Designation: C1567 – 13

Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)[1]

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 (ε) 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:*[2]

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

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.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregatesand is the direct responsibility of Subcommittee C09.26 on Chemical Reactions.

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[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. 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**).[3]

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 ± 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 polythylene have been found to be acceptable.

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

6. Reagents

6.1 *Sodium Hydroxide (NaOH)*—USP or technical grade may be used, provided the Na^+ and OH^- 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 ± 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 ± 2.0 °C.

[3] 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 alkalies 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-µm (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:

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 µm (No. 30)	25
600 µm (No. 30)	300 µm (No. 50)	25
300 µm (No. 50)	150 µm (No. 100)	15

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:

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

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 ± 7.5 percentage points of a control mortar without silica fume or metakaolin as determined in accordance with Test

Method C1437 using 10 drops of the flow table. If liquid HRWR is used, the water present in the liquid must be included in the calculation of the water-cementitious material ratio.

8.5.4 *Mixing of Mortar*—Mix the mortar in accordance with the requirements of Practice C305.

8.5.5 *Molding of Test Specimens*—Mold test specimens within a total elapsed time of not more than 2 min and 15 s after completion of the original mixing of the mortar batch. Fill the molds with two approximately equal 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 off the mortar flush with the top of the mold and smooth the surface with a few strokes of the trowel.

9. Procedure

9.1 *Initial Storage and Reading*—Place each mold in the moist cabinet or room immediately after molds have been filled. The specimens shall remain in the molds for 24 ± 2 h. Remove the specimens from the molds and, while they are being protected from loss of moisture, properly identify and make an initial comparator reading. Make and record the initial and all subsequent readings to the nearest 0.002 mm. Place the specimens made with each aggregate sample in a storage container with sufficient tap water to totally immerse them. The temperature of the water used to immerse the specimens shall be 23.0 ± 2.0°C at the time of immersion. Seal and place the containers in an oven or water bath at 80.0 ± 2.0 °C for a period of 24 h ± 2 h.

9.2 *Zero Readings*—Remove the containers from the oven or water bath one at a time. Remove other containers only after the bars in the first container have been measured and returned to the oven or water bath. The time elapsed between removal and return of the specimens to the oven or water bath shall not exceed 10 min. Remove the bars one at a time from the water and dry their surface with a towel paying particular attention to the two metal gage studs. Take the zero reading (see Note 6) of each bar immediately after drying, and read as soon as the bar is in position. Complete the process of drying and reading within 15 ± 5 s of removing the specimen from the water. After taking comparator readings, leave the specimen on a towel until comparator readings have been taken on the remainder of the bars. Place all specimens made with each unique cementitous materials-aggregate combination in a separate container with sufficient 1N NaOH, at 80.0 ± 2.0 °C for the specimens to be totally immersed. Seal the container and return it to the oven or water bath.

NOTE 6—The reference bar should be read prior to each set of specimens since the heat from the mortar bars may cause the length of the comparator to change.

9.3 *Subsequent Storage and Measurement*—Make subsequent comparator readings of the specimens periodically, with at least three intermediate readings, for 14 days after the zero reading, at approximately the same time each day. If readings are continued beyond the 14-day period, take at least one reading per week. The procedure is identical to that described in the 9.2, except that the specimens are returned to their own container after measurement.

10. Calculation

10.1 Calculate the difference between the zero comparator reading of the specimen and the reading at each period to the nearest 0.001 % of the effective gage length and record as the expansion of the specimen for that period. Report the average expansion of the three specimens of a given cementitious materials-aggregate combination to the nearest 0.01 % as the expansion for the combination for a given period.

11. Report

11.1 Report the following information:

11.1.1 Type and source of aggregate,

11.1.2 Type and source of hydraulic cement,

11.1.3 Type, source, and proportions of pozzolan

11.1.4 Grade, source, and proportions of ground granulated blast-furnace slag

11.1.5 Autoclave expansion and alkali content of cement as percent potassium oxide (K_2O), sodium oxide (Na_2O), and calculated sodium oxide (Na_2O) equivalent (Na_2O_{eq} = $\%Na_2O$ + 0.658 × $\%K_2O$),

11.1.6 Average length change in percent at each reading of the specimens,

11.1.7 Any relevant information concerning the preparation of aggregates, including the grading of the aggregate when it differs from that given in 8.2,

11.1.8 Any significant features revealed by examination of the specimens during and after test,

11.1.9 Amount of mixing water expressed as a mass fraction of the total cementitious material,

11.1.10 A graph of the length change data from the time of the zero reading to the end of the 16 day period.

12. Precision and Bias

12.1 The following precision statements are taken from Test Method C1260, and are based on tests without pozzolans or ground slag.

12.2 *Within-Laboratory Precision*—It has been found that the average within-laboratory coefficient of variation for materials with an average expansion greater than 0.1 % at 14 days is 2.94 % **(5)** (Note 7). Therefore, the results of two properly conducted tests within the same laboratory on specimens of a sample of aggregate should not differ by more than 8.3 % (Note 7) of the mean expansion.

12.3 *Multi-Laboratory Precision*—It has been found that the average multilaboratory coefficient of variation for materials with an average expansion greater than 0.1 % at 14 days is 15.2 % **(5)** (Note 7). Therefore, the results of two properly conducted tests in different laboratories on specimens of a sample of aggregate should not differ by more than 43 % (Note 7) of the mean expansion.

NOTE 7—These numbers represent, respectively, the (1s %) and (d2s %) limits as described in Practice C670.

12.4 *Bias*—Since there is no accepted reference material for determining the bias of this test method, no statement on bias is being developed.

13. Keywords

13.1 aggregate; alkali-silica reactivity; length change; mortar; pozzolans, slag, sodium hydroxide

APPENDIX

(Nonmandatory Information)

X1. INTERPRETATION OF TEST RESULTS

X1.1 There is good agreement in the published literature (**2, 10-12**) for the following expansion limits:

X1.1.1 Combinations of cement, pozzolan, or ground granulated blast-furnace slag, and aggregate that expand less than 0.10 % at 16 days after casting are likely to produce acceptable expansions when tested in concrete (that is, Test Method C1293) and to have a low risk of deleterious expansion when used in concrete under field conditions.

X1.1.2 Combinations of cement, pozzolan, or ground granulated blast-furnace slag, and aggregate that expand more than 0.10 % at 16 days after casting are indicative of potentially deleterious expansion. However, the potential for deleterious reaction should be confirmed by testing the same combination of materials in concrete (that is, Test Method C1293). The expansion may be reduced by retesting the material combination using the pozzolan or ground granulated blast-furnace slag at a higher replacement level.

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SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C1567–11, that may impact the use of this test method. (Approved January 1, 2013)

(1) Section 9.1 was revised.

Committee C09 has identified the location of selected changes to this test method since the last issue, C1567–08, that may impact the use of this test method. (Approved August 1, 2011)

(1) Added new 4.2 to indicate that only one aggregate product should be tested in a single batch. Renumbered subsequent paragraphs.