 184 mL. Include sufficient test solution to ensure complete immersion of the mortar bars.

6.3.1 **Warning**—Before using NaOH, review: (1) the safety precautions for using NaOH; (2) first aid for burns; and (3) the emergency response to spills, as described in the manufacturer's Material Safety Data Sheet or other reliable safety literature. NaOH can cause very severe burns and injury to unprotected skin and eyes. Suitable personal protective equipment must always be used. These include full-face shields, rubber aprons, and gloves impervious to NaOH. Gloves must be checked periodically for pinholes.

## 7. Conditioning

7.1 Maintain the temperature of the molding room and dry materials at not less than 20 °C and not more than 27.5 °C. The temperature of the mixing water, and of the moist closet or moist room, shall not vary from 23 °C by more than 2 °C.

7.2 Maintain the relative humidity of the molding room at not less than 50 %. The moist closet or room shall conform to Specification C511.

7.3 Maintain the storage oven or water bath in which the specimens are stored at a temperature of  $80.0 \pm 2.0$  °C.

<sup>3</sup> The boldface numbers in parentheses refer to a list of references at the end of the text.

## 8. Sampling and Preparation of Test Specimens

8.1 *Selection of Aggregate*—Process materials proposed for use as fine aggregate in concrete as described in 8.2 with a minimum of crushing. Process materials proposed for use as coarse aggregate in concrete by crushing to produce as nearly as practical a graded product from which a sample can be obtained. Grade the sample as prescribed in Table 1. The sample shall represent the composition of the coarse aggregate as proposed for use.

8.1.1 When a given quarried material is proposed for use both as coarse and as fine aggregate, test only a selection of the fine aggregate, unless there is reason to expect that the coarse aggregate has a different composition than the fine aggregate. If such a difference is expected and if the differences might significantly affect expansion due to reaction with the alkalis in cement or from the environment of service, test the coarse aggregate in a manner similar to that employed in testing the fine aggregate.

8.2 *Preparation of Aggregate*—Grade aggregates to provide a sample meeting the requirements given in Table 1. Crush aggregates in which sufficient quantities of the sizes specified in Table 1 do not exist until the required material has been produced. In the case of aggregates containing insufficient amounts of one or more of the larger sizes listed in Table 1, and if no larger material is available for crushing, the first size in which sufficient material is available shall contain the cumulative percentage of material down to that size as determined from the grading specified in Table 1. When such procedures are required, make a special note thereof in the test report. After the aggregate has been separated into the various sieve sizes, wash each size 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.

### 8.3 Selection and Preparation of Cement:

8.3.1 *Hydraulic Cement*—Use a hydraulic cement meeting the requirements of Specification C150 (Note 3). In addition, the autoclave expansion in Test Method C151 shall be less than 0.20 %.

NOTE 3—The alkali content of the cement has been found to have negligible (3) or minor (6) effects on expansion in this test.

8.3.2 *Preparation of Cement*—Pass cement for use in this test through an 850- $\mu\text{m}$  (No. 20) sieve to remove lumps before use.

8.4 *Selection of pozzolan or ground granulated blast-furnace slag*—Use one, or a combination, of the following:

8.4.1 Fly ash or natural pozzolan meeting the requirements of Specification C618.

8.4.2 Silica fume meeting the requirements of Specification C1240.

8.4.3 Ground granulated blast furnace slag meeting the requirements of Specification C989.

### 8.5 Preparation of Test Specimens:

8.5.1 *Number of Specimens*—Make at least three test specimens for each cementitious materials-aggregate combination.

8.5.2 *Preparation of Molds*—Prepare the specimen molds in accordance with the requirements of Practice C490 except, the interior surfaces of the molds shall be covered with a release agent (see Note 4). A release agent is acceptable if it serves as a parting agent without affecting the time of setting of the cement and without leaving any residue that will inhibit the penetration of water into the specimen.

NOTE 4—TFE-fluorocarbon tape complies with the requirements for a mold release agent.

8.5.3 *Proportioning of Mortar*—Proportion the dry materials for the test mortar using 1 part of cementitious materials (hydraulic cement plus pozzolan or ground granulated blast-furnace slag) to 2.25 parts of graded aggregate by mass for aggregates with a relative density (OD) at or above 2.45. For aggregates with a relative density (OD) below 2.45, determine the aggregate proportion as follows:

$$\text{Aggregate Proportion} = 2.25 \times \frac{D}{2.65}$$

where:

$D$  = relative density (OD) of test aggregate.

8.5.3.1 For aggregates with a relative density (OD) equal to or greater than 2.45, the quantities of dry materials to be mixed at one time in the batch of mortar for making three specimens shall be 440 g of cementitious material and 990 g of aggregate made up by recombining the portions retained on the various sieves in the grading prescribed in Table 1. Use a water-cement ratio equal to 0.47 by mass (see Note 5).

8.5.3.2 For aggregates with a relative density (OD) less than 2.45, the quantities of dry materials to be mixed at one time in the batch of mortar for making three specimens shall be 440 g of cementitious material and mass of aggregate shall be 440 g multiplied by the aggregate proportion determined in 8.5.3. This aggregate mass shall be made up by recombining the portions retained on the various sieves in the grading prescribed in Table 1. Use a water-cementitious material ratio equal to 0.47 by mass (see Note 5).

NOTE 5—Ruggedness tests indicated that mortar bar expansions were less variable at a fixed water-cement ratio than when gauged to a constant flow (3).

8.5.3.3 If silica fume or metakaolin are used, a high range water reducer (HRWR), meeting the requirements of Specification C494/C494M Type F, shall be used (if necessary) to provide adequate dispersion and workability of the mixture. The water-cementitious material ratio shall remain 0.47 by mass and the amount of HRWR shall be that to obtain a flow of  $\pm 7.5$  percentage points of a control mortar without silica fume or metakaolin as determined in accordance with Test

**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 $\mu\text{m}$ (No. 30)	25
600 $\mu\text{m}$ (No. 30)	300 $\mu\text{m}$ (No. 50)	25
300 $\mu\text{m}$ (No. 50)	150 $\mu\text{m}$ (No. 100)	15